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Effectiveness Monitoring Report (EMR) for the P-Area Groundwater (PAGW) Operable Unit (OU) Zero Valent Iron Permeable Reactive Barrier (ZVI-PRB) Removal Action (U)

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~	approximately
1Q20	first quarter of 2020
1Q22	first quarter of 2022
2Q20	second quarter of 2020
2Q21	second quarter of 2021
3Q21	third quarter of 2021
4Q21	fourth quarter of 2021
ac	acre
amsl	above mean sea level
cis-DCE	cis-1,2-dichloroethylene
cm	centimeter
cVOC	chlorinated volatile organic compound
1,1-DCE	1,1-dichloroethylene
DO	dissolved oxygen
DOC	dissolved organic carbon
EMP	Effectiveness Monitoring Plan
EMR	Effectiveness Monitoring Report
ft	feet/foot
ft/d	feet per day
ft/yr	feet per year
ha	hectare
HPIT	Hydraulic Pulse Interference Testing
in.	inch
km	kilometer
LAZ	Lower Aquifer Zone
m	meter
m/d	meter per day
m/yr	meter per year
MCL	maximum contaminant level
MDL	maximum detection limit
mg/L	milligram per liter
mi	mile
mV	millivolt
NTC	non-time critical
ORP	oxidation-reduction potential
OU	operable unit
PAGW	P-Area Groundwater
PAOU	P-Area Operable Unit
PCE	tetrachloroethylene
PDI	Pre-Design Investigation
PQL	practical quantification limit
PRB	permeable reactive barrier
P-RBC	P-Reactor Building Complex (105-P)

PSA	potential source area
RA	removal action
RADP	Removal Action Design Plan
RAO	removal action objective
RAR	Removal Action Report
RSER/EE/CA	Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis
SAP	Sampling and Analysis Plan
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site
TCCZ	Tan Clay Confining Zone
TCE	trichloroethylene
TOC	total organic carbon
trans-DCE	trans-1,2-dichloroethylene
UAZ	Upper Aquifer Zone
µg/L	microgram per liter
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
UTRA	Upper Three Runs Aquifer
VC	vinyl chloride
WSRC	Washington Savannah River Company LLC
yr	year
ZVI	zero-valent iron
ZVI-PRB	zero-valent iron permeable reactive barrier

1.0 INTRODUCTION

The P-Area Groundwater (PAGW) operable unit (OU) encompasses approximately (~) 2,226 hectares (ha) (5,500 acres [ac]) of groundwater beneath Savannah River Site's (SRS) P Area. Groundwater in the PAGW OU is contaminated with chlorinated volatile organic compounds (cVOCs), primarily trichloroethylene (TCE), and tritium. With approval from the United States Environmental Protection Agency and the South Carolina Department of Health and Environmental Control, the United States Department of Energy (USDOE) conducted a non-time critical (NTC) removal action (RA) at the PAGW OU.

Field activities in support of the PAGW OU NTC RA were completed on January 14, 2020, in accordance with the approved Removal Action Design Plan (RADP) (Savannah River Nuclear Solutions [SRNS] 2019). The NTC RA consisted of emplacing ~672 metric tons (741 US tons) of zero-valent iron (ZVI) to construct an 80.5 meter (m) (264 feet [ft]) long permeable reactive barrier (PRB) with an average thickness greater than 10.2 centimeters (cm) (4 inches [in.]), as detailed in the Removal Action Report (RAR) (SRNS 2020b). Baseline sampling was conducted in March of 2019 and effectiveness monitoring began in February 2020 following construction of the ZVI-PRB. Effectiveness monitoring is being conducted in accordance with the approved Effectiveness Monitoring Plan (EMP) for the PAGW OU NTC RA (SRNS 2019). This Effectiveness Monitoring Report (EMR) is the second of five annual reports to document performance and effectiveness of the NTC RA technology. After the fifth annual EMR, the reporting frequency will be re-evaluated with the Core Team.

2.0 OPERABLE UNIT DESCRIPTION AND HISTORY

P Area is located in the central portion of the SRS ~4.0 kilometers (km) (2.5 miles [mi]) east-southeast of the geographic center of the SRS and about 6.4 km (4 mi) west of the nearest site boundary (Figure 1). P Area consists of a closed nuclear reactor building complex and several surface OUs and structures that were previously characterized and identified as sources to soil and groundwater contamination (Washington Savannah River Company, LLC [WSRC] 2006).

The P Area surface units identified as posing a risk to human health, the environment, and contributing to groundwater contamination were remediated as part of the P-Area Operable Unit

(PAOU), including the P-Area Reactor Building Complex (P-RBC) (105-P) (SRNS 2008). Remedial actions associated with surface units included in the PAOU have been completed and are documented in the PAOU Post Construction Report (SRNS 2012). In particular, one surface unit, Potential Source Area (PSA)-3A, was determined to be the source of TCE plumes discharging to Steel Creek. PSA-3A was remediated in 2011 and remedial goals were met using soil vapor extraction enhanced with soil fracturing and In-Situ Chemical Oxidation injection.

Groundwater beneath P Area was impacted due to reactor and facility operations between 1954 and 1991. The PAGW OU was established for the purposes of groundwater modeling and encompasses the groundwater beneath P Area, northwest to Steel Creek, northeast toward PAR Pond and SRS Road F, and southeast to Meyers Branch (Figure 2). Groundwater plumes are present in the PAGW OU Upper Aquifer Zone (UAZ) and Lower Aquifer Zone (LAZ) of the Upper Three Runs Aquifer (UTRA).

2.1 Physiographic Setting

Topography of the PAGW OU ranges from 101 m (330 ft) above mean sea level (amsl) near P Area to 57.9 m (190 ft) amsl at the downstream end of Meyers Branch and Steel Creek. The area near the P-RBC is higher in elevation than the surrounding land. Surface drainage on the west side of the P-RBC is to the west, towards Steel Creek. Surface drainage on the east side of the P-RBC drains to unnamed tributaries that drain to PAR Pond. Surface drainage on the south side drains to wetlands and unnamed tributaries to Meyers Branch.

2.2 Hydrogeologic Setting

A detailed description of the hydrostratigraphy of the PAGW OU can be found in the 2013 Sampling and Analysis Plan (SAP) for the PAGW OU (SRNS 2013). The groundwater encompassed by the PAGW OU is in the Floridan aquifer system. The aquifer of interest for this NTC RA is the UTRA, which is divided into the UAZ and the LAZ by an aquitard, the Tan Clay Confining Zone (TCCZ). The near-surface groundwater in P Area is isolated by PAR Pond to the east, Steel Creek to the west, and Meyers Branch to the south and east.

The 30-year (yr) average (1992 - 2021) rainfall for SRS is 119.8 cm per yr (47.15 in. per yr) (Savannah River National Laboratory [SRNL] 2021). P Area received 151 cm (42.78 in.) of rainfall in 2021 based on data from the 100-P rain gauge (Figure 3). The P-RBC area is a zone of local groundwater recharge, therefore a portion of rainfall in the area translates to the water table by moving vertically downward (WSRC 2008). Regionally, water levels have decreased in 2021 due to decreased rainfall. This decrease is reflected in water elevation measurements in ZVI-PRB monitoring wells, as demonstrated on hydrographs in Appendix B.

2.3 Nature and Extent of Contamination

The nature and extent of contamination was investigated for the PAGW OU using groundwater monitoring wells, direct-push technology, and surface water samples (SRNS 2013 and SRNS 2018b). Groundwater contamination associated with cVOCs is primarily exhibited in a narrow band north of the P-RBC and extends to the west to Steel Creek, where impact is known, and east towards an unnamed tributary to PAR Pond. Several areas in the P Area facility area were determined to be PSAs for the cVOC plumes, primarily tetrachloroethylene (PCE) and TCE. TCE contamination originating from P Area impacts the PAGW OU and follows groundwater flow for the UAZ and LAZ of the UTRA, shown in Figure 4 and Figure 5, respectively. It should be noted that the TCE plumes were updated with the most recent well and surface water sampling results. The 2018 SAP Addendum data were retained to illustrate the extent and magnitude of TCE contamination in the distal area downgradient of the ZVI-PRB (SRNS 2018b). As such, Figures 4 and 5 make note of the data from 2018 and 2022 were used in construction of the figures. In the UAZ, groundwater flows west-southwest, from the P-RBC, toward Steel Creek. The UAZ TCE plume impacts surface water in Steel Creek around surface water station SC-03.

The groundwater plume from the P-RBC to Steel Creek has been delineated into three sections, the source area, the neck area, and the distal area (Figures 4 and 5). The source area encompasses the portion of the plume where the source initially impacts groundwater and is centered northwest of the P-RBC within the P Area facility area. The neck area represents the area where the cVOC groundwater plumes are controlled by a buried geologic feature thus creating a narrowing of the groundwater plumes and is located to the west just outside of the P Area facility area. In this zone, the UAZ and upper LAZ contain large cobblestones in a sandy-clay matrix, promoting a narrowed zone of preferential groundwater flow. The plume then reaches further toward Steel Creek, where it begins to expand. This is in the distal area where the source of contamination has been cut-off by the ZVI-PRB. The distal area is where a large amount of mass is now concentrated and is largely bound up in low-permeability sediments in the subsurface, as determined by investigation as part of the 2018 SAP Addendum (SRNS 2018b).

Maximum contaminant level (MCL) exceedances in groundwater occur over an area of ~8.7/12 ha (21/30 ac) for TCE in the UAZ/LAZ, respectively (SRNS 2020a). PCE and cis-1,2-dichloroethylene (cis-DCE) plumes present in the UAZ and LAZ are contained within the TCE plume area as described and shown in the SAP Addendum (SRNS 2018b). Table 1 lists the maximum reported concentrations in first half of 2019 for TCE, PCE, and cis-DCE in the UAZ and LAZ within the three sections prior to implementation of the PAGW OU NTC RA. Due to the highly aerobic nature of SRS groundwater, incomplete degradation of PCE/TCE is occurring as evident by buildup of cis-DCE and no detection of other degradation byproducts. Surface water in Steel Creek is impacted by discharges of TCE-contaminated groundwater above the MCL of 5 micrograms per liter (µg/L). The area of impact is localized to the upper section of the creek at surface water location SC-03 (Figure 4) and confirmed through characterization completed as part of the 2018 SAP Addendum (SRNS 2018b). Maximum TCE concentrations in Steel Creek were observed at 28.3 µg/L in 2013 (surface water station SC-03). The most recent (first quarter of 2022 [1Q22]) measured TCE concentration at SC-03 was 15.2 µg/L.

The Core Team determined the PAGW OU contamination warranted a NTC RA to reduce cVOC mass flux. Installation of a ZVI-PRB to intersect TCE plume(s) in the neck area was chosen as the preferred method in the *Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis for Trichloroethylene Plumes Discharging to Steel Creek in P-Area Groundwater Operable Unit (NBN) (U)* (SRNS 2018a). The selected NTC RA was presented to the public in the *Action Memorandum and Responsiveness Summary for the Non-Time Critical Removal Action for the P-Area Groundwater Operable Unit (U)* (USDOE 2018). The Removal Action Objective (RAO), as presented in the PAGW OU Action Memorandum, is to protect human health and the environment by reducing the mass and down-gradient transport of the PAGW OU TCE groundwater plume. As stated in the Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA), a TCE mass flux reduction of 80% should be sufficient to achieve the MCL in Steel Creek over time (SRNS 2018a).

In support of the PAGW OU NTC RA, a Pre-Design Investigation (PDI) was performed in the neck area of the TCE plumes to confirm site lithology, hydrogeologic, geochemical characteristics, and confirm extent of cVOC contamination as it relates to design, construction, and performance of the ZVI-PRB. During the RSER/EE/CA process, the assumption was that both the UAZ and LAZ TCE plumes would be targeted with the ZVI-PRB (SRNS 2018a). Data from the PDI indicated that TCE concentrations in the LAZ were lower than in the UAZ and that groundwater flow direction of the LAZ was much more northerly than what was expected (SRNS 2019). Considering that the LAZ groundwater flow direction would lead to inefficient capture of the TCE plume by the ZVI-PRB proposed, and the TCE concentration data which showed ~95% of the TCE mass is present in the UAZ, focus was placed on constructing a ZVI-PRB to target the UAZ TCE plume. However, as a result of ZVI-PRB installation, fracking did propagate into the top of the LAZ and therefore injection of ZVI did occur in this unit. This did not diminish the overall performance of the ZVI-PRB on its effectiveness in removing cVOCs from the UAZ, rather placement of ZVI in the upper portion of the LAZ has aided in the treatment in cVOCs that were identified as part of the PDI.

2.4 Removal Action Implementation and Monitoring Goals

Design and construction details for the final design are provided in the RADP and the RAR for the PAGW OU NTC RA (SRNS 2019 and SRNS 2020b). ZVI injections were completed on December 11, 2019 with the emplacement of ~672 metric tons (741 US tons) of ZVI. ZVI was mixed with hydroxypropylguar prior to injection to produce a viscous solution able to be injected into the subsurface. Additionally, sodium chloride was added to the solution to increase the conductivity of the injected solution and allowed for resistance mapping of the injections. Details of the mix and injections are provided in the RADP (SRNS 2019). The completed ZVI-PRB is estimated to be 80.5 linear meters (264 linear feet) long and has a cross-sectional area of 2,140 square meters (23,040 square feet) intersecting groundwater flow in the UAZ (Figure 6). Figure 6 is a cross-section of the ZVI-PRB trace (Figure 7) and soil concentrations for the plume are based on soil plug samples collected from soil cores collected along the ZVI-PRB trace as part of the PDI. There are high cVOC concentrations entrained within the low-permeability sediments of the area, which are reflected in soil plug samples. However, monitoring wells are screened in more permeable zones and therefore groundwater samples indicate lower concentrations. Field activities were completed with closure of the injection wells on January 14, 2020.

Groundwater monitoring in support of the PAGW OU NTC RA was planned to begin the first month following implementation and follow the frequency outlined in the EMP, as summarized in Table 2. The monitoring plan approved in the RADP with EMP (SRNS 2019) will provide results that allow for assessment of the ZVI-PRB technology's effectiveness in destruction of cVOCs. A key component of assessment is four in-wall monitoring wells, which will provide direct results from the center of the implemented technology. The takeaways from this assessment will provide useful insight in the technology's potential applicability for future actions on site, or at other sites within the USDOE Complex. The primary focus of the EMP will be to assess performance of the PAGW OU NTC RA in meeting the RAO. Five annual EMRs will be submitted with the initial report submitted within 180 days of monitoring well completion (SRNS 2019).

The implemented ZVI-PRB is anticipated to reduce the mass flux of TCE through the neck area of the PAGW OU TCE plume by at least 80% in order to meet the RAO. This will be assessed through the monitoring of cVOC concentrations over time in 26 monitoring wells identified in the EMP for performance monitoring (SRNS 2019). ZVI is a recognized technology for reducing high level cVOCs (PCE and TCE) to harmless end-products without the build-up of harmful intermediates, such as cis-DCE, trans-1,2-dichloroethylene (trans-DCE), and chloroethene (vinyl chloride [VC]). In addition to TCE and PCE, degradation by-products will also be monitored.

Important geochemical and field measurements will be monitored to assess geochemical changes in the target zone. The high reducing potential of ZVI presents the favorable possibility of flipping an aerobic aquifer to anaerobic, reducing conditions, traveling down-gradient as a reducing front over time. An anaerobic, reducing environment is conducive to the potential formation of natural anaerobic microbial activity, which are often heavy consumers of organic compounds, including the targeted contaminant TCE. The presence of guar that was used to inject the ZVI will provide a reliable carbon source aiding in further destruction of cVOCs. The presence of a reducing environment in the UAZ of the PAGW OU will be measured by oxidation-reduction potential (ORP). Negative ORP values indicate a reducing environment, with higher negative numbers indicating the strength of the reducing agents in groundwater. In an environment with promising conditions for anaerobic microbes, the presence of intermediate cVOC degradation products are indicators of natural biodegradation, as ZVI is not anticipated to form a large mass of intermediates.

In addition, the selected analytes will provide data on the health of the ZVI-PRB. Nitrate, calcium, and sulfate are commonly occurring constituents in groundwater and are found in detectable concentrations within the UAZ of the UTRA in the PAGW OU. In literature, at the interface between groundwater and ZVI, nitrate has been observed to interact with the ZVI and result in a lessened reactivity, and therefore a decreased performance, known as passivation (Ritter, Odziemkowski, and Gillham 2002; Mishra and Farrell 2005). A decrease in nitrate concentrations down-gradient of the ZVI-PRB may indicate consumption of the ion by ZVI, and therefore may be indications of passivation. Sulfate and calcium ions in a reducing, high pH environment more readily precipitate out of solution. Precipitation within the ZVI-PRB leads to a decreased performance as the porosity, and therefore the retention time within the barrier, will decrease. This reduces the contact time of cVOCs with ZVI, and therefore reduces the potential for complete degradation. However, based on the treatability study performed during design activities of the PRB, it was concluded that it was unlikely, unless conditions changed, that the PRB would exhibit reduced effectiveness due to passivation and/or precipitation. However, overtime, under normal circumstances, it is expected that ZVI will lose some of its reactivity.

2.5 PAGW OU NTC RA Monitoring Network

As outlined in the RADP with EMP (SRNS 2019), the PAGW OU NTC RA monitoring network includes 26 monitoring wells. Table 2 provides construction details for the monitoring network and Figure 7 shows the locations for each monitoring point. Eight of the monitoring wells (PRW001C/DL/DU, PRW003C/DL/DU, and P003U/L) are located to the east of the ZVI-PRB and 14 wells (PRW002C/DL/DU, PRW004C/DL/DU, PRW005DL/DU, PRW006C/DL/DU, PRW007DL/DU, and P002U) are located to the west. The P003 well cluster is located farther to the east of the ZVI-PRB than the other wells and is considered a background monitoring well for monitoring in support of the PAGW OU RA EMP.

A baseline analysis was completed at 15 of the monitoring well locations in March of 2019 prior to construction of the ZVI-PRB. Baseline results are presented in in Table 3. Figure 8 presents baseline TCE results at the ZVI-PRB monitoring locations. Comparisons of baseline contaminant concentrations with monitoring well results east and west of the ZVI-PRB allows for assessment of the NTC RA performance in reducing TCE mass flux. In addition to the 22 monitoring wells on either side of the ZVI-PRB, four injection wells were retrofit with 2.5 cm (1 in.) diameter monitoring wells (PIW001D, PIW002D, PIW003D, and PIW004D). The in-wall monitoring wells present a key perspective, allowing for assessment of the conditions within the barrier itself. The approved EMP for the PAGW OU NTC RA outlined the analytes and frequency to be followed for the 26 monitoring wells as shown in Table 2 and Figure 7 (SRNS 2019).

For the four in-wall monitoring wells, the approved EMP for the PAGW OU NTC RA proposed sampling bimonthly for the first quarter, monthly sampling for the second quarter, and quarterly sampling for the remainder of the five year monitoring plan. This frequency was proposed with intentions of observing rapid changes in geochemical parameters and then to track these parameters over time. All other monitoring wells, with the exception of the PRW006 cluster, are scheduled to be sampled quarterly. The PRW006 well cluster is set farther west of the PRB and will be sampled annually.

Monitoring results are presented in Section 3.0 and discussed in Section 4.0. The complete data sets are presented in the appendices. Appendix A tabulates monitoring data from second quarter of 2021 (2Q21) to 1Q22 for all wells and analytes in the PAGW OU NTC RA EMP. Appendix B presents hydrographs of water levels at the PAGW OU NTC RA monitoring wells from 2018 to present. Appendix C consists of time-series plots for select constituents from 2005 to present of the outlined analytes for the EMP to support the PAGW OU NTC RA.

3.0 MONITORING RESULTS AND DEVIATIONS

3.1 Deviations from the Monitoring Plan

Monitoring wells included in the PAGW OU NTC RA were sampled and analyzed as outlined in the RADP with EMP, with one deviation between 2Q21 to 1Q22 (SRNS 2019). Monitoring results from 2Q21 to 1Q22 are presented in Appendix A. The one deviation was:

1. Included in the geochemical analyses for the in-wall monitoring wells are total iron, ferric iron, and ferrous iron. Analyzing for the separate oxidation states of iron allows for

assessment of the reductive environment created by the ZVI-PRB. However, following second quarter of 2020 (2Q20) sampling, the laboratory contracted for ferric and ferrous iron analyses was no longer available. Therefore, ferric and ferrous iron analyses were not conducted from 2Q20 to 2Q21. SRS has worked out laboratory issues, and ferric/ferrous iron analyses resumed starting third quarter of 2021 (3Q21).

3.2 Upper Aquifer Zone

3.2.1 Groundwater Elevation Measurements and Groundwater Flow Direction

Hydrographs for UAZ monitoring wells of the effectiveness monitoring plan are presented in Appendix B. Recent decreases in water elevations are reflective of decreased precipitation in recent years as shown in Figure 3. Regional water elevations and potentiometric contours for the UAZ are presented in Figure 9 using 1Q22 synchronous water level data. The regional groundwater flow direction in the UAZ is to the west towards Steel Creek. Hydraulic conductivity was calculated to be 10.59 meters per day (m/d) (34.76 feet per day [ft/d]) for the UAZ within the ZVI-PRB area through Hydraulic Pulse Interference Testing (HPIT) (SRNS 2019). The hydraulic gradient was calculated between approximately PMW005DL and PGW026DL as 0.0083 ft/ft. Using an estimated effective porosity of 0.2 for the UAZ in P Area (SRNS 2019), the resulting regional groundwater flow velocity is 160.6 meters per year (m/yr) (526.9 feet per year [ft/yr]) in the NTC RA area. In Figure 10, focus is placed on the ZVI-PRB localized area within the UAZ potentiometric surface. In the vicinity of the ZVI-PRB, the hydraulic gradient is estimated between approximately P003U and PRW006DU to get 0.0067 ft/ft. This results in an estimated groundwater flow velocity of 39.50 m/yr (129.6 ft/yr). Groundwater flow velocity in the vicinity of the ZVI-PRB is much slower than the flow velocity for the UAZ to the west towards Steel Creek. The slower groundwater flow velocity can be attributed to the location of the ZVI-PRB near P Area close to the groundwater divide and also because of the impact the ZVI-PRB is having on localized groundwater flow. This is illustrated on Figures 9 and 10 as evident by further spaced potentiometric surface contours west of the ZVI-PRB around the PRW002 monitoring well cluster. The variability in the UAZ potentiometric surface near the PRB indicates localized slowing of groundwater flow and is consistent with regional groundwater elevation changes across P Area. This observation is not expected to negatively impact the performance of the ZVI-PRB, as upgradient water is flowing towards/into the permeable barrier.

Groundwater depth measurements are not included for the P00 series monitoring wells due to the diameter of the monitoring well and size of the installed pump, which does not allow access of a groundwater tape for measurement.

3.2.2 Chlorinated Volatile Organic Compounds

Per the EMP for the PAGW OU NTC RA (SRNS 2019), all monitoring wells are sampled and analyzed quarterly for select cVOCs, including PCE, TCE, cis-DCE, trans-DCE, 1,1-dichloroethylene (1,1-DCE), and VC. Between 2Q21 and 1Q22, 78 samples were collected and analyzed for cVOCs at the PAGW UAZ EMP wells. Out of the 78 samples, there were no results above the practical quantification limit (PQL) for 1,1-DCE. There were four and one result above the PQL for VC and trans-DCE, respectively. The maximum concentrations were 4.00 µg/L and 1.13 µg/L for VC and trans-DCE, respectively. For the PAGW OU NTC RA, the targeted constituent is TCE. Baseline concentrations are summarized for all cVOCs in Table 3 and are compared to 1Q22 results in Table 4.

Data from east of the ZVI-PRB are upgradient and would be considered background concentrations. However, because of the proximity of the PRW001 cluster to the ZVI-PRB, the data reported are elevated relative to key baseline indicators. For instance, chloride, dissolved organic carbon (DOC), ethane, methane, and total organic carbon (TOC) are all elevated. This is primarily due to the impact of the ZVI-PRB on groundwater surrounding this well cluster. Field data from this well cluster also support the relative impact the ZVI-PRB is having on groundwater as illustrated by the low ORP and dissolved oxygen (DO) results (Appendix A). West of the ZVI-PRB, the data indicates impact of the NTC RA on groundwater as shown by increases in TCE degradation by-products (e.g., cis-DCE and ethane) as well as increases in chloride, iron, and methane. The data also indicates elevated levels of TCE, which is not unexpected. As cVOCs are removed by the ZVI-PRB from groundwater, the cleaner groundwater moves through the higher permeability material downgradient of the ZVI PRB, TCE is being diffused from the low permeable sediments through "back diffusion" into the cleaner groundwater. Back diffusion is a phenomenon where cVOCs, such as TCE, have adsorbed into low permeability sediments and seeks equilibrium with the "clean" groundwater. A concentration gradient then persists that promotes TCE diffusion from the low permeability sediments and into the groundwater. This phenomenon is beneficial, as it results in more TCE mass being removed from the subsurface, but it is also likely to result in elevated TCE results in monitoring wells west of the ZVI-PRB for some time until most of the cVOC mass has diffused from the low permeable sediments. Therefore, data from the in-wall wells provide the best indication on the effect the ZVI-PRB is having on groundwater as it passes through the ZVI-PRB. The primary contaminants are mostly not detected and there are elevated concentrations of the end by-products, ethane and ethylene.

Trichloroethylene

For the UAZ, 1Q22 TCE results are presented in Figure 11. TCE concentrations in the background monitoring wells P003U and P003L were estimated values of 558 µg/L and 2,410 µg/L, respectively. TCE concentrations in eastern UAZ monitoring wells ranged from 0.61 to 961 µg/L in 1Q22, with the maximum detection at PRW003DL. In western UAZ monitoring wells, TCE ranged from 0.77 to 617 µg/L, with the maximum at PRW007DU. The second highest TCE result in western UAZ monitoring wells was 98.8 µg/L, recorded at PRW006DL. TCE time-series plots are presented in Appendix Figures C.29 to C.40.

The concentration of TCE in groundwater monitoring wells west of the ZVI-PRB with baseline data (P002U, PRW002 and PRW004 clusters) has decreased over baseline, with the exception of PRW004DL (Figure 12), which initially dropped below detection but has since rebounded with a most recent result of 72.5 µg/L. TCE concentrations in the remaining monitoring well clusters west of the ZVI-PRB (PRW005, PRW006, and PRW007 clusters) are presented in Figure 13. Concentrations have remained steady below the MCL (5 µg/L) at PRW005DL and PRW005DU, and at the MCL for PRW006DU. TCE concentrations have a decreasing trend at PRW006DL and PRW007DU. The only location with an increasing trend is PRW007DL, which increased from 6.62 µg/L in July 2020 to 31.6 µg/L in February 2022.

The four in-wall monitoring wells (PIW series) were sampled for TCE starting in 2Q20, post-completion of the ZVI-PRB (Appendix Figures C.30 – C.33). Initially, TCE results in the in-wall monitoring wells were low, with only 3 of 12 sample results in 2020 above the PQL and a maximum of 5.03 µg/L (PIW003D in fourth quarter of 2020). TCE concentrations at PIW001D, PIW002D, and PIW004D remained below detection for 9 of 12 samples collected between 2Q21 and 1Q22. The three detectable results were 5.31 µg/L, 7.92 µg/L, and 22.6 µg/L. TCE concentrations at in-wall monitoring well PIW003D remained above the MCL from 2Q21 to 1Q22, with a maximum detection of 19.2 µg/L (fourth quarter of 2021 [4Q21]). The maximum result of the in-wall monitoring wells (22.6 µg/L) is 97.6% lower than the maximum 1Q22 result east of the ZVI-PRB (961 µg/L). It is important to note that the in-wall monitoring wells are located within the ZVI-PRB. Therefore, the detected results are located in the middle of the barrier and further degradation of detected cVOCs is likely to occur before groundwater exits the ZVI-PRB.

Tetrachloroethylene and Cis-1,2-Dichloroethylene

From 2Q21 to 1Q22, 10 of 78 samples collected for the UAZ EMP wells reported PCE detections above the method detection limit (MDL). None of the detections were above the PQL in monitoring wells west of the ZVI-PRB, with the exception of PRW006DU, which is located farthest to the west. All results from 2Q21 to 1Q22 were below the maximum PCE baseline of 5.15 µg/L, with the exception of the 1Q22 result at PRW003DL (11.8 µg/L), located east of the ZVI-PRB.

In the 1Q22 sampling event, the maximum UAZ result for cis-DCE was 382 µg/L at background monitoring well P003L. The maximum 1Q22 result east of the ZVI-PRB, excluding the background wells, was 60.7 µg/L at PRW003DL. The maximum result west of the ZVI-PRB was 76.6 µg/L at PRW004DL. West of the ZVI-PRB, cis-DCE concentrations have increased from baseline and remained steady ranging between 1.41 µg/L and 76.6 µg/L in the 1Q22 sampling event. The presence of cis-DCE and ethane west of the ZVI-PRB indicates conditions are supportive for further degradation of TCE and PCE. Cis-DCE time-series plots are presented in Appendix Figures C.5 to C.16 for the PAGW OU NTC RA monitoring wells.

Out of the four in-wall monitoring wells, PIW003D is the only monitoring well with consistent detections of cis-DCE. Concentrations in the two most recent sampling events were 53.7 µg/L and 41.3 µg/L (4Q21 and 1Q22, respectively). Cis-DCE concentrations in P003U and P002U decreased slightly from July 2007 until monitoring began post-construction of the ZVI-PRB. P003L remained steady around the detection limit over the same time. Concentrations increased significantly in P003L during the baseline (892 µg/L) and have decreased slightly until 1Q22 (382 µg/L). Concentrations in P002U have increased since completion of the ZVI-PRB, with a 1Q22 result of 54.8 µg/L.

3.2.3 Geochemical Analyses

Samples collected in support of the ZVI-PRB monitoring were analyzed for select geochemical analytes in line with the approved EMP, summarized in Table 2. During the baseline sampling event, all completed monitoring wells were sampled and analyzed for geochemical analytes. In ongoing sampling events, only the in-wall monitoring wells were sampled for geochemical analyses.

Chloride, Ethylene, and Ethane Results

The breakdown of cVOCs produces end-products such as chloride, ethylene, and ethane. The maximum chloride concentration in baseline sampling of the UAZ monitoring wells was 3.64 milligram per liter (mg/L) at PRW002DU. Chloride concentrations in western groundwater monitoring wells are increasing slightly, with a 1Q22 maximum at PRW007DU of 37.4 mg/L. The maximum background chloride concentration from 2Q21 to 1Q22 was 3.05 mg/L at P003U.

MDLs for ethane and ethylene analyses remained elevated due to laboratory and analytical method capabilities. SRNS is continuing to coordinate with the contracted laboratories to ensure the lowest possible MDLs are achieved, which has been 10 µg/L for ethane and ethylene from 4Q21 to 1Q22. The corresponding EQL is 25 µg/L. In UAZ monitoring wells, the maximum baseline ethane result 0.17 µg/L. Ethane results in background wells were below the MDL in 1Q22. For all UAZ detections in 1Q22, the ethane results ranged from 15.7 µg/L to 87.8 µg/L, with the maximum detection at PIW003D. The maximum ethane concentration west of the ZVI-PRB was 54 µg/L at PRW002DU.

The baseline ethylene concentration in UAZ monitoring wells was 0.55 µg/L. Of the 21 UAZ groundwater monitoring wells sampled in 1Q22, the only result above the MDL for ethylene was 52.4 µg/L at PIW003D.

Methane

Methane concentrations remained elevated in the UAZ between 2Q21 and 1Q22. The maximum methane concentration in the baseline sampling was 2,400 µg/L and the 1Q22 background monitoring well results (P003U and P003L) were below the MDL of 10 µg/L. Of the 78 samples collected in the UAZ between 2Q21 and 1Q22, there were 64 detections above the MDL.

In 1Q22, detectable results in the UAZ ranged from 15.2 µg/L to 25,700 µg/L, with the maximum at PRW001DL. Methane concentrations west of the ZVI-PRB at monitoring well clusters PRW002 and PRW004 remain elevated above 10,000 µg/L with the exception of PRW004DL, which has returned to within baseline. In-wall monitoring wells ranged from 1,250 µg/L to 6,170 µg/L. PIW003D had the maximum and is following an increasing trend since ZVI-PRB completion. Elevated methane levels were not unexpected due to ZVI reactivity with cVOCs and anaerobic processes utilizing the food-grade guar material. The elevated methane levels are not expected to negatively impact the performance of the ZVI-PRB.

Nitrate, Sulfate, Calcium, and Iron

Certain cations and anions in groundwater are useful to make assessments of ZVI-PRB health, as well as to assess if anaerobic conditions are present. Nitrate concentrations have decreased to below MDL (0.017 mg/L) in all samples, down from a maximum UAZ baseline concentration of 2.82 mg/L. Sulfate also saw a decrease in concentration from the maximum baseline, with a maximum 1Q22 results down 92% (from 13.4 mg/L to 1.02 mg/L). Total iron concentrations for the in-wall monitoring wells have decreased from a maximum baseline of 741 µg/L to a 1Q22 maximum of 149 µg/L at PIW003D. Total iron concentrations in all monitoring well clusters west of the ZVI-PRB have remained elevated with a 1Q22 maximum of 18,400 µg/L at P002U. The only exception was the PRW006 monitoring well cluster, located farther west of the ZVI-PRB. The decreasing concentrations of nitrate and sulfate are favorable indicators that passivation of the ZVI-PRB is not a major concern.

Concentrations of calcium have increased significantly from baseline and remain elevated in 1Q22. The maximum calcium concentration in the ZVI-PRB monitoring well baseline event was 4,810 µg/L in the UAZ. The 1Q22 calcium results for in-wall monitoring wells ranged from 47,400 µg/L to 128,000 µg/L. Refer to Section 4.3 of this report for further discussion on calcium.

3.2.4 Field Measurements

In addition to analytes listed in the PAGW OU NTC RA EMP, field measurements are collected during each sampling event and at each sampling location. These measurements are collected to ensure the samples have reached stability and the sample collected is representative of the targeted groundwater. However, the values collected during field measurements are also useful in assessment of conditions in the aquifer. Field measurements of ORP have significantly decreased from baseline in March 2019 to 1Q22.

Negative ORP is a favorable condition created by ZVI which promotes reductive dechlorination. During the baseline sampling, the range of UAZ ORP values was +124 millivolts (mV) to +428 mV. In 1Q22, the range of recorded ORP values for in-wall monitoring wells was -406 mV to -349 mV. The range of ORP results in monitoring wells west of the ZVI-PRB (excluding PRW006 cluster) was -155 mV to +163 mV. At the PRW006 monitoring well cluster further to the west, effects of a reducing front are not obvious, with ORP results consistent with background and baseline results.

Impacts to groundwater pH were observed following the ZVI-PRB installation. During baseline sampling, the maximum pH of the UAZ monitoring wells was 6.5. The range of pH at in-wall monitoring wells for 1Q22 was 10.5 to 10.8. Monitoring wells west of the ZVI-PRB had a slight increase initially, with a maximum pH in first quarter of 2020 (1Q20) of 8.8 for UAZ monitoring wells. The pH in these wells has since returned to near baseline levels with a 1Q22 maximum of 6.7. For monitoring wells located further west of the ZVI-PRB, pH levels were not significantly affected.

3.3 Lower Aquifer Zone

3.3.1 Groundwater Elevation Measurements and Groundwater Flow Direction

The regional water elevations and potentiometric contours are mapped for the LAZ in Figure 14 using 1Q22 synchronous water level data. Potentiometric contours indicate a northward groundwater flow direction in the vicinity of the ZVI-PRB. Using the potentiometric surface, a hydraulic gradient of 0.0094 ft/ft was calculated. The calculated hydraulic conductivity for the LAZ in HPIT testing was 10.82 m/d (35.51 ft/d). Assuming a porosity of 0.2, the regional groundwater flow velocity was calculated as 185.8 m/yr (609.6 ft/yr) for the LAZ.

3.3.2 Chlorinated Volatile Organic Compounds

During installation of the ZVI injection wells, the bottom expansion joints were installed at the base of the TCCZ to ensure total capture of groundwater in the UAZ. As a result of fracking during the installation of the ZVI-PRB, ZVI was emplaced in the upper part of the LAZ. Secondarily to the main objective to treat groundwater in the UAZ, this emplacement has led to a reduction in TCE concentrations in this aquifer unit.

Trichloroethylene

There are five LAZ monitoring wells in the EMP (PRW001C, PRW002C, PRW003C, PRW004C, and PRW006C). TCE concentrations over time in the LAZ monitoring wells are shown in Figure 15. Excluding PRW006C, TCE concentrations are overall decreasing in the LAZ monitoring wells. The maximum baseline detection from LAZ wells for TCE was 664 µg/L at eastern well location PRW003C. In the 1Q22 sampling event, the maximum TCE concentration in the same four LAZ monitoring wells was 8.53 µg/L (PRW004C). Concentrations at PRW006C have increased, from 24.3 to 110 µg/L. TCE results for 1Q22 in the LAZ are shown in Figure 16.

Tetrachloroethylene, Cis-1,2-Dichloroethylene, and Chloroethene

For the LAZ, the maximum baseline PCE result was at monitoring well PRW002C with a detection of 1.6 µg/L. From 2Q21 to 1Q22, there were 17 samples collected for LAZ monitoring wells with only two detections above the MDL for PCE. Both detections were in 1Q22 from PRW003C and PRW006C, with results of 1.97 µg/L and 1.51 µg/L, respectively.

The maximum baseline cis-DCE result for the LAZ was 138 µg/L at PRW003C. The maximum cis-DCE result in 1Q22 was 96.2 µg/L at PRW002C. Cis-DCE concentrations in the LAZ monitoring wells are presented over time in Figure 17.

Of the 17 samples collected from LAZ monitoring wells from 2Q21 to 1Q22, five samples were above the MDL for VC and two samples were above the PQL. The maximum VC detection was 4 µg/L at PRW002C in 4Q21. There were no VC detections above the MDL in 1Q22.

3.3.3 Geochemical Analyses

Although baseline samples collected in the LAZ to support the ZVI-PRB monitoring were analyzed for the entire geochemical analyte list, post-installation samples were not analyzed for the entire geochemical analyte list in accordance with the EMP (Table 2). However, a select list of geochemical analyses was performed for post-installation samples including total iron, chloride, and dissolved gases (ethane, ethylene, and methane).

For baseline LAZ sampling, iron ranged from 80.1 µg/L to 496 µg/L. In the 1Q22 sampling event, iron results west of the ZVI-PRB at PRW002C and PRW004C were 18,600 µg/L and 9,910 µg/L, respectively. This is a decrease from the last reporting period, however total iron remains elevated compared to baseline. Total iron farther west at PRW006C remains non-detect.

Chloride concentrations in 1Q22 range from 14.0 mg/L to 26.7 mg/L in monitoring wells near the ZVI-PRB. The maximum baseline concentration in the LAZ was 3.03 mg/L. Chloride concentrations are decreasing since an initial spike following completion of the ZVI-PRB, however concentrations remain elevated near the ZVI-PRB compared to baseline. Results from PRW006C (2.23 mg/L), located farther west of the ZVI-PRB, indicate concentrations are consistent with baseline.

With the exception of PRW006C, ethane concentrations remain elevated in the LAZ, ranging from 135 µg/L to 373 µg/L in 1Q22. Likewise, ethylene concentrations are increasing in PRW001C and PRW002C, with 1Q22 detections of 136 µg/L and 214 µg/L, respectively. Baseline LAZ concentrations for both ethane and ethylene were below 1 µg/L.

Baseline concentrations for methane in the LAZ ranged from 0.64 µg/L to 2.0 µg/L. The 1Q22 results in nearby LAZ monitoring wells ranged from 895 µg/L to 21,100 µg/L. Methane concentrations remain elevated in the LAZ monitoring wells near the ZVI-PRB for 1Q22 and are consistent with previous reporting. Farther west of the ZVI-PRB at PRW006C, the 1Q22 methane result was below the MDL.

3.3.4 Field Measurements

Field measurements taken in the LAZ monitoring wells present evidence of ZVI-PRB effects. In baseline sampling, the range of ORP in the LAZ was +181 mV to +294 mV. In 1Q22, ORP in the LAZ monitoring wells ranged from -417 mV to -61 mV, in the vicinity of the ZVI-PRB. Located further to the west at PRW006C, the ORP in 1Q22 was +151 mV.

In the LAZ monitoring wells, baseline pH values ranged from 5.3 to 7.2. Immediately following ZVI-PRB construction in 1Q20, the maximum pH in the LAZ was 10.5. From 2Q21 to 1Q22, pH remained around baseline levels for the LAZ monitoring wells, with a range from 4.9 to 7.4. The only exception is PRW001C, which has an increasing pH since 3Q21. The 1Q22 pH at PRW001C was 10.5.

4.0 MONITORING PERFORMANCE AND EFFECTIVENESS DISCUSSIONS

4.1 Groundwater Elevation and Flow Path

Groundwater flow across the ZVI-PRB in the UAZ is westerly towards Steel Creek, as expected, with groundwater velocity calculated as 39.50 m/yr (129.6 ft/yr) in 1Q22 (Figure 10). After two years of monitoring, it appears impact to the UAZ groundwater potentiometric surface is minimal. The ZVI-PRB installation does appear to slow groundwater flow west of the ZVI-PRB, as indicated by the potentiometric surface between the PRW001 cluster and the PRW006 cluster. This impact is not expected to affect the ZVI-PRB performance, as the groundwater flow direction was ultimately not impacted, and flow through the ZVI-PRB in the UAZ is supported by the 1Q22 data.

The 1Q22 LAZ potentiometric surface (Figure 14) indicates a northward groundwater flow direction in the vicinity of the ZVI-PRB. The 1Q22 LAZ potentiometric surface is consistent with the 1Q21 potentiometric surface presented in last year’s report, however the groundwater divide (~258 ft amsl) has shifted to the north (SRNS 2021). This has resulted in a much more northerly groundwater flow direction in the vicinity of the ZVI-PRB. The difference between the potentiometric surface contours between the two reports is not believed to be an effect of the ZVI-PRB and instead the difference is due to natural variation in regional water levels.

By design, the ZVI-PRB was intended to target the UAZ, and the bottom was intended to key into the TCCZ that splits the UAZ and LAZ. However, due to variability in the TCCZ elevation and the method for ZVI injections, the ZVI-PRB extends through the TCCZ and does break through into the LAZ, likely at multiple locations along the length. Therefore, the higher permeability ZVI provides a conduit for groundwater flow between the UAZ and LAZ, which could impact the potentiometric surface in either unit. However, this impact is minimal, due to the nature of the TCCZ, which is understood to be an incompetent confining zone. Additionally, the connection between the UAZ and LAZ created by the ZVI-PRB will not move contamination, as any groundwater traveling along this conduit will experience an increased contact time with the reductive ZVI media, resulting in clean water entering the LAZ.

4.2 ZVI-PRB cVOC Degradation

Effectiveness of the ZVI-PRB technology is demonstrated best by the in-wall monitoring well TCE results. East of the ZVI-PRB, UAZ TCE concentrations remain elevated, with a 1Q22 maximum of 961 µg/L and a maximum background concentration of 2,410 µg/L (P003L). The only 1Q22 in-wall TCE detection was 10.4 µg/L, which demonstrates greater than 95% reduction in groundwater concentration from 961 µg/L. Across the entire ZVI-PRB, the reduction of TCE, based on average concentrations of monitoring wells east of the ZVI-PRB (1,060 µg/L) and of in-wall monitoring wells (3.35 µg/L), equates to an estimated TCE reduction of >99%. This supports a mass flux reduction greater than the RAO of 80%. Although there is a large uncertainty associated with a mass flux estimate since flow is difficult to directly measure across the entire ZVI-PRB cross-sectional area. TCE concentrations have increased slightly at PIW003D since sampling of PIW series wells began in 2Q20. Since 1Q21, concentrations have remained steady between 7 µg/L and 20 µg/L. A slight rebound of concentrations was not unexpected, as the groundwater within the barrier reaches equilibrium following the large injection volumes associated with the ZVI-PRB construction. Additionally, out of the four in-wall monitoring wells, PIW003D is screened within the zone of highest contamination based on PDI soil concentrations (Figure 6 and Table 2).

Overall, TCE concentrations are decreasing in UAZ monitoring well clusters west of the ZVI-PRB (Figure 12 and Figure 13). Excluding the PRW006 and PRW007 monitoring well clusters, TCE concentrations have decreased in all western UAZ monitoring wells (except PRW004DL) since installation of the ZVI-PRB and the maximum 1Q22 result (72.5 µg/L) demonstrates a 92.5% reduction from the maximum concentration east of the ZVI-PRB (961 µg/L). PRW004DL initially decreased to a non-detection in 2Q20, and then increased gradually to 72.5 µg/L in 1Q22. This rebounding is potentially due to the expected back diffusion of TCE out of low permeability sediments and into the clean groundwater front leaving the ZVI-PRB, as discussed in Section 3.2.2. Back diffusion of TCE from the low-permeability sediments will ultimately aid in reduction of cVOCs in groundwater migrating to the distal area of the plume.

PRW006 and PRW007 monitoring well clusters are located further from the ZVI-PRB than the other western monitoring well clusters. PRW007 monitoring wells are ~12.2 m (40 ft) from the ZVI-PRB centerline, which is double the distance of the closer monitoring wells. The small increase in distance may be enough for back diffusion to slow the observed decrease in TCE concentrations. This is evidenced by the in-wall monitoring wells PIW003D and PIW004D demonstrating almost complete TCE degradation, while PRW007DU and PRW007DL continue to present appreciable TCE concentrations. Similarly, PRW006 monitoring wells have demonstrated little to no impact from the ZVI-PRB, which can be attributed to the distance from the ZVI-PRB (~36.6 m [120 ft]).

Reductive dechlorination by-products, chloride and ethylene, were included in the ZVI-PRB sampling. For P002U, the parent and daughter products of reductive dechlorination are plotted over time in Figure 18. P002U was chosen because it is located in close proximity west of the ZVI-PRB, and depicts the best example of expected trends. Chloride concentrations increased slightly but have returned to baseline conditions in western monitoring wells. A slight increase in chloride is expected with dechlorination of cVOCs, however the increase observed may be more related to injection of sodium chloride during ZVI-PRB construction. Ethylene increased slightly from baseline to 1Q20, however issues with the MDL led to an elevated MDL (25 µg/L and above) in all results from 2Q20 to 1Q22. SRS is working with the contracted laboratory to reduce the MDL and get meaningful results in future dissolved gas analyses. The only UAZ location with ethylene results above the PQL from 2Q21 to 1Q22 was PIW003D. This elevated ethylene result provides further indication of reductive dechlorination by the ZVI-PRB, not surprisingly located at the in-wall monitoring well within the highest zone of TCE contamination.

4.3 ZVI-PRB Health and Longevity

In literature and studies of past ZVI-PRB installations, it was noted that the presence of some geochemical analytes in large concentrations can lead to precipitation within a ZVI-PRB, as well as coating of ZVI media resulting in reduced reactivity, or passivation (He, Wilson, and Wilkin 2008; Gu et al. 2001; Ritter 2000). Specific analytes of interest include, but are not limited to, sulfate, calcium, and nitrate. Results after two years of monitoring indicate nitrate and sulfate concentrations have decreased in the ZVI-PRB.

Influent concentrations and concentrations within the ZVI-PRB are believed to be low enough to conclude that precipitation and/or passivation of the ZVI-PRB is not a concern (Battelle 2002; Yabusaki et al. 2001; Wilkin, Puls, and Sewell 2003; Gu et al. 2001). Influent concentrations shown to cause short term effects on performance were sulfate concentrations above 1,000 mg/L and nitrate on the order of 120 mg/L. In addition, a treatability study was conducted prior to ZVI-PRB installation to verify the geochemistry of the site groundwater and subsurface would not result in a significant loss in ZVI-PRB performance (SRNS 2019). The following conclusions were made from the treatability study results:

- Geochemistry of site groundwater, site soils, and ZVI material are favorable for extended long-term performance.
- No observation of mineral precipitation causing loss in reactivity towards cVOCs.
- No expectation of precipitation/clogging causing a significant loss in permeability, and therefore performance.

Based on the results of the treatability study and observations of other ZVI-PRB applications (SRNS 2019), the longevity of the ZVI-PRB is expected to be at least 25 years, maintaining its effectiveness and performance.

Calcium concentrations have increased significantly, from a maximum UAZ baseline of 4,810 ug/L to a 1Q22 maximum of 178,000 μg/L for in-wall monitoring wells. The significant spike in calcium concentration is most likely related to the amount of grout used to complete the injection wells for ZVI-PRB construction. There were 22 injection wells installed to construct the ZVI-PRB, with all of the annulus space filled with grout to ensure the specialized expansion casings propagated the ZVI fractures correctly. This quantity of grout cement is likely to leach calcium due to the high pH levels created by the ZVI. The volume of grout used accounts for only 1.48% of the total volume of ZVI injected, therefore the performance of the ZVI-PRB is not anticipated to be impacted by the resulting calcium levels. Monitoring of changes in the calcium concentrations will continue for the ZVI-PRB to assess health of the ZVI-PRB, as calcium can precipitate out and result in a loss in ZVI-PRB porosity, and therefore reduce contact time with cVOCs.

4.4 ZVI-PRB Reducing Environment

Within the ZVI-PRB, reducing conditions are evidenced by high negative ORP values between -350 and -406 mV in 1Q22. Baseline ORP results in the UAZ ranged from +124 to +428 mV. The results indicate the aquifer in the vicinity of the ZVI-PRB has flipped from an oxidizing environment to a reducing environment. The highly reducing environment created by the ZVI promotes reductive dechlorination of cVOCs entering the ZVI-PRB.

The flip to reducing conditions in the aquifer support natural reductive dechlorination of cVOCs by microbial degradation as the anaerobic conditions extend out from the ZVI-PRB. However, the natural presence of anaerobic microbial species which degrade cVOCs is not guaranteed. General conditions that can support anaerobic microbial activity capable of cVOC degradation include:

- Depleted DO, nitrate, and sulfate
- Elevated ferrous iron, manganese, methane, ethylene, ethane, chloride, and alkalinity
- Negative ORP
- Substrate availability (TOC/DOC concentrations)
- Presence of cVOCs
- pH range between ~6-8

Based on the results from 1Q22 sampling, evidence exists of conditions in the vicinity of the ZVI-PRB that may support further microbial degradation of cVOCs (i.e., reducing conditions, increasing and/or elevated TOC and methane). However, the focus of this RA is abiotic degradation of cVOCs by ZVI reactions. Reductive dechlorination via interaction with ZVI is supported by the multiple lines of evidence presented in this report, however, there is not clear evidence of microbial degradation of cVOCs. The buildup of methane and potential microbial activity is not believed to play a significant role in cVOC degradation or to result in any performance reduction of the ZVI-PRB at this time.

The reducing conditions created by the ZVI also result in alkaline groundwater ($pH > 9.5$) as evident by the in-wall monitoring wells. The primary source of elevated pH levels in the anoxic conditions of the ZVI-PRB is associated with the reaction of ZVI and water:

$$2Fe^0 + 4H_2O + 4e^- \rightarrow 2H_2 + 4OH^- + 2Fe^{2+} + 4e^-$$

Secondary to this process, when considering leaching of the cement grout used to construct the injection wells could also be contributing to the increased pH levels, it appears that the contribution is significantly less when comparing the volume of grout in the injection wells to the volume of ZVI injected. Volumetrically, the total amount of grout for each of the 22 injection wells accounts for only 1.48% of the total ZVI volume injected. Therefore, even though leaching of the grout could be occurring, high groundwater pH is primarily attributed to groundwater interactions with ZVI.

4.5 ZVI-PRB Impact on the LAZ

The ZVI-PRB design intended injection wells to key into the TCCZ as a means of hydraulic control, however the potential for penetration into the LAZ was recognized and therefore LAZ monitoring was retained in the EMP.

Groundwater elevation measurements and potentiometric surface mapping for the LAZ indicate there is not a significant impact from the ZVI-PRB (Figure 14). Changes to the groundwater flow direction in the vicinity of the ZVI-PRB are believed to be due to natural variations in regional groundwater elevations. The groundwater flow directions at the ZVI-PRB is more northerly based on the 1Q22 potentiometric surface, and therefore groundwater flow does not intersect the ZVI-PRB, but instead flows parallel.

Monitoring results for TCE in the LAZ indicate a decrease in concentrations since installation of the ZVI-PRB, with TCE decreasing from a baseline maximum of 664 µg/L to a 1Q22 maximum of 110 µg/L. The drop in TCE concentrations, combined with the flip in ORP values from high positive to very high negative, are indications of the ZVI-PRB impacts on groundwater geochemistry in the LAZ. The observed impacts to the LAZ at this time are positive, demonstrating TCE degradation, which was not expected from the ZVI-PRB since it was primarily designed to target the UAZ. This is further supported by significant 1Q22 ethylene concentrations in PRW001C and PRW002C of 136 µg/L and 214 µg/L, respectively. Ethylene concentrations at this level are a strong indicator of reductive dechlorination.

Effects on the LAZ will continue to be monitored in future reporting.

5.0 SUMMARY AND RECOMMENDATIONS

The PAGW OU NTC RA was completed in January 2020 with the construction of a 80.5 linear meter (264 linear feet) long ZVI-PRB, designed to intersect groundwater flow in the UAZ of the UTRA to degrade cVOCs, primarily TCE. The PAGW OU NTC RAO is to protect human health and the environment by reducing the mass and down-gradient transport of the PAGW OU TCE groundwater plume. A TCE mass flux reduction of 80% was determined to be sufficient to meet the RAO.

After two years of effectiveness monitoring of ZVI-PRB performance, the effectiveness in the immediate vicinity of the PRB is highlighted by the following results:

- Groundwater elevation data and potentiometric surfaces for the UAZ and LAZ indicate that the ZVI-PRB is having minimal impact to groundwater flow, as it was designed. Therefore, there is no indication that contaminated groundwater is by-passing the ZVI-PRB.

- In-wall monitoring well results indicate TCE concentration reduction greater than 95% and an estimated TCE mass flux reduction across the entire ZVI-PRB of greater than the RAO of 80%.

- To the west of the ZVI-PRB, in the UAZ, TCE concentrations are following a decreasing trend. However, because of back diffusion of TCE into the groundwater front leaving the ZVI-PRB, it will take some time before an overall impact to TCE concentrations can be realized.

- ORP results for the in-wall wells indicate a strong reductive environment is present, extending to the west in the UAZ monitoring wells. The reductive environment is favorable for promoting reductive dechlorination of TCE.

- The installed ZVI-PRB also influences the LAZ, evidenced by observed reducing conditions, reduced TCE concentrations, and elevated ethylene concentrations.

In-wall monitoring wells provide the strongest evidence of the ZVI-PRB effectiveness at this time. Results from the in-wall monitoring wells consistently show greater than 95% reduction in TCE concentrations compared to baseline, which supports 80% mass flux reduction to meet the RAO. Analytical results to the west of the ZVI-PRB provide evidence of a reducing environment traveling away from the barrier with groundwater flow. Monitoring results indicate that the ZVI-PRB is impacting cVOC concentrations to the west of the ZVI-PRB with observations of back diffusion apparent in PRW004DL and the PRW007 monitoring well cluster. As more cVOC mass is removed by the ZVI-PRB, and clean groundwater flushes out cVOCs adsorbed to the low permeability sediments, the ZVI-PRB will continue to reach peak optimization. As indicated in the RADP and RAR, this is anticipated to take 3-5 years from ZVI-PRB installation (SRNS 2019 and SRNS 2020b). Most recent 1Q22 results west of the ZVI-PRB indicate greater than 80% reduction in TCE concentration compared to baseline is being achieved in all monitoring wells with the exception of PRW007DU. SRS recommends continued analytical monitoring in accordance with the approved EMP for the PAGW OU NTC RA.

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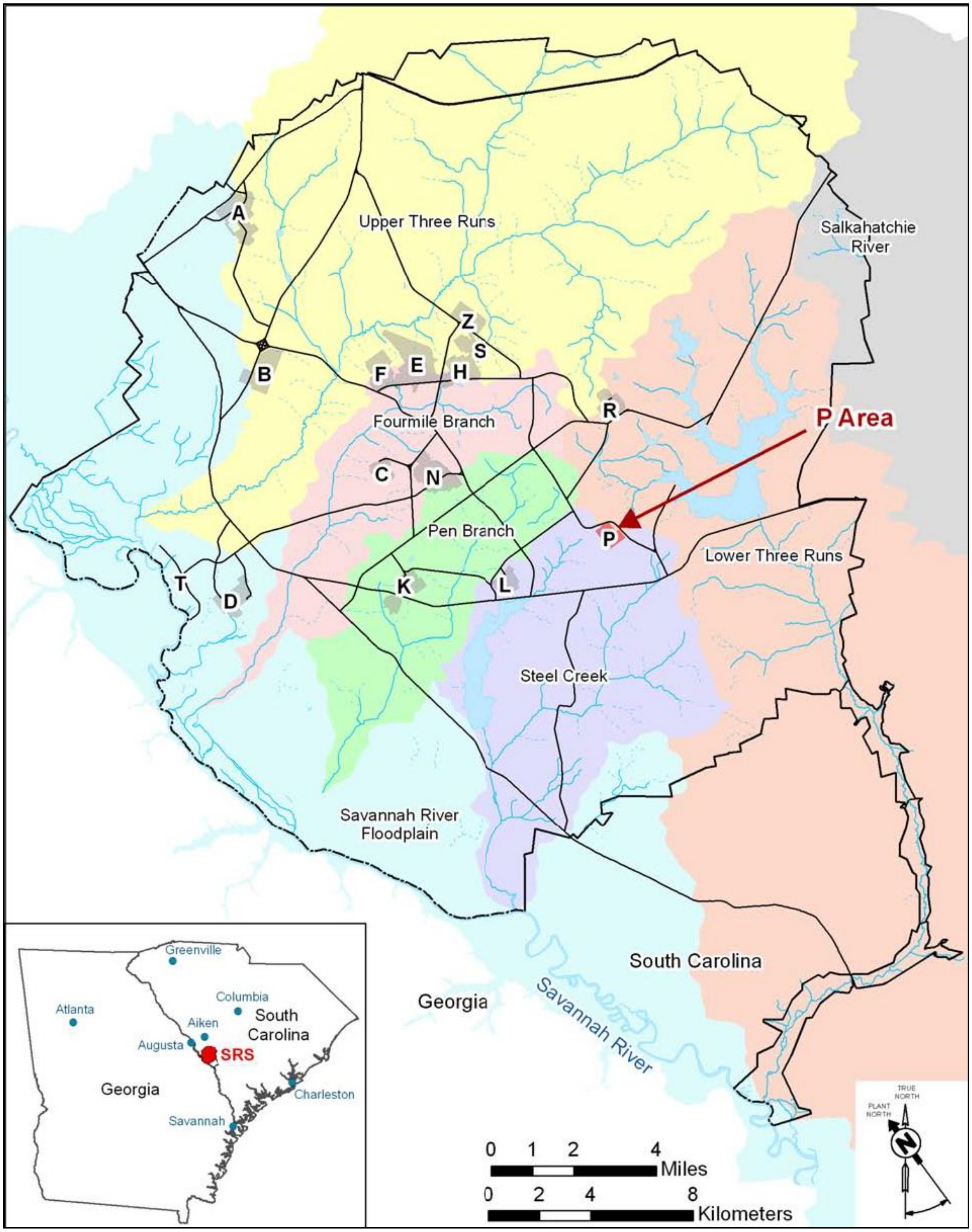

Figure 1. Location of P Area at the Savannah River Site

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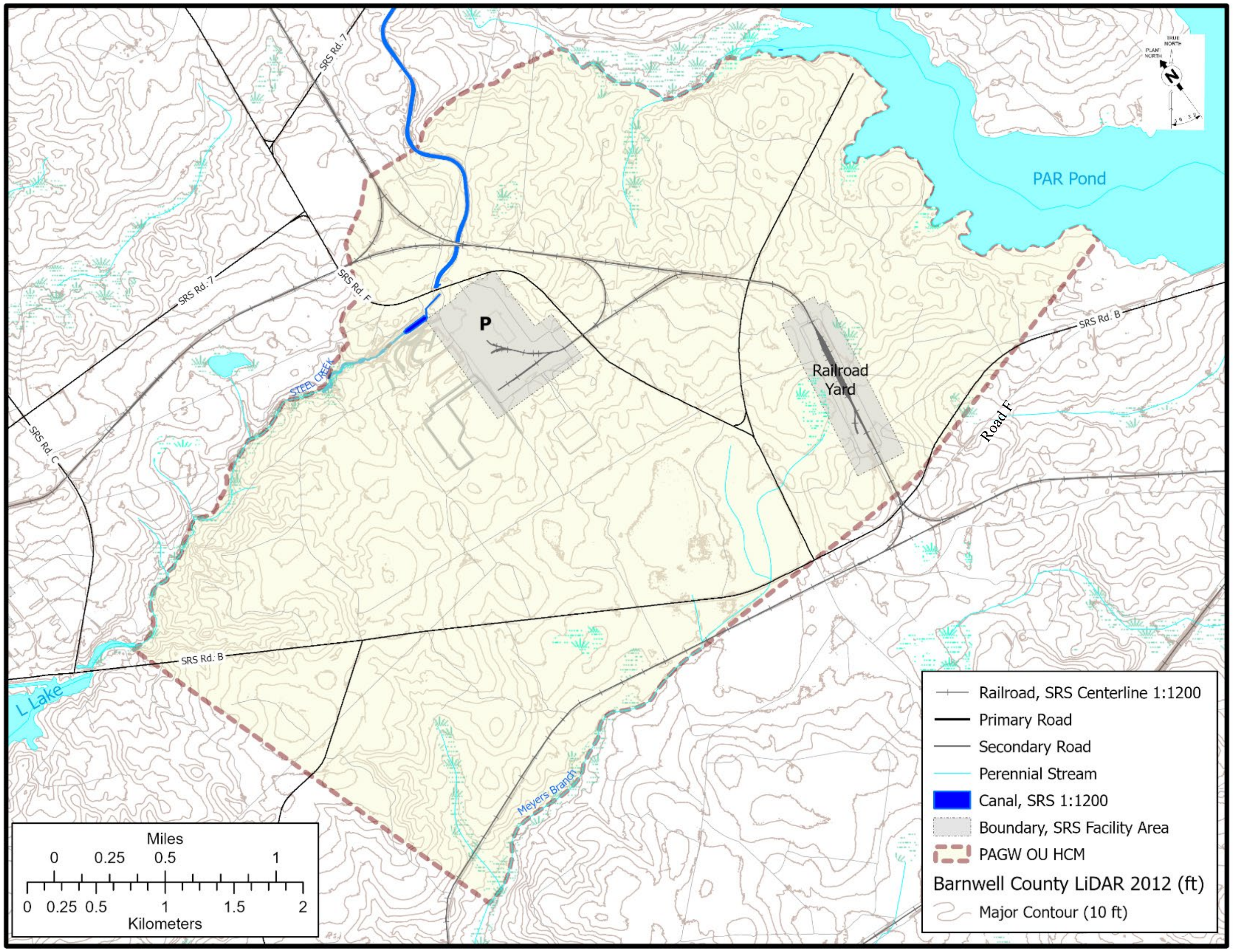

Figure 2. P-Area Groundwater Operable Unit Boundary Map

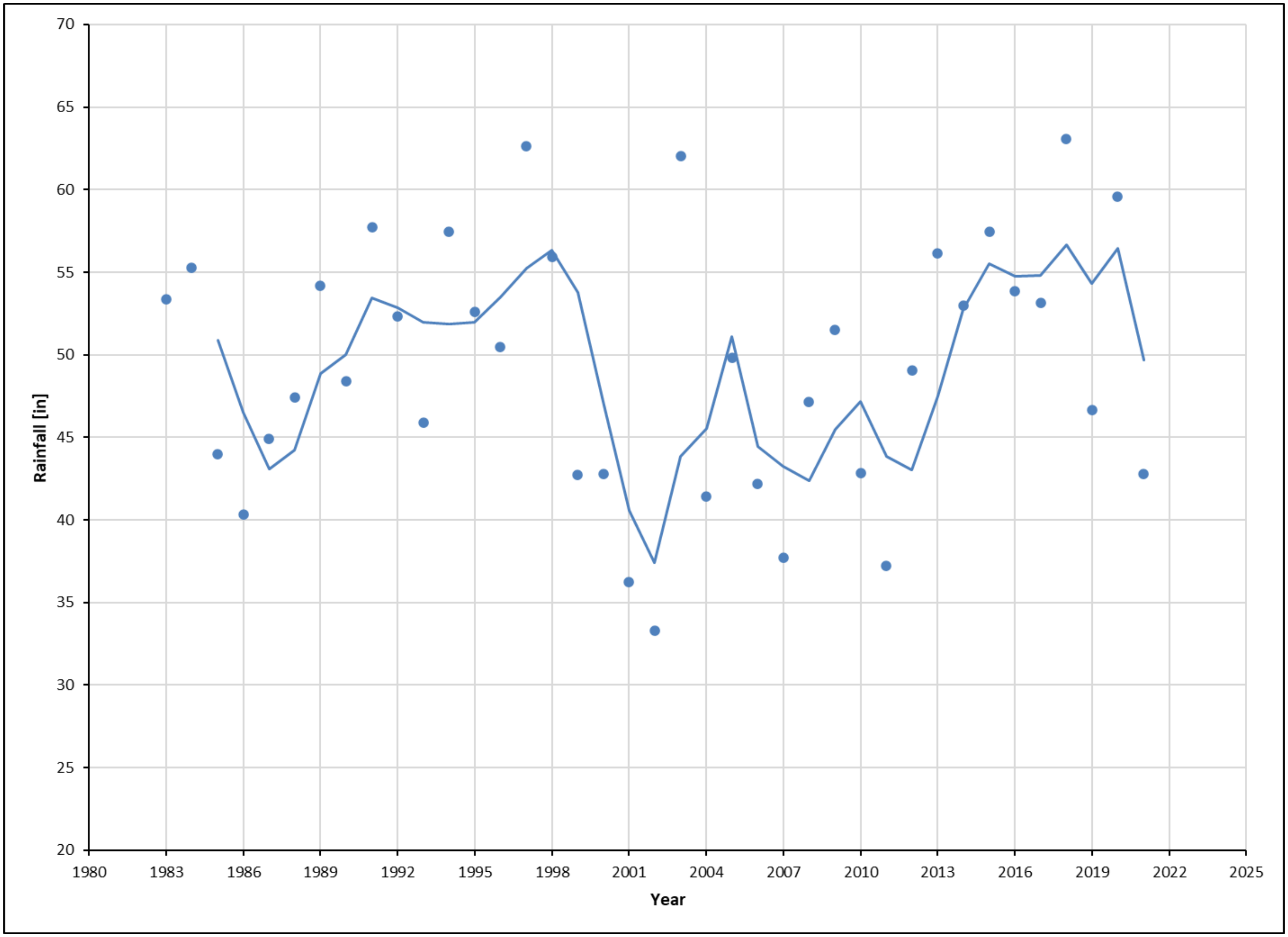

Figure 3. Total Annual Rainfall at 100-P Rain Gauge with a 3-Year Moving Average Trendline

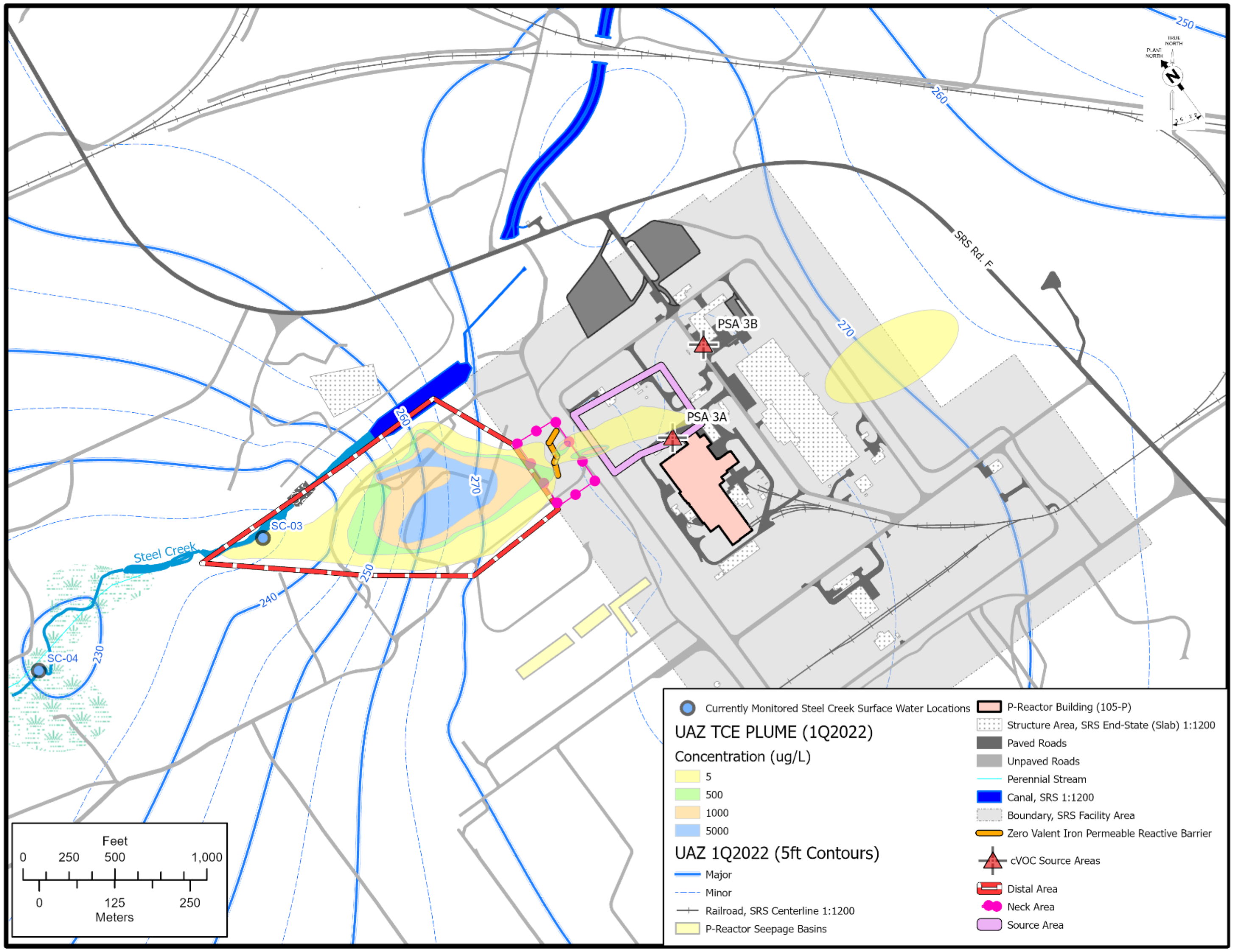

Figure 4. Trichloroethylene Plume Map for the Upper Aquifer Zone of the Upper Three Runs Aquifer (2018/2022 Data)

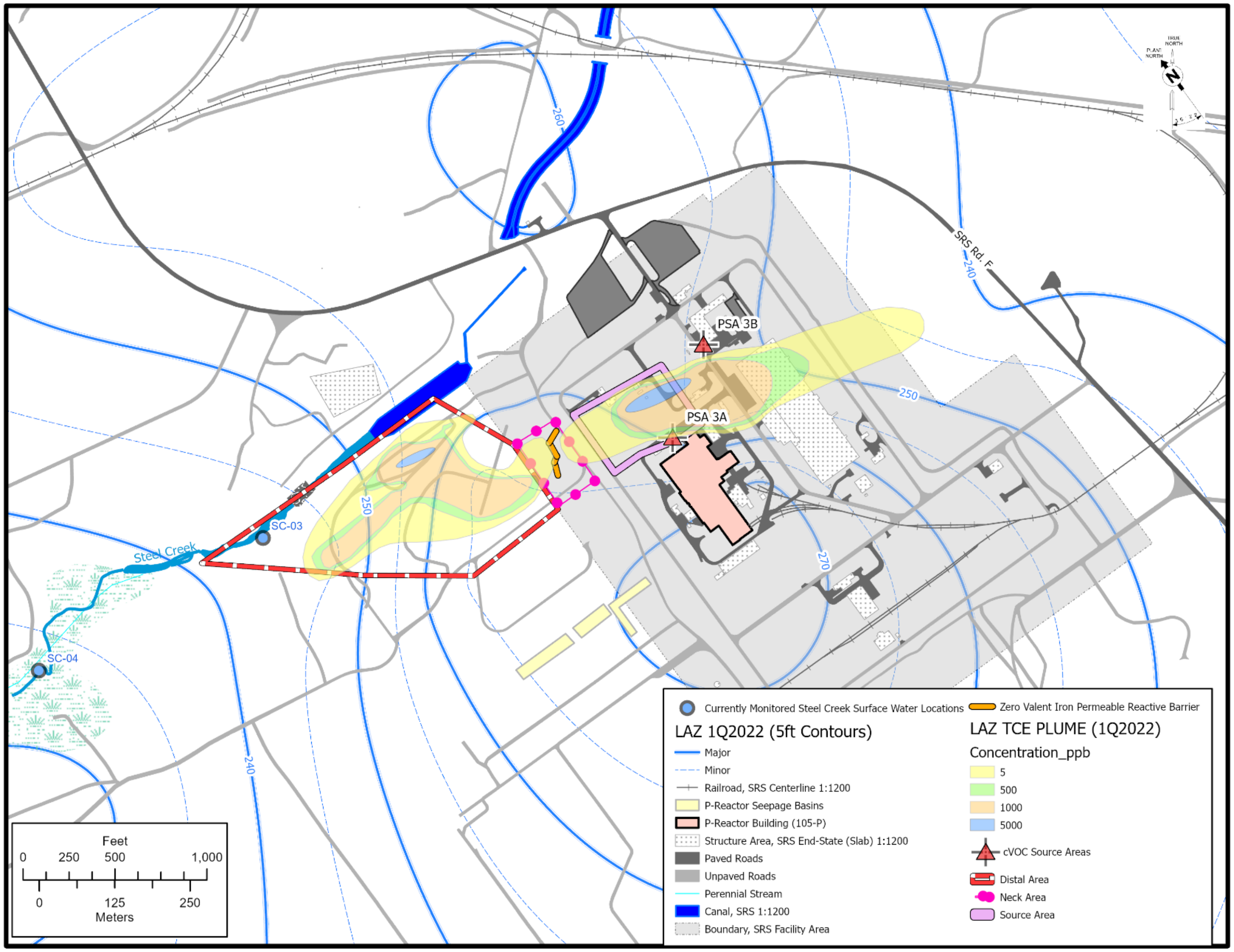

Figure 5. Trichloroethylene Plume Map for the Lower Aquifer Zone of the Upper Three Runs Aquifer (2018/2022 Data)

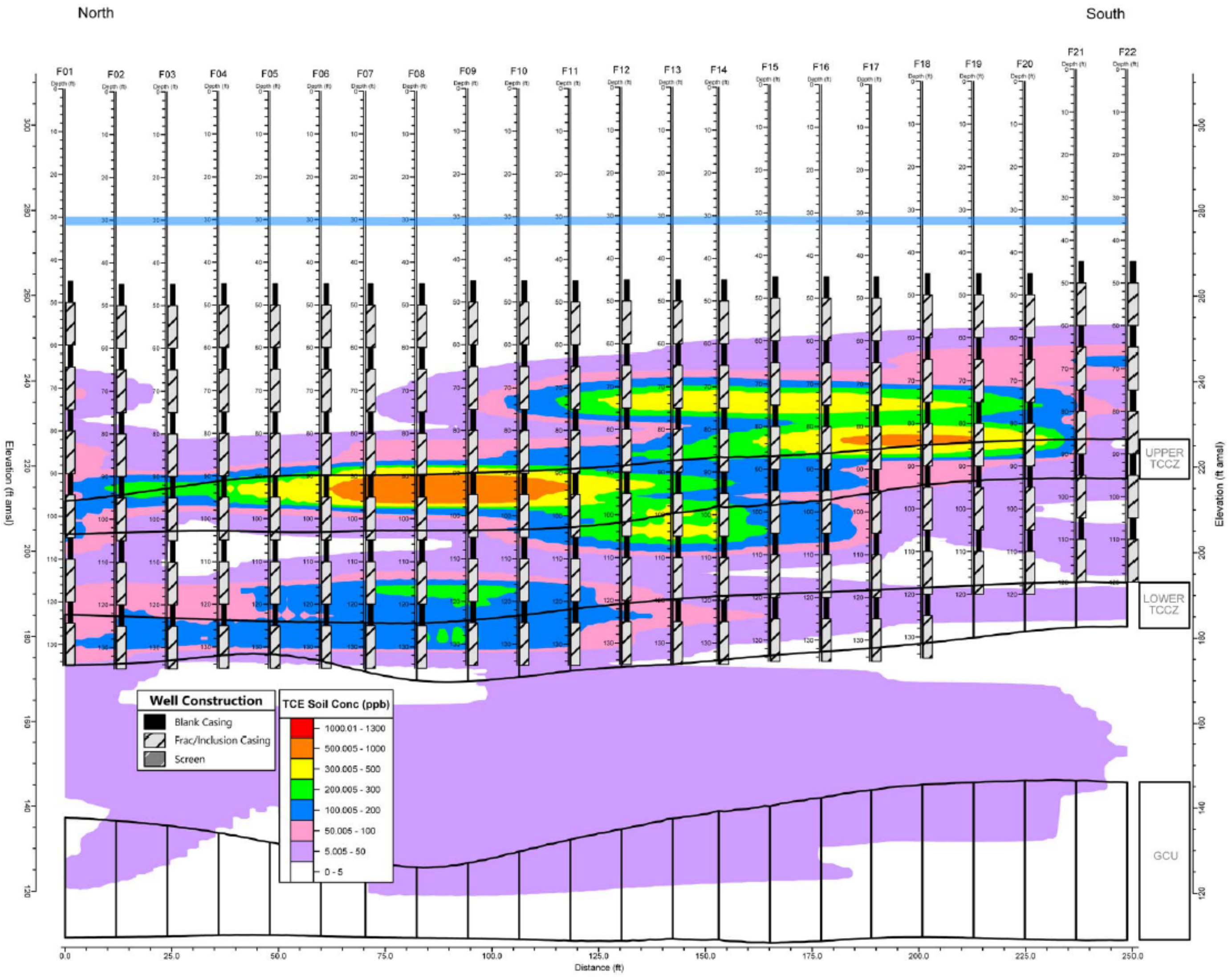

Figure 6. TCE Plume North-South Cross-Section with ZVI-PRB Injection Wells

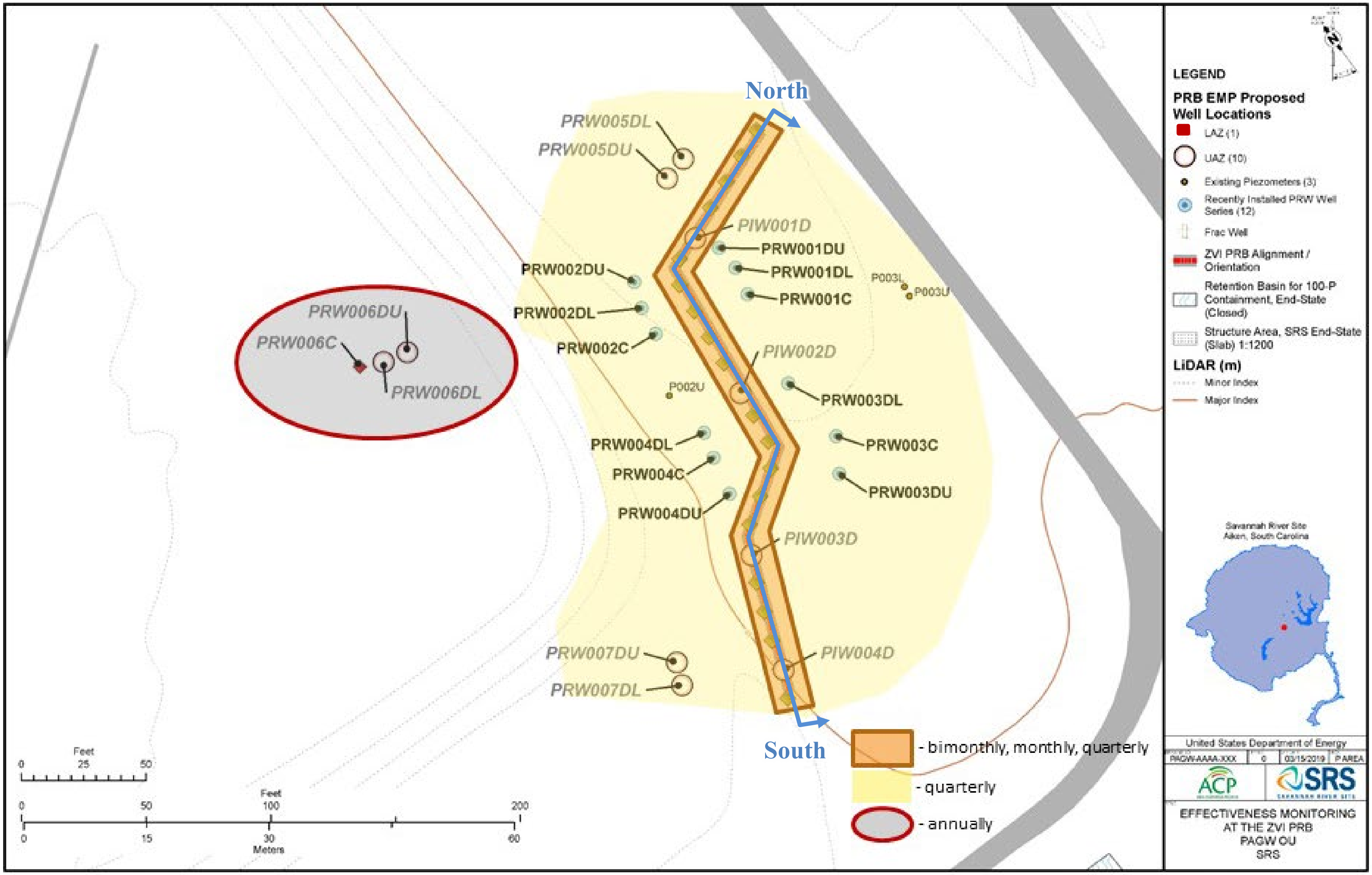

Figure 7. Effectiveness Monitoring Plan Locations

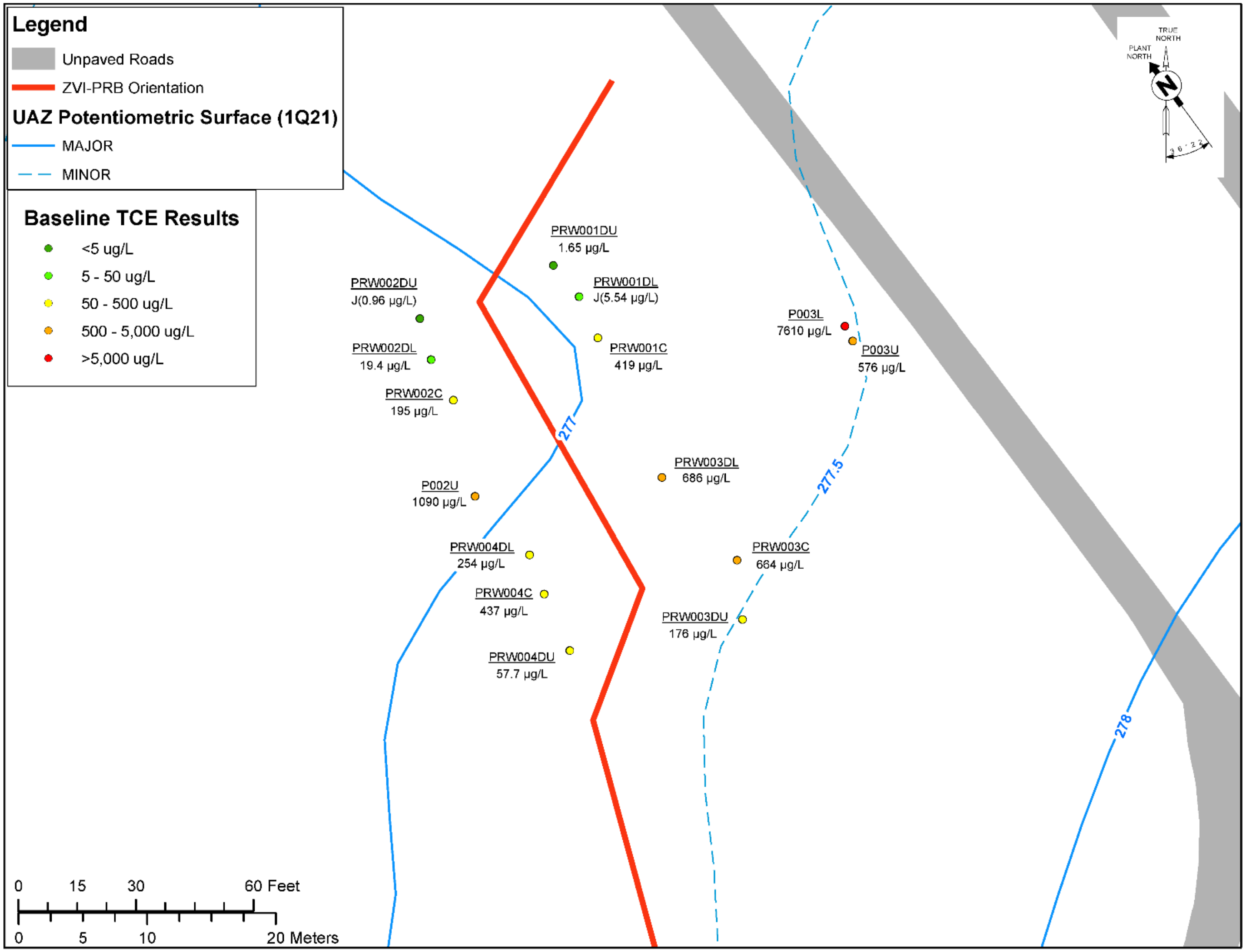

Figure 8. Baseline Concentrations of TCE in the PAGW OU EMP Monitoring Wells

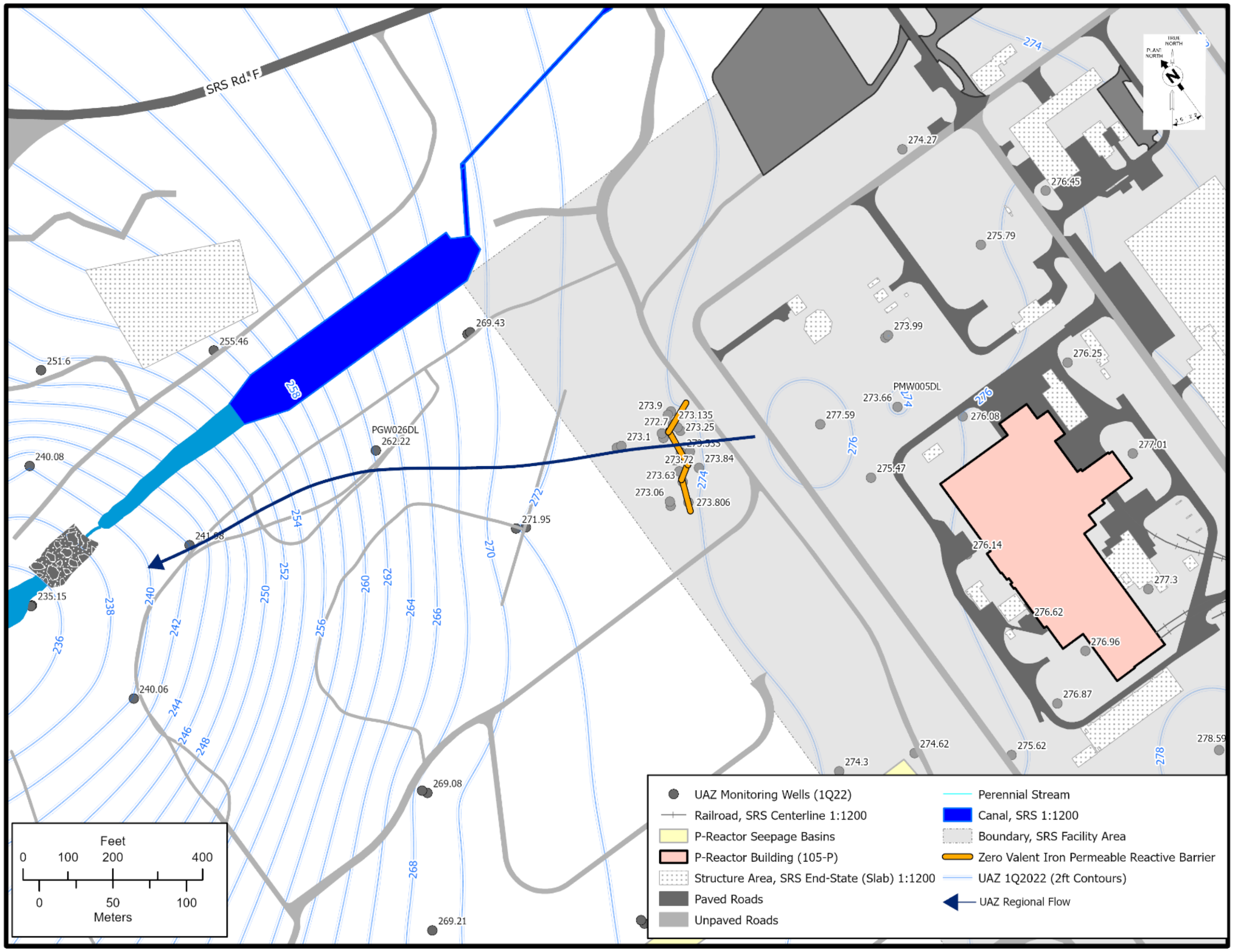

Figure 9. **Regional UAZ Groundwater Elevations and Flow Direction (1Q22)**

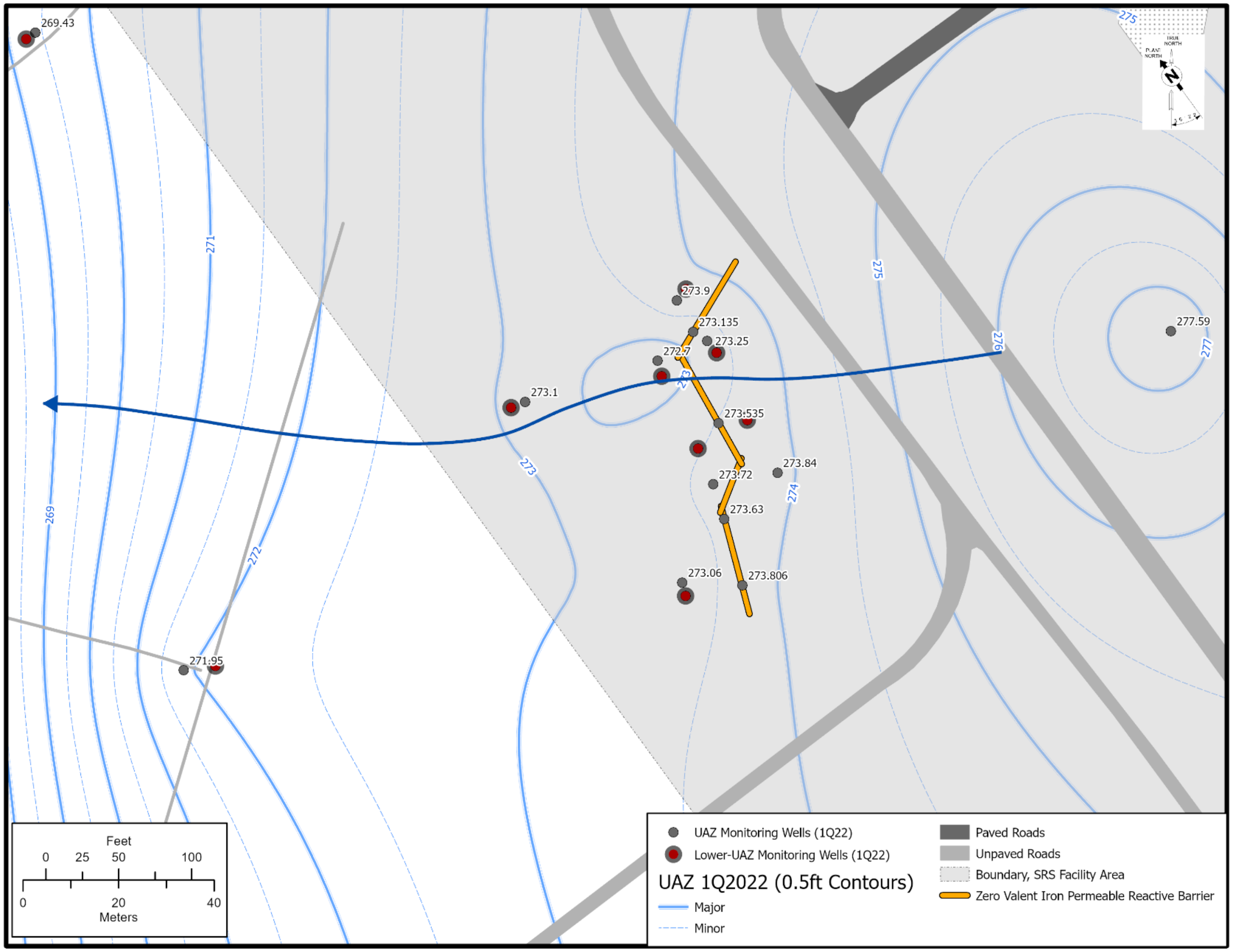

Figure 10. **UAZ Water Elevations for 1Q22 at PAGW OU RA EMP Monitoring Wells**

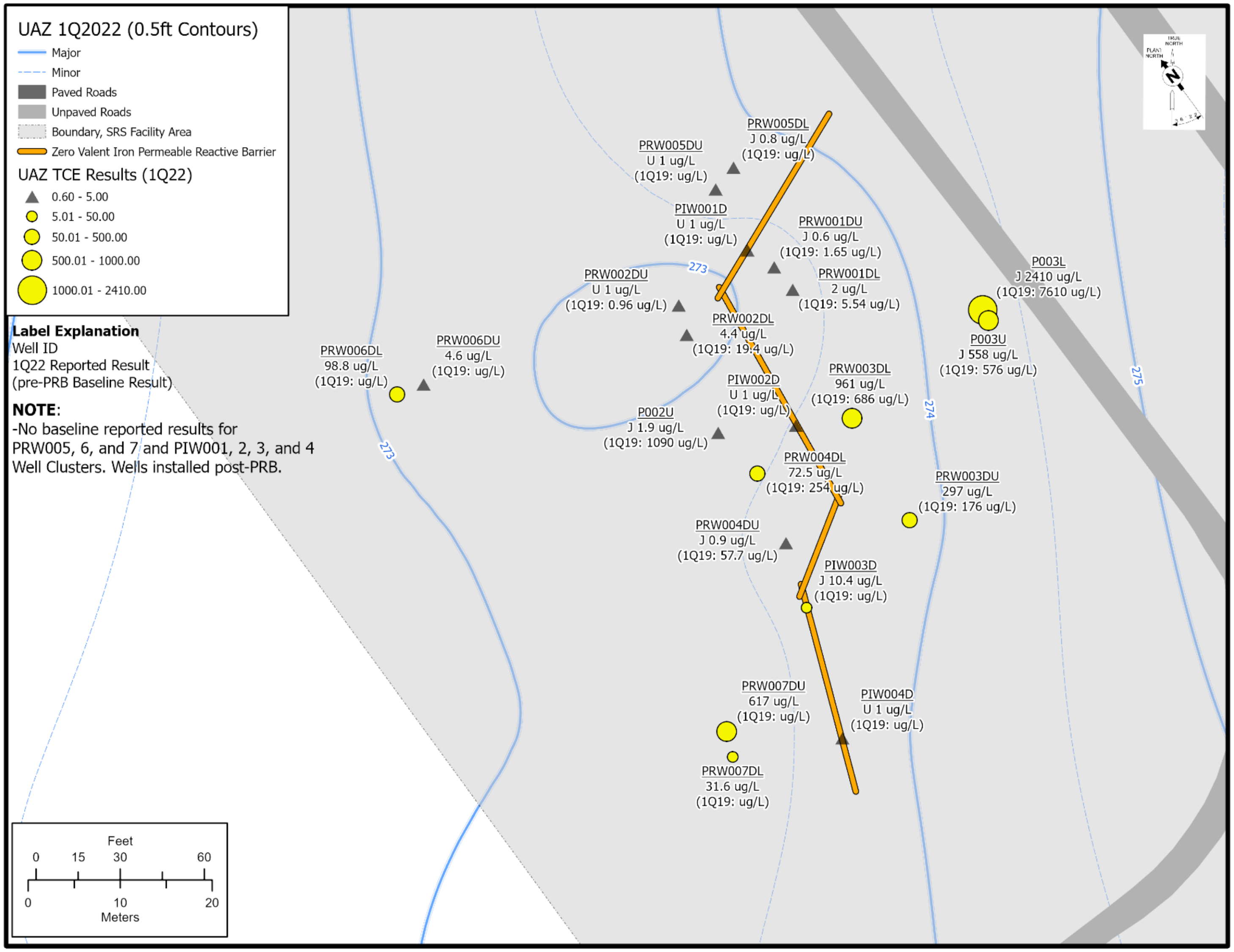

Figure 11. TCE Results for ZVI-PRB UAZ Monitoring Wells Sampled in 1Q22

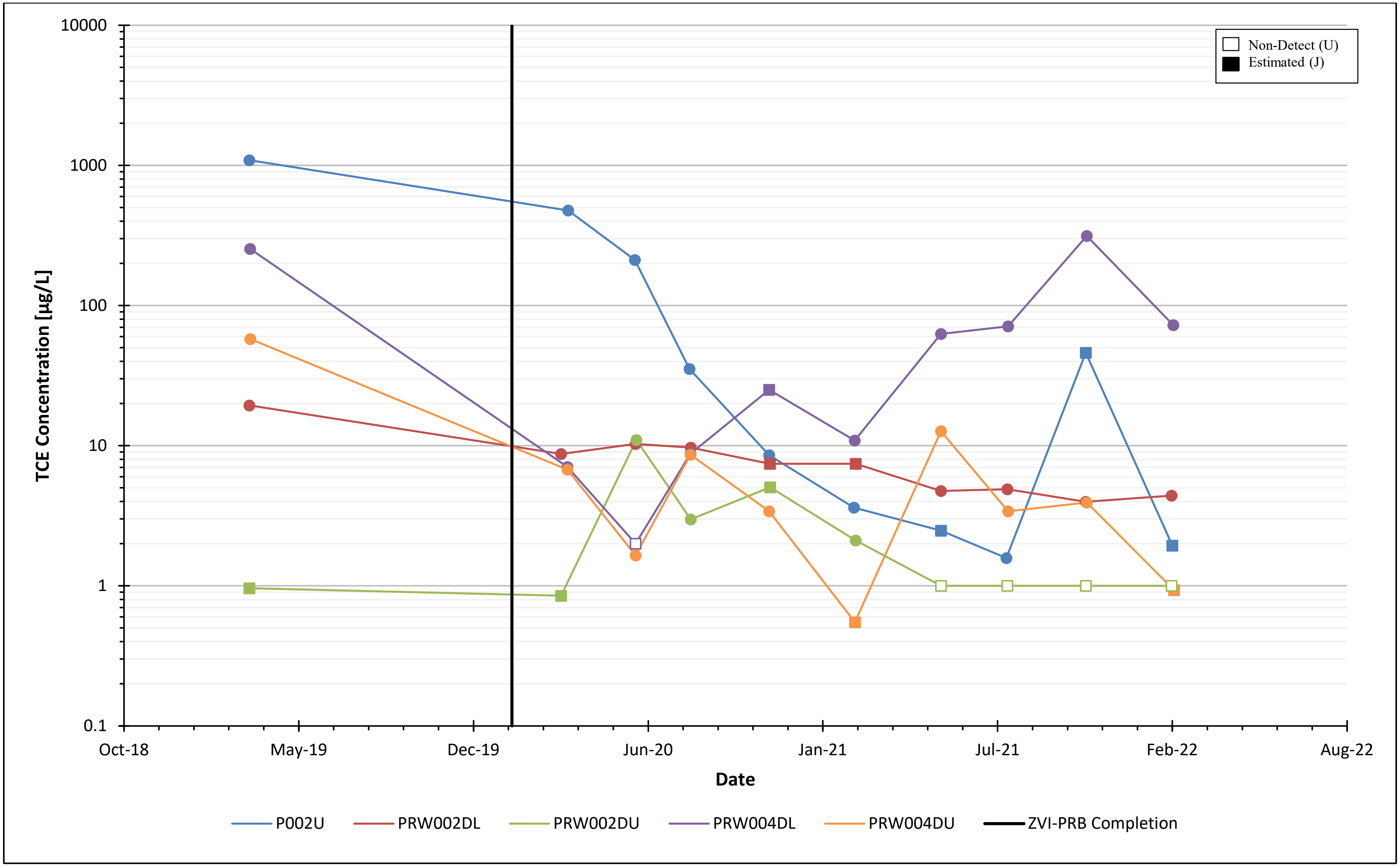

Figure 12. Time-Series Plot for TCE at UAZ Monitoring Well Clusters for P002U, PRW002, and PRW004

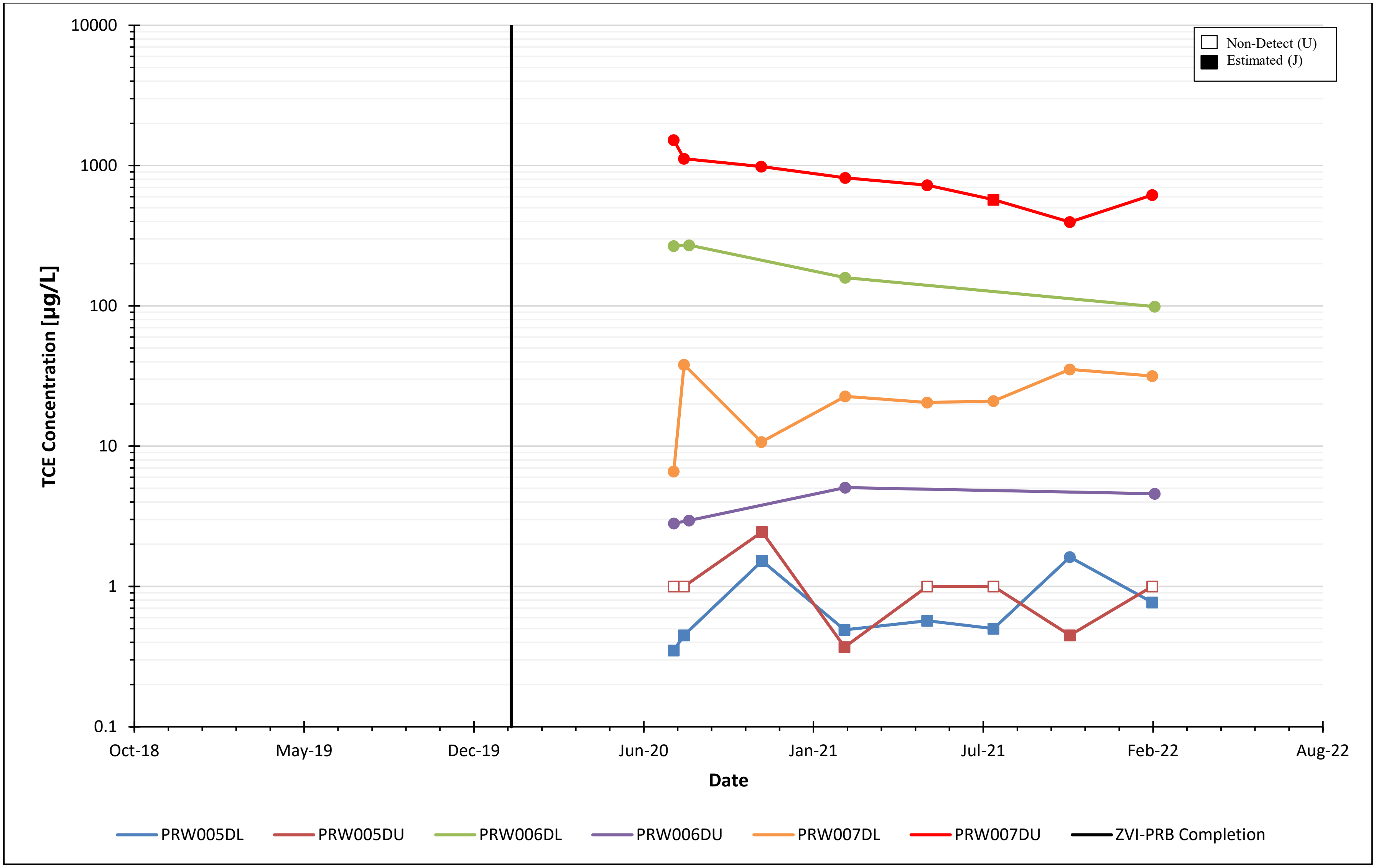

Figure 13. Time-Series Plot for TCE at UAZ Monitoring Well Clusters for PRW005, PRW006, and PRW007

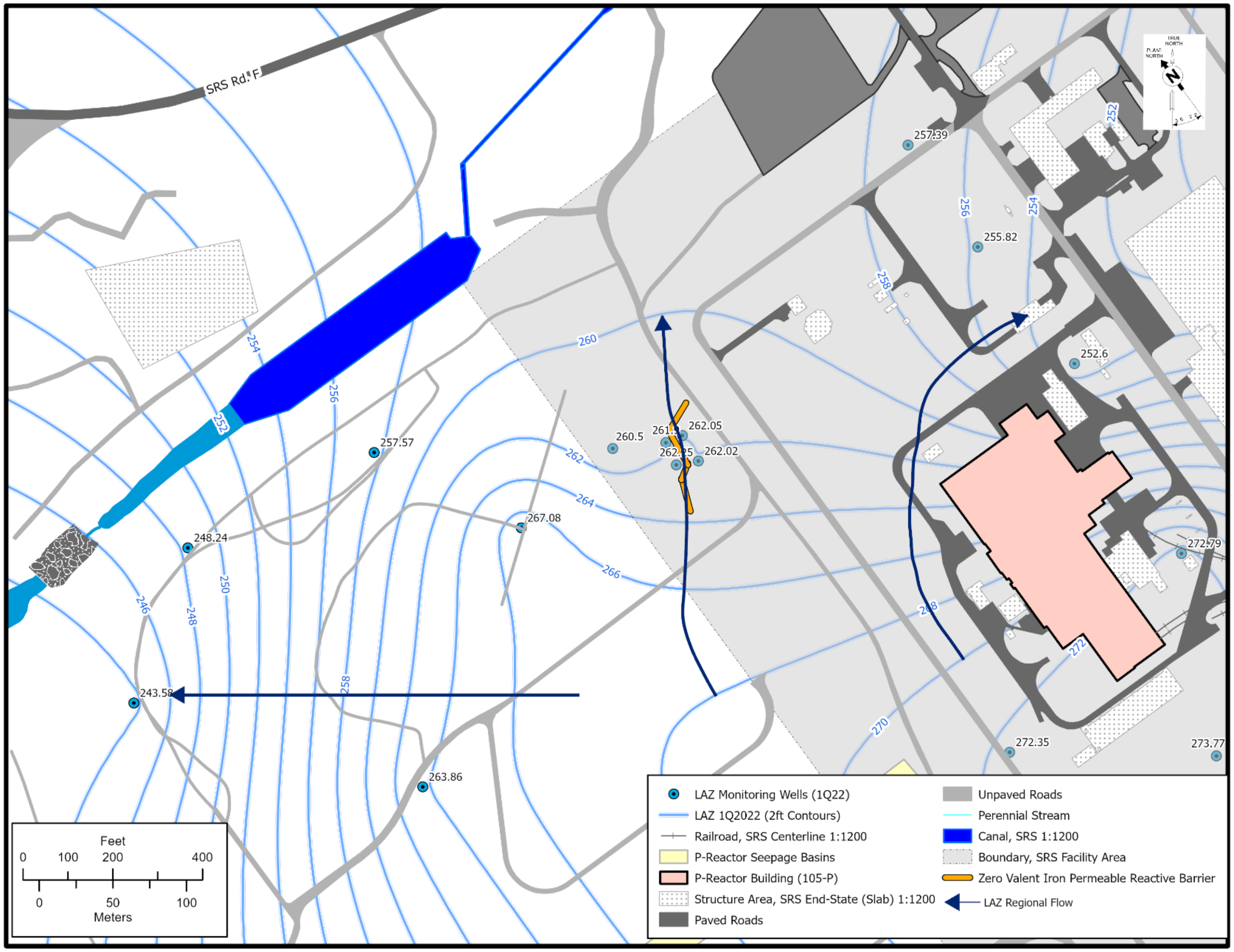

Figure 14. **Regional LAZ Groundwater Elevations and Flow Direction (1Q22)**

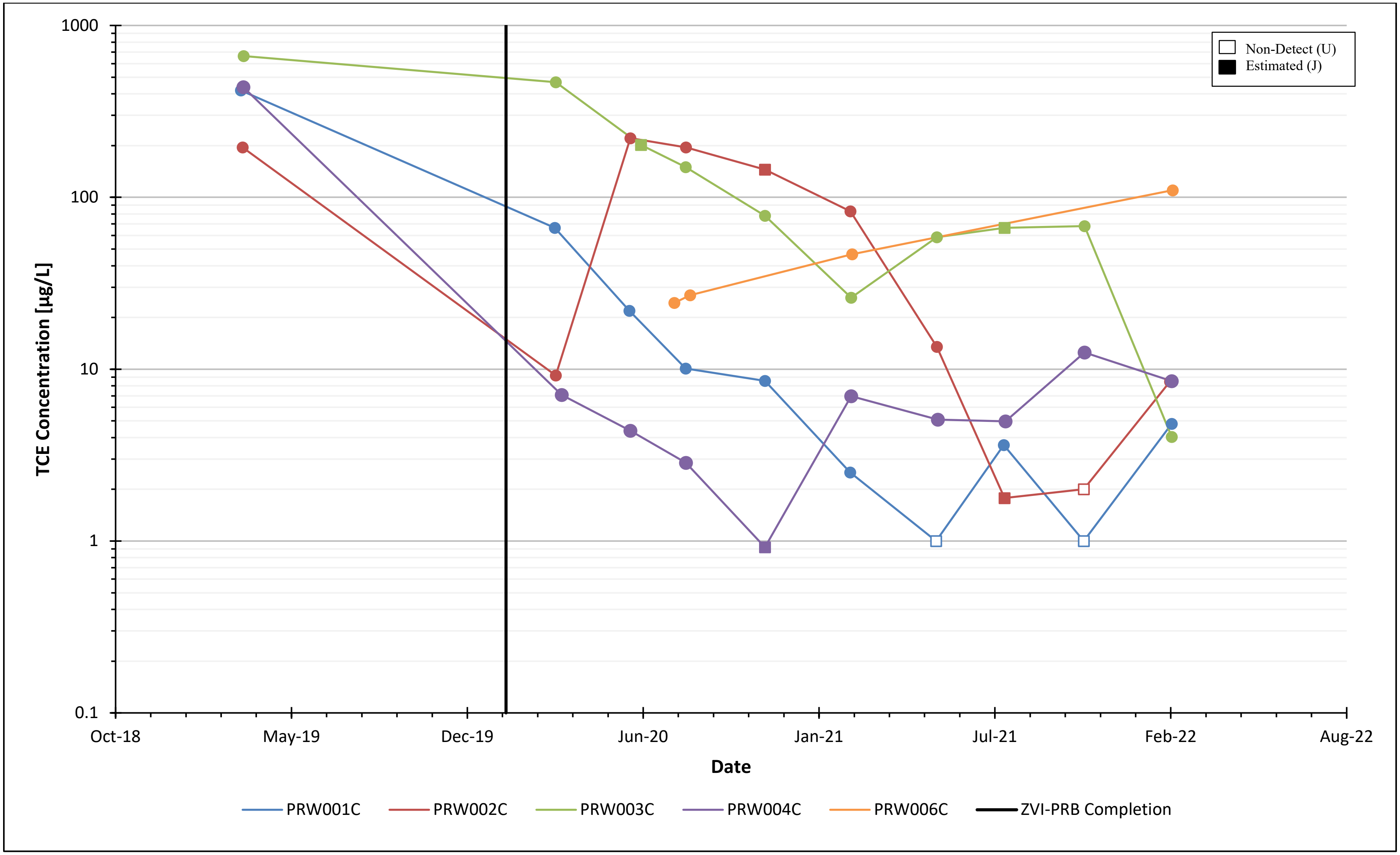

Figure 15. Time-Series Plot for TCE at LAZ Monitoring Wells of the PAGW OU NTC RA EMP

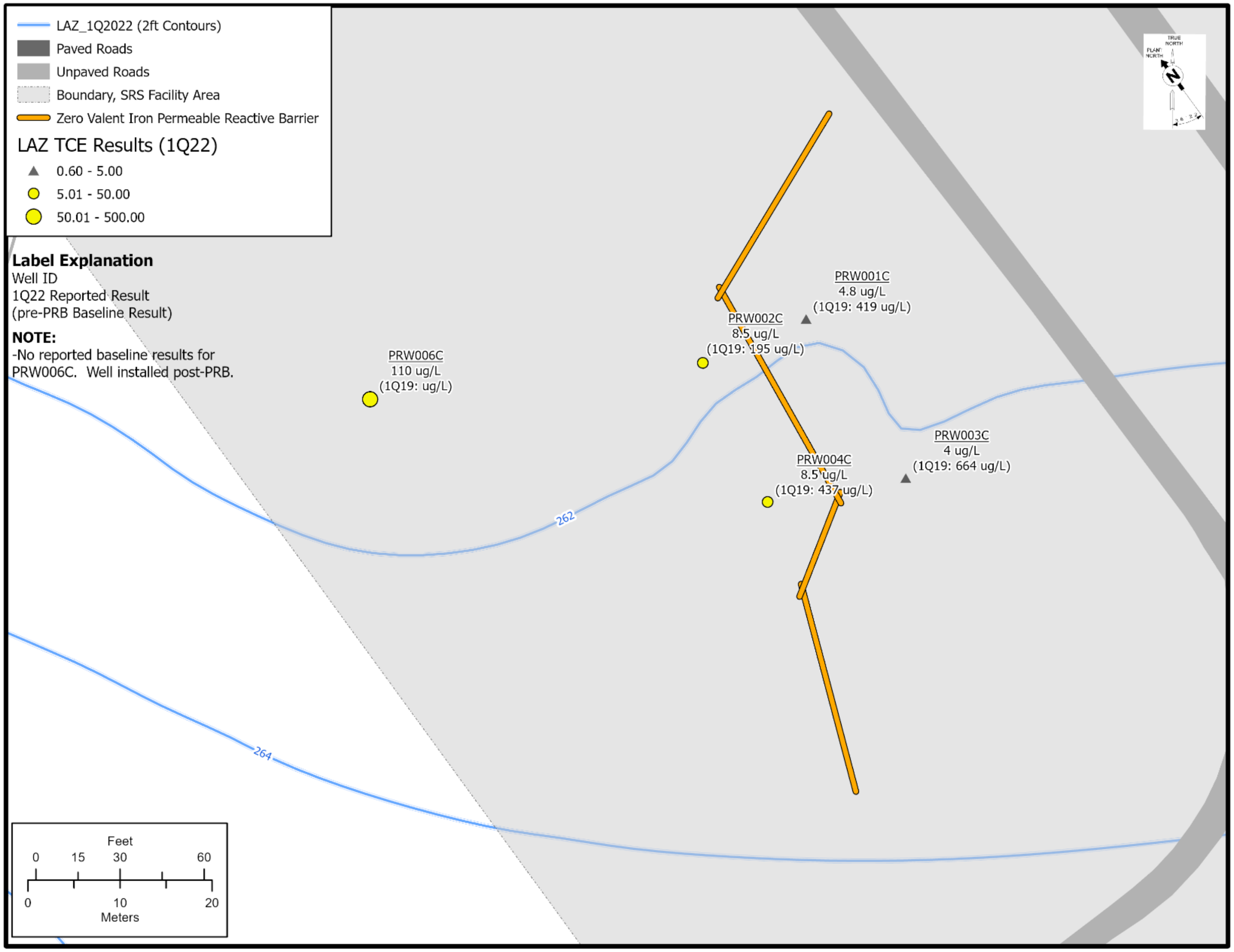

Figure 16. TCE Results for ZVI-PRB LAZ Monitoring Wells Sampled in 1Q22

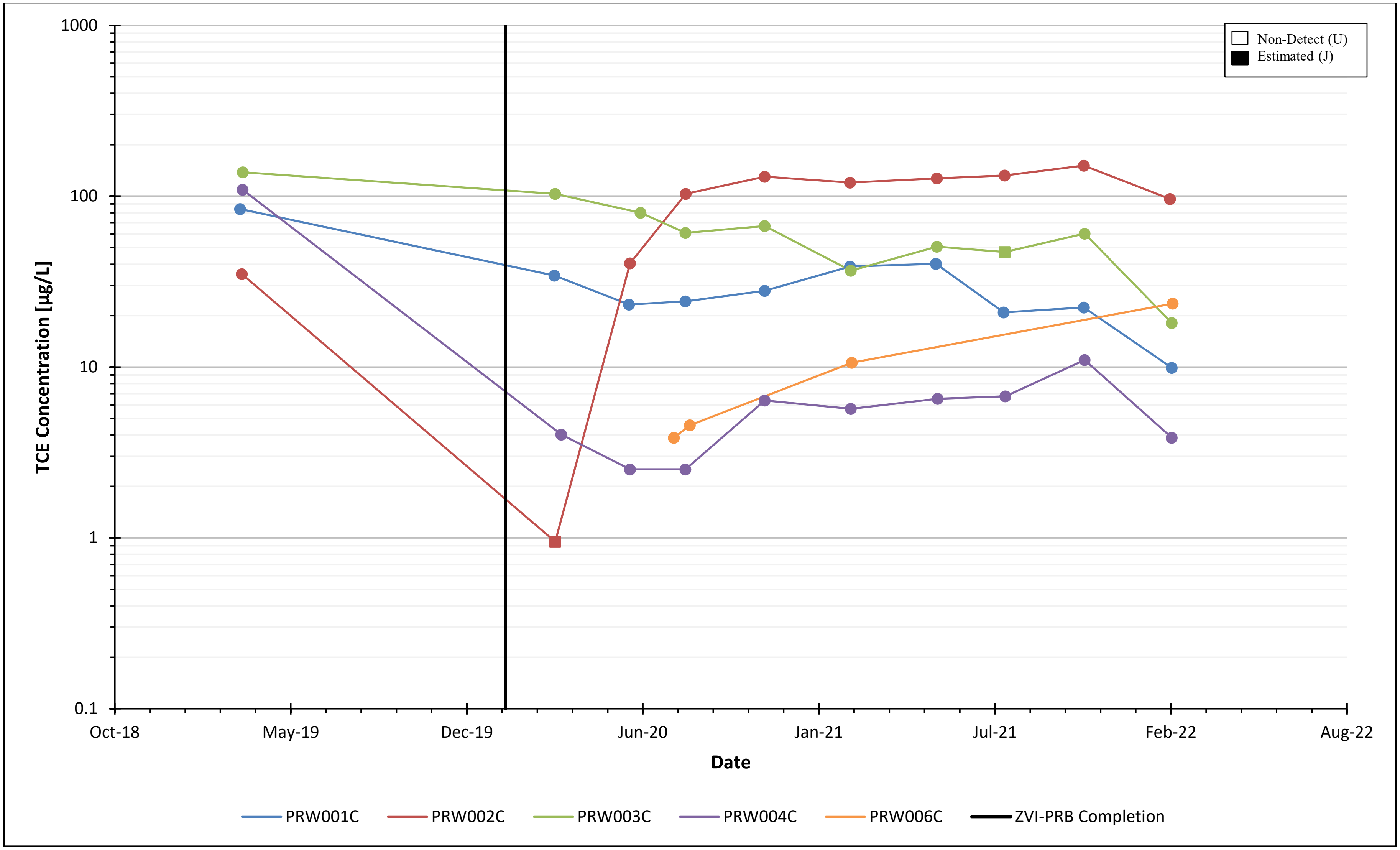

Figure 17. Cis-DCE Concentration Over Time for LAZ Monitoring Wells

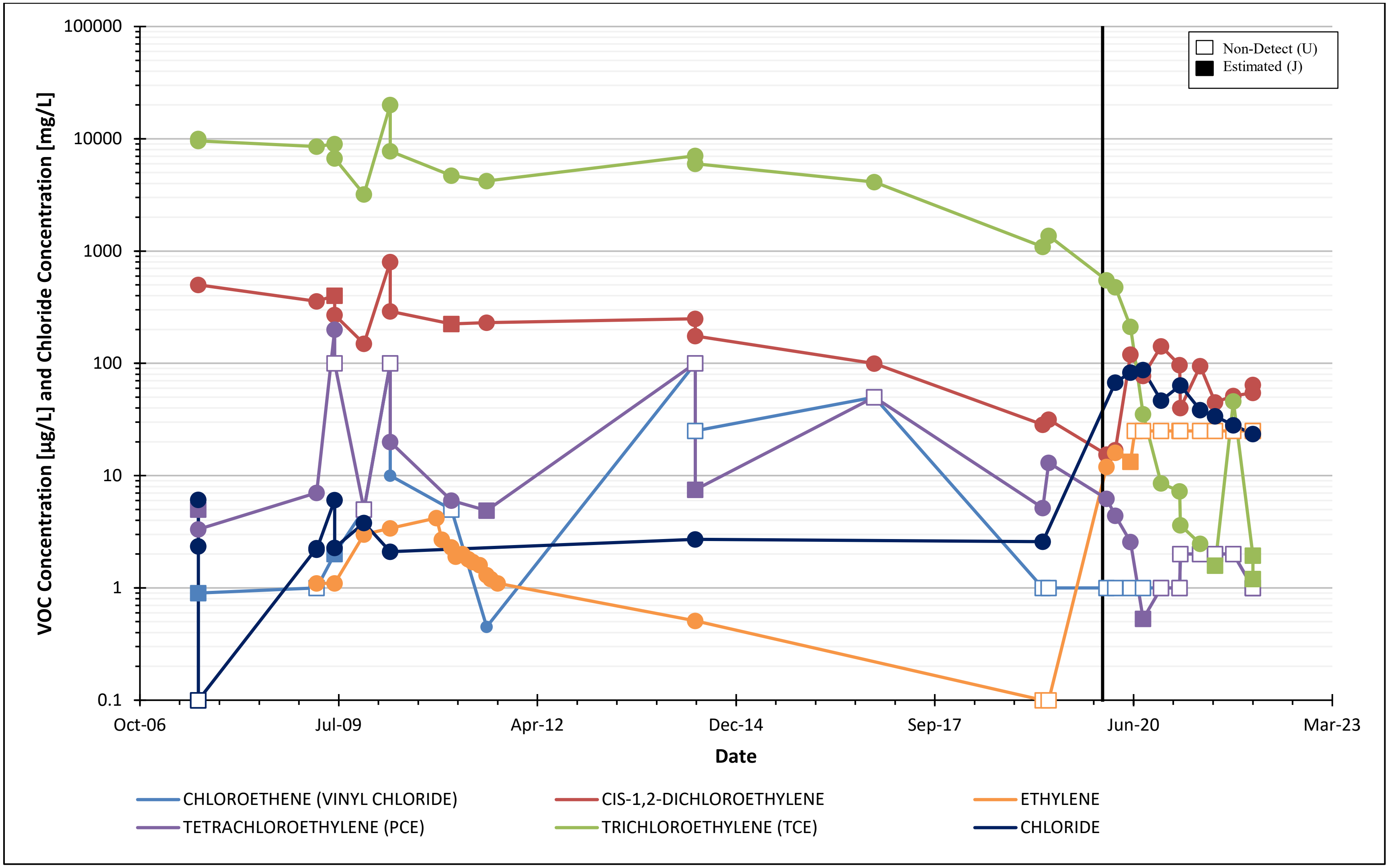

Figure 18. cVOC Degradation at P002U

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Table 1. Maximum Concentrations of PCE, TCE, and cis-DCE in the Three Plume Areas

Contaminant	**MCL**[1] *[µg/L]*	**Maximum Concentration in UAZ** *[µg/L]*			**Maximum Concentration in LAZ** *[µg/L]*		
		Source Area	**Neck Area**	**Distal Area**	**Source Area**	**Neck Area**	**Distal Area**
PCE	5	80.6	13.0	1.32	4.85	1.77	17
TCE	5	2,150	7,730	6,320	5,180	(791)	5,560
cis-DCE	70	195	892	(300)	69.0	138	168

[1] MCL – maximum contaminant level

Parenthesis indicate estimated values.

Table 2. Effectiveness Monitoring Plan Well Details

Station ID	EMP Analytes	Sampling Frequency	Aquifer Zone	UTM NAD27 Coordinates		Screen Interval *[ft bgs]*
				Northing	Easting	
PRW001DU	1	Quarterly	UAZ	445596.3162	3676631.902	81.64 – 91.64
PRW001DL	1	Quarterly	UAZ	445598.3731	3676629.427	109.78 – 119.67
PRW001C	1	Quarterly	LAZ	445599.9071	3676626.031	146 – 156
PRW002DU	1	Quarterly	UAZ	445585.9390	3676627.649	80.66 – 90.66
PRW002DL	1	Quarterly	UAZ	445586.9572	3676624.563	107.21 – 117.21
PRW002C	1	Quarterly	LAZ	445588.4929	3676621.475	148.06 – 158.06
PRW003DU	1	Quarterly	UAZ	445611.1735	3676604.102	61.82 – 71.82
PRW003DL	1	Quarterly	UAZ	445604.7647	3676615.225	94.85 – 104.85
PRW003C	1	Quarterly	LAZ	445610.6833	3676609.033	136.58 – 146.58
PRW004DU	1	Quarterly	UAZ	445597.7006	3676601.714	64.91 – 74.91
PRW004DL	1	Quarterly	UAZ	445594.6377	3676609.430	111.45 – 121.45
PRW004C	1	Quarterly	LAZ	445595.6558	3676606.345	144.38 – 154.38
PRW005DU	1	Quarterly	UAZ	445590.1508	3676640.252	86 – 96
PRW005DL	1	Quarterly	UAZ	445591.9763	3676642.705	108 – 118
PRW006DU	1	Annually	UAZ	445558.1963	3676619.181	90 – 100
PRW006DL	1	Annually	UAZ	445555.3423	3676617.965	120 – 130
PRW006C	1	Annually	LAZ	445552.4918	3676617.365	160 – 170
PRW007DU	1	Quarterly	UAZ	445591.1164	3676581.425	65 – 75
PRW007DL	1	Quarterly	UAZ	445591.8774	3676578.649	100 – 110
P002U	1	Quarterly	UAZ	445590.2617	3676613.766	87.5 – 92.5
P003U	1	Quarterly	UAZ	445619.5780	3676625.921	84.3 – 89.3
P003L	1	Quarterly	UAZ	445619.0672	3676627.156	113.6 – 118.6
PIW001D	1, 2	Quarterly	UAZ	445593.7400	3676634.072	90 – 110
PIW002D	1, 2	Quarterly	UAZ	445599.0687	3676614.949	85 – 105
PIW003D	1, 2	Quarterly	UAZ	445600.2528	3676595.233	70 – 90
PIW004D	1, 2	Quarterly	UAZ	445604.3150	3676581.044	60 – 80

ft bgs – feet below ground surface

1 Volatile Organic Compounds: tetrachloroethylene (PCE), trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-DCE), trans-1,2-dichloroethylene (trans-DCE), chloroethene (vinyl chloride [VC]), and 1,1-dichloroethylene (1,1-DCE)

2 Geochemical Analyses: Dissolved Organic Carbon (DOC), Total Organic Carbon (TOC), Total Dissolved Solids (TDS), alkalinity, chloride, nitrate-nitrite as nitrogen, sulfate, sulfide, methane, ethane, ethylene, phosphate, calcium, iron, ferrous iron (Fe^{2+}), ferric iron (Fe^{3+}), potassium, manganese, magnesium, sodium

Table 3. Baseline Concentrations for cVOCs and Geochemical Analytes

Analyte	Units	UAZ Range	UAZ Location of Maximum	LAZ Range	LAZ Location of Maximum
PCE	µg/L	0.34 – 5.15	P002U	0.65 – 1.60	PRW002C
TCE	µg/L	0.96 – 7610	P003L	195 – 664	PRW003C
cis-DCE	µg/L	0.45 – 892	P003L	35.0 – 138	PRW003C
trans-DCE	µg/L	0.54 – 15.3	P003L	1.08 – 2.84	PRW003C
1,1-DCE	µg/L	1.96[A]	P003L	ND (1.0)[B]	
VC	µg/L	1.10[A]	P003L	ND (1.0)[B]	
Alkalinity	mg/L	2.00 – 38.4	PRW004DL	6.00 – 40.8	PRW001C
Calcium	µg/L	536 – 4810	PRW001DL	804 – 13500	PRW001C
Chloride	mg/L	2.11 – 3.64	PRW002DU	2.20 – 3.03	PRW003C
DOC	mg/L	0.461 – 0.683	P002U	0.410 – 0.531	PRW002C
Ethane	µg/L	0.12 – 0.17	P003L	0.12 – 0.14	PRW002C
Ethylene	µg/L	0.11 – 0.55	PRW003DU	0.15 – 0.25	PRW002C
Ferric Iron	mg/L	ND (0.50)[B]		ND (0.50)[B]	
Ferrous Iron	mg/L	0.87[A]	PRW004DU	ND (0.50)[B]	
Total Iron	µg/L	104 – 852	P003L	80.1 – 496	PRW002C
Magnesium	µg/L	341 – 1360	PRW003DU	237 – 312	PRW003C
Manganese	µg/L	4.72 – 174	PRW004DU	55.1 – 262	PRW002C
Methane	µg/L	0.93 – 2400	PRW003DU	0.64 – 2.0	PRW002C
Nitrate	mg/L	0.217 – 2.82	PRW003DU	0.448 – 0.856	PRW003C
Phosphate	mg/L	0.045 – 0.089	PRW002DL	0.076 – 0.097	PRW002C
Potassium	µg/L	255 – 16800	PRW004DL	929 – 2810	PRW001C
Sodium	µg/L	2000 – 14400	PRW001DL	3370 – 9880	PRW004C
Sulfate	mg/L	0.533 – 13.4	PRW001DL	0.828 – 8.12	PRW003C
TDS	mg/L	4.29 – 65.7	PRW004DU	18.6 – 111	PRW001C
TOC	mg/L	0.362 – 0.595	PRW004DU	0.354 – 0.463	PRW001C

[A] Only one detection above the MDL

[B] All results were non-detect; PQL in parenthesis

Reported baseline values are from the following monitoring wells:

- UAZ: P002U, P003U, P003L, PRW001DU, PRW001DL, PRW002DU, PRW002DL, PRW003DU, PRW003DL, PRW004DU, PRW004DL
- LAZ: PRW001C, PRW002C, PRW003C, PRW004C

Table 4. Baseline Concentration Comparison with Most Recent Results for UAZ (1Q22)

		East of ZVI-PRB [A]		West of ZVI-PRB [A]		In-Wall [A]
Analyte	Units	Baseline	1Q22	Baseline	1Q22	1Q22
PCE	µg/L	0.34 - 1.43	1.00 - 11.8	0.7 - 5.15	0.37 - 0.87	ND (1) [C]
TCE	µg/L	1.65 - 686	0.61 - 961	0.96 - 1,090	0.77 - 617	10.4 [B]
cis-DCE	µg/L	0.45 - 47.5	0.42 - 60.7	2.08 - 28.4	1.41 - 76.6	41.3 [B]
trans-DCE	µg/L	0.57 [B]	ND (10) [C]	0.54 [B]	0.69 [B]	ND (1) [C]
1,1-DCE	µg/L	ND (1) [C]	ND (10) [C]	ND (1) [C]	0.37 [B]	ND (1) [C]
VC	µg/L	ND (1) [C]	ND (10) [C]	ND (1) [C]	ND (25) [C]	0.80 [B]
Alkalinity	mg/L	5.8 - 37	0 - 84	2.2 - 38.4	5 - 48	104 - 295
Calcium	µg/L	1,190 - 4,810	NS [D]	850 - 2,230	NS [D]	47,400 - 128,000
Chloride	mg/L	2.82 - 3.18	2.46 - 44.8	2.11 - 3.64	2.89 - 37.4	13.8 - 53.2
DOC	mg/L	0.461 - 0.638	0.594 - 13.7	0.488 - 0.683	1.29 - 14.3	27.4 - 59.8
Ethane	µg/L	0.12 [B]	15.9 - 17.9	ND (0.1) [C]	15.7 - 54.0	17.4 - 87.8
Ethylene	µg/L	0.55 [B]	ND (25) [C]	0.11 [B]	ND (25) [C]	52.4 [B]
Ferric Iron	mg/L	ND (0.5) [C]	NS [D]	ND (0.5) [C]	NS [D]	0.13 - 1.00
Ferrous Iron	mg/L	ND (0.5) [C]	NS [D]	0.87 [B]	NS [D]	ND (0.05) [C]
Total Iron	µg/L	53.3 - 178	NS [D]	148 - 741	245 - 15,100	33 - 149
Magnesium	µg/L	341 - 1,360	NS [D]	376 - 1,070	NS [D]	10.3 - 132
Manganese	µg/L	9.1 - 24.1	NS [D]	5.07 - 174	NS [D]	1.05 - 3.04
Methane	µg/L	0.93 - 2,400	15.2 - 25,700	1.9 - 600	49.6 - 10,200	1,250 - 6,170
Nitrate	mg/L	0.217 - 2.82	NS [D]	0.278 - 2.6	NS [D]	ND (0.5) [C]
Phosphate	mg/L	0.0456 - 0.0736	NS [D]	0.0449 - 0.0891	NS [D]	0.0201 - 0.0223
Potassium	µg/L	255 - 11,000	NS [D]	556 - 16,800	NS [D]	1,210 - 4,650
Sodium	µg/L	2,630 - 14,400	NS [D]	3,240 - 12,200	NS [D]	7,990 - 22,800
Sulfate	mg/L	0.533 - 13.4	NS [D]	0.589 - 6.22	NS [D]	0.221 - 1.09
TDS	mg/L	40 - 47.1	NS [D]	4.29 - 65.7	NS [D]	187 - 509
TOC	mg/L	0.362 - 0.533	0.487 - 10.1	0.38 - 0.595	0.608 - 11.5	25.7 - 57.7

[A] Wells included in each set are:
East of ZVI-PRB: PRW001DU, PRW001DL, PRW003DU, PRW003DL
West of ZVI-PRB: PRW002DU, PRW002DL, PRW004DU, PRW004DL, PRW005DU, PRW005DL, PRW007DU, PRW007DL
In-Wall: PIW001D, PIW002D, PIW003D, PIW004D

[B] Only one value reported above MDL.

[C] No detections; Maximum PQL reported in parenthesis.

[D] Not sampled.

Table 5. Baseline Concentration Comparison with Most Recent Results for LAZ (1Q22)

Analyte	Units	East of ZVI-PRB [A]		West of ZVI-PRB [A]	
		Baseline	1Q22	Baseline	1Q22
PCE	µg/L	0.65 - 1.15	1.97 [B]	0.86 – 1.6	ND (2) [C]
TCE	µg/L	419 - 664	4.04 - 4.81	195 - 437	8.48 – 8.53
cis-DCE	µg/L	84.1 - 138	9.89 - 18.1	35.0 - 109	3.86 – 96.2
trans-DCE	µg/L	2.13 - 2.84	0.44 [B]	1.08 – 2.63	ND (2) [C]
1,1-DCE	µg/L	ND (1) [C]	ND (1) [C]	ND (1) [C]	ND (2) [C]
VC	µg/L	ND (1) [C]	ND (1) [C]	ND (1) [C]	ND (2) [C]
Alkalinity	mg/L	9.6 - 40.8	58 - 66	3.0 – 6.8	28 - 47
Chloride	mg/L	2.20 - 3.03	14.6 - 26.7	2.32 – 2.39	14.0 – 19.9
DOC	mg/L	0.410 - 0.426	4.94 - 25.7	0.480 - 0.531	2.06 – 8.40
Ethane	µg/L	0.12 [B]	155 - 371	0.14 [B]	135 - 373
Ethylene	µg/L	0.15 - 0.18	18.6 - 136	0.25 [B]	214 [B]
Total Iron	µg/L	80.1 - 188	NS [D]	361 - 496	9,910 - 18,600
Methane	µg/L	0.64 - 1.7	2,340 - 6,340	2.0 [B]	895 - 21,100
TOC	mg/L	0.382 - 0.463	4.36 - 20.7	0.35 - 0.43	1.33 – 5.99

[A] Wells included in each set are:
East of ZVI-PRB: PRW001C and PRW003C
West of ZVI-PRB: PRW002C and PRW004C

[B] Only one value reported above MDL.

[C] No detections; Maximum PQL reported in parenthesis.

[D] Not sampled.

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APPENDIX A

PAGW OU RA EMR Analytical Data 2021-2022

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Table A. PAGW RA EMR Monitoring Well Data, 2Q21 - 1Q22			Field Data												Geochemical Analytes																			
			SAMPLE COLLECTION DATE	AIR TEMPERATURE	OXIDATION/REDUCTION POTENTIAL	OXYGEN	PH	SPECIFIC CONDUCTANCE	TURBIDITY	VOLUME PURGED	WATER TEMPERATURE	DEPTH TO WATER	SAMPLING EVENT WATER ELEVATIO	FIELD CONDITIONS	CALCIUM	CHLORIDE	DISSOLVED ORGANIC CARBON	ETHANE	ETHYLENE	FERRIC IRON	FERROUS IRON	IRON	MAGNESIUM	MANGANESE	METHANE	NITRATE-NITRITE AS NITROGEN	POTASSIUM	SODIUM	SULFATE	SULFIDE	TOTAL ALKALINITY (AS CACO3)	TOTAL DISSOLVED SOLIDS	TOTAL ORGANIC CARBON	TOTAL PHOSPHATES (AS P)
			D-M-Y	degC	mV	mg/L	unitless	uS/cm	NTU	gal	degC	ft	ft	Unit	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	mg/L	mg/L	ug/L	mg/L	ug/L	ug/L	ug/L
Station	Well Use	Aquifer Zone					8.5							GWPS								14000		430		10								
P002U	Monitoring Well	UAZ_UTRAU	19-May-2021	22.7	-130	111	6.5	310	19.8	2	20.9	NS	NS	No Comments	NS	38400	13500	<EQL (25)	<EQL (25)	NS	NS	28800	NS	NS	[423]	NS	NS	NS	NS	NS	NS	NS	36200	NS
			02-Aug-2021	28.8	-112	114	6.4	294	17.8	2	22.2	NS	NS	No Comments	NS	33800	31600	[16.7]	<EQL (25)	NS	NS	24400	NS	NS	510	NS	NS	NS	NS	NS	NS	NS	36100	NS
			01-Nov-2021	22.3	-114.3	105	6.4	246	23.7	2	20.7	NS	NS	No Comments	NS	28200	25500	<EQL (25)	<EQL (25)	NS	NS	21700	NS	NS	196	NS	NS	NS	NS	NS	NS	NS	27200	NS
			08-Feb-2022	6.2	-94	9.3	6.4	249	103	3	18.9	NS	NS	No Comments	NS	23500	25600	29.6	<EQL (25)	3500	20000	23000	NS	NS	4450	<EQL (0.10)	NS	NS	<EQL (0.4)	<EQL (100)	NS	NS	18300	<EQL (50)
P003L	Monitoring Well	UAZ_UTRAU	19-May-2021	31.2	183	126	5.1	21	7.9	2	22.2	NS	NS	No Comments	NS	2240	[763]	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[511]	NS
			02-Aug-2021	30.2	191	6.79	4.8	25	5.1	1	23.6	NS	NS	No Comments	NS	2070	[640]	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[485]	NS
			01-Nov-2021	21.7	236	122	5.3	20	13.1	3	21.3	NS	NS	No Comments	NS	2040	3530	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[428]	NS
			08-Feb-2022	8.7	166	10.8	5.1	23	8.3	1	18.6	NS	NS	No Comments	NS	2060	2700	<EQL (25)	<EQL (25)	290	<EQL (50)	320	NS	NS	<EQL (25)	0.575	NS	NS	0.629	<EQL (100)	NS	NS	[555]	<EQL (50)
P003U	Monitoring Well	UAZ_UTRAU	19-May-2021	25.5	249	117.6	5.4	34	4.5	2	21	NS	NS	No Comments	NS	2880	1090	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[415]	NS
			02-Aug-2021	32.8	202	122.1	5.4	38	22.8	1	22.1	NS	NS	No Comments	NS	3050	[923]	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[579]	NS
			01-Nov-2021	20	173	111	5.6	36	14	3	21.6	NS	NS	No Comments	NS	2860	3100	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	[11.2]	NS	NS	NS	NS	NS	NS	NS	[414]	NS
			08-Feb-2022	11.1	263	10.8	5.1	35	10.7	2	19.1	NS	NS	No Comments	NS	2690	2590	<EQL (25)	<EQL (25)	<EQL (100)	<EQL (50)	<EQL (100)	NS	NS	<EQL (25)	2060	NS	NS	1.05	<EQL (100)	NS	NS	[610]	<EQL (50)
PIW001D	Monitoring Well	UAZ_UTRAU	17-May-2021	28.2	-520	0	10.9	570	2.7	2	22.2	35.67	277.37	No Comments	57100	22400	<EQL (5000)	39	<EQL (25)	NS	NS	[71.8]	78	[1.24]	1280	<EQL (0.05)	5200	15.8	[0.434]	<EQL (100)	149	271000	<EQL (5000)	73.4
			02-Aug-2021	24.2	-436	3	11	606	2.8	1	22.8	37.2	275.84	No Comments	80200	22500	39700	34.2	<EQL (25)	<EQL (100)	<EQL (50)	[69.6]	[26.5]	[1.72]	856	<EQL (0.5)	5280	11.7	0.539	<EQL (100)	207	343000	33000	<EQL (50)
			04-Nov-2021	9.8	-290	21	10.7	455	2.7	1	18	39.2	273.84	No Comments	49300	27400	<EQL (5000)	[21]	<EQL (25)	<EQL (100)	<EQL (50)	[67.3]	217	[1.53]	1390	<EQL (0.5)	4910	21.2	0.404	<EQL (100)	130	224000	33900	[51.9]
			08-Feb-2022	6.2	-378	2	10.7	498	0.7	1	16.5	40.33	272.71	No Comments	59000	22900	37300	[17.4]	<EQL (25)	1000	<EQL (50)	[34.8]	132	[1.05]	1980	<EQL (0.5)	4650	16.1	[0.301]	<EQL (100)	148	229000	31200	[22.3]
PIW002D	Monitoring Well	UAZ_UTRAU	17-May-2021	29.3	-337	0	11.1	858	2.5	2	21.6	36.74	277.6	No Comments	86200	46700	70800	76.2	<EQL (25)	NS	NS	[71.4]	63	[1.68]	667	<EQL (0.05)	3570	32	1.07	<EQL (100)	220	450000	76300	[32.9]
			02-Aug-2021	29.6	-448	2	11.2	845	1.6	1	22	38.1	276.24	No Comments	88600	45600	74400	63.1	<EQL (25)	<EQL (100)	<EQL (50)	[57.7]	[25.3]	[1.82]	854	<EQL (0.5)	3280	32.4	1.41	<EQL (100)	211	383000	65600	<EQL (50)
			04-Nov-2021	11.1	-366	9	10.9	777	0.9	1	20	39.92	274.42	No Comments	80700	35100	64300	58	<EQL (25)	<EQL (100)	<EQL (50)	131	38.8	[2.56]	701	<EQL (0.5)	2620	24.9	1.06	<EQL (100)	185	319000	63600	[59.5]
			08-Feb-2022	9.5	-349.7	8	10.8	680	0.5	1	18.5	41.4	272.94	No Comments	86400	33900	59800	60.7	<EQL (25)	<EQL (100)	<EQL (50)	[33]	[10.3]	[1.08]	1980	<EQL (0.5)	2720	22.8	1.09	<EQL (100)	190	353000	57700	[20.1]
PIW003D	Monitoring Well	UAZ_UTRAU	17-May-2021	29.5	-342	0.9	10.9	454	2.2	2	22.1	37.75	277.68	No Comments	53900	15900	29300	104	91.5	NS	NS	118	38.5	[3.21]	3850	<EQL (0.05)	1660	9.72	0.493	<EQL (100)	149	229000	29900	[44.5]
			02-Aug-2021	31.2	-459	1	10.9	423	1.1	1	21.7	39	276.43	No Comments	55500	16600	29700	74.8	75.8	<EQL (100)	<EQL (50)	[97.1]	[28.4]	[2.86]	4060	<EQL (0.5)	1660	9.25	0.436	<EQL (100)	124	229000	28400	<EQL (50)
			04-Nov-2021	12.2	-345	4	10.3	373	1.4	1	20.3	40.12	275.31	No Comments	44200	14300	32400	74.4	53.9	<EQL (100)	<EQL (50)	[57.9]	63.4	[3.7]	2410	<EQL (0.5)	1400	8.73	[0.333]	<EQL (100)	110	180000	27000	<EQL (50)
			08-Feb-2022	10.6	-404.8	2	10.5	344	0.5	1	19.4	42.5	272.93	No Comments	47400	13800	27400	87.8	52.4	130	<EQL (50)	149	51.2	[3.04]	6170	<EQL (0.5)	1210	7.99	[0.221]	<EQL (100)	104	187000	25700	<EQL (50)
PIW004D	Monitoring Well	UAZ_UTRAU	17-May-2021	30.2	-480	2	10.8	1025	0.8	2	21.4	38.96	277.95	No Comments	126000	71200	59300	56.8	<EQL (25)	NS	NS	212	51.4	[3.55]	1130	<EQL (0.05)	3940	28.6	0.553	<EQL (100)	313	700000	61800	63.9
			02-Aug-2021	33.1	-418	2	11	831	0.7	1	21.4	40.2	276.71	No Comments	178000	76200	96200	39.5	[10.5]	<EQL (100)	<EQL (50)	[75.4]	[14]	[2.64]	1050	<EQL (0.5)	3940	22.5	0.949	<EQL (100)	377	814000	67900	51.5
			04-Nov-2021	12.7	-322	12	10.6	914	4.9	1	19.9	41.48	275.43	No Comments	132000	62800	66600	27	<EQL (25)	<EQL (100)	<EQL (50)	[39.4]	[22]	[1.55]	639	<EQL (0.5)	3290	21	[0.367]	<EQL (100)	269	564000	48900	<EQL (50)
			08-Feb-2022	11.1	-393	4	10.7	847	0.7	1	19.4	43.79	273.12	No Comments	128000	53200	50900	32.6	<EQL (25)	<EQL (100)	<EQL (50)	[65]	[11.7]	[1.95]	1290	<EQL (0.5)	2730	14.9	0.449	<EQL (100)	295	509000	53500	<EQL (50)
PRW001C	Monitoring Well	LAZ_UTRAU	17-May-2021	17.8	-385	1.2	7.2	199	7.1	6	20.9	47	266.3	No Comments	NS	19900	19400	445	234	NS	NS	NS	NS	NS	12400	NS	NS	NS	NS	NS	NS	NS	22800	NS
			02-Aug-2021	33.2	-375	-0.2	9.7	183	23.3	3	22.9	43.38	269.92	No Comments	NS	17500	21700	462	256	NS	NS	NS	NS	NS	6890	NS	NS	NS	NS	NS	NS	NS	19500	NS
			01-Nov-2021	14.4	-427	1	9.1	179	14.8	4	20.7	50	263.3	No Comments	NS	16500	18800	[643]	224	NS	NS	NS	NS	NS	6790	NS	NS	NS	NS	NS	NS	NS	18700	NS
			09-Feb-2022	5.8	-417	0.7	10.5	246	14.7	2	20.5	51.6	261.7	No Comments	NS	14600	25700	371	136	NS	NS	NS	NS	NS	2340	NS	NS	NS	NS	NS	NS	NS	20700	NS
PRW001DL	Monitoring Well	UAZ_UTRAU	17-May-2021	24.1	-128	4.7	6.3	122	6.3	1	21.1	36.7	276.49	No Comments	NS	10300	25100	[12.5]	<EQL (25)	NS	NS	NS	NS	NS	11700	NS	NS	NS	NS	NS	NS	NS	3750	NS
			03-Aug-2021	23.7	-162	1.6	6.4	435	1.4	2	21.2	38.2	274.99	No Comments	NS	37800	16600	27.3	<EQL (25)	NS	NS	NS	NS	NS	22800	NS	NS	NS	NS	NS	NS	NS	17300	NS
			01-Nov-2021	17.8	-121	10	6.5	248	3.5	2	22.1	39.88	273.31	No Comments	NS	28000	17800	[11.4]	<EQL (25)	NS	NS	NS	NS	NS	9340	NS	NS	NS	NS	NS	NS	NS	15800	NS
			09-Feb-2022	10.9	-155	0.4	6.2	325	6.4	1	20.4	41.5	271.69	No Comments	NS	44800	13700	[15.9]	<EQL (25)	NS	NS	NS	NS	NS	25700	NS	NS	NS	NS	NS	NS	NS	10100	NS
PRW001DU	Monitoring Well	UAZ_UTRAU	17-May-2021	28.3	-160	5.8	6.7	102	3.1	1	21.1	35	278.18	No Comments	NS	11800	7980	[22]	<EQL (25)	NS	NS	NS	NS	NS	13700	NS	NS	NS	NS	NS	NS	NS	3530	NS
			03-Aug-2021	23.6	-115.8	1.5	6.4	98	0.8	2	21	36.9	276.28	No Comments	NS	9410	4190	30	<EQL (25)	NS	NS	NS	NS	NS	7210	NS	NS	NS	NS	NS	NS	NS	4840	NS
			01-Nov-2021	18.9	-99.1	9	6.5	100	1.4	3	21.3	38.56	274.62	No Comments	NS	9470	7620	[16.6]	<EQL (25)	NS	NS	NS	NS	NS	6750	NS	NS	NS	NS	NS	NS	NS	3940	NS
			09-Feb-2022	15.7	-144	3.5	6.3	99	1.8	1	20.4	39.3	273.88	No Comments	NS	9540	3430	[17.9]	<EQL (25)	NS	NS	NS	NS	NS	11300	NS	NS	NS	NS	NS	NS	NS	5750	NS
PRW002C	Monitoring Well	LAZ_UTRAU	18-May-2021	28.7	-163	1	6.5	356	3.4	3	21.1	47.52	266.09	No Comments	NS	43500	8710	204	120	NS	NS	37000	NS	NS	8240	NS	NS	NS	NS	NS	NS	NS	8630	NS
			03-Aug-2021	23.4	-174	8	6.6	282	10.8	2	21.2	48.9	264.71	No Comments	NS	29600	4700	458	290	NS	NS	31300	NS	NS	3210	NS	NS	NS	NS	NS	NS	NS	2030	NS
			01-Nov-2021	20.1	-142	3.6	6.7	178	3.9	2	20.5	50.53	263.08	No Comments	NS	[13300]	4440	478	344	NS	NS	19900	NS	NS	[1300]	NS	NS	NS	NS	NS	NS	NS	1310	NS
			07-Feb-2022	5.2	-61	3.9	6.5	155	1	4	19.9	52	261.61	No Comments	NS	14000	2150	373	214	NS	NS	18600	NS	NS	895	NS	NS	NS	NS	NS	NS	NS	1400	NS
PRW002DL	Monitoring Well	UAZ_UTRAU	19-May-2021	23.4	-9.5	10	6	143	3	3	21.1	37.54	276.15	No Comments	NS	15600	3160	<EQL (250)	<EQL (250)	NS	NS	5620	NS	NS	[3980]	NS	NS	NS	NS	NS	NS	NS	2150	NS
			03-Aug-2021	23.5	23.9	10	5.9	149	2.2	2	21	38.82	274.87	No Comments	NS	19900	2090	[21]	<EQL (25)	NS	NS	10900	NS	NS	7640	NS	NS	NS	NS	NS	NS	NS	2310	NS
			01-Nov-2021	28.3	44	6.3	5.9	124	3.5	2	21.4	40.5	273.19	No Comments	NS	11200	4900	<EQL (25)	<EQL (25)	NS	NS	[1790]	NS	NS	[2250]	NS	NS	NS	NS	NS	NS	NS	1380	NS
			07-Feb-2022	4.8	51	9.2	5.8	123	2.8	3	20.1	42.11	271.58	No Comments	NS	15300	2340	<EQL (25)	<EQL (25)	NS	NS	9810	NS	NS	3000	NS	NS	NS	NS	NS	NS	NS	2080	NS
PRW002DU	Monitoring Well	UAZ_UTRAU	19-May-2021	27.8	-184	1	6.6	214	2.4	2	21.4	36.57	277.06	No Comments	NS	26300	3660	<EQL (1250)	<EQL (1250)	NS	NS	16600	NS	NS	[13800]	NS	NS	NS	NS	NS	NS	NS	3350	NS
			03-Aug-2021	25.2	-138	0.9	6.6	202	0.7	2	21	37.9	275.73	No Comments	NS	26600	2630	46.9	<EQL (25)	NS	NS	14800	NS	NS	17200	NS	NS	NS	NS	NS	NS	NS	2850	NS
			01-Nov-2021	26.2	-150	9	6.6	180	2.8	2	21.8	39.53	274.1	No Comments	NS	23300	5130	33.3	<EQL (25)	NS	NS	12100	NS	NS	14000	NS	NS	NS	NS	NS	NS	NS	2530	NS
			07-Feb-2022	7.1	-134	4.3	6.6	157	0.6	2	20.1	41.15	272.48	No Comments	NS	21800	2210	54	<EQL (25)	NS	NS	12500	NS	NS	7330	NS	NS	NS	NS	NS	NS	NS	1880	NS
PRW003C	Monitoring Well	LAZ_UTRAU	18-May-2021	24.7	-291	0	7.2	186	7.3	2	21	47.24	266.17	No Comments	NS	22400	8590	69.2	[15.7]	NS	NS	NS	NS	NS	3920	NS	NS	NS	NS	NS	NS	NS	7930	NS
			03-Aug-2021	24.9	-279	1	7.2	186	8.3	2	20.9	48.5	264.91	No Comments	NS	21400	6020	65.4	[22.4]	NS	NS	NS	NS	NS	1690	NS	NS	NS	NS	NS	NS	NS	3810	NS
			02-Nov-2021	18.2	-209	1	7.4	178	12.5	2	20.7	50.28	263.13	No Comments	NS	19800	5380	66.8	[18]	NS	NS	NS	NS	NS	1870	NS	NS	NS	NS	NS	NS	NS	2280	NS
			09-Feb-2022	4.2	-178	2	6.7	197	16	7	20	51.67	261.74	No Comments	NS	26700	5040	155	[18.6]	NS	NS	NS	NS	NS	6340	NS	NS	NS	NS	NS	NS	NS	4510	NS
PRW003DL	Monitoring Well	UAZ_UTRAU	18-May-2021	20.4	163	53	5.7	68	0.8	1	20.6	37.56	276.46	No Comments	NS	2580	[975]	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[586]	NS
			03-Aug-2021	24.3	154	47	6	66	6.4	1	21.2	38.7	275.32	No Comments	NS	2760	2730	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	34.6	NS	NS	NS	NS	NS	NS	NS	[390]	NS
			02-Nov-2021	12.1	155	52	5.8	65	0.7	1	19.9	40.54	273.48	No Comments	NS	2450	2920	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	35.3	NS	NS	NS	NS	NS	NS	NS	[440]	NS
			09-Feb-2022	11.6	75.7	50	6.1	61	0.3	3	20.1	42.21	271.81	No Comments	NS	2460	[594]	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	[15.2]	NS	NS	NS	NS	NS	NS	NS	[551]	NS
PRW003DU	Monitoring Well	UAZ_UTRAU	18-May-2021	25.6	171	4	4.6	44	3.8	4	20.7	35.53	278.27	No Comments	NS	2800	1180	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	2870	NS	NS	NS	NS	NS	NS	NS	[586]	NS
			03-Aug-2021	26.8	184	6	4.7	44	2.7	4	20.5	36.9	276.9	No Comments	NS	3070	2890	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	1910	NS	NS	NS	NS	NS	NS	NS	[485]	NS
			02-Nov-2021	24.8	122	8	4.8	45	5.3	1	20.8	38.51	275.29	No Comments	NS	2710	2830	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	3680	NS	NS	NS	NS	NS	NS	NS	[596]	NS
			09-Feb-2022	11.5	162.5	3	4.8	44	0.7	2	20.2	40.26	273.54	No Comments	NS	2800	[793]	<EQL (25)	<EQL (25)	NS	NS	NS	NS	NS	4770	NS	NS	NS	NS	NS	NS	NS	[487]	NS
PRW004C	Monitoring Well	LAZ_UTRAU	19-May-2021	27.7	-134	20.6	6.6	203	4.5	2	22	48.43	266.46	No Comments	NS	29500	16200	<EQL (1250)	<EQL (1250)	NS	NS	9090	NS	NS	[14800]	NS	NS	NS	NS	NS	NS	NS	17400	NS
			04-Aug-2021	20.8	-167	3	6.7	197	4.5	1	21.9	49.94	264.95	No Comments	NS	25500	10700	126	[10.9]	NS	NS	8030	NS	NS	10400	NS	NS	NS	NS	NS	NS	NS	9730	NS
			02-Nov-2021	13.9	-175	2	6.8	185	6.2	2	21.3	51.34	263.55	No Comments	NS	20800	9240	132	<EQL (25)	NS	NS	10100	NS	NS	13000	NS	NS	NS	NS	NS	NS	NS	8130	NS
			09-Feb-2022	1	-315	1.6	6.8	152	5.7	2	20	53.1	261.79	No Comments	NS	19900	8400	135	<EQL (25)	NS	NS	9910	NS	NS	21100	NS	NS	NS	NS	NS	NS	NS	5990	NS
PRW004DL	Monitoring Well	UAZ_UTRAU	19-May-2021	28.1	-133	3.8	6.7	164	0.4	2	21	38.82	275.81	No Comments	NS	3760	1180	<EQL (25)	<EQL (25)	NS	NS	1870	NS	NS	[360]	NS	NS	NS	NS	NS	NS	NS	[793]	NS
			04-Aug-2021	23.6	-113	8	6.6	159	1	1	21.7	40.14	274.49	No Comments	NS	3270	1080	<EQL (25)	<EQL (25)	NS	NS	1330	NS	NS	135	NS	NS	NS	NS	NS	NS	NS	[642]	NS
			02-Nov-2021	7.8	-80	2.7	6.4	150	1.4	3	20.5	41.71	272.92	No Comments	NS	3110	3290	<EQL (25)	<EQL (25)	NS	NS	588	NS	NS	62.3	NS	NS	NS	NS	NS	NS	NS	[747]	NS
			09-Feb-2022	15.8	-49.7	4	6.5	136	0.4	1	20.7	43.4	271.23	No Comments	NS	3370	1290	<EQL (25)	<EQL (25)	NS	NS	1530	NS	NS	49.6	NS	NS	NS	NS	NS	NS	NS	[881]	NS
PRW004DU	Monitoring Well	UAZ_UTRAU	19-May-2021	29.7	-48	0.7	6	84	1.8	2	21	36.95	278.17	No Comments	NS	3360	1520	<EQL (500)	<EQL (500)	NS	NS	15600	NS	NS	[8360]	NS	NS	NS	NS	NS	NS	NS	1400	NS
			04-Aug-2021	24.3	-84	9	6	89	1.6	2	21.2	38.33	276.79	No Comments	NS	3030	1300	45.3	<EQL (25)	NS	NS	16500	NS	NS	6260	NS	NS	NS	NS	NS	NS	NS	[723]	NS
			02-Nov-2021	17.8	-87	1	6	84	7.4	4	20.7	39.87	275.25	No Comments	NS	2710	3930	37.1	<EQL (25)	NS	NS	14300	NS	NS	8640	NS	NS	NS	NS	NS	NS	NS	1140	NS
			10-Feb-2022	3.9	70.4	6.8	6	77	3	1	18.8	41.72	273.4	No Comments	NS	2890	1540	42.4	<EQL (25)	NS	NS	15100	NS	NS	10200	NS	NS	NS	NS	NS	NS	NS	[774]	NS
PRW005DL	Monitoring Well	UAZ_UTRAU	18-May-2021	27.3	53	60	5.2	38	1.7	1	21.3	37.1	275.61	No Comments	NS	4980	3330	<EQL (25)	<EQL (25)	NS	NS	854	NS	NS	30.2	NS	NS	NS	NS	NS	NS	NS	1120	NS
			04-Aug-2021	21.3	69	57	5.2	41	1.4	1	21.2	37.8	274.91	No Comments	NS	5820	3210	<EQL (25)	<EQL (25)	NS	NS	763	NS	NS	31.4	NS	NS	NS	NS	NS	NS	NS	[925]	NS
			02-Nov-2021	21.1	125	23	5.2	44	2.1	4	21.6	39.42	273.29	No Comments	NS	5930	3720	<EQL (25)	<EQL (25)	NS	NS	1040	NS	NS	48.8	NS	NS	NS	NS	NS	NS	NS	[1840]	NS
			07-Feb-2022	3.4	72	5.8	5.2	43	1.6	1	19	41	271.71	No Comments	NS	6000	3830	<EQL (25)	<EQL (25)	NS	NS	599	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[870]	NS
PRW005DU	Monitoring Well	UAZ_UTRAU	18-May-2021	28.1	-70	4.3	6.1	87	5.3	1	21.4	35.1	277.8	No Comments	NS	8570	3140	<EQL (25)	<EQL (25)	NS	NS	6930	NS	NS	261	NS	NS	NS	5.91	NS	NS	NS	[877]	NS
			04-Aug-2021	23.6	-54	4.7	5.9	60	4.7	1	21.1	35.7	277.2	No Comments	NS	3580	3310	[11.5]	<EQL (25)	NS	NS	5080	NS	NS	163	NS	NS	NS	NS	NS	NS	NS	[506]	NS
			02-Nov-2021	23.8	-110	3	6.3	66	1.4	3	21.1	37.63	275.27	No Comments	NS	3430	3080	<EQL (25)	<EQL (25)	NS	NS	9140	NS	NS	128	NS	NS	NS	NS	NS	NS	NS	[613]	NS
			07-Feb-2022	5.1	-115	5	6.7	59	4.3	1	19.7	38.5	274.4	No Comments	NS	3440	3320	<EQL (25)	<EQL (25)	NS	NS	7750	NS	NS	76.2	NS	NS	NS	NS	NS	NS	NS	[707]	NS
PRW006C	Monitoring Well	LAZ_UTRAU	10-Feb-2022	11.2	151	91	4.9	17	0.3	1	17.3	69.96	260.84	No Comments	NS	2230	1220	<EQL (25)	<EQL (25)	NS	NS	<EQL (100)	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[410]	NS
PRW006DL	Monitoring Well	UAZ_UTRAU	10-Feb-2022	6.2	186	66	4.4	37	1.3	2	19.7	61.4	268.85	No Comments	NS	2960	2870	<EQL (25)	<EQL (25)	NS	NS	<EQL (100)	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[541]	NS
PRW006DU	Monitoring Well	UAZ_UTRAU	10-Feb-2022	17.9	185	34	5	77	6.4	2	19.5	57.5	272.82	No Comments	NS	4650	3670	<EQL (25)	<EQL (25)	NS	NS	[82.4]	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[778]	NS
PRW007DL	Monitoring Well	UAZ_UTRAU	18-May-2021	20.3	158	34	5.3	74	5.9	1	20	41.4	275.38	No Comments	NS	5610	3030	<EQL (25)	<EQL (25)	NS	NS	[62.8]	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[773]	NS
			04-Aug-2021	26.4	79	42	5.2	73	4.5	1	20.4	42	274.78	No Comments	NS	5140	2790	<EQL (25)	<EQL (25)	NS	NS	[33.9]	NS	NS	[20.8]	NS	NS	NS	NS	NS	NS	NS	[401]	NS
			02-Nov-2021	24.7	142	46	5.3	73	0.8	2	20.7	44.34	272.44	No Comments	NS	4960	3010	<EQL (25)	<EQL (25)	NS	NS	<EQL (100)	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[440]	NS
			07-Feb-2022	6.8	75	4.7	5.4	65	2	1	19.2	45.5	271.28	No Comments	NS	5090	3060	<EQL (25)	<EQL (25)	NS	NS	<EQL (100)	NS	NS	<EQL (25)	NS	NS	NS	NS	NS	NS	NS	[608]	NS
PRW007DU	Monitoring Well	UAZ_UTRAU	18-May-2021	25.7	141	2.4	5.2	75	4.7	1	20.4	37.8	278.63	No Comments	NS	6490	5340	<EQL (25)	<EQL (25)	NS	NS	173	NS	NS	206	NS	NS	NS	NS	NS	NS	NS	3420	NS
			04-Aug-2021	27.7	102	4.5	4.8	90	4.1	1	20.7	38.1	278.33	No Comments	NS	8250	7520	[19.5]	<EQL (25)	NS	NS	[36.2]	NS	NS	440	NS	NS	NS	NS	NS	NS	NS	5720	NS
			02-Nov-2021	25.3	175	12	4.9	145	2.8	2	21.5	41.9	274.53	No Comments	NS	22400	11900	[15.6]	<EQL (25)	NS	NS	[45.7]	NS	NS	852	NS	NS	NS	NS	NS	NS	NS	9420	NS
			07-Feb-2022	7.2	149	2	4.9	176	2.9	1	18.8	43.5	272.93	No Comments	NS	37400	14300	[15.7]	<EQL (25)	NS	NS	245	NS	NS	803	NS	NS	NS	NS	NS	NS	NS	11500	NS

Explanation	
[##]	EPA Functional Guideline Code of 'J' was applied to the result, indicating an estimated quanity.
<EQL(##)	Constituent was below detection. The sample-specific Estimated Quantitation Limit is in parentheses.
🟥	Result exceeds applicable limit.
REJ	Result Rejected.
	Result is less than the applicable limit and without EPA Functional Guidline qualifiers.
NS	Requested to be sampled but was not. See comments as to why not.
Blue Text	Not a required sample analysis.
[##]	Oxygen values reported as % versus mg/L.

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APPENDIX B

PAGW OU RA EMR Hydrographs

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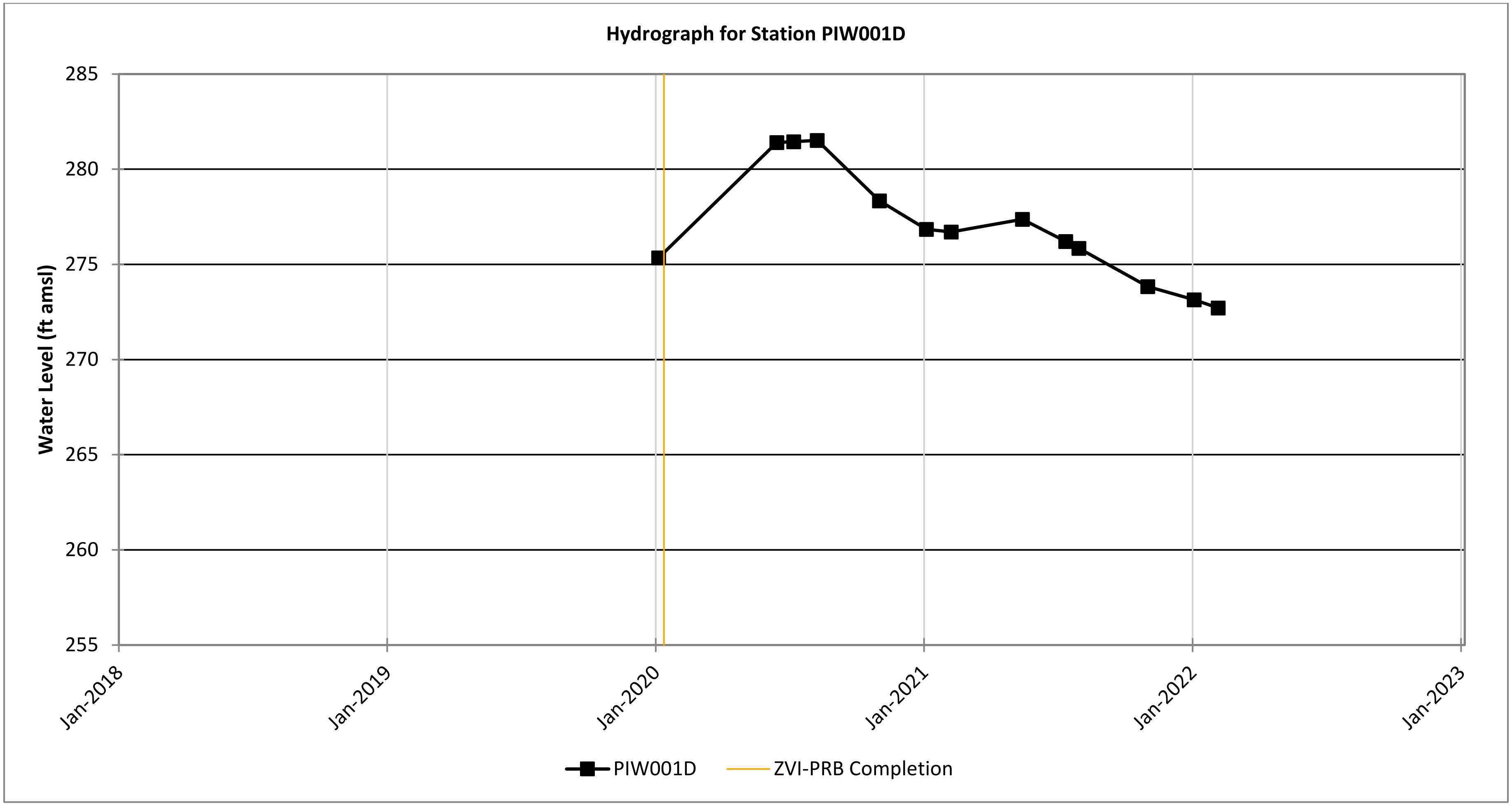

Figure B.1. Hydrograph for PIW001D

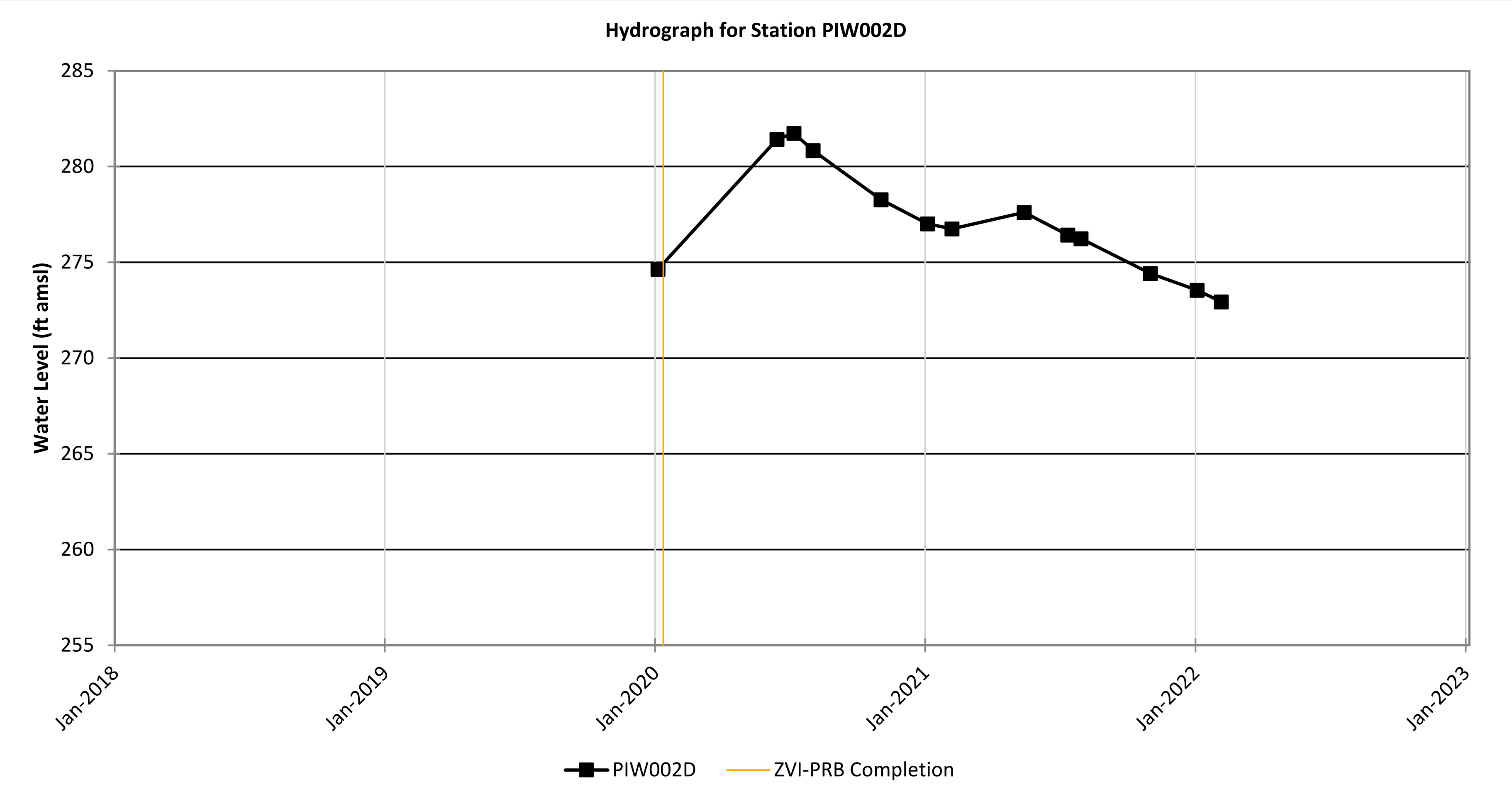

Figure B.2. Hydrograph for PIW002D

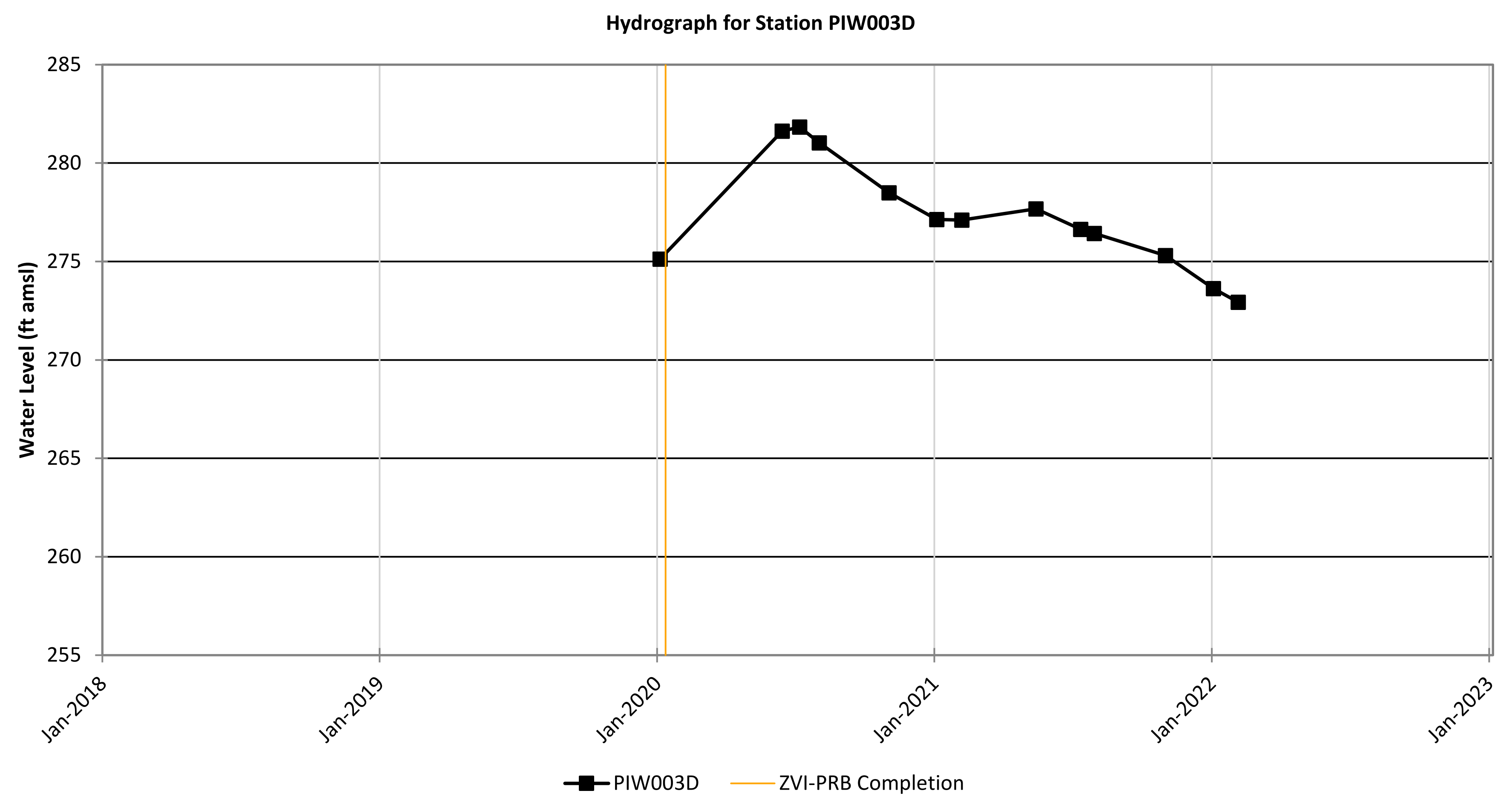

Figure B.3. Hydrograph for PIW003D

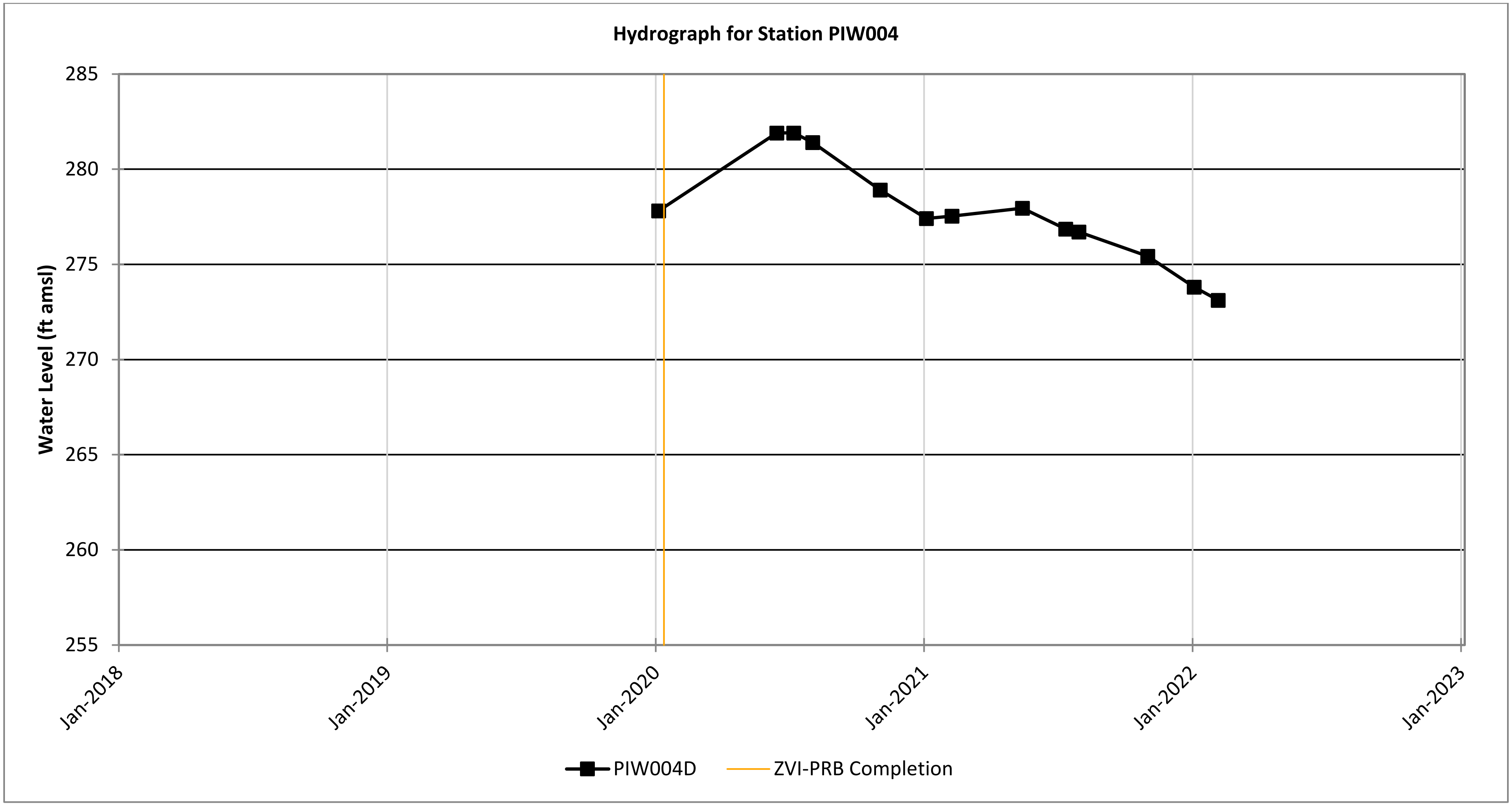

Figure B.4. Hydrograph for PIW004D

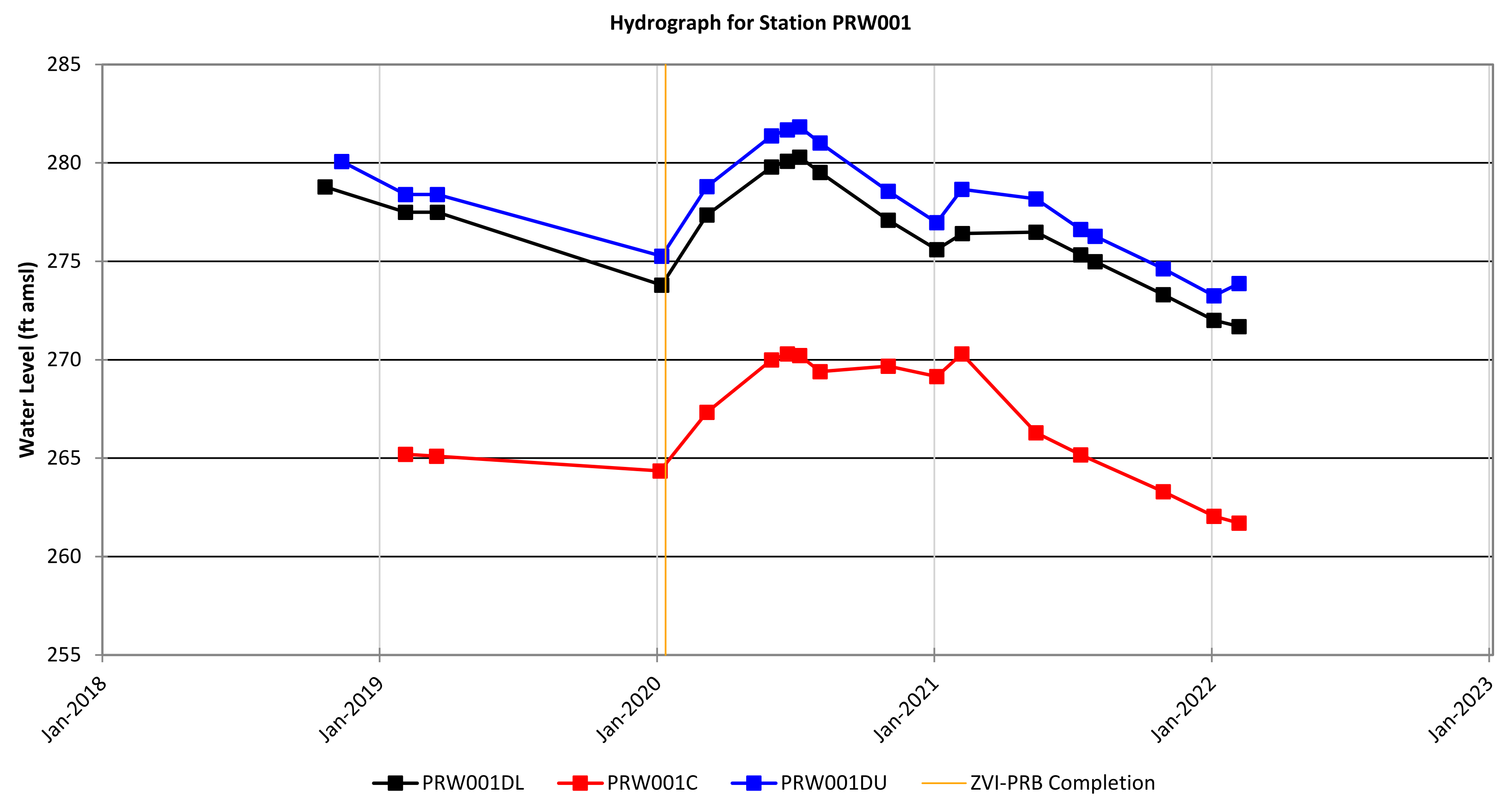

Figure B.5. Hydrograph for PRW001 Cluster

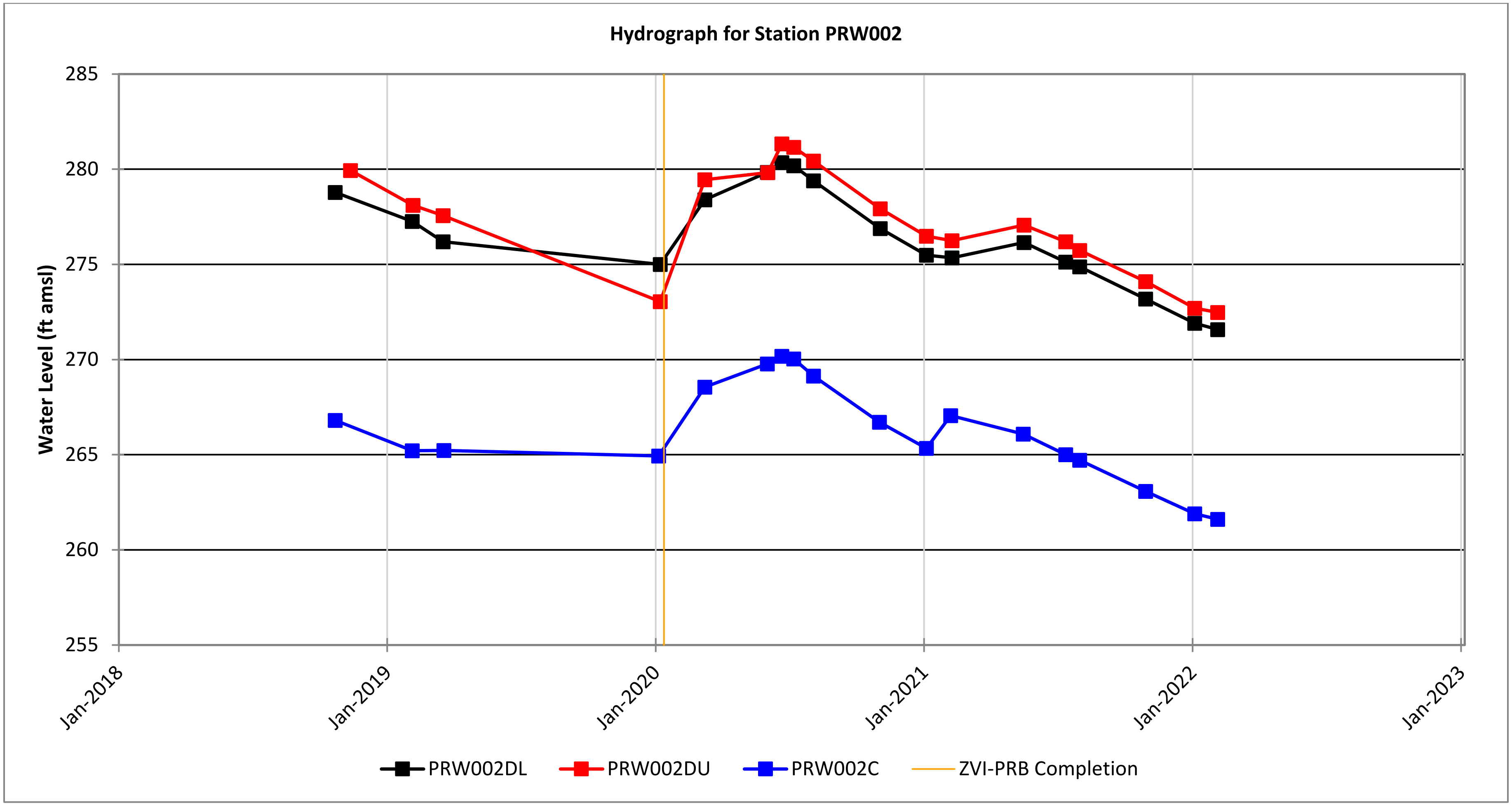

Figure B.6. Hydrograph for PRW002 Cluster

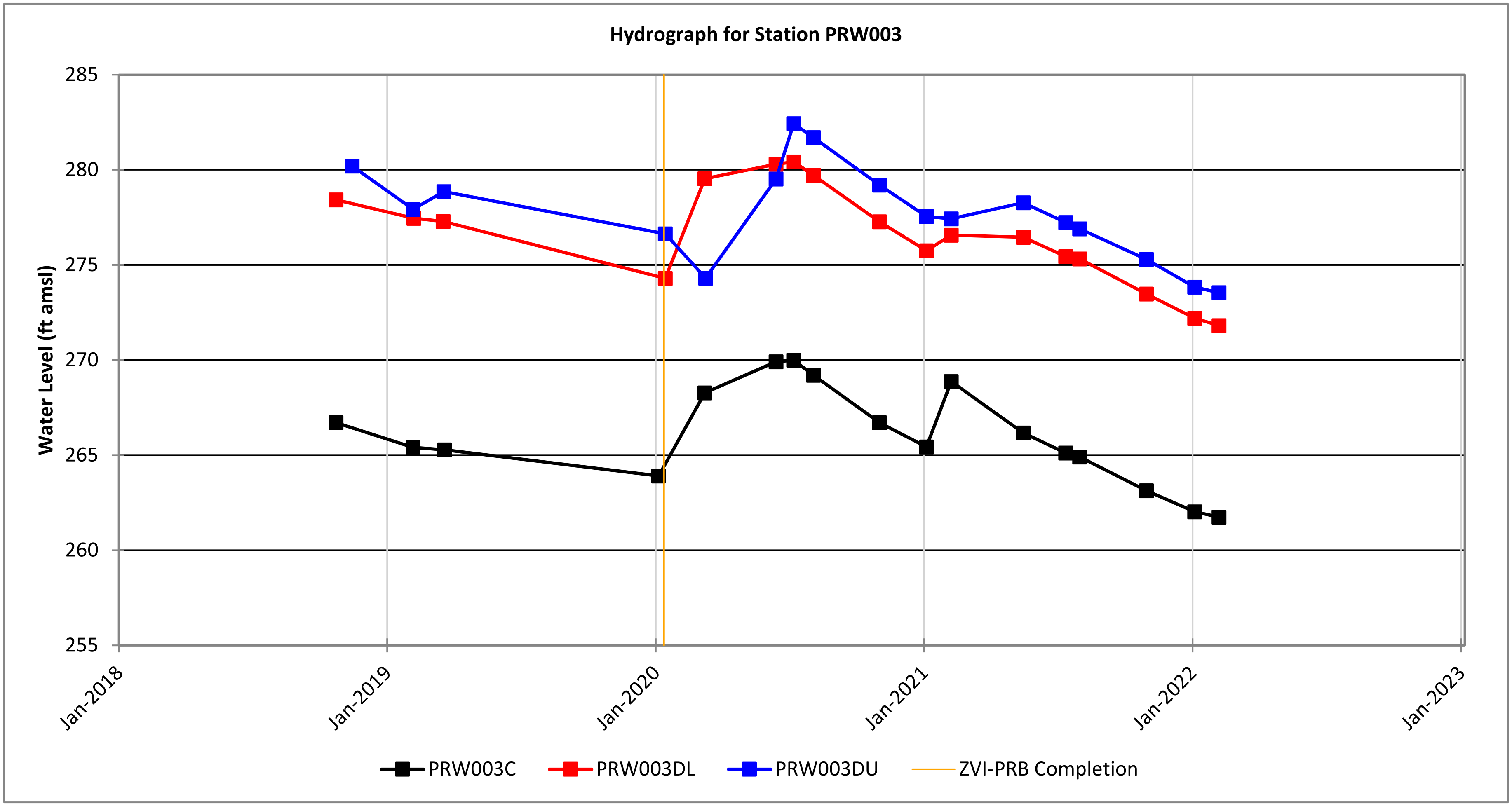

Figure B.7. Hydrograph for PRW003 Cluster

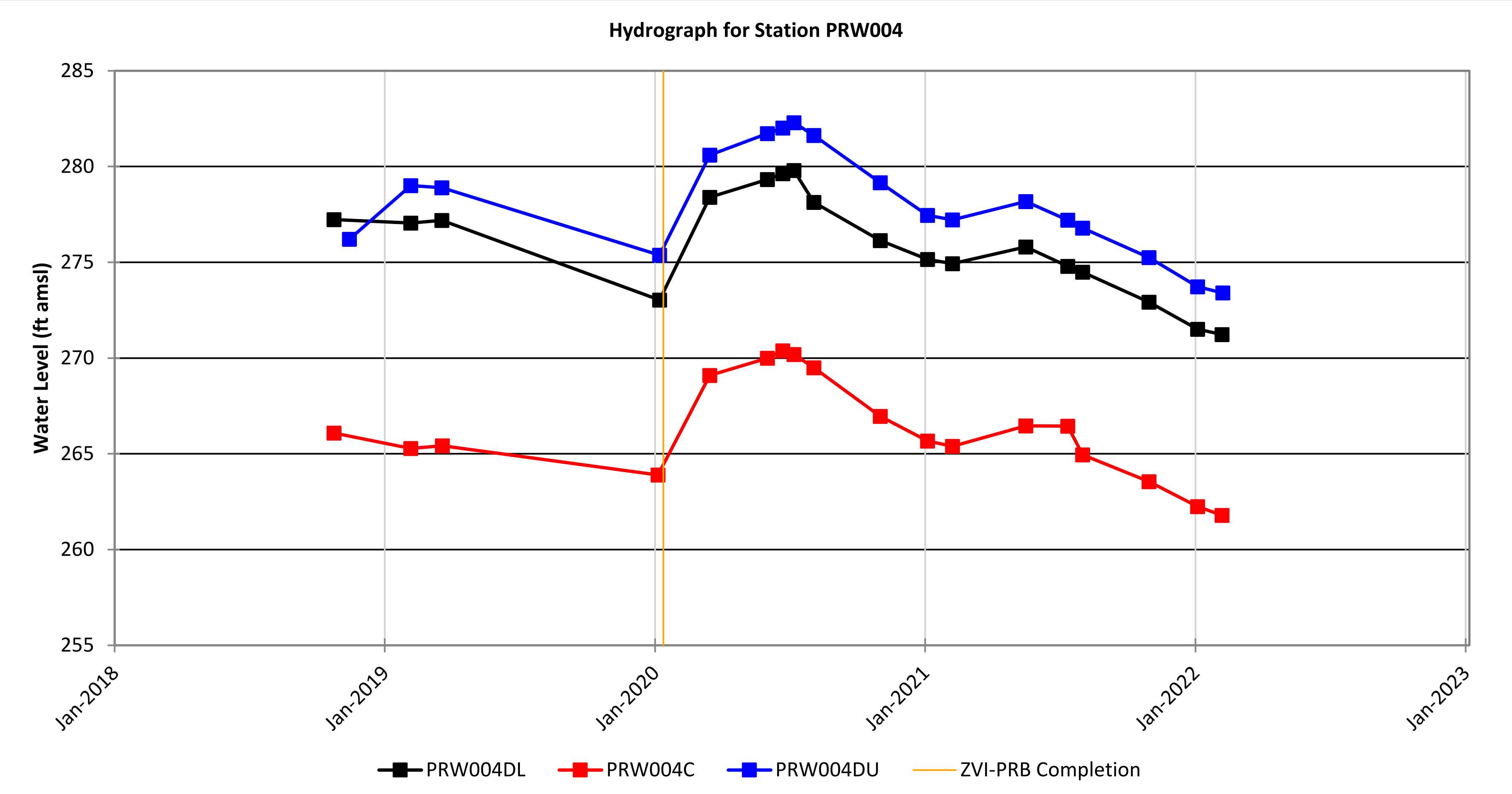

Figure B.8. Hydrograph for PRW004 Cluster

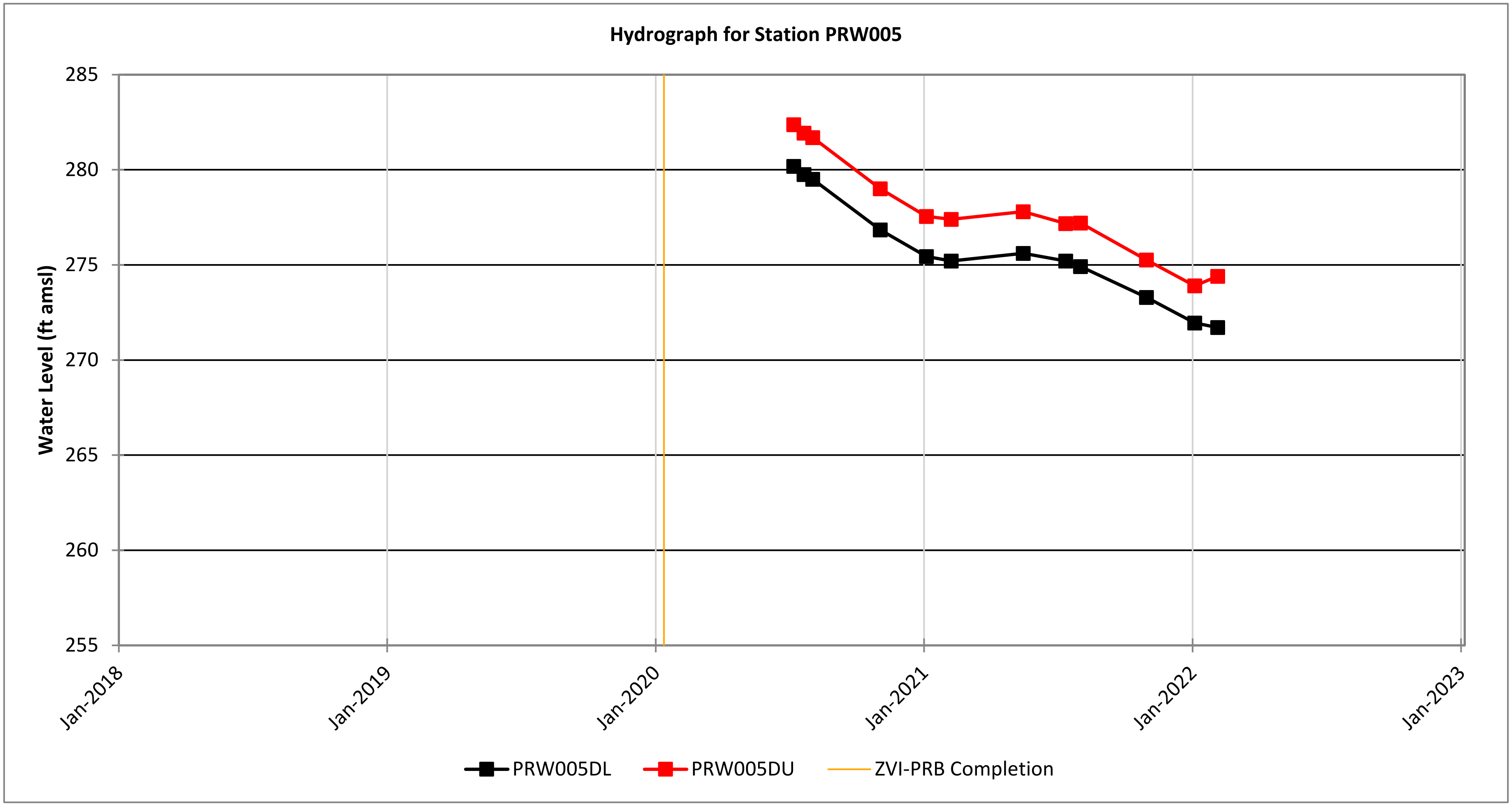

Figure B.9. Hydrograph for PRW005 Cluster

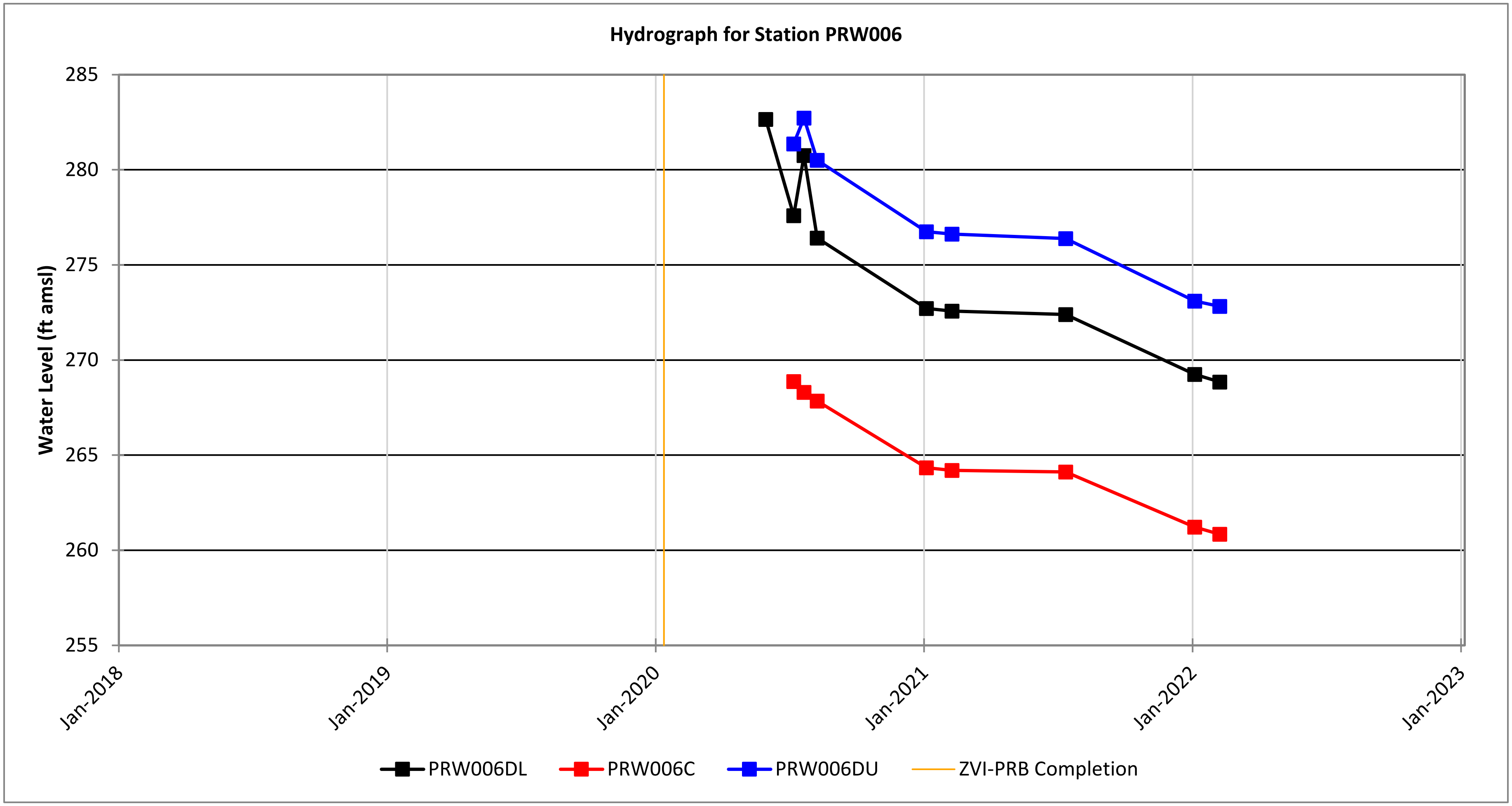

Figure B.10. Hydrograph for PRW006 Cluster

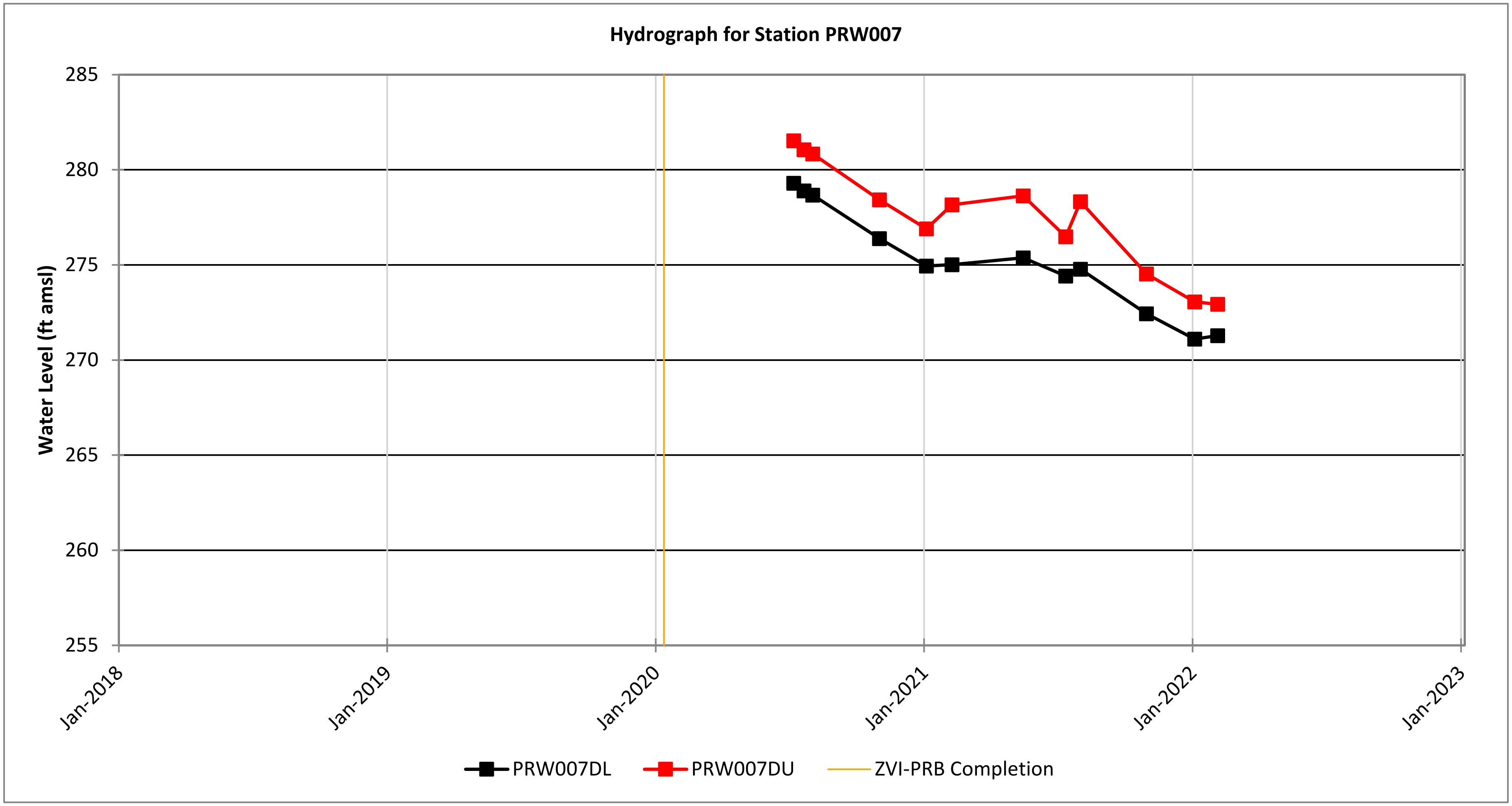

Figure B.11. Hydrograph for PRW007 Cluster

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APPENDIX C

PAGW OU RA EMR Time-Series Plots

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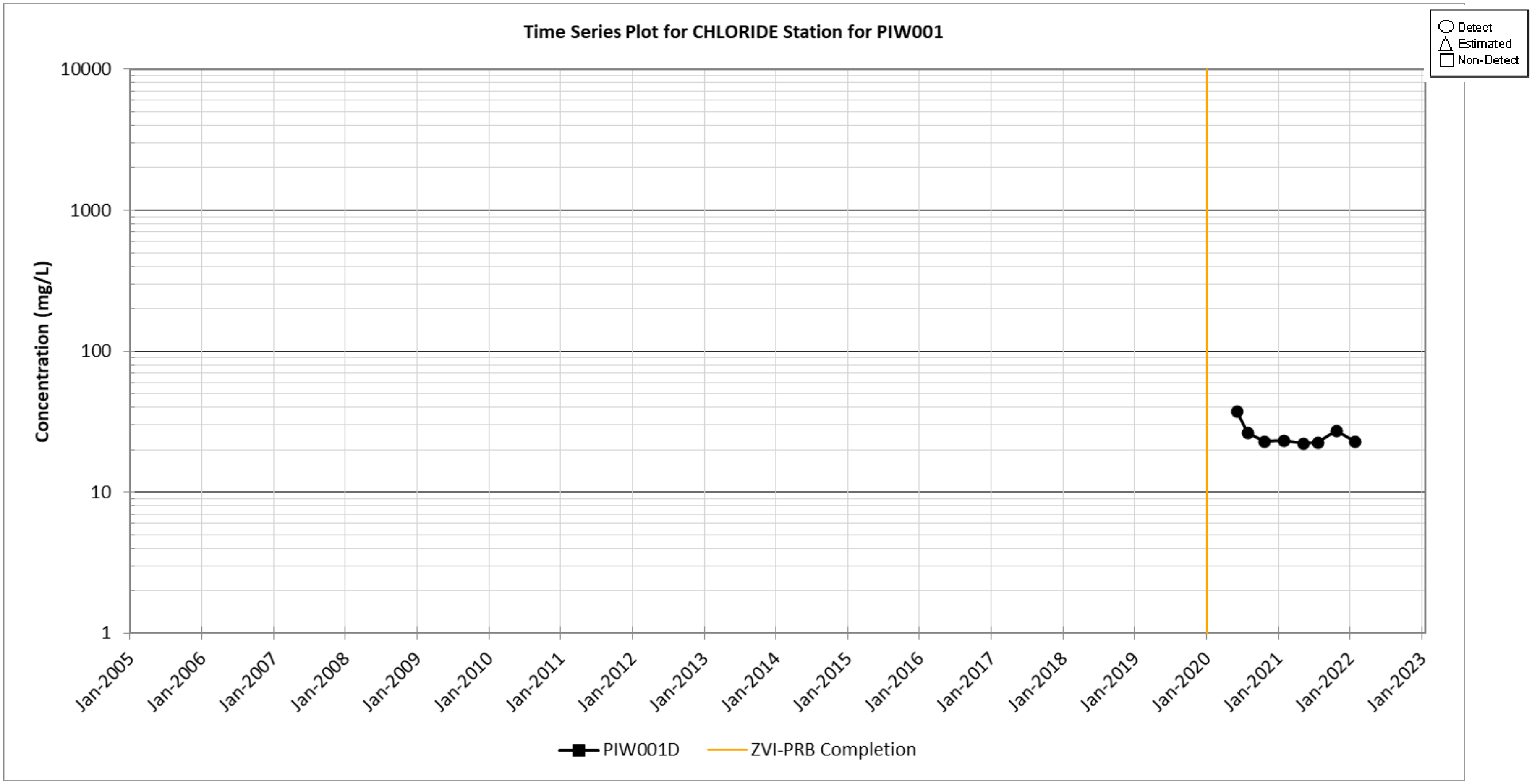

Figure C.1. Time Series Plot for Chloride at Monitoring Well PIW001D

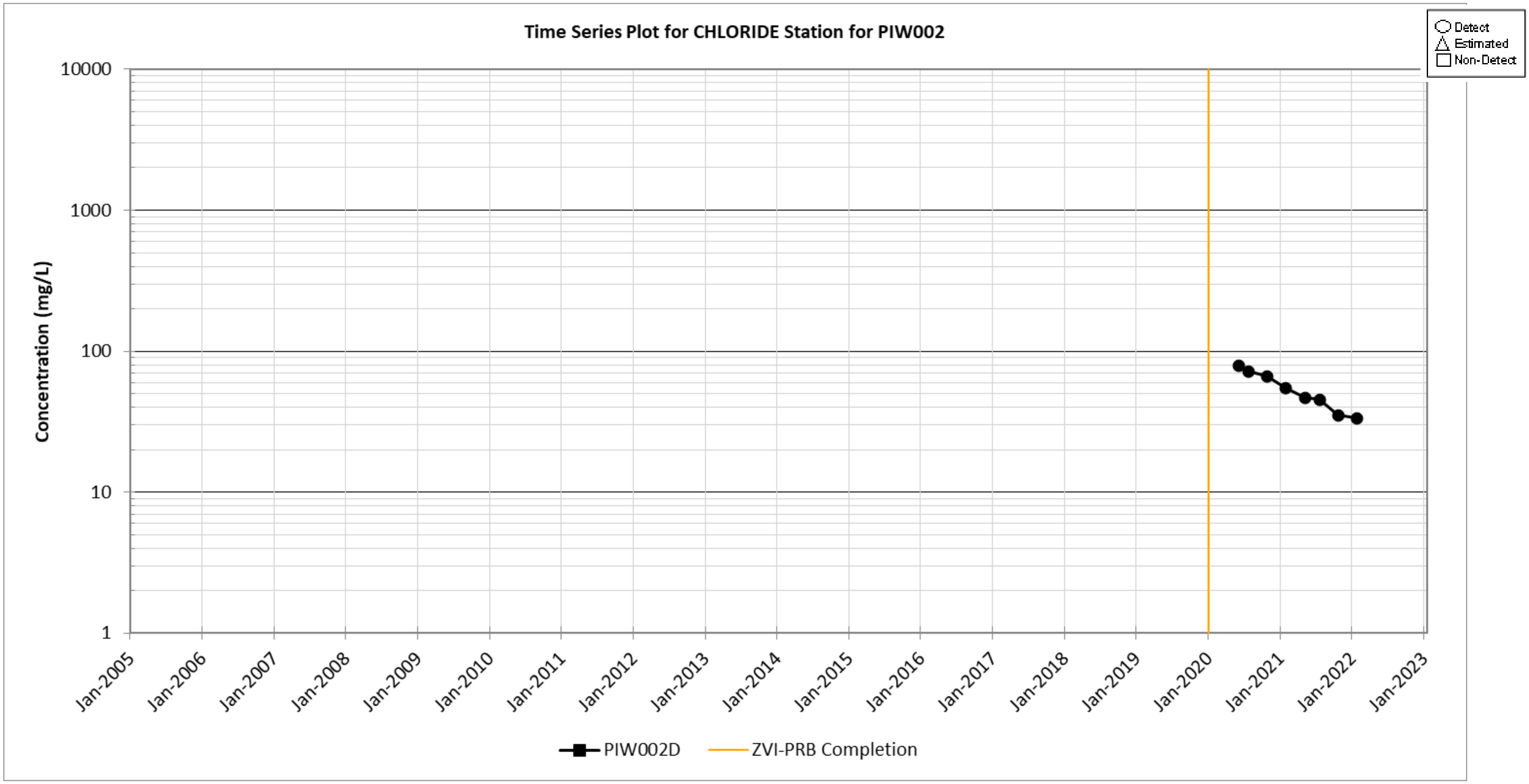

Figure C.2. Time Series Plot for Chloride at Monitoring Well PIW002D

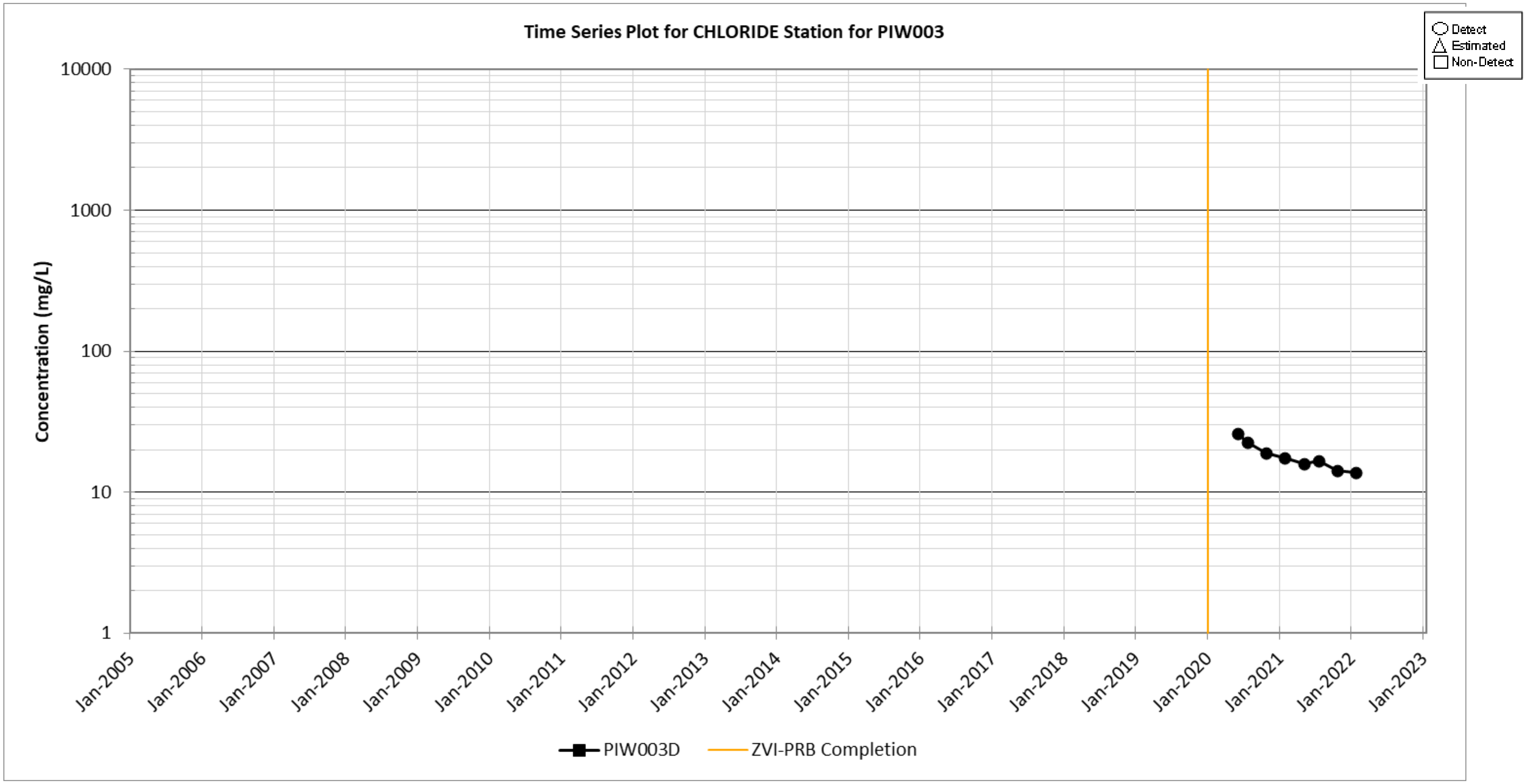

Figure C.3. Time Series Plot for Chloride at Monitoring Well PIW003D

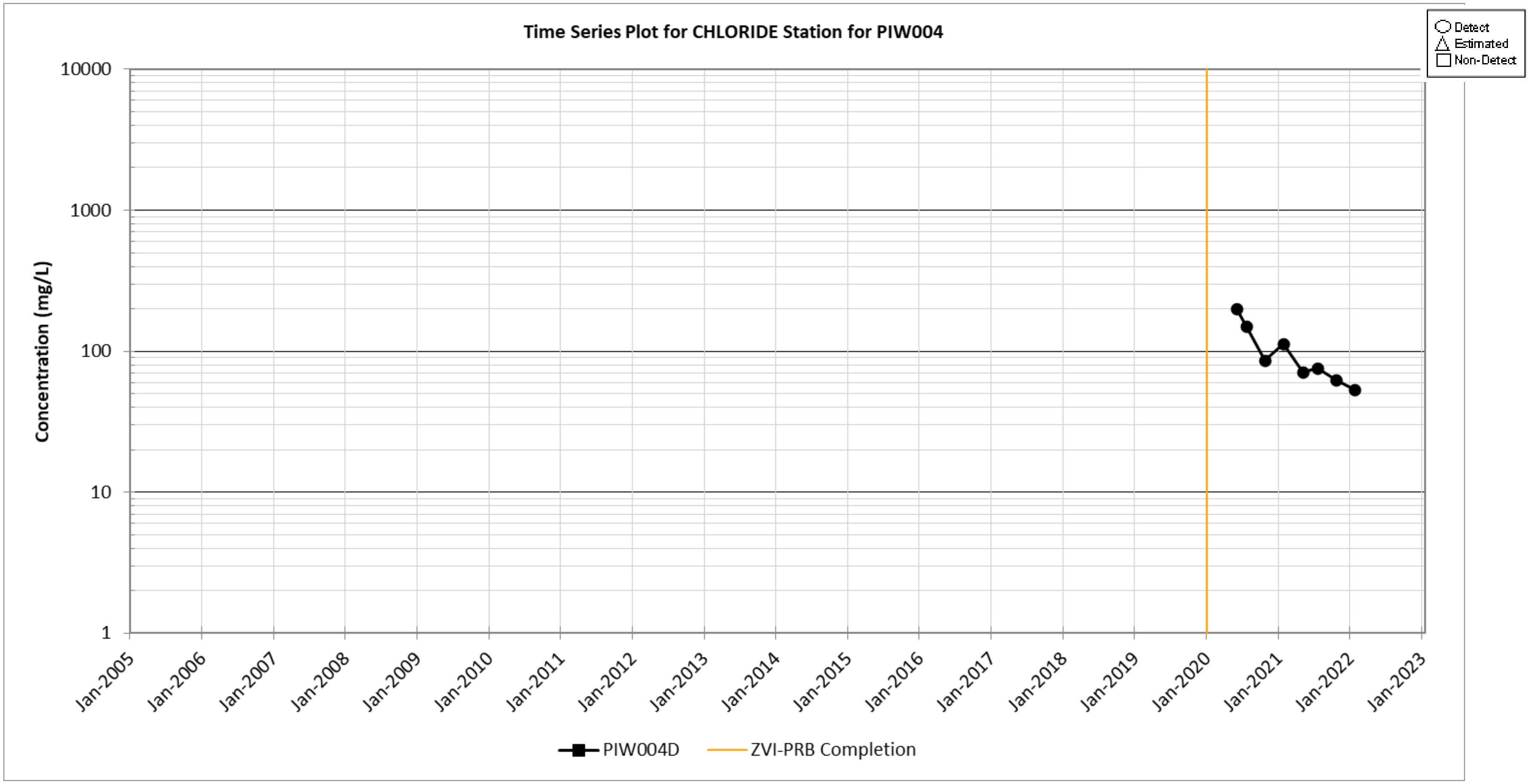

Figure C.4. Time Series Plot for Chloride at Monitoring Well PIW004D

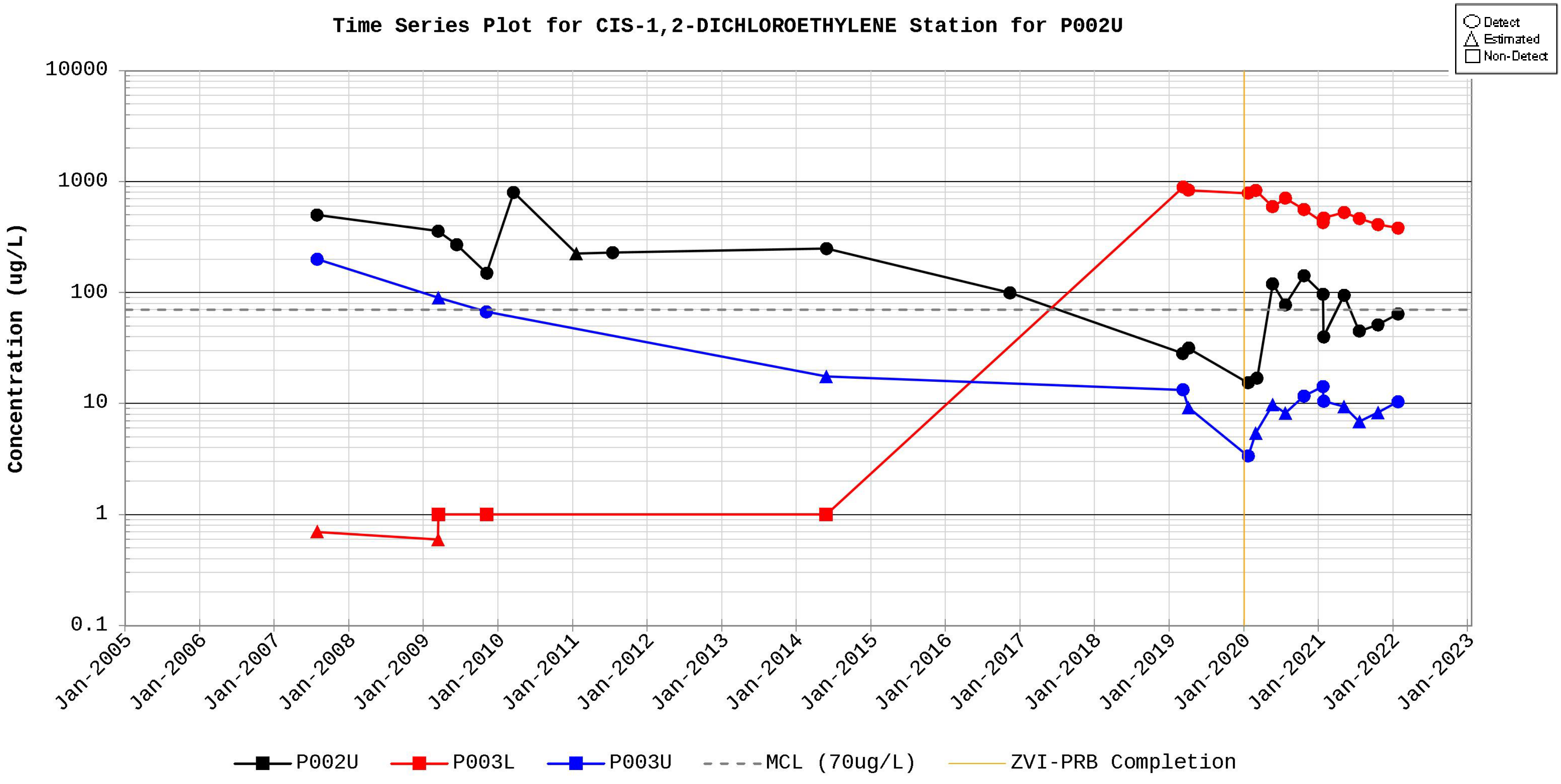

Figure C.5. Time Series Plot for Cis-1,2-Dichloroethylene at P00 Series Monitoring Wells

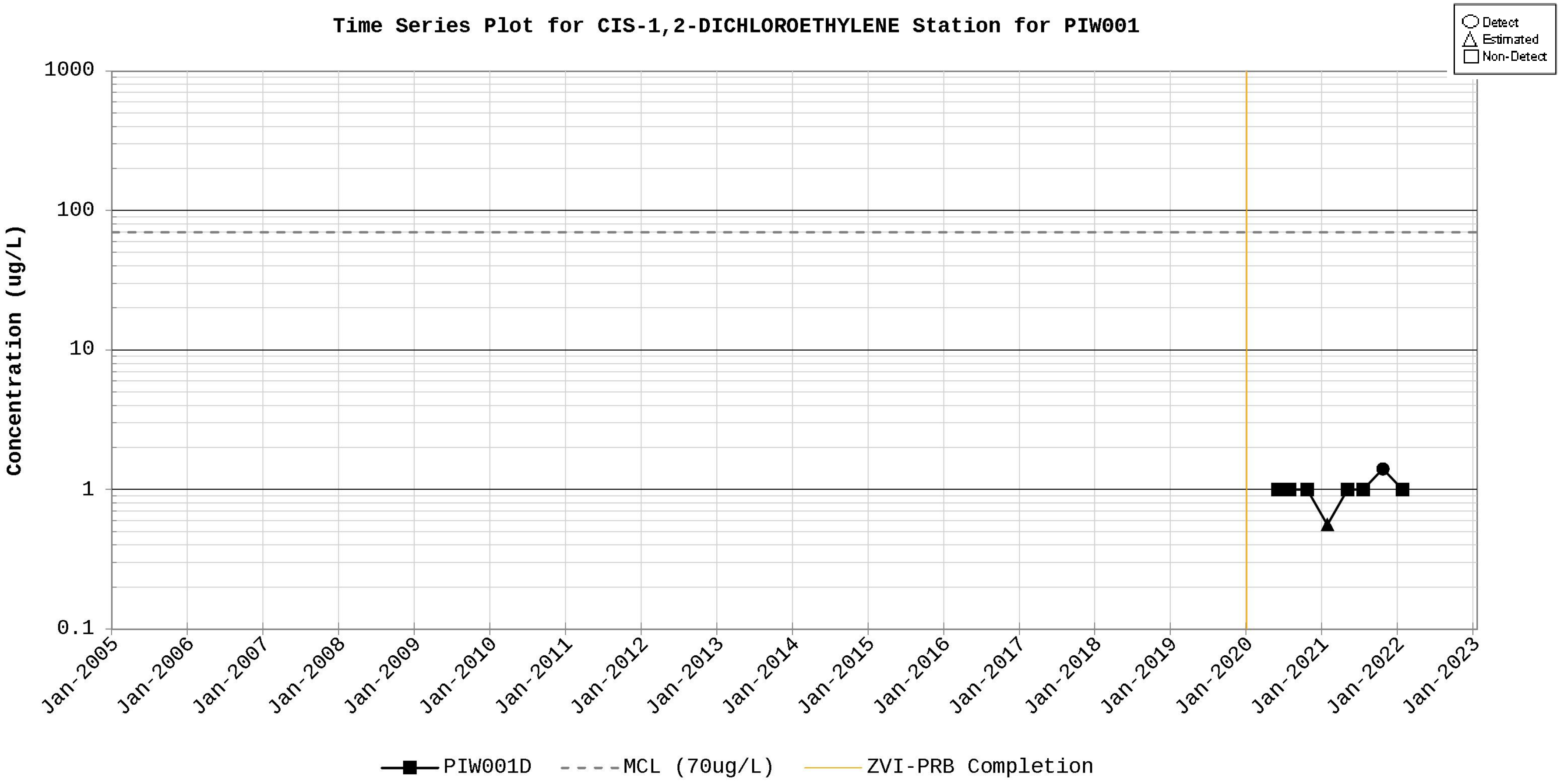

Figure C.6. Time Series Plot for Cis-1,2-Dichloroethylene at Monitoring Well PIW001D

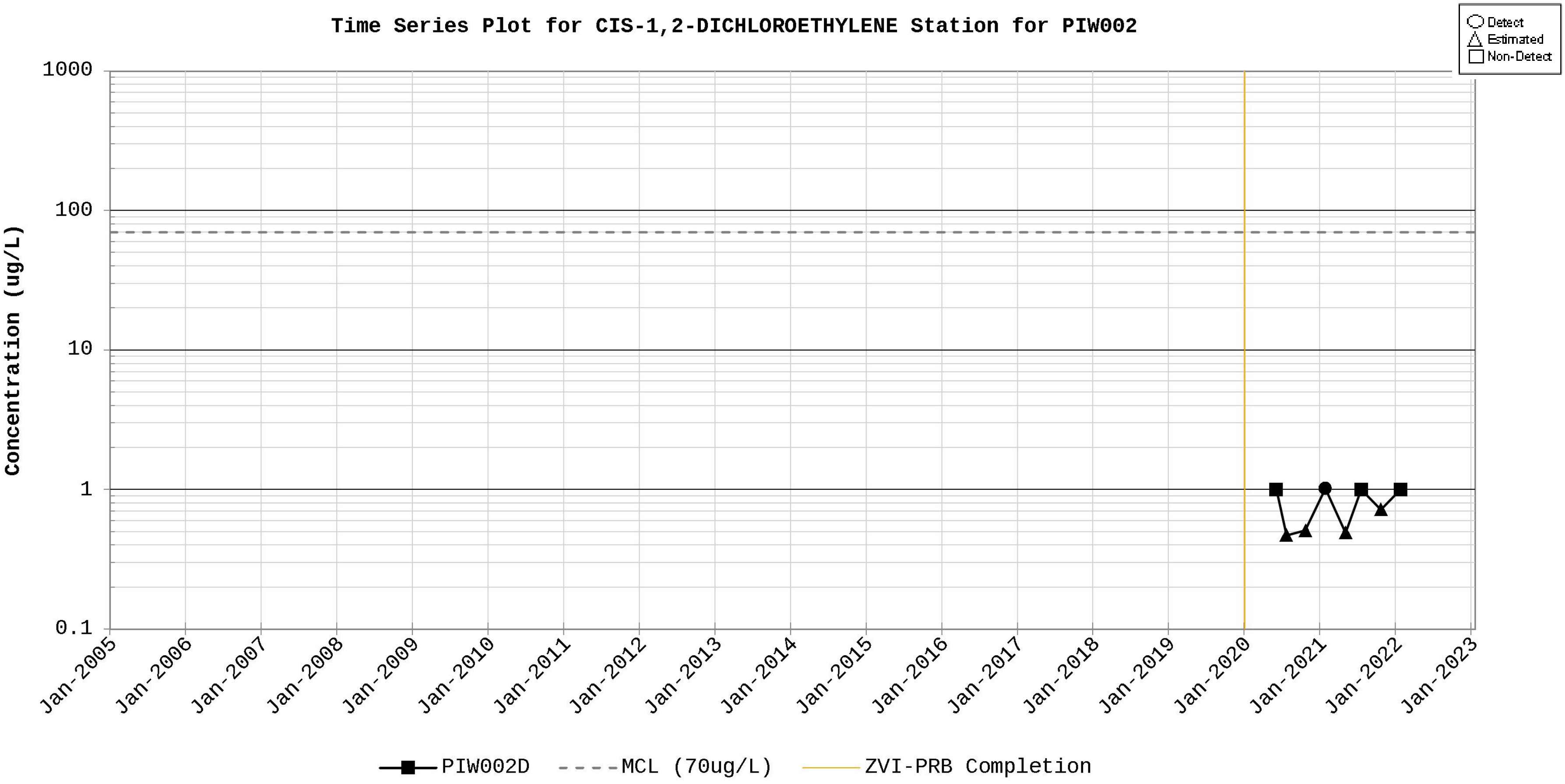

Figure C.7. Time Series Plot for Cis-1,2-Dichloroethylene at Monitoring Well PIW002D

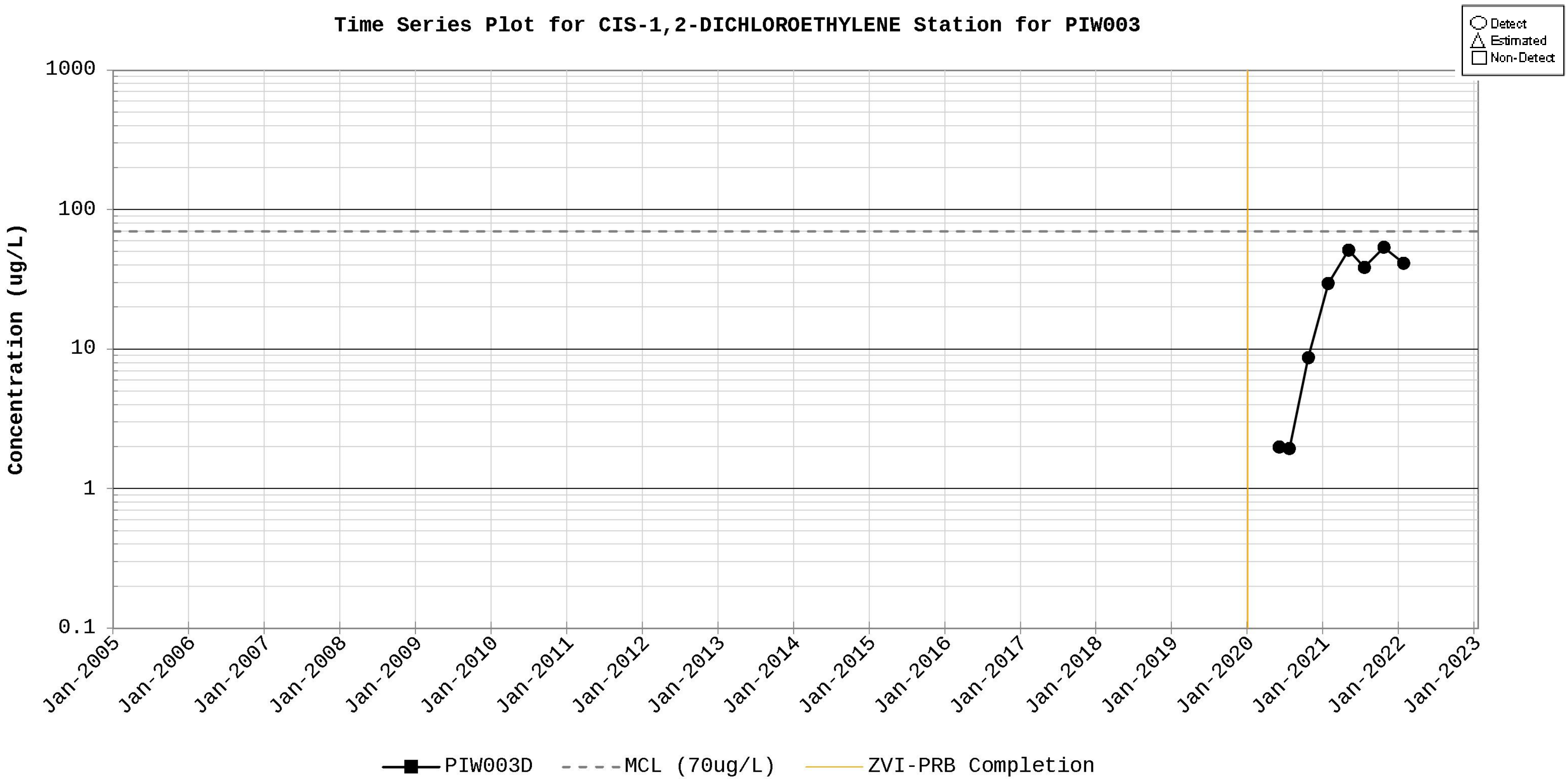

Figure C.8. Time Series Plot for Cis-1,2-Dichloroethylene at Monitoring Well PIW003D

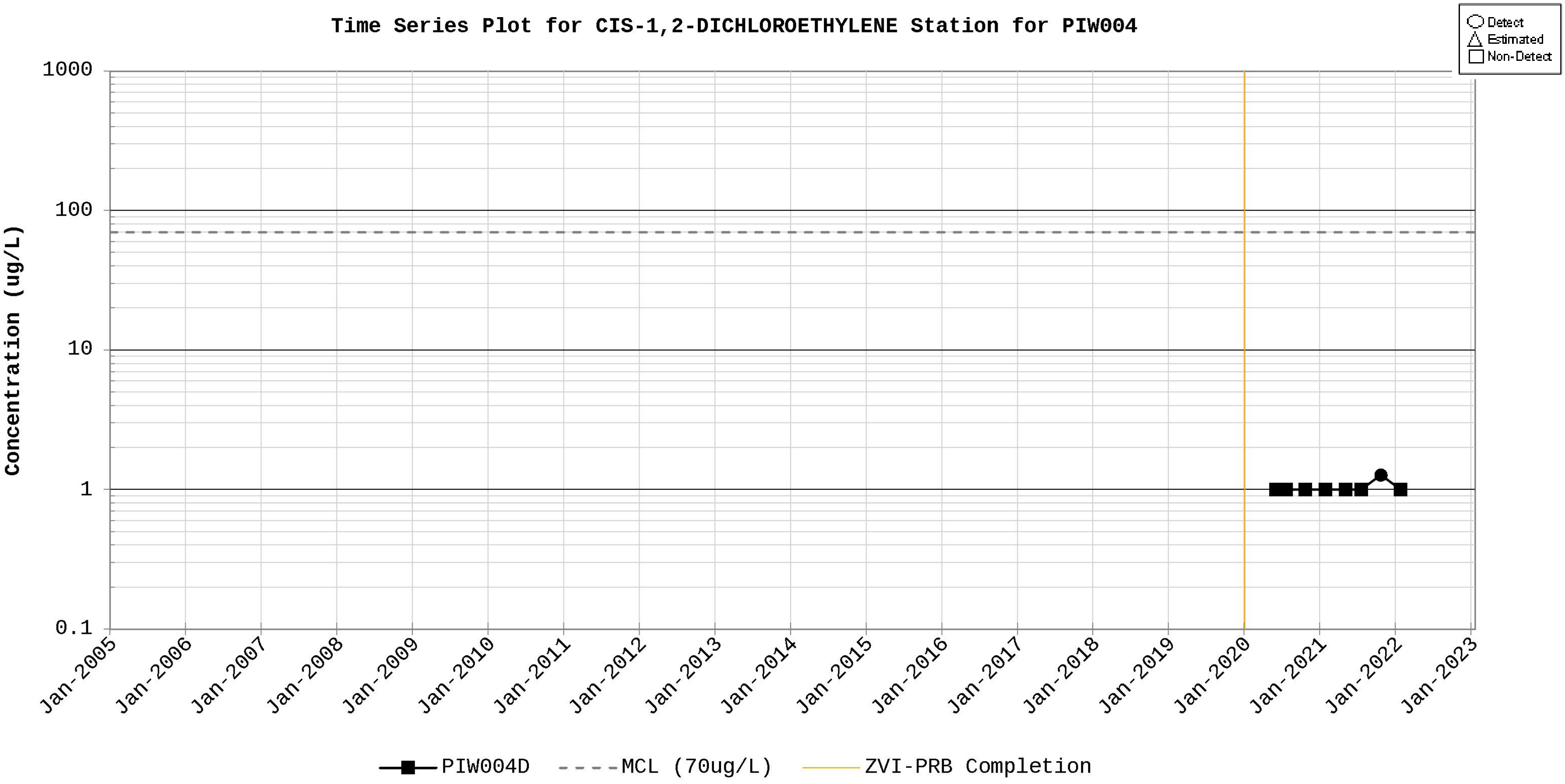

Figure C.9. Time Series Plot for Cis-1,2-Dichloroethylene at Monitoring Well PIW004D

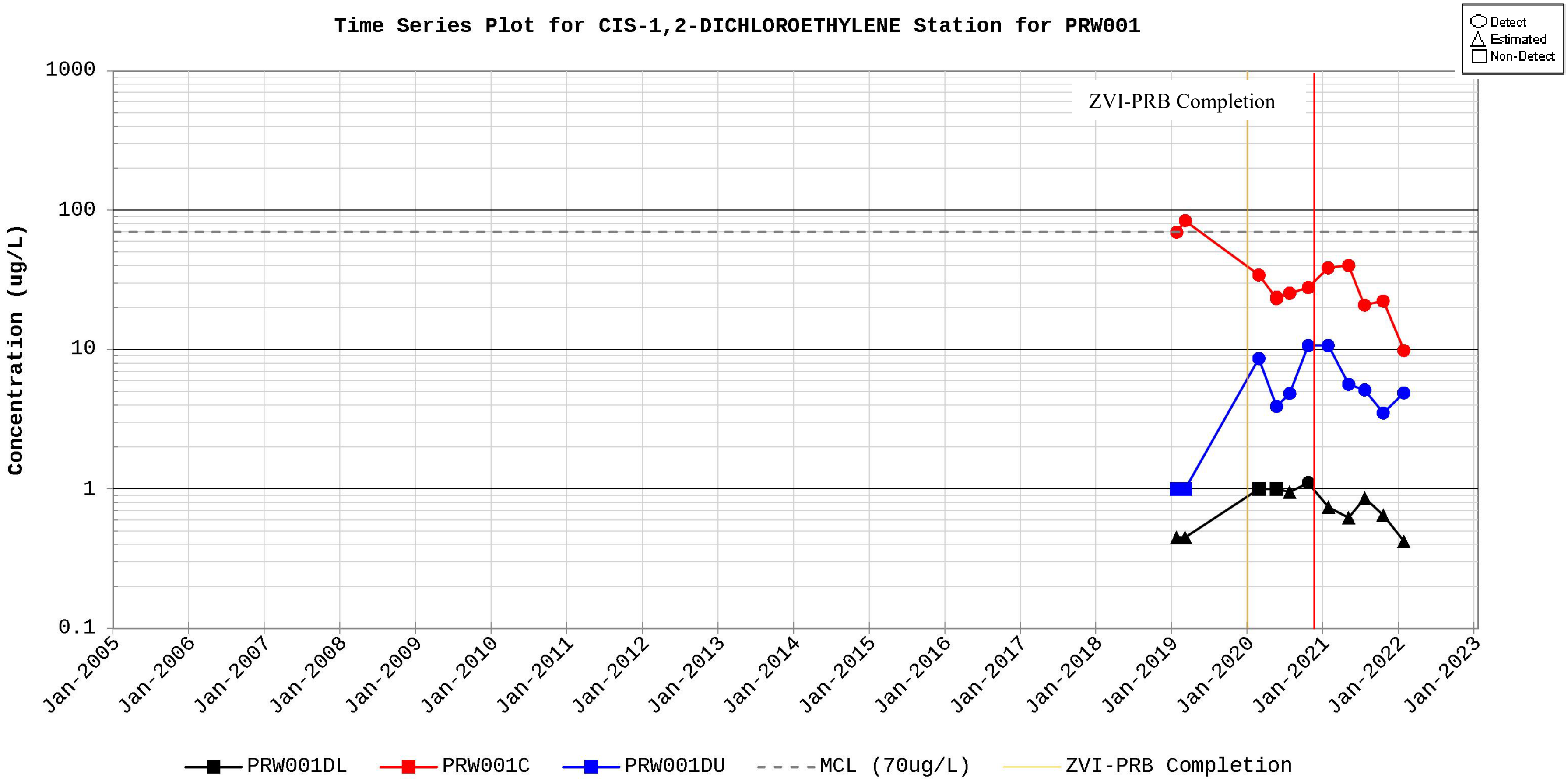

Figure C.10. Time Series Plot for Cis-1,2-Dichloroethylene at PRW001 Series Monitoring Wells

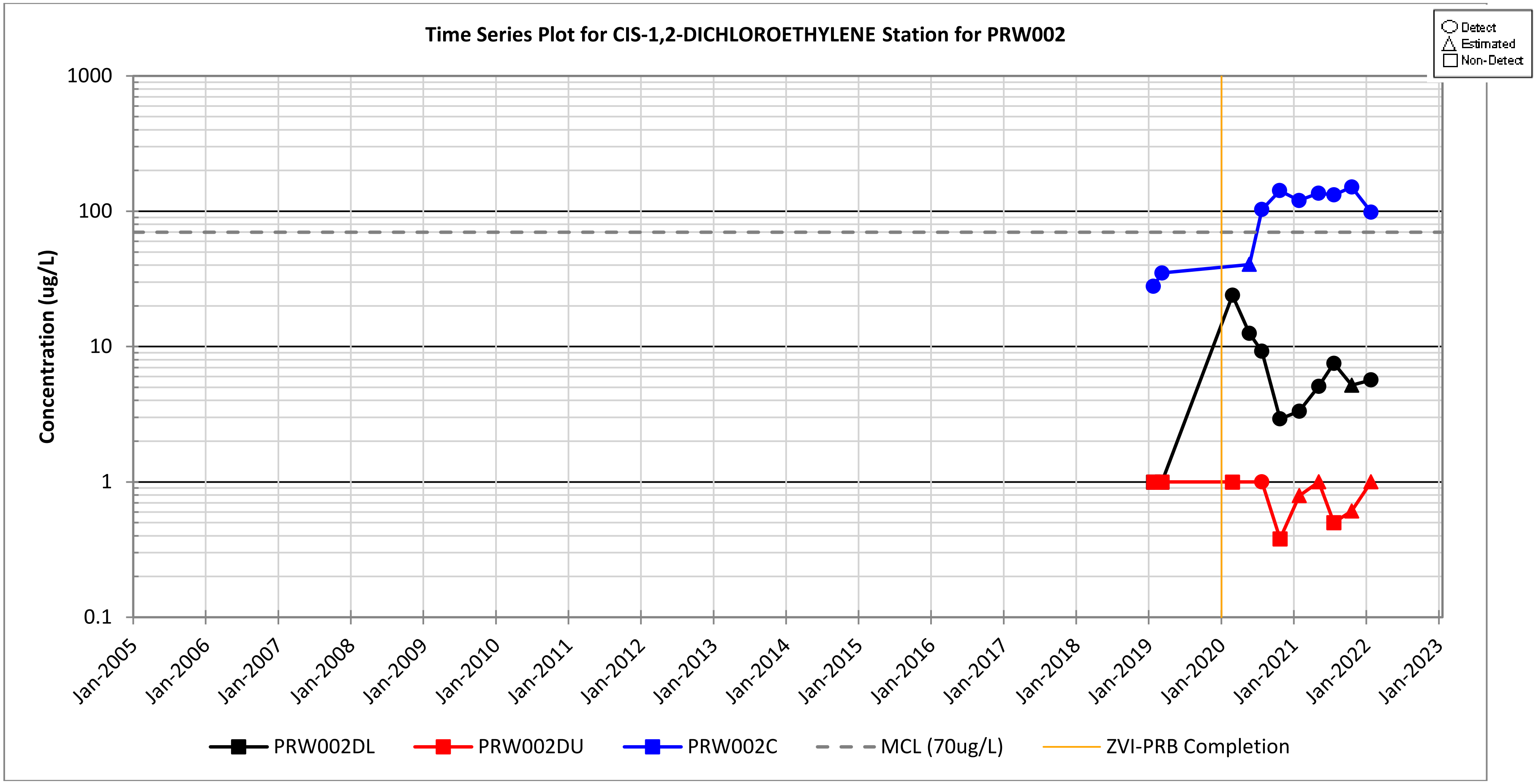

Figure C.11. Time Series Plot for Cis-1,2-Dichloroethylene at PRW002 Series Monitoring Wells

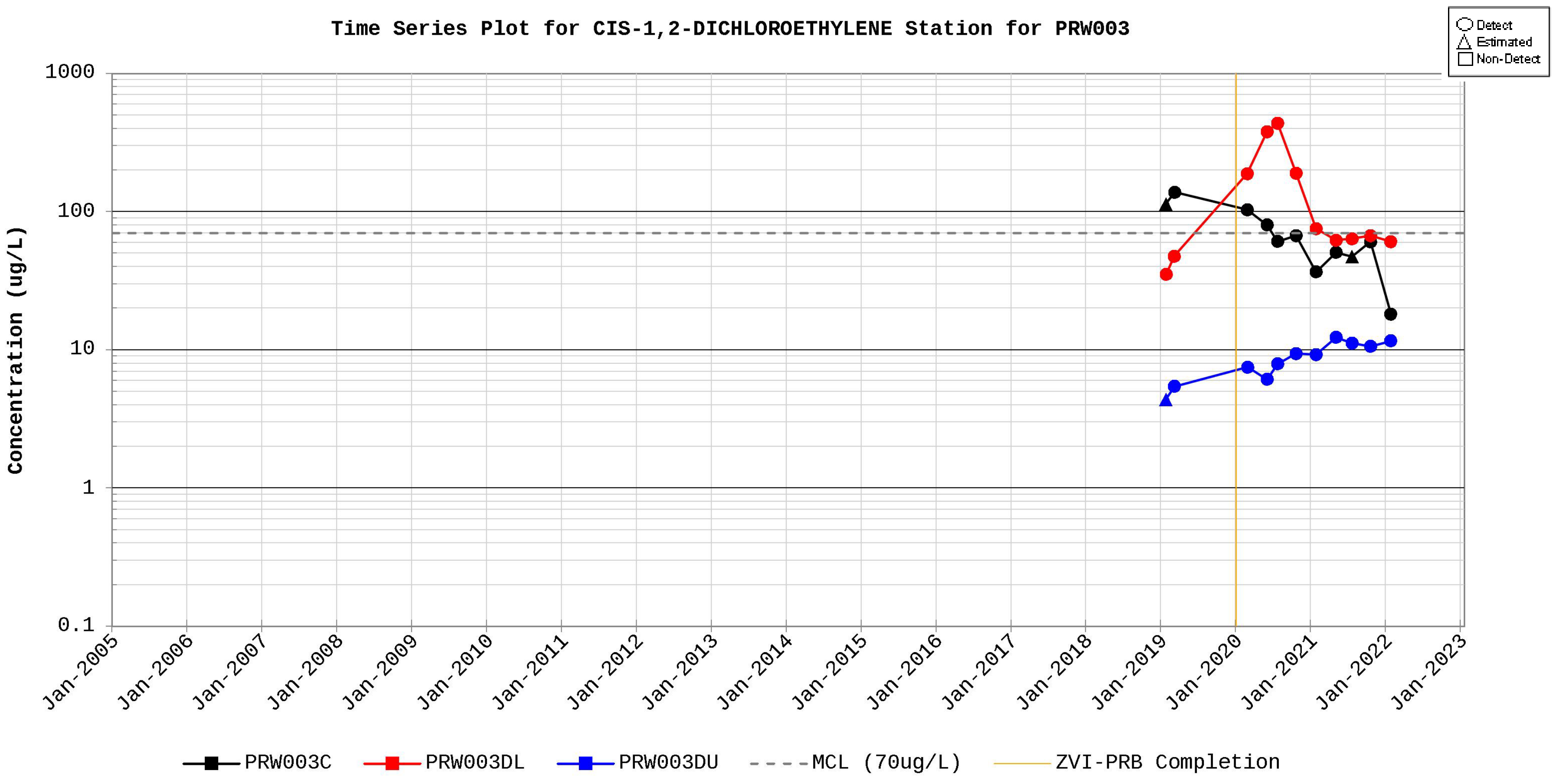

Figure C.12. Time Series Plot for Cis-1,2-Dichloroethylene at PRW003 Series Monitoring Wells

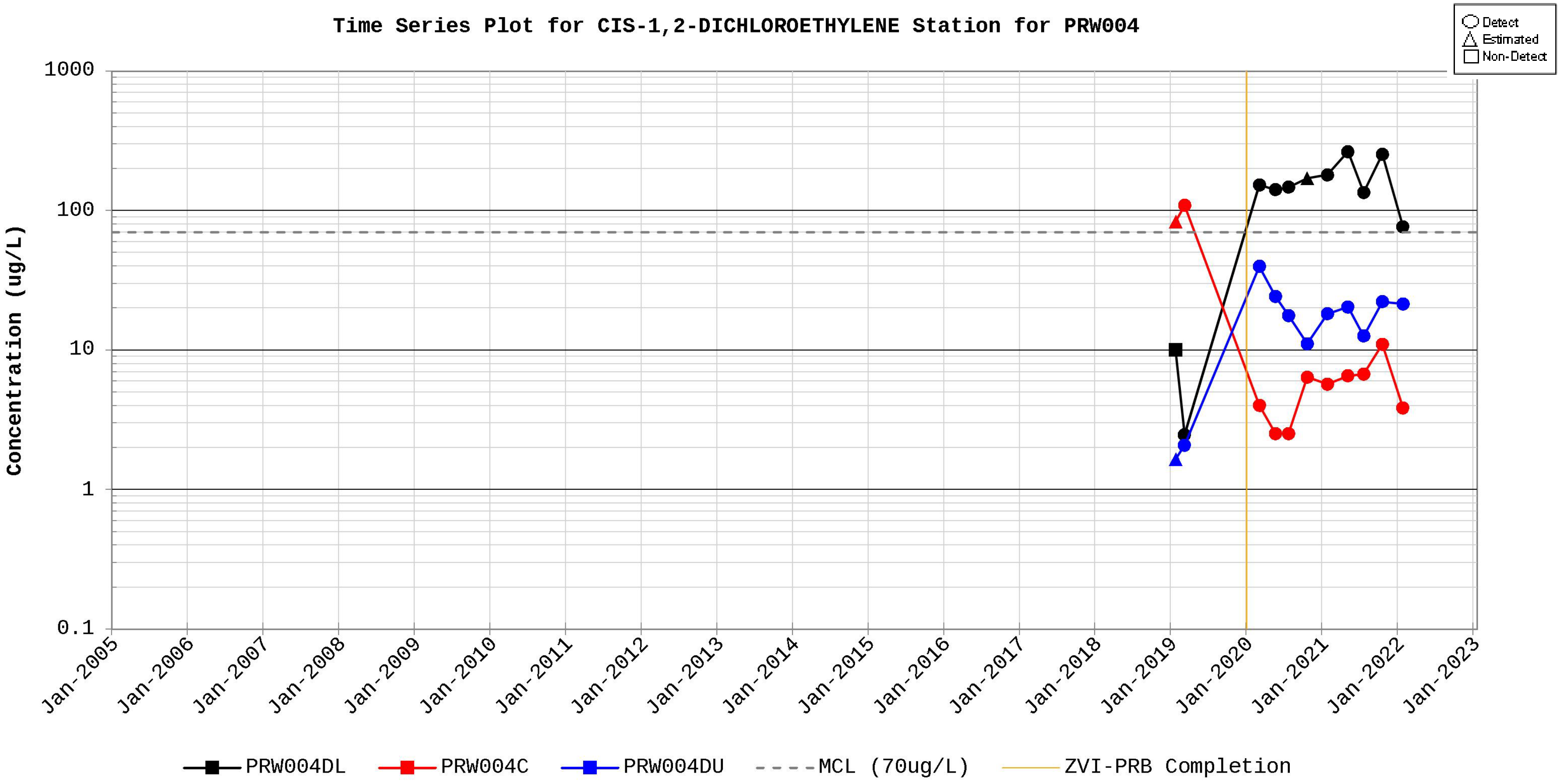

Figure C.13. Time Series Plot for Cis-1,2-Dichloroethylene at PRW004 Series Monitoring Wells

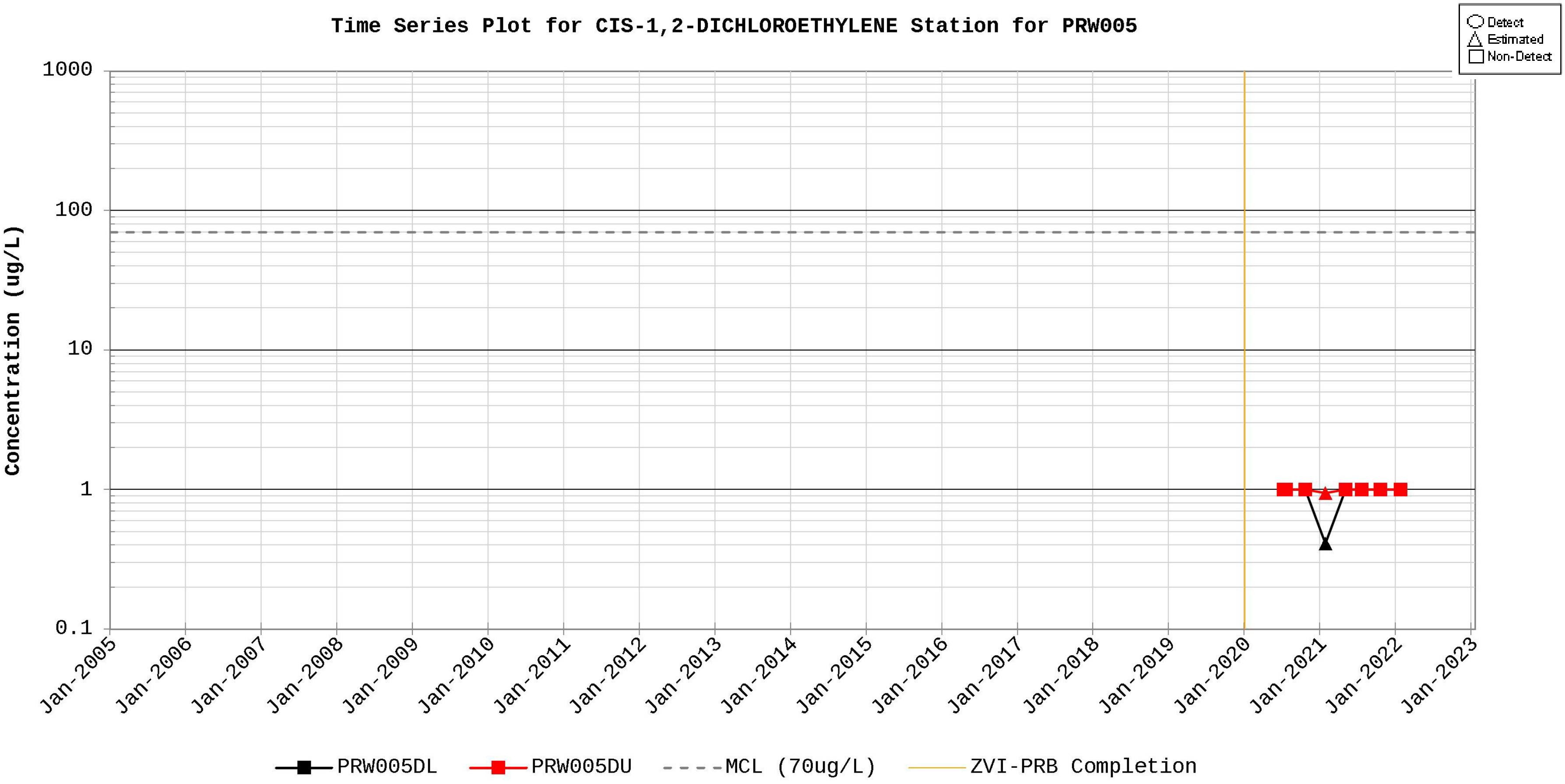

Figure C.14. Time Series Plot for Cis-1,2-Dichloroethylene at PRW005 Series Monitoring Wells

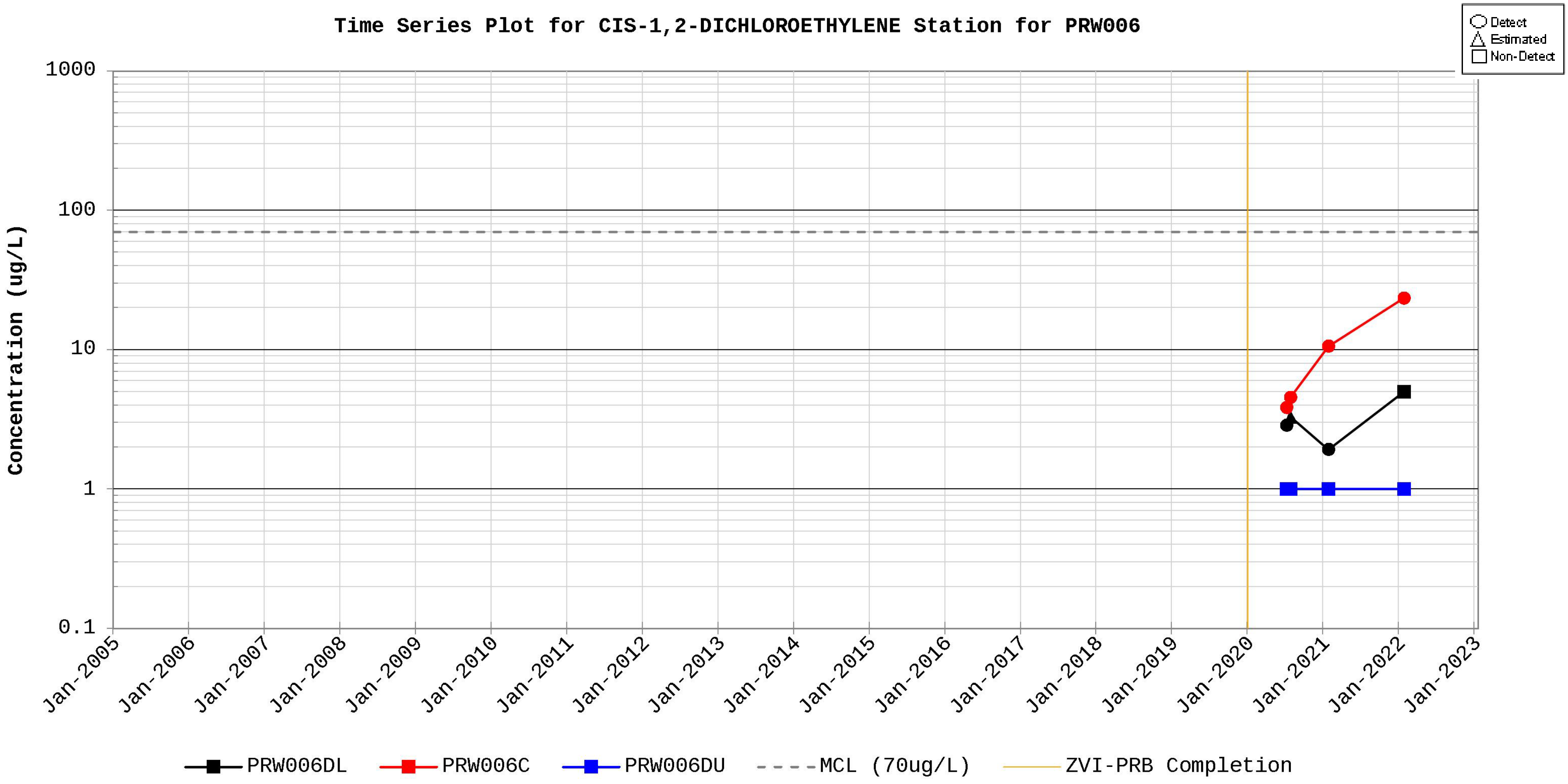

Figure C.15. Time Series Plot for Cis-1,2-Dichloroethylene at PRW006 Series Monitoring Wells

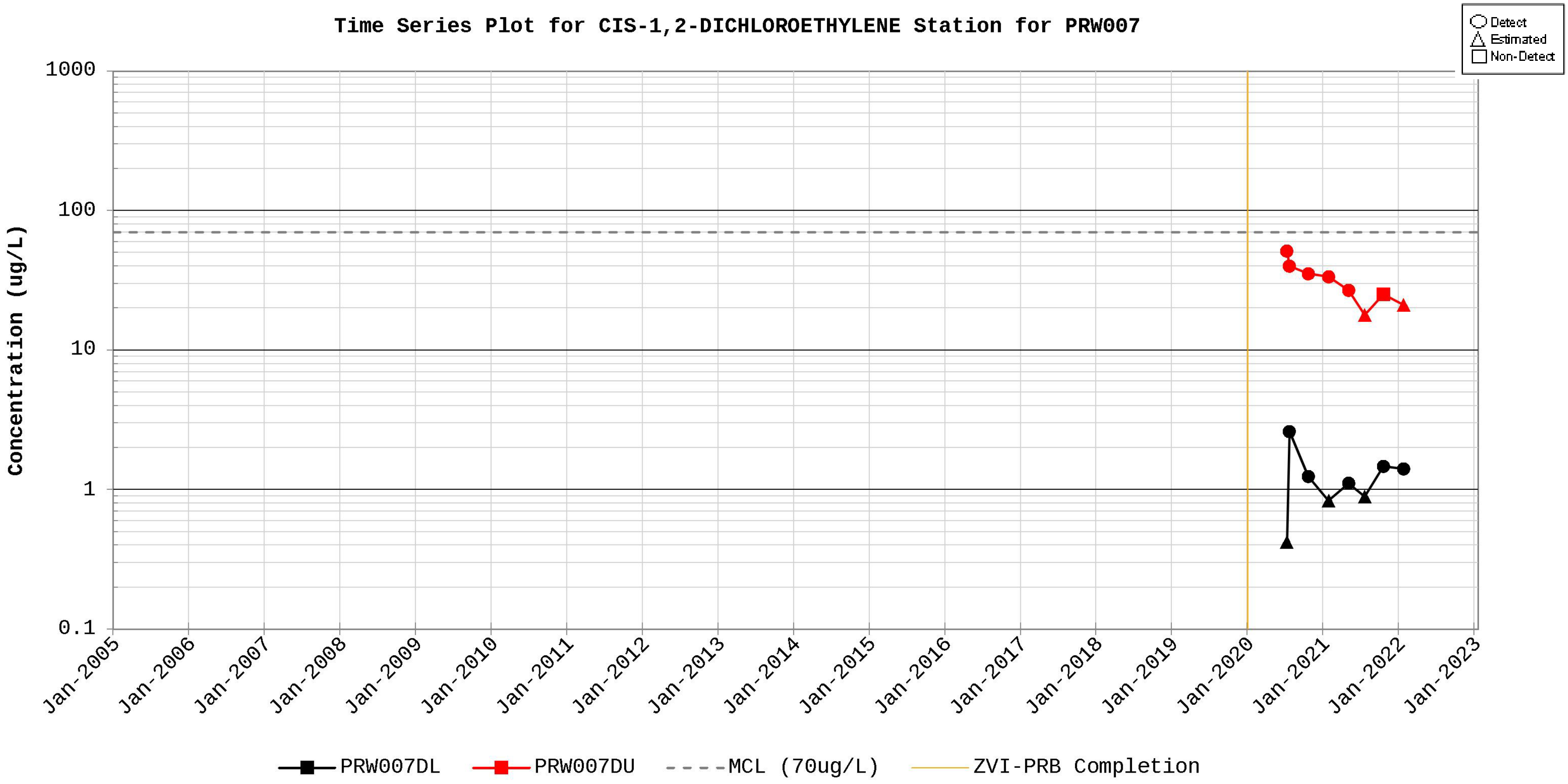

Figure C.16. Time Series Plot for Cis-1,2-Dichloroethylene at PRW007 Series Monitoring Wells

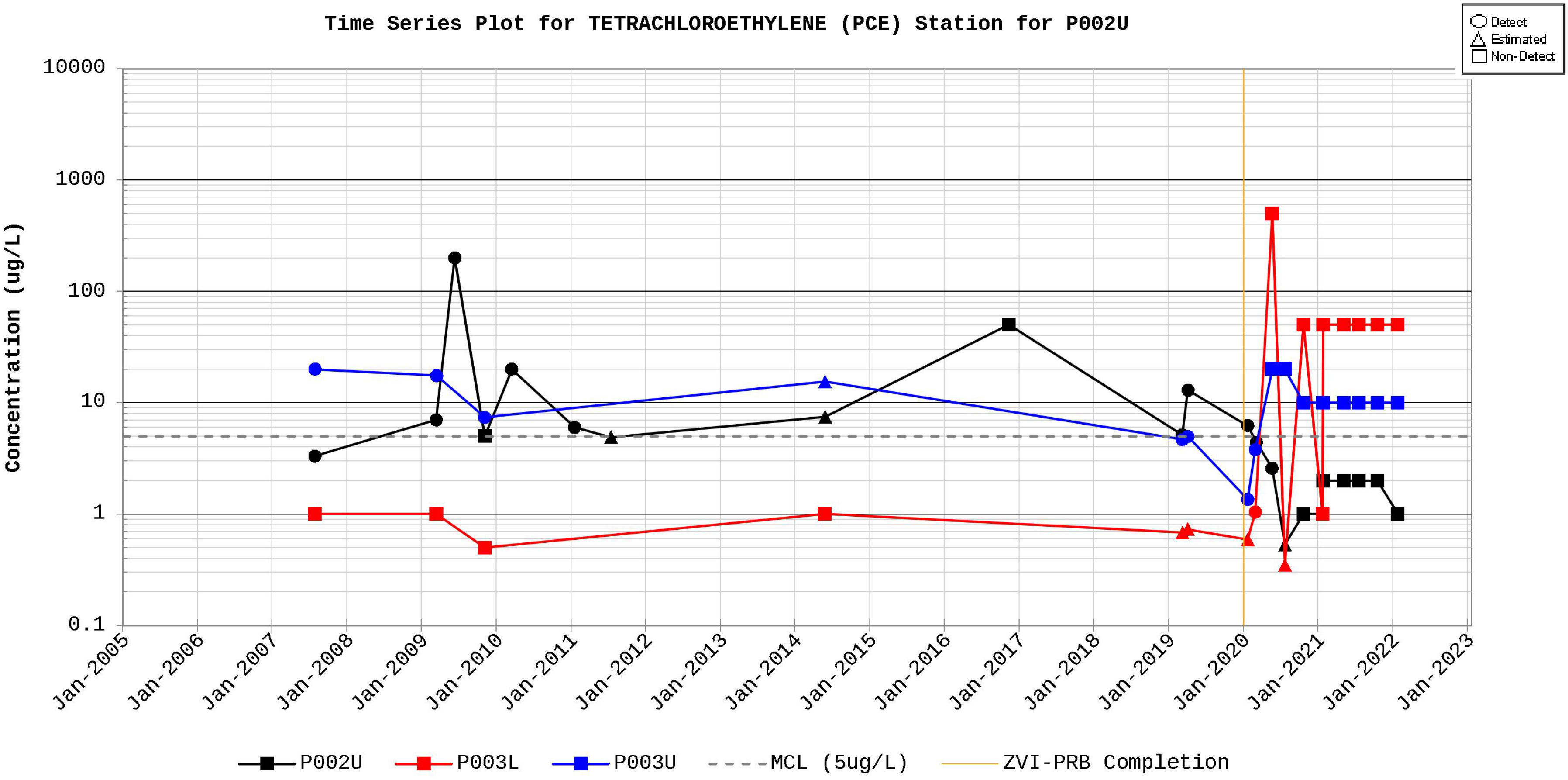

Figure C.17. Time Series Plot for Tetrachloroethylene (PCE) at P00 Series Monitoring Wells

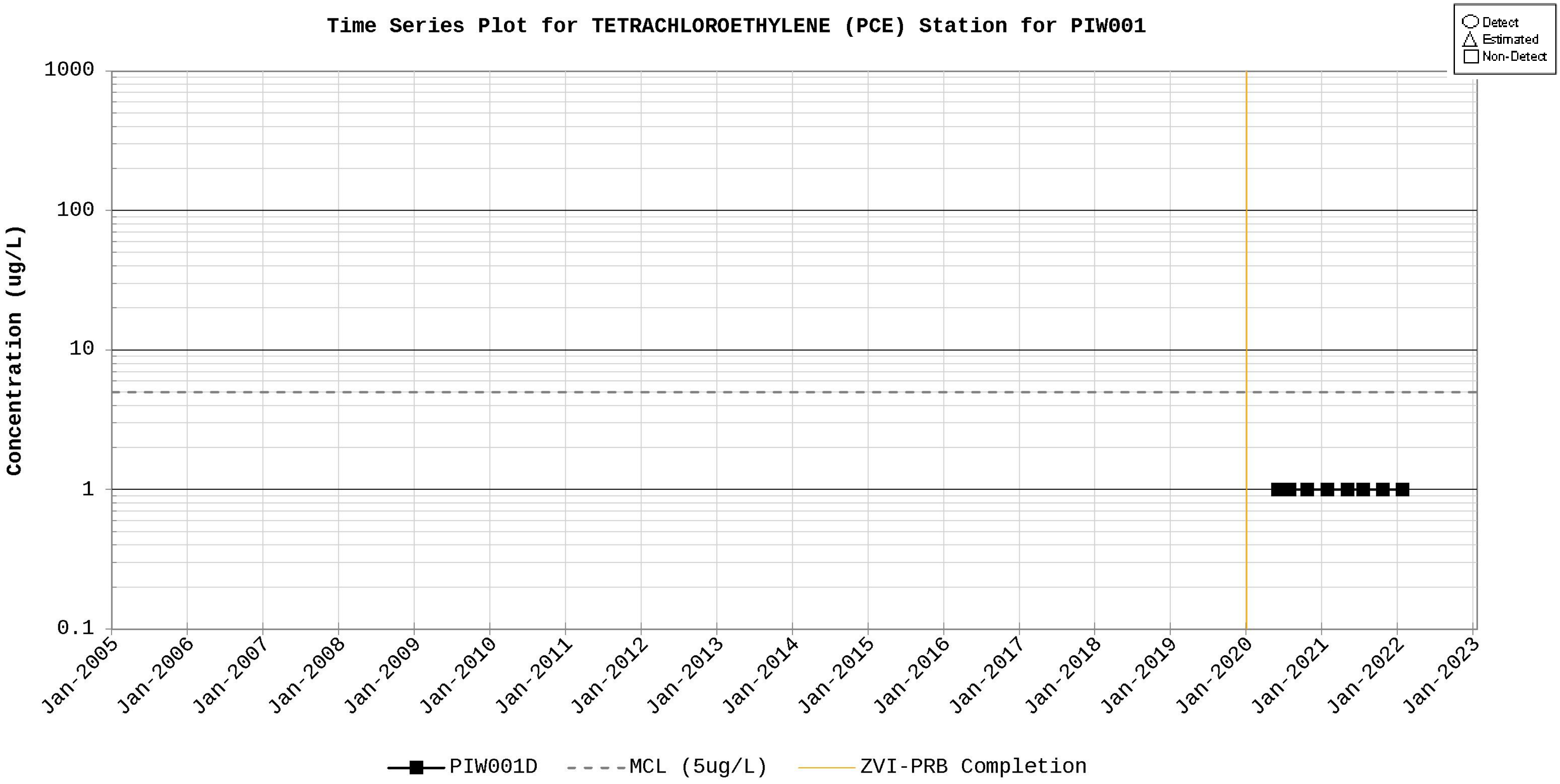

Figure C.18. Time Series Plot for Tetrachloroethylene (PCE) at Monitoring Well PIW001D

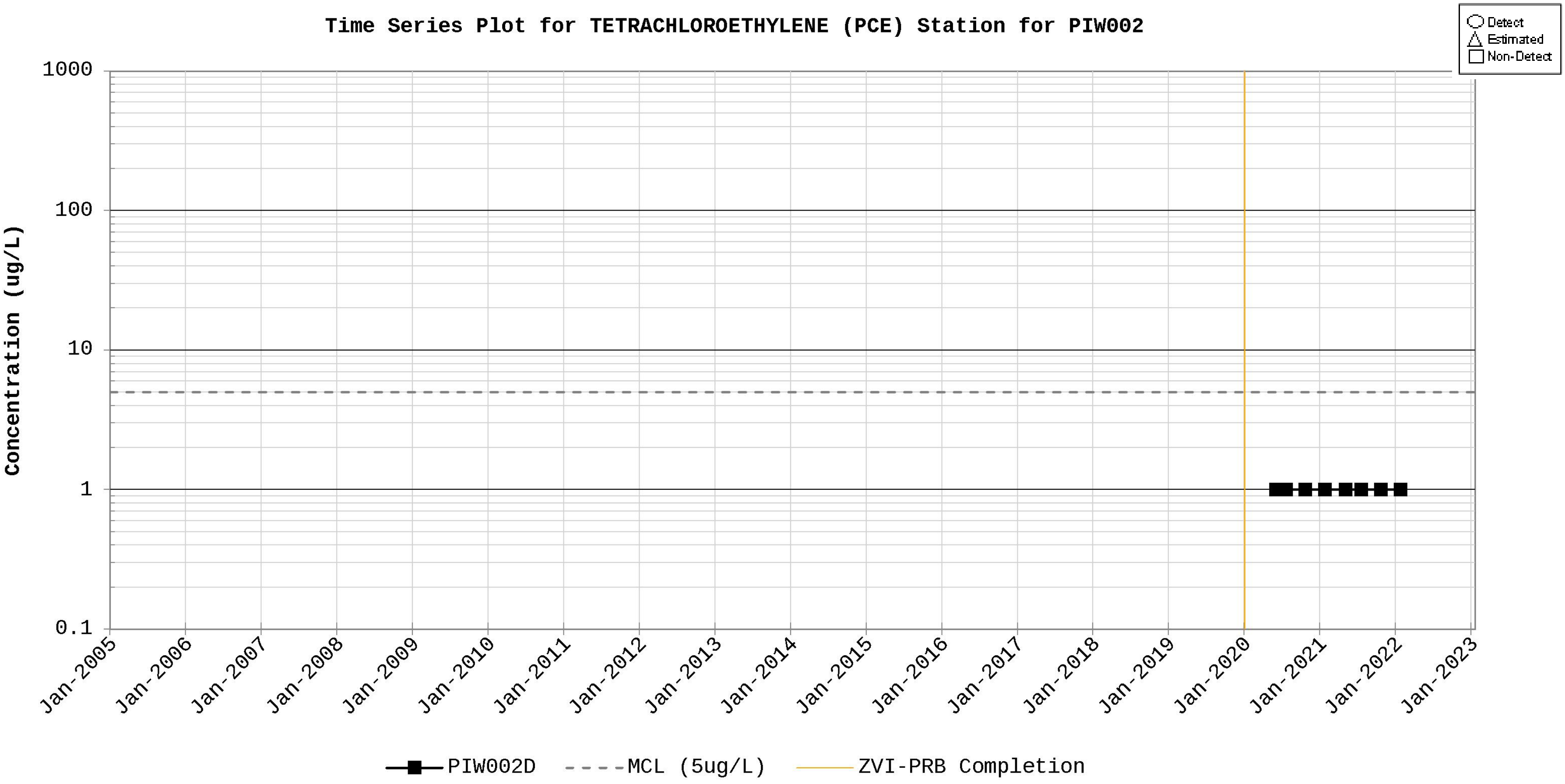

Figure C.19. Time Series Plot for Tetrachloroethylene (PCE) at Monitoring Well PIW002D

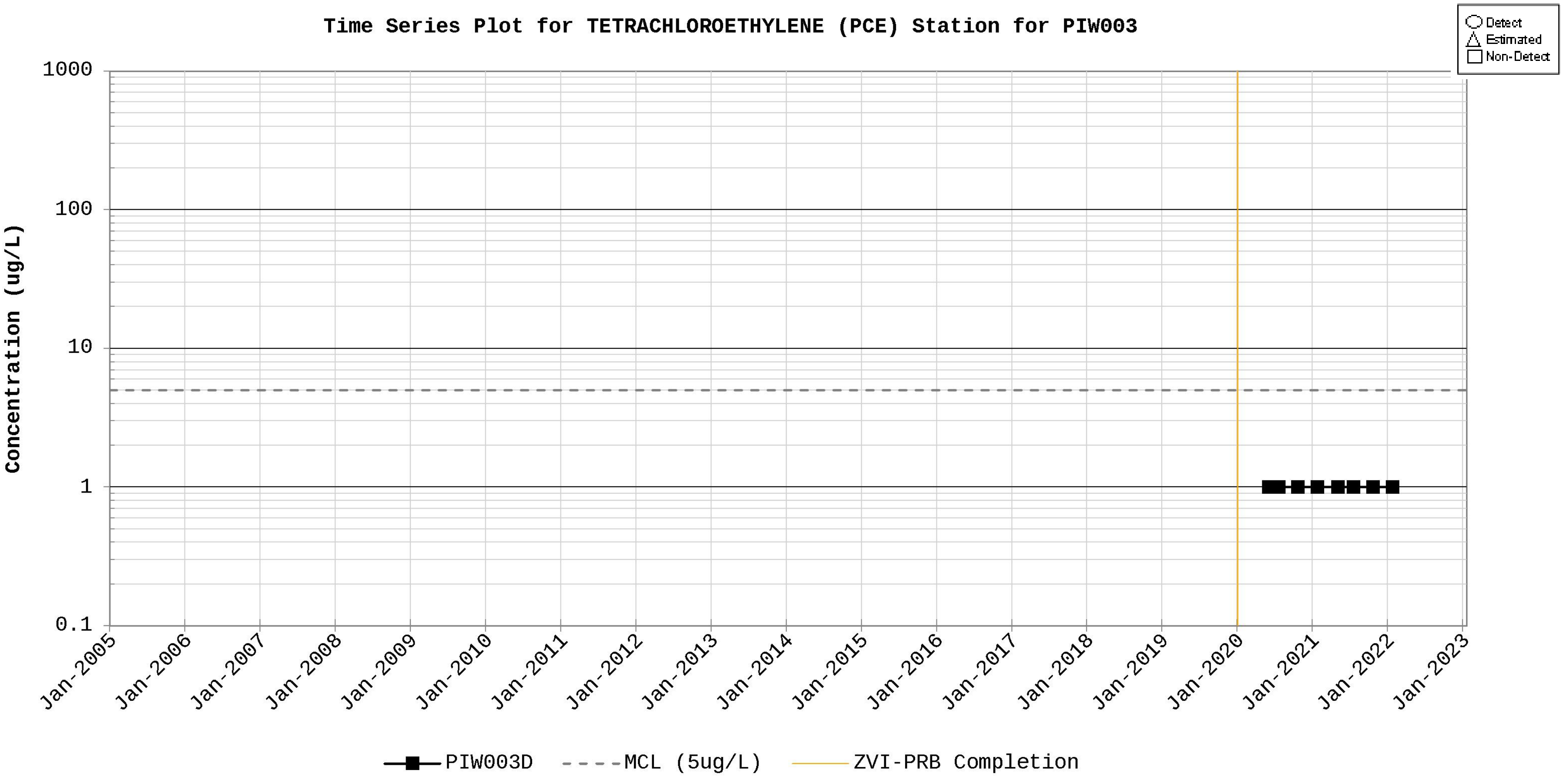

Figure C.20. Time Series Plot for Tetrachloroethylene (PCE) at Monitoring Well PIW003D

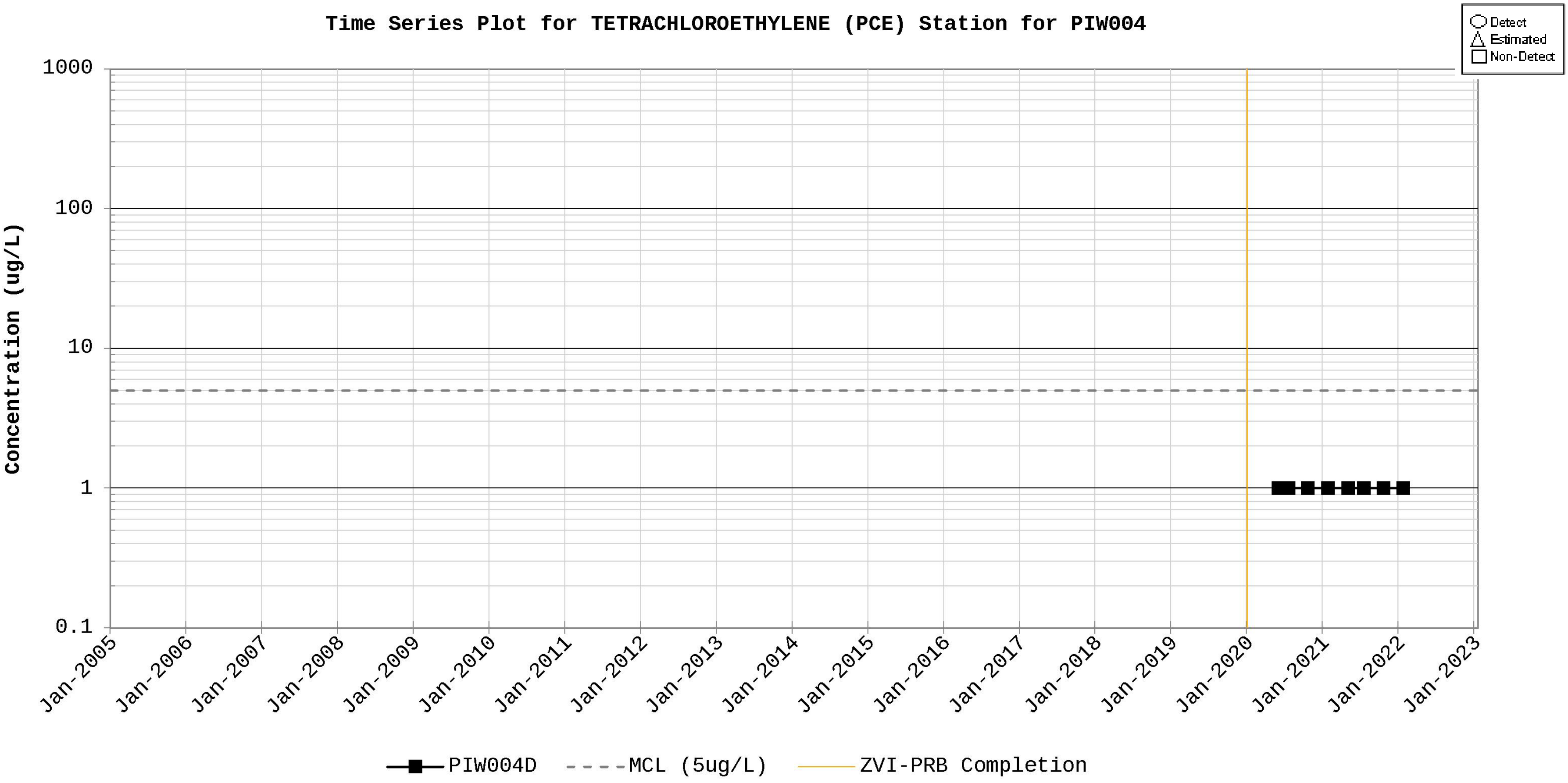

Figure C.21. Time Series Plot for Tetrachloroethylene (PCE) at Monitoring Well PIW004D

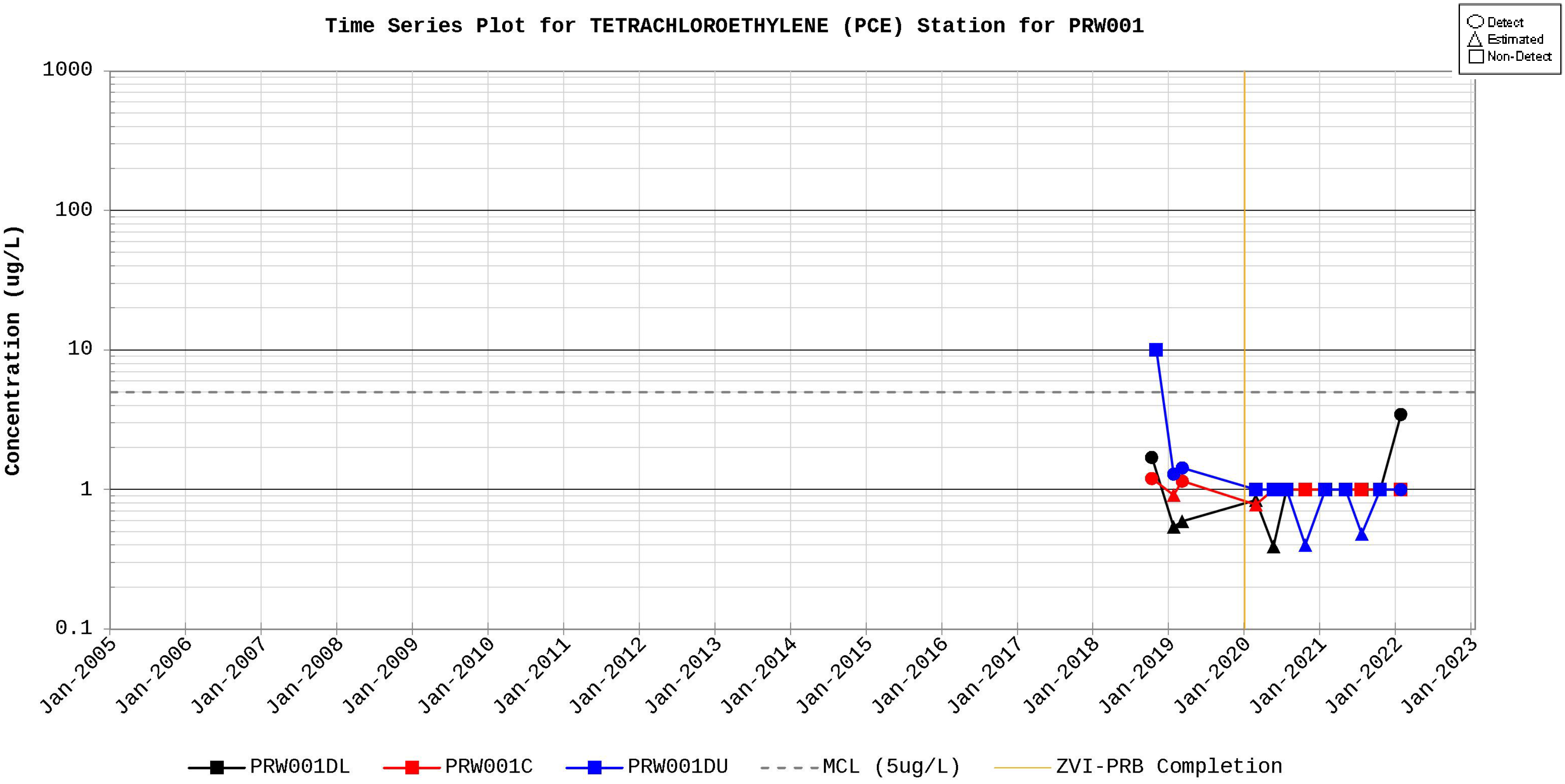

Figure C.22. Time Series Plot for Tetrachloroethylene (PCE) at PRW001 Series Monitoring Wells

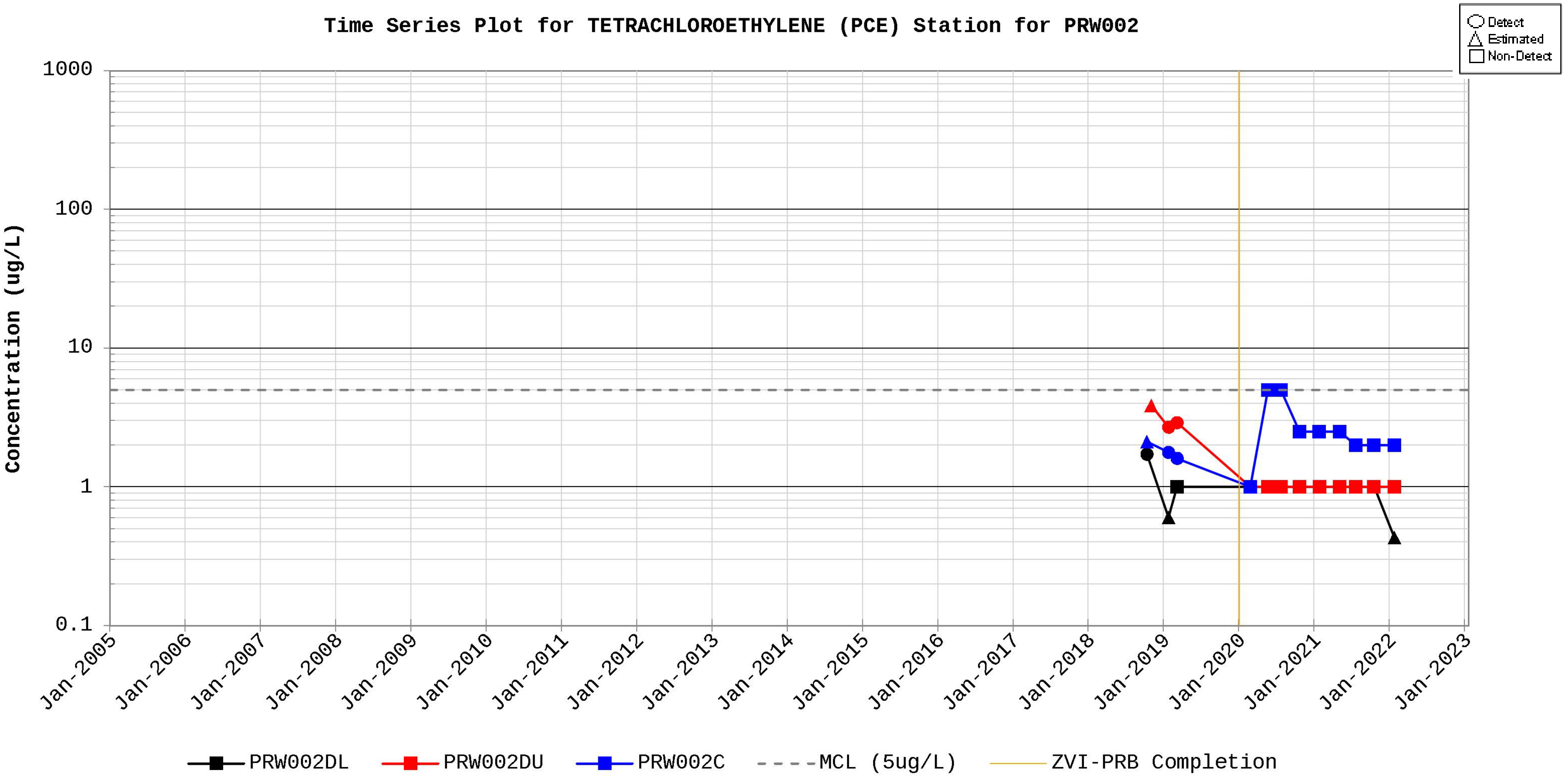

Figure C.23. Time Series Plot for Tetrachloroethylene (PCE) at PRW002 Series Monitoring Wells

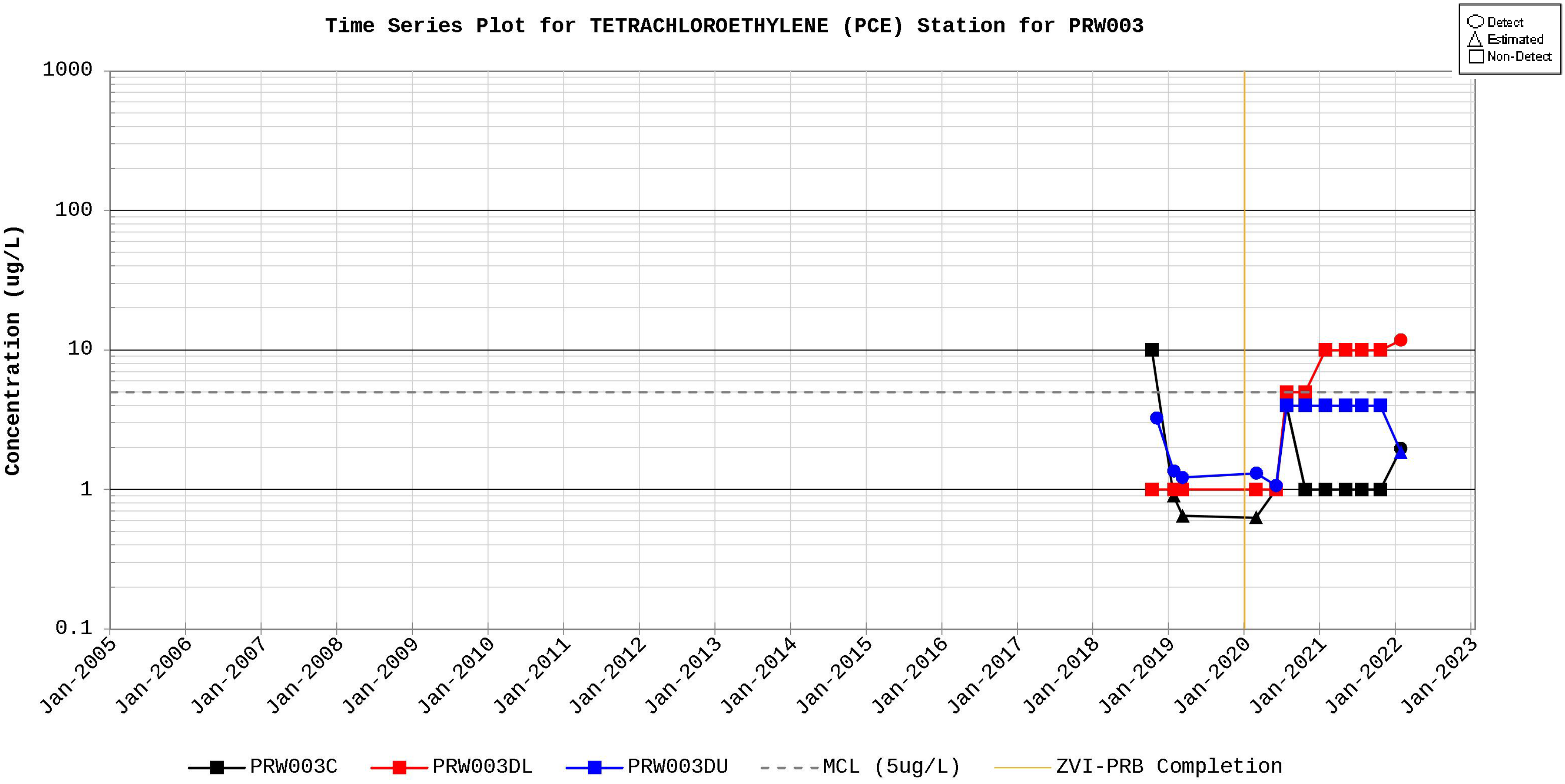

Figure C.24. Time Series Plot for Tetrachloroethylene (PCE) at PRW003 Series Monitoring Wells

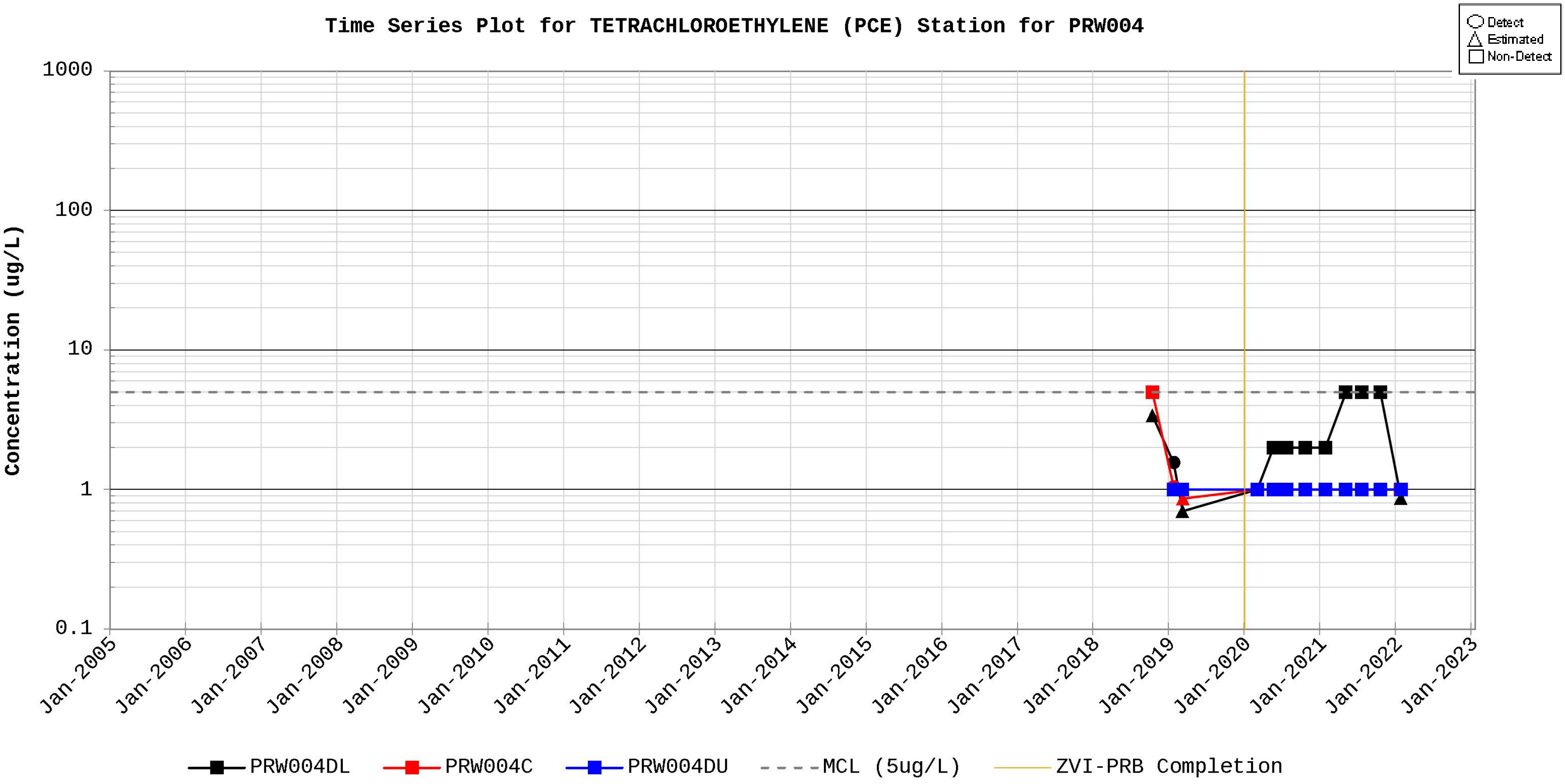

Figure C.25. Time Series Plot for Tetrachloroethylene (PCE) at PRW004 Series Monitoring Wells

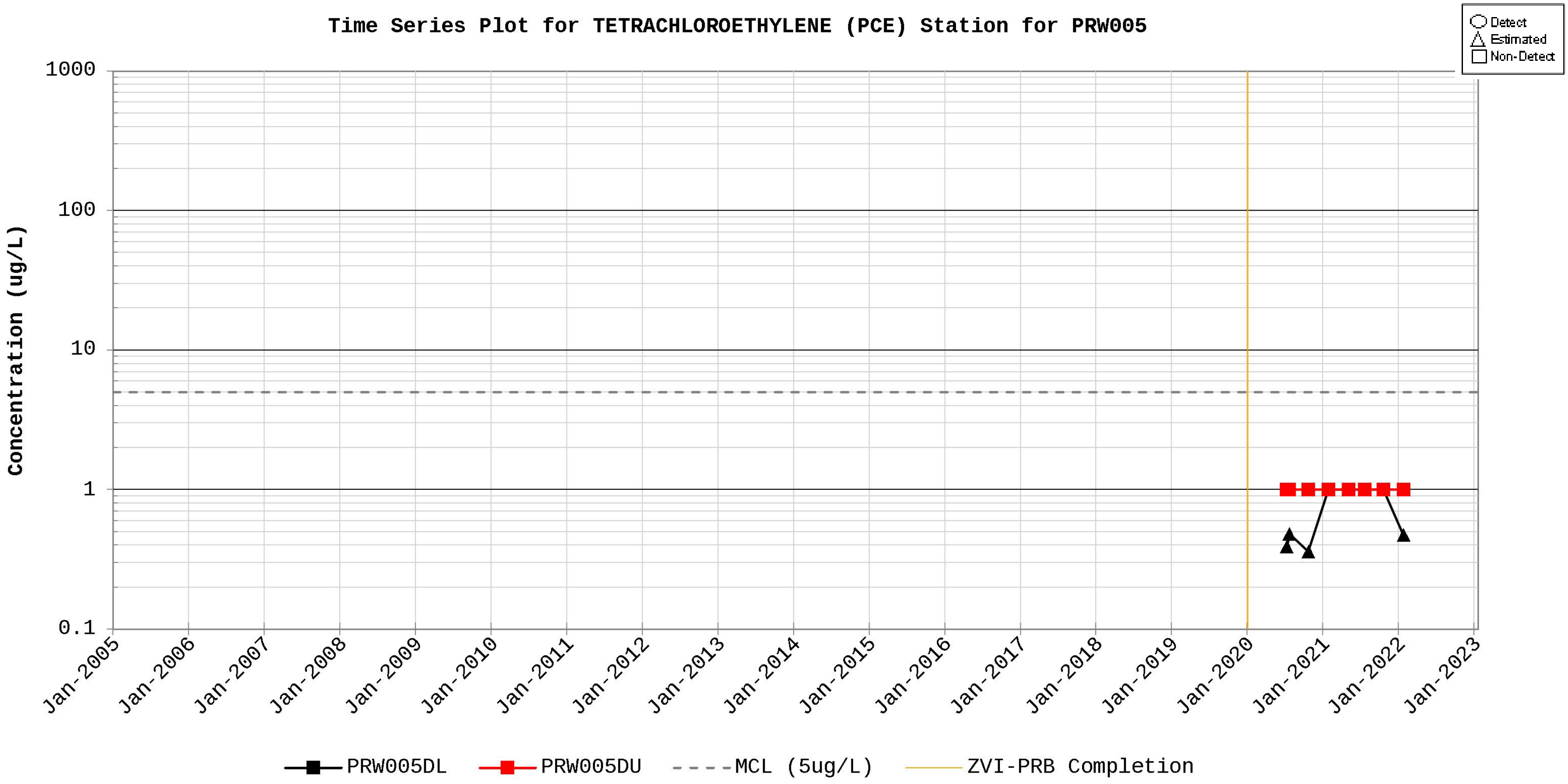

Figure C.26. Time Series Plot for Tetrachloroethylene (PCE) at PRW005 Series Monitoring Wells

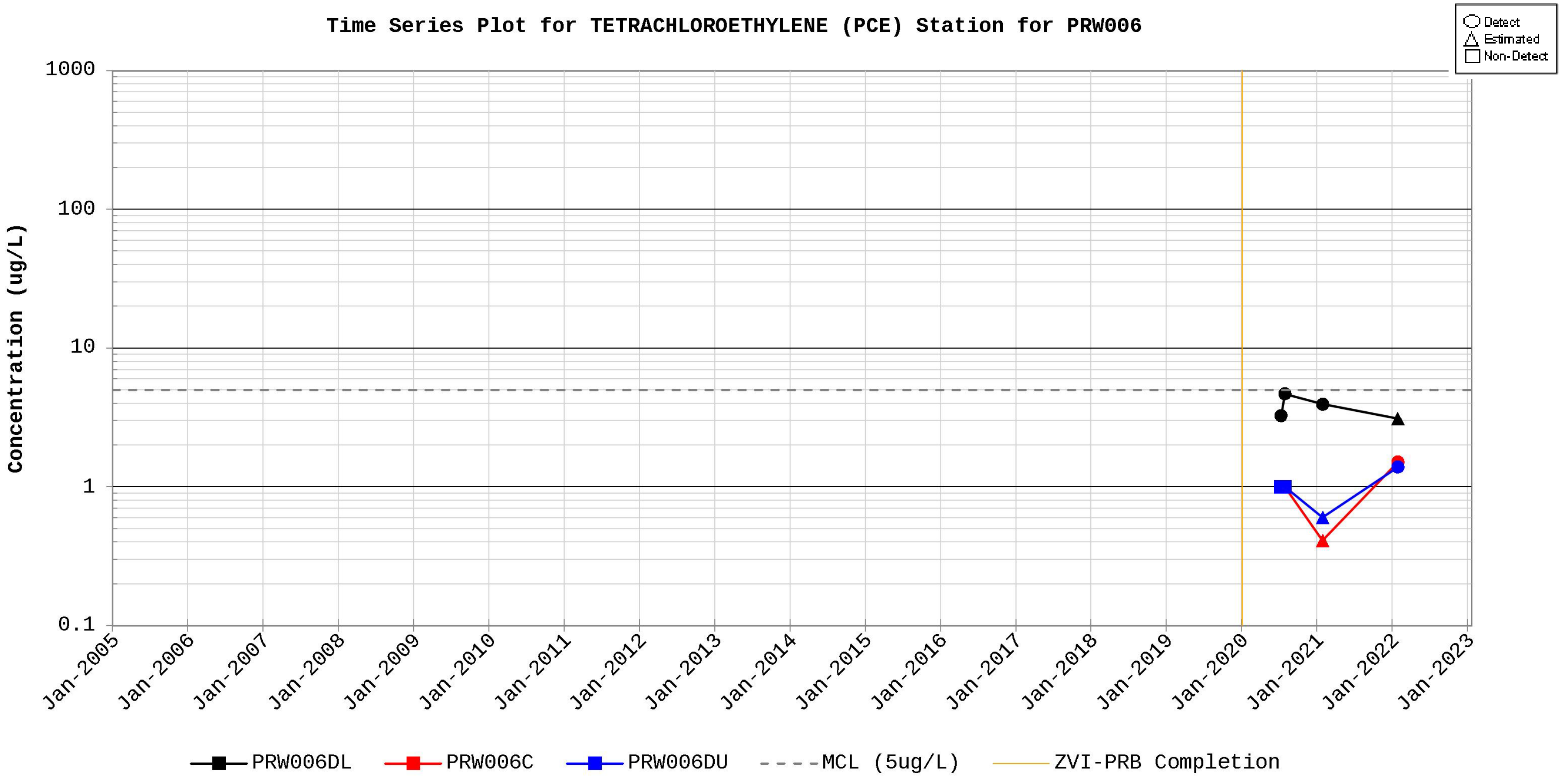

Figure C.27. Time Series Plot for Tetrachloroethylene (PCE) at PRW006 Series Monitoring Wells

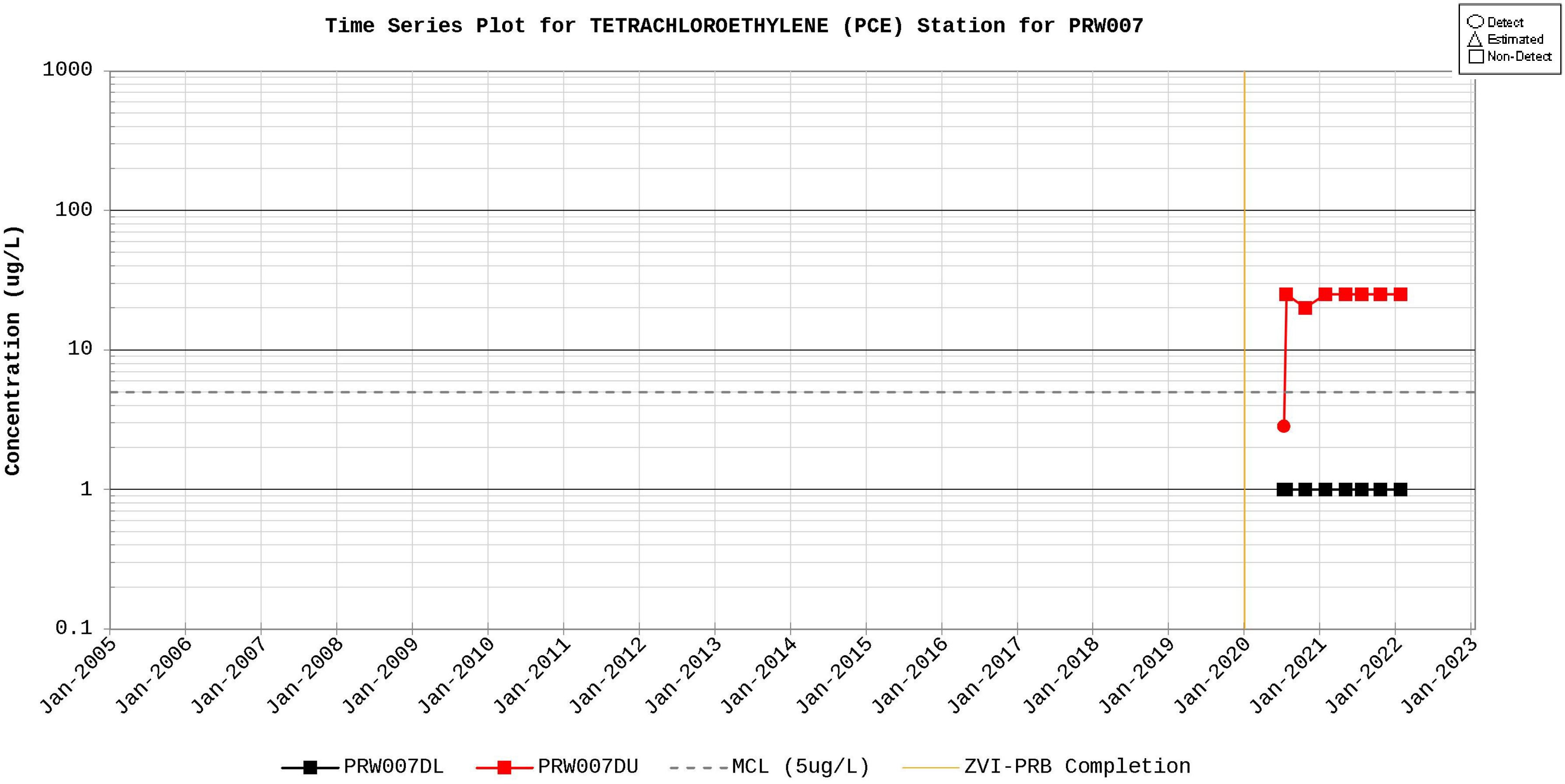

Figure C.28. Time Series Plot for Tetrachloroethylene (PCE) at PRW007 Series Monitoring Wells

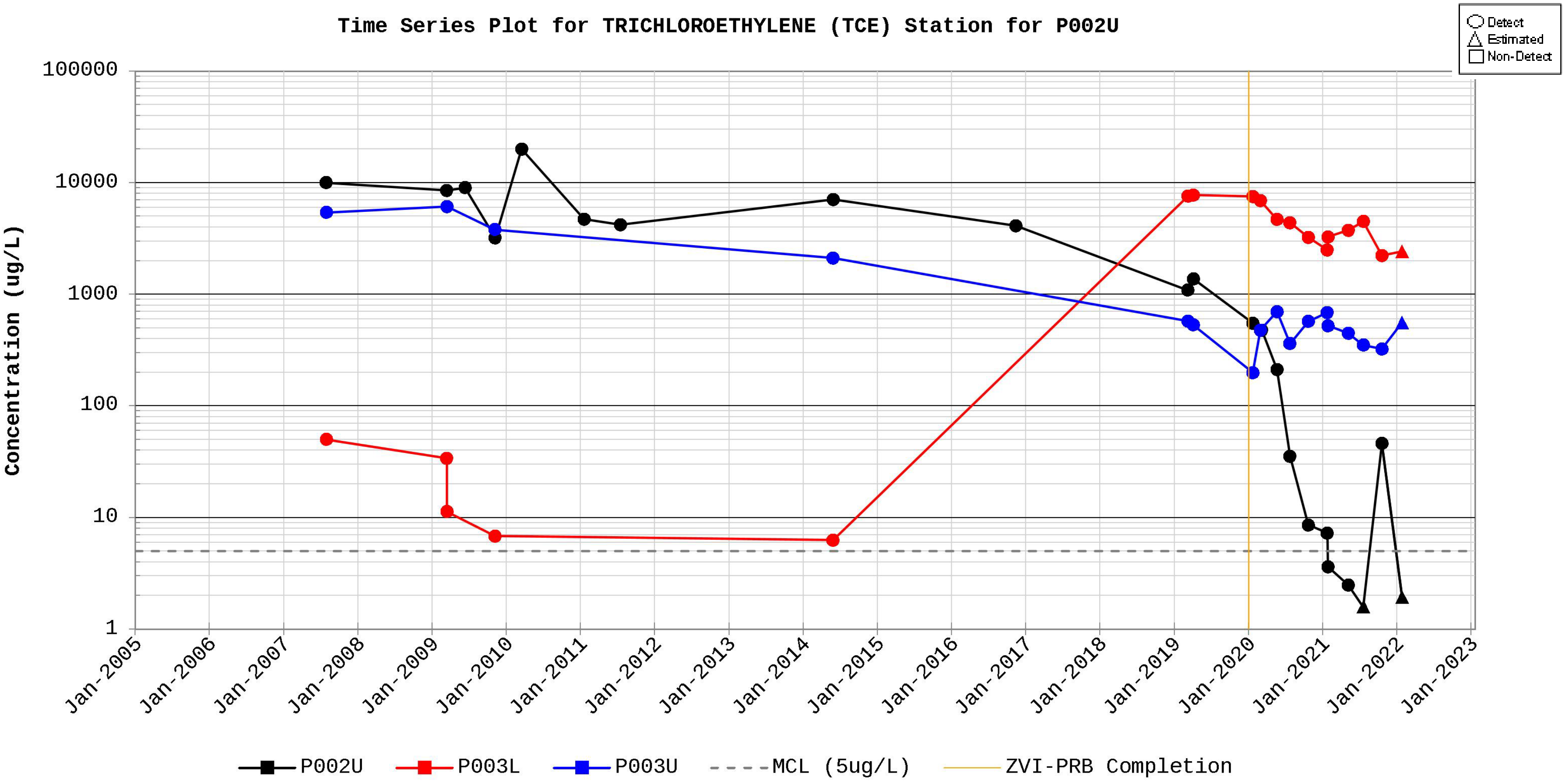

Figure C.29. Time Series Plot for Trichloroethylene (TCE) at P00 Series Monitoring Wells

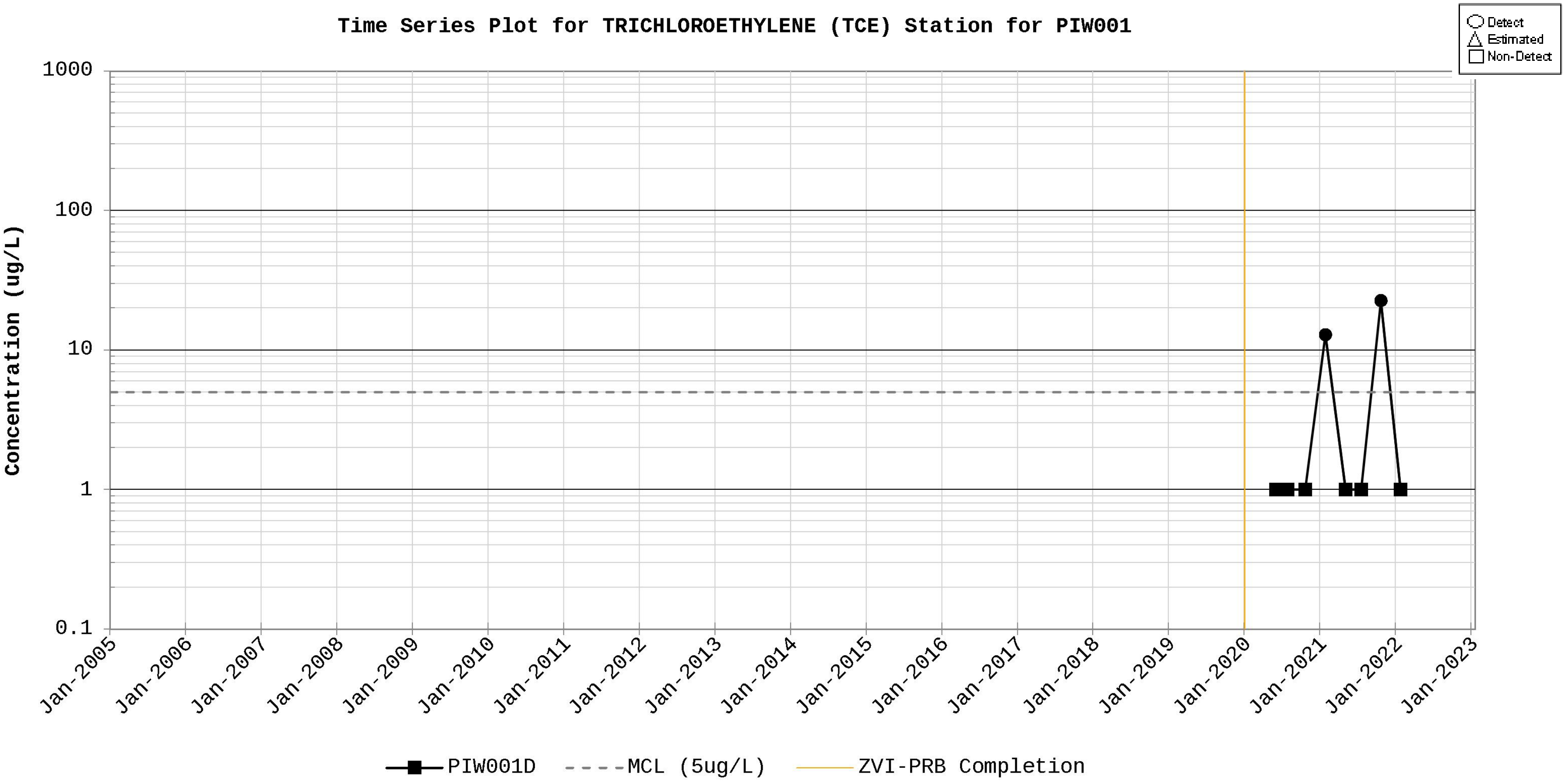

Figure C.30. Time Series Plot for Trichloroethylene (TCE) at Monitoring Well PIW001D

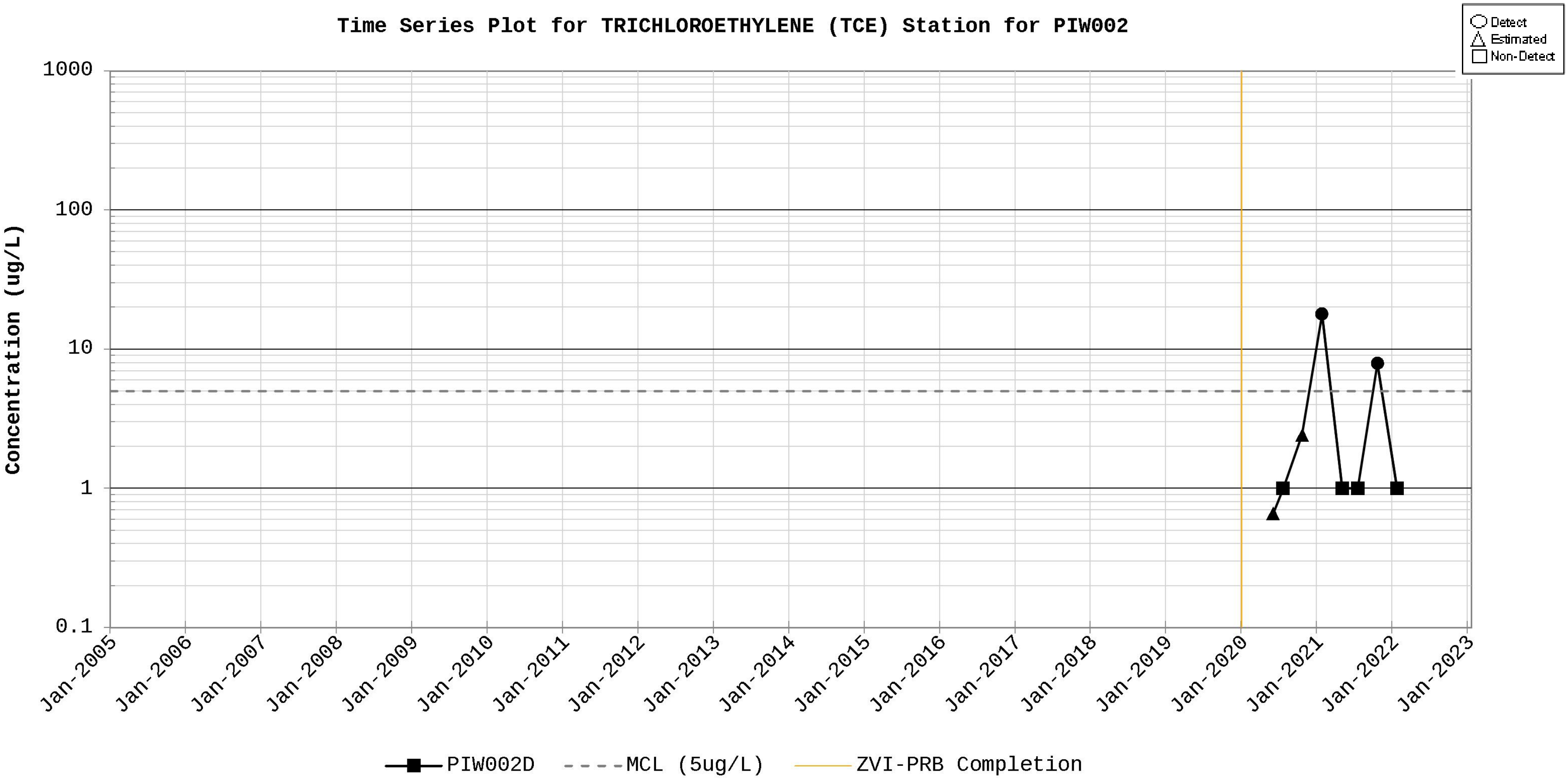

Figure C.31. Time Series Plot for Trichloroethylene (TCE) at Monitoring Well PIW002D

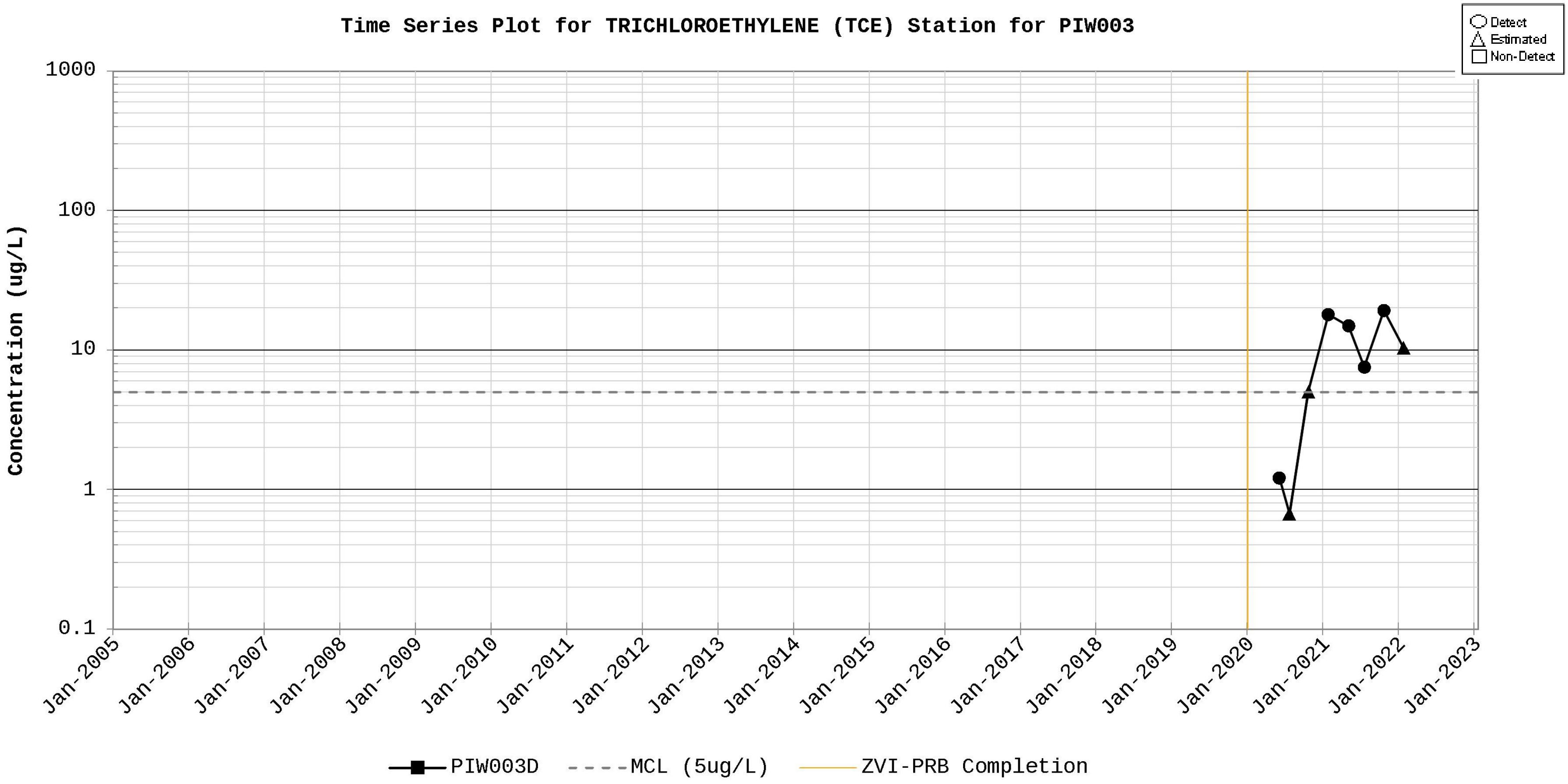

Figure C.32. Time Series Plot for Trichloroethylene (TCE) at Monitoring Well PIW003D

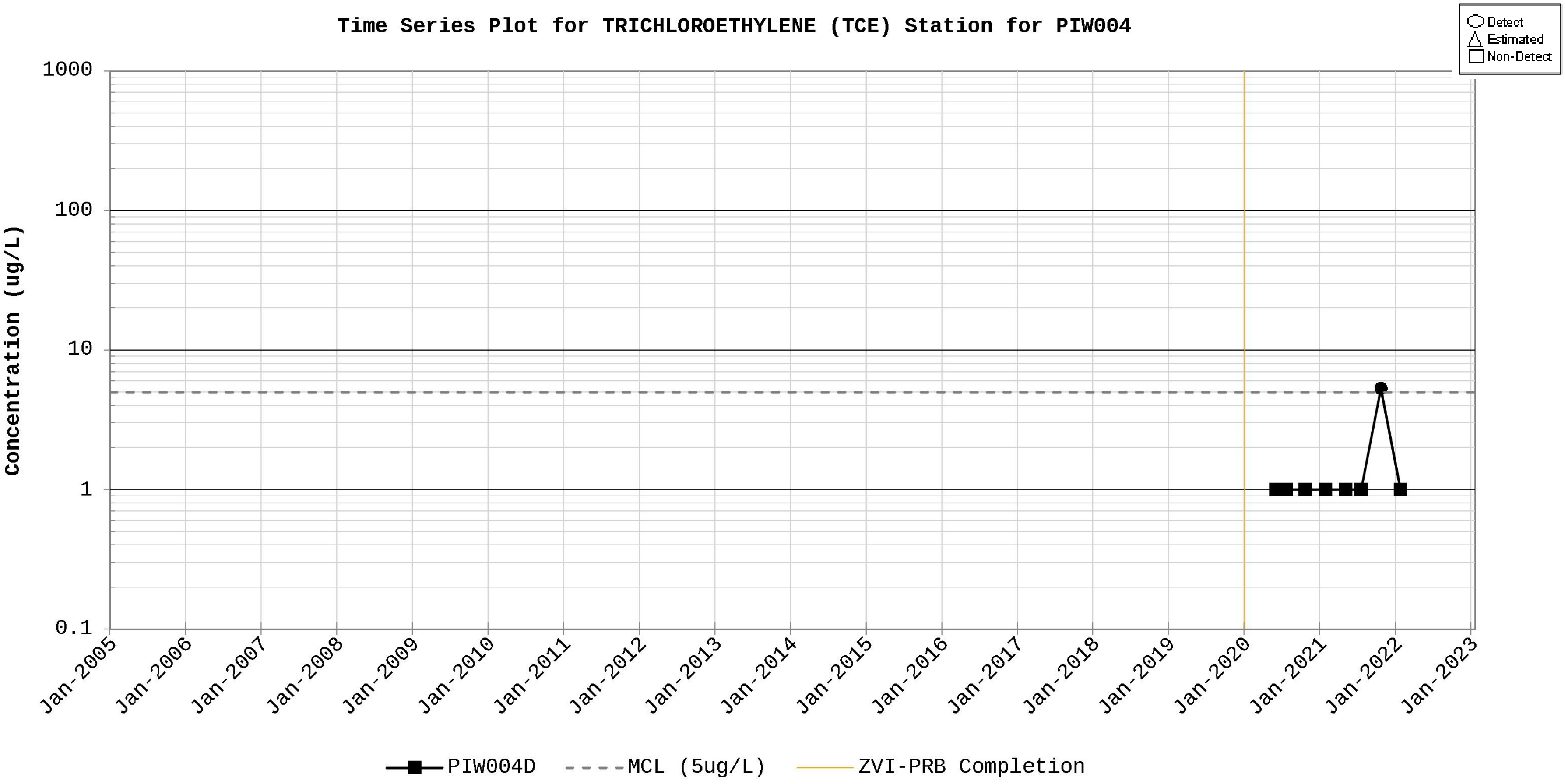

Figure C.33. Time Series Plot for Trichloroethylene (TCE) at Monitoring Well PIW004D

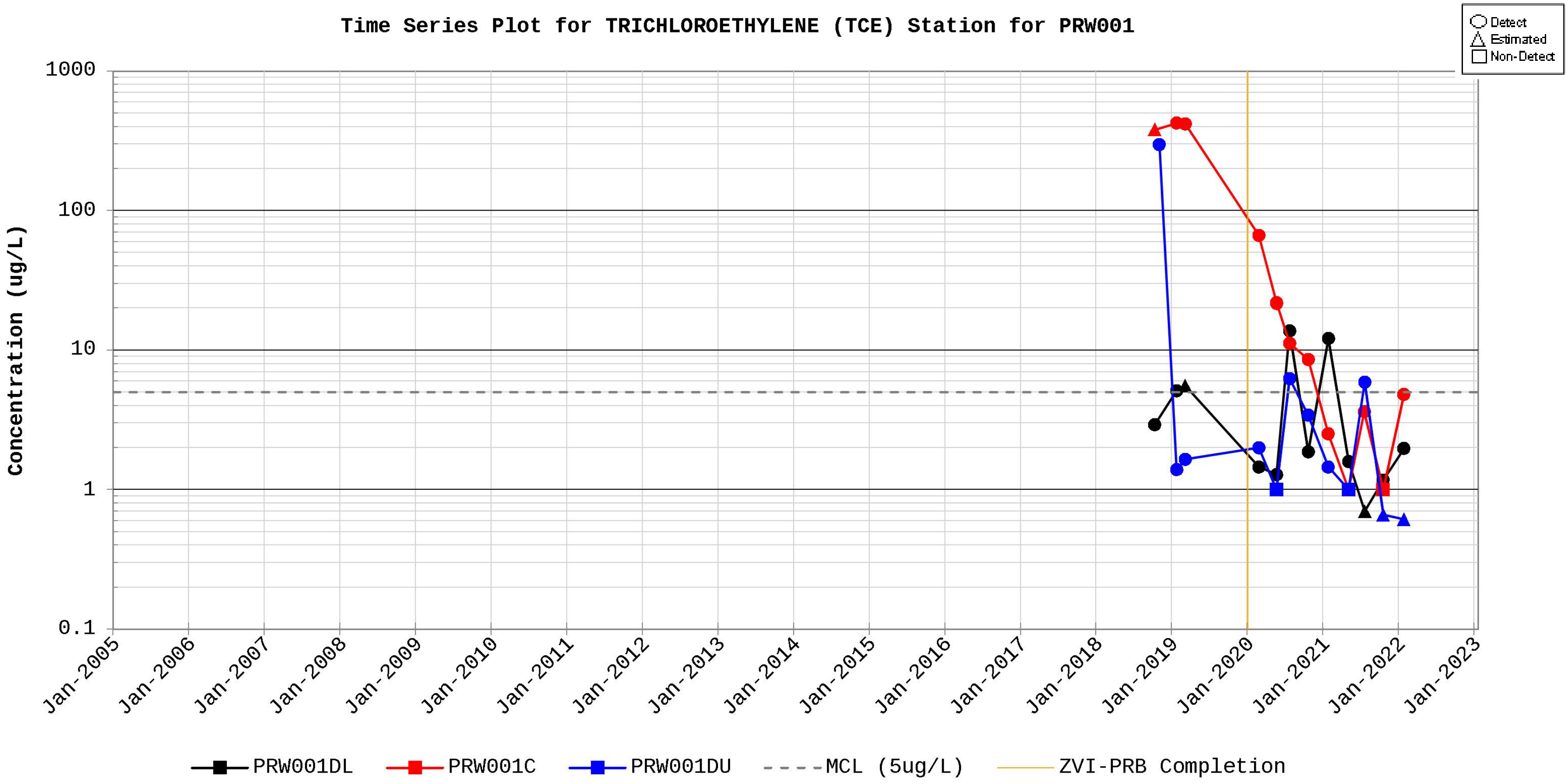

Figure C.34. Time Series Plot for Trichloroethylene (TCE) at PRW001 Series Monitoring Wells

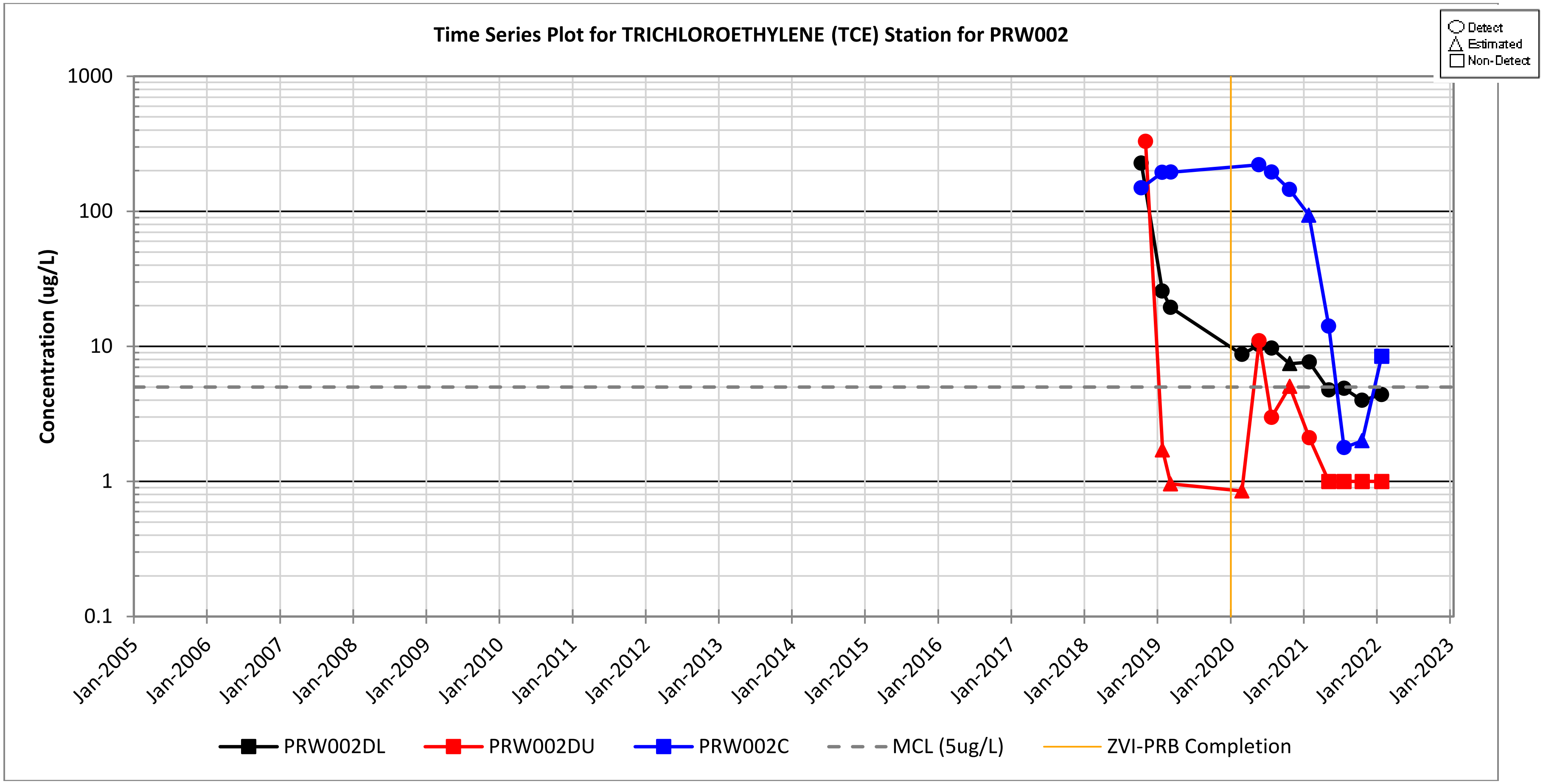

Figure C.35. Time Series Plot for Trichloroethylene (TCE) at PRW002 Series Monitoring Wells

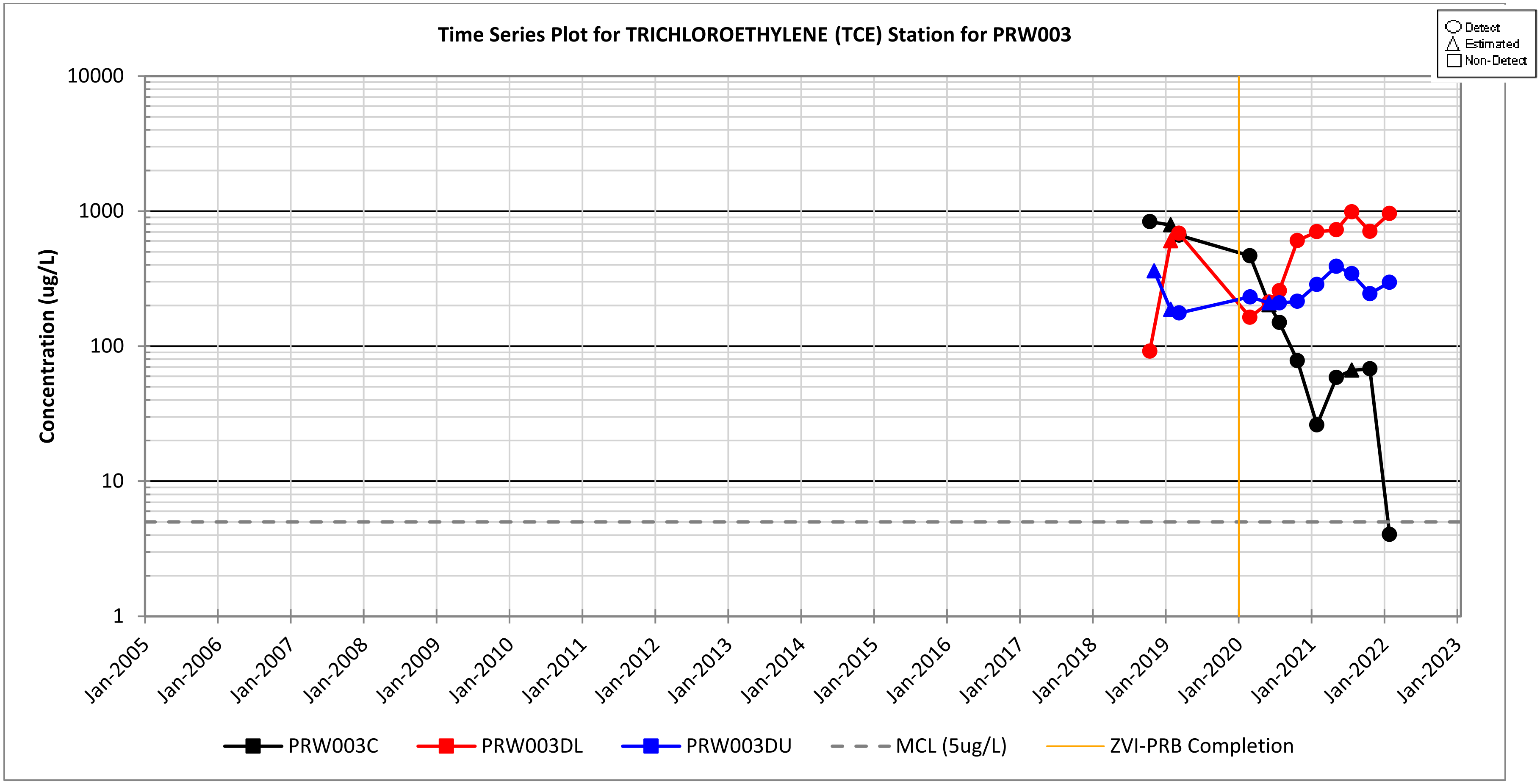

Figure C.36. Time Series Plot for Trichloroethylene (TCE) at PRW003 Series Monitoring Wells

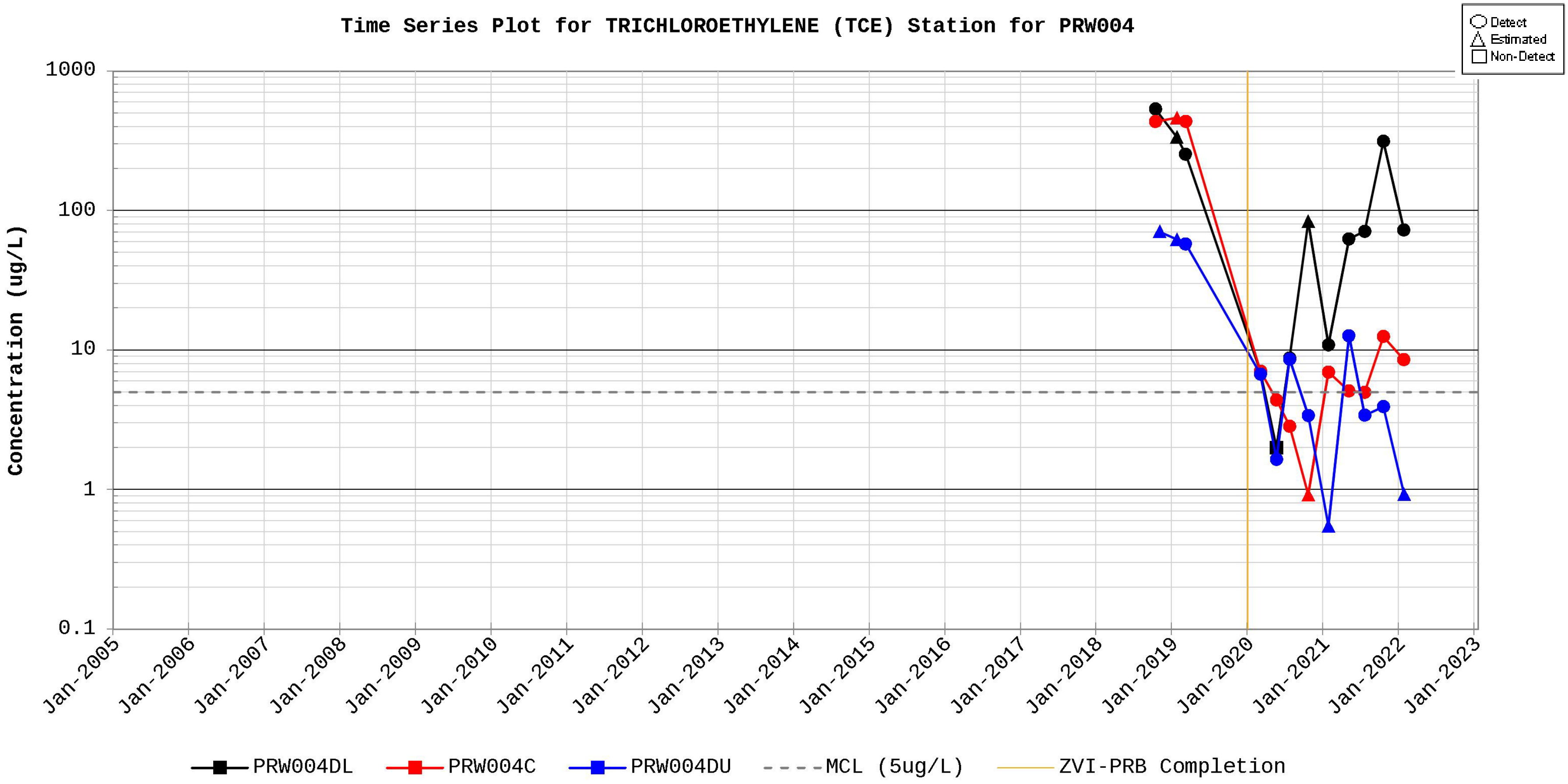

Figure C.37. Time Series Plot for Trichloroethylene (TCE) at PRW004 Series Monitoring Wells

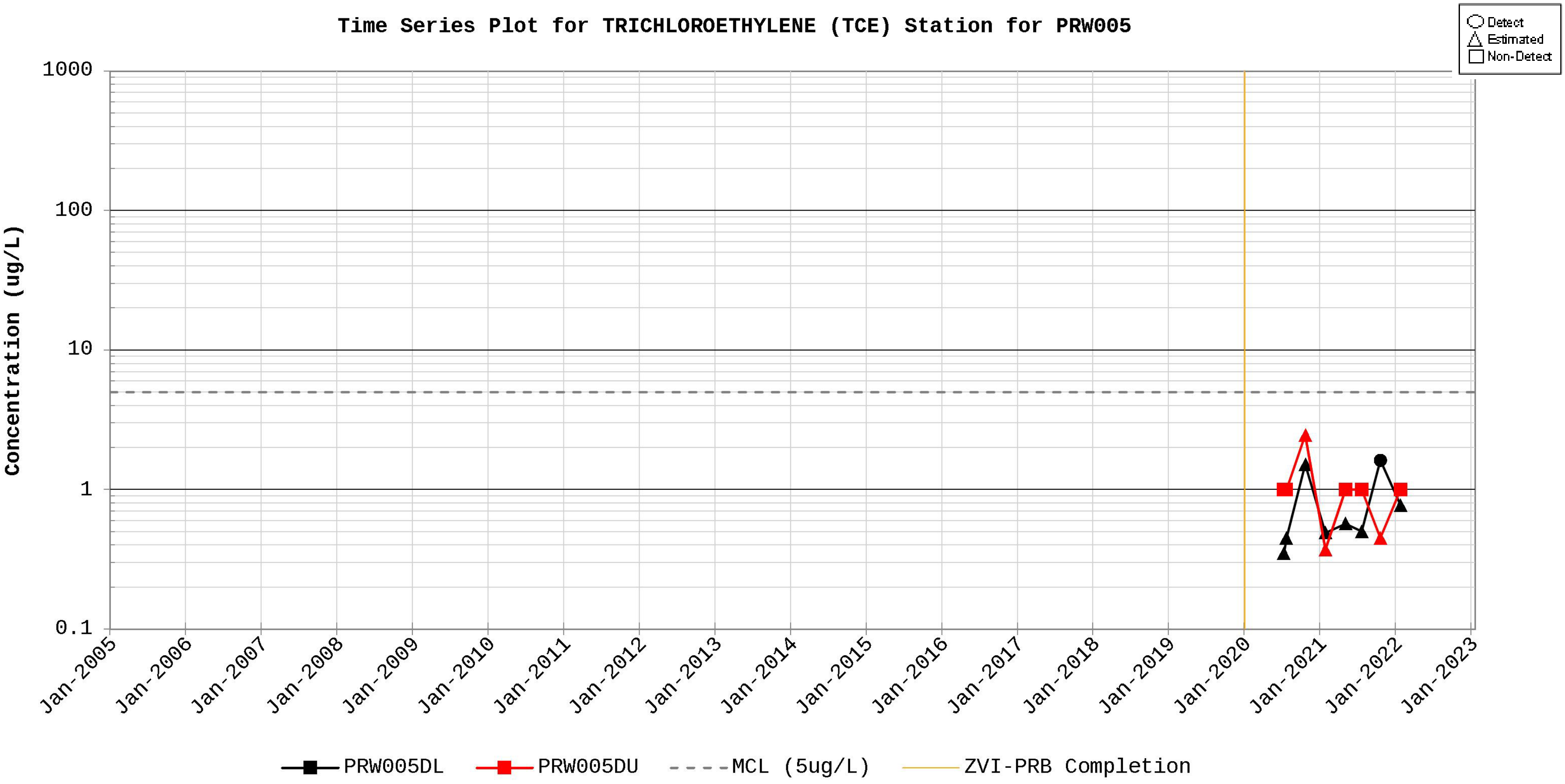

Figure C.38. Time Series Plot for Trichloroethylene (TCE) at PRW005 Series Monitoring Wells

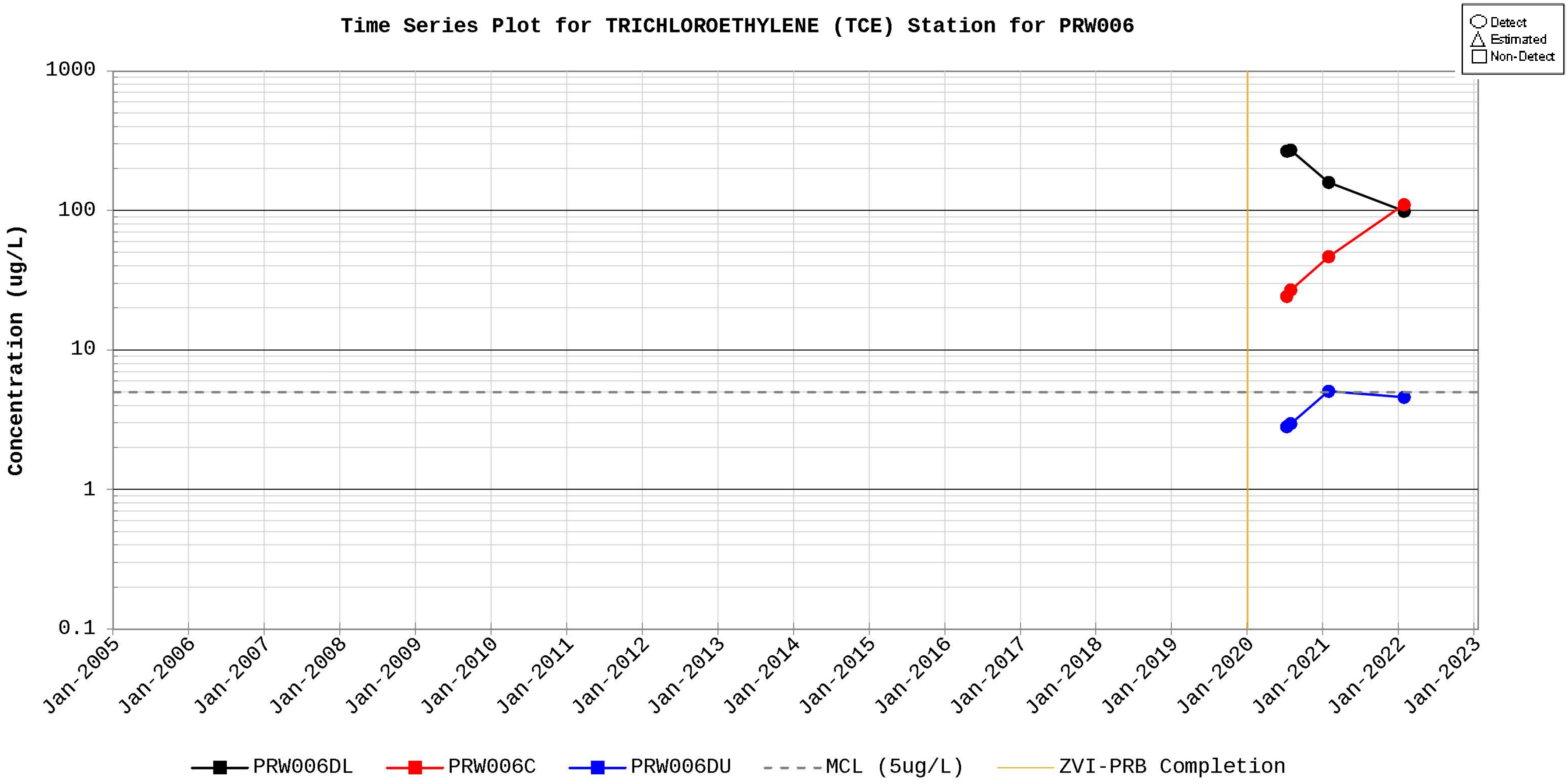

Figure C.39. Time Series Plot for Trichloroethylene (TCE) at PRW006 Series Monitoring Wells

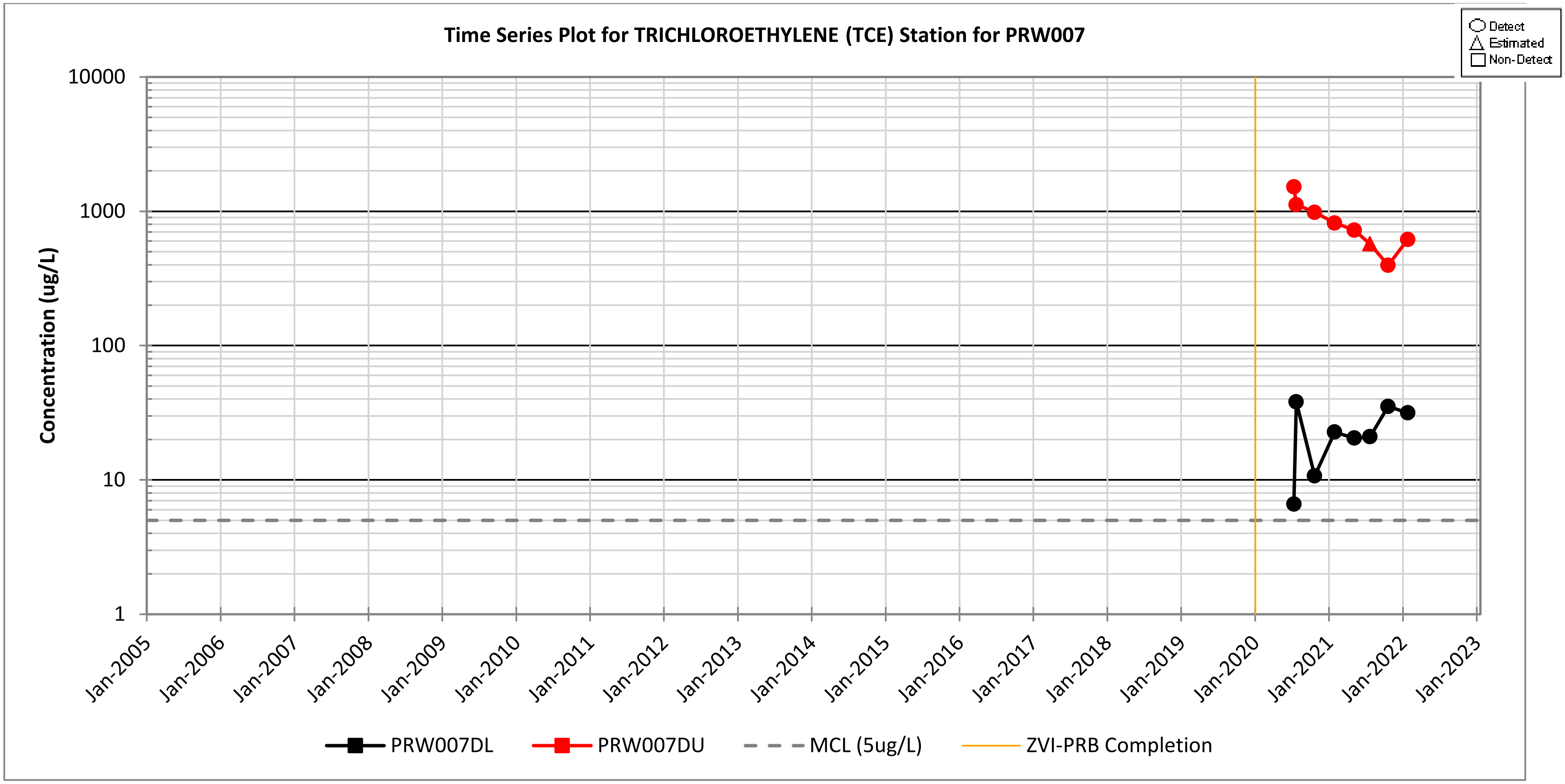

Figure C.40. Time Series Plot for Trichloroethylene (TCE) at PRW007 Series Monitoring Wells