EMID-700356

DEPARTMENT OF ENERGY
Environmental Management Los Alamos Field Office (EM-LA)
Los Alamos, New Mexico 87544

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NMED
Hazardous Waste Bureau

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Mr. John E. Kieling
Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Dear Mr. Kieling:

Subject: Submittal of the Semiannual Progress Report on Chromium Plume Control Interim Measure Performance

Enclosed please find two hard copies with electronic files of the "Semiannual Progress Report on Chromium Plume Control Interim Measure Performance." This progress report presents data and results from the initial start-up in January 2017 through December 2018. This report is being submitted to fulfill Fiscal Year 2019 Milestone 2 in Appendix B of the 2016 Compliance Order on Consent (Consent Order).

Pursuant to Section XXIII.C of the Consent Order, pre-submission review meetings were held with the U.S. Department of Energy Environmental Management Los Alamos Field Office (EM-LA); Newport News Nuclear BWXT-Los Alamos, LLC (N3B); and the New Mexico Environment Department (NMED) on January 24 and February 26, 2019, to discuss NMED's comments on the previous semiannual progress report. EM-LA and N3B defined what would be included in the annual progress report in response to the comments. Agreed-upon elements of the report include a description of the operational issues with CrEX-3, additional analytical data from CrEX-3, a discussion on tracer deployments and findings, a baseline water-table map from May 2018 (with all water-table maps at 1-ft contour intervals), and a table of water-level data from dual-screen well locations in the chromium project area.

If you have any questions, please contact Steve White at (505) 309-1370 (steve.white@em-la.doe.gov) or Cheryl Rodriguez at (505) 665-5330 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Arturo Q. Duran
Compliance and Permitting Manager
Environmental Management
Los Alamos Field Office

Enclosures:
1. Semiannual Progress Report on Chromium Plume Control Interim Measure Performance (EM2019-0059)

cc (letter with hard-copy enclosure[s]):
S. White, N3B
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cc (letter and enclosure[s] emailed):
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R. Martinez, San Ildefonso Pueblo, NM
D. Chavarria, Santa Clara Pueblo, NM
S. Yanicak, NMED
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PRS Website

EM-LA-40AD-00415

March 2019
EM2019-0059

Semiannual Progress Report on Chromium Plume Control Interim Measure Performance

EM2019-0059

Semiannual Progress Report on Chromium Plume Control Interim Measure Performance

March 2019

Responsible program director:

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Responsible DOE EM-LA representative:

Arturo Q. Duran		Compliance and Permitting Manager	Office of Quality and Regulatory Compliance	3/21/19
Printed Name	Signature	Title	Organization	Date

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1.0 INTRODUCTION

This progress report on chromium plume control interim measure (IM) performance presents data and results related to IM activities starting with initial start-up in January 2017 through December 2018. This report is prepared to fulfill reporting requirements proposed in the April 2018 “Chromium Plume Control Interim Measure Performance Monitoring Work Plan” (LANL 2018, 603010) and additional reporting commitments made to the New Mexico Environment Department (NMED) in technical team meetings and pursuant to comments provided by NMED on the “Annual Progress Report on Chromium Plume Control Interim Measure Performance” submitted in September 2018 (N3B 2018, 700088). The monitoring and associated reporting is being conducted to evaluate performance of the IM conducted under the May 2015 “Interim Measures Work Plan for Chromium Plume Control” (IMWP) (LANL 2015, 600458).

The principal objective of the IM is to achieve and maintain the 50-ppb downgradient chromium plume edge within the Los Alamos National Laboratory (LANL or the Laboratory) boundary with a specific metric of reduction of chromium concentrations at monitoring well R-50 to the 50-µg/L New Mexico groundwater standard or less over a period of approximately 3 yr. A secondary objective is to hydraulically control plume migration in the eastern downgradient portion of the plume.

The current IM operations consist of pumping from three extraction wells, CrEX-1, CrEX-2, and CrEX-3; treatment at a centralized treatment facility; and injection of treated water into injection wells CrIN-3, CrIN-4, and CrIN-5 (Figure 1.0-1). This initial operational configuration addresses the downgradient portion of the plume. In addition to the southern boundary, full operation will address the eastern portion of the plume after the final configuration of the remaining components of the IM infrastructure is in place and operational.

Characterization data from CrIN-6 led to an evaluation of the optimal operational configuration to meet the IM objectives. The results of the CrIN-6 evaluation are presented in the “Evaluation of Chromium Plume Control Interim Measure Operational Alternatives for Injection Well CrIN-6” submitted to NMED in April 2018 (LANL 2018, 603032). NMED provided a response on June 6, 2018, that approved proceeding with the recommendation to convert CrIN-6 from an injection well to an extraction well (CrEX-5) (NMED 2018, 700011). Two injection wells, CrIN-1 and CrIN-2, are currently not operating because of uncertainty whether continuous injection in those two wells, without concurrent extraction from CrEX-5, would push the plume to the north of CrIN-1 and thus not achieve complete hydraulic control of the eastern portion of the plume. The fourth extraction well, CrEX-4, has been used to date only for short-term extraction testing. Inclusion of CrEX-4 into the IM operational configuration is pending authorization from the New Mexico Office of the State Engineer.

This report presents operational information for the period of July 2018 through December 2018. A period of record inclusive of analytical data from performance monitoring wells collected through December 2018 is included in Appendix A to provide additional context for interpretation.

2.0 INTERIM MEASURE OPERATIONS

A discussion of IM operations is presented below.

2.1 2018 Operations and Testing

Table 2.1-1 presents significant operational and maintenance activities for July 2018 through December 2018.

2.1.1 System Operations

The first sustained operation of the treatment system and pipeline and infrastructure network started on March 20, 2018. This included pumping at CrEX-1, CrEX-2, and CrEX-3 with injection occurring at CrIN-3, CrIN-4, and CrIN-5. All six wells were operated at a nominal flow rate of 60 gallons per minute (gpm) with a total treatment volume of 180 gpm. The system did not operate between April 23 and May 22, 2018, during the U.S. Department of Energy (DOE) Environmental Management Los Alamos Field Office (EM-LA) contractor turnover period, and was restarted on May 23, 2018. Flow rates at all locations were maintained at the nominal 60 gpm through July 23, 2018.

Increasing influent pressure at the treatment unit and extraction pipeline, and accompanying reduction in extraction well pumping rates were observed in the second half of July 2018. Changing the pre-treatment influent bag filters immediately remedied the issue, but the problem would return within a few days. CrEX-3 was shut down on July 23, 2018, based on speculation of pumping amendment-impacted water from either nearby wells R-28 or R-42. CrEX-3 remained off until September 20 except for one wellhead sampling event on August 16. CrEX-3 was returned to service on September 20 and was operated through October 30 in order to confirm that it was indeed the source of the influent filter plugging. Observations made while CrEX-3 was shut down during August and September and during the September and October pumping indicate that CrEX-3 currently produces water responsible for plugging the influent filters and causing high-pressure spikes in the system. CrEX-3 was turned off on October 30 and remained off except for wellhead sampling events on November 26 and December 18. An analysis of CrEX-3 is underway and results will be reported in upcoming chromium amendments quarterly reports.

Figure 2.1-1 presents flow rates for the CrEX wells. The condition of cumulative extraction flow reduction as the influent filters plug is apparent, particularly during September and October. During periods when CrEX-3 was off, flows at CrEX-1 and CrEX-2 were increased in order to make total treatment volume approximately 150 gpm. During these periods, injection flow was maintained at 60 gpm at both CrIN-4 and CrIN-5, with CrIN-3 receiving the balance of treated effluent.

CrIN-3, CrIN-4, and CrIN-5 remain the only injection wells to have seen enough sustained service to evaluate performance. Figure 2.1-2 presents water level and flow rates for each of the three CrIN wells from July 1 through the end of December 2018. Stable injection flow rates and stable to slowly rising water levels continue to indicate reliable and predictable performance. The slowly and consistently rising water levels indicate that there are no serious problems related to injection well fouling. Injection well performance has been and continues to be good at all three locations.

2.1.2 Routine and Nonroutine Activities

Tracer introductions took place at CrIN-3, CrIN-4, and CrIN-5 in September 2018. Groundwater was pumped from each well to mix with a unique tracer at each location. Each location received an introduction of 50 kg of tracer mixed with 12,000 gal. of water followed by 3000 gal. of chase water. The pumping events associated with the tracer work also served as maintenance events at each well. Each injection well was taken out of service one at a time for the tracer introductions while the rest of the IM system continued to operate.

CrIN-3 tracer introduction activities were performed on September 11 and 12, 2018. The CrIN-3 injection system was shut off on September 11 before purging the well. The pump was cycled on and off during initial purging as a maintenance event. A total of 15,008 gal. was purged from the well at an average flow rate of approximately 95 gpm. On September 12, trisodium 1,3,6-naphthalenetrisulfonate (Na-1,3,6 NTS) tracer and chase water were introduced into the well.

CrIN-4 tracer introduction activities were performed on September 13 and 17, 2018. The CrIN-4 injection system was shut off on September 13 before purging the well. The pump was cycled on and off during initial purging as a maintenance event. A total of 15,005 gal. was purged from the well at an average flow rate of approximately 69 gpm. On September 17, disodium 2,6-naphthalenedisulfonate (Na-2,6 NDS) tracer and chase water were introduced into the well.

CrIN-5 tracer introduction activities were performed on September 14 and 18, 2018. The CrIN-5 injection system was shut off on September 14 before purging the well. The pump was cycled on and off during initial purging as a maintenance event. A total of 14,346 gal. was purged from the well at an average flow rate of approximately 78 gpm (approximately 650 gal. of residual water was in the frac tank from previous maintenance activities). On September 18, disodium 2,7-naphthalenedisulfonate (Na-2,7 NDS) tracer and chase water were introduced into the well.

2.1.3 Chromium Mass Removal

Table 2.1-2 presents estimates for chromium mass removal for 2017 and 2018. Although mass removal rates and efficiency are not directly related to IM performance, they may provide insights into observed plume response.

3.0 PERFORMANCE MONITORING RESULTS

The IMWP (LANL 2015, 600458) states that performance monitoring will be conducted to evaluate plume response associated with IM operations and guide adjustments in operational strategies. Water quality (including tracer data) and water level results are presented in this section.

3.1 Sampling

Sampling under the IMWP (LANL 2018, 603010) effectively began in February 2017 with monthly monitoring of wells R-50 (screens 1 and 2 [S1 and S2]) and SIMR-2 because of their proximity to IM operations that were conducted at CrEX-1, CrIN-4, and CrIN-5 in 2017. Monthly monitoring at R-44 (S1 and S2), R-45 (S1 and S2), and R-61 began in October 2017, largely to collect baseline information on temporal variations at those wells that can be compared with trends that may occur in association with pending IM operations in those areas. Additional wells (R-35a, R-35b, and R-11) have since been added to the monthly performance monitoring. All performance monitoring wells are sampled monthly under the Interim Facility-Wide Groundwater Monitoring Plan (N3B 2018, 700000), and five piezometers (CrPZ-1, CrPZ-2a, CrPZ-3, CrPZ-4, and CrPZ-5) are sampled quarterly. Figure 3.1-1 shows the locations of the wells in the chromium plume area and also shows which monitoring wells and piezometers are sampled under the IMWP (LANL 2018, 603010). Beginning in September 2018, a standard purge protocol for the piezometers was established at 12 casing volumes based on data from extended purge tests conducted at the piezometers to optimize data quality.

The analyte suite for sampling at performance monitoring wells focuses on a subset of key indicator constituents in the intervening monthly samples compared with the quarterly samples collected for the same wells. Table 3.1-1 shows the IM performance monitoring wells, piezometers and the sample frequency for each constituent category.

3.2 Monitoring Results

Time-series plots for the performance monitoring wells and piezometers are provided as Figures 3.2-1 through 3.2-17. Plots with data from extraction wells are also included as Figures 3.2-18 through 3.2-20. The period of record for the plots varies based on the period that information is available. For each performance monitoring well or piezometer, two plots are provided that each include a subset of key constituents (perchlorate, nitrate, sulfate, tritium, and chloride) also found within the chromium plume. Each plot also shows the hydrograph of water levels at that location for context. A full data set from the performance monitoring wells for the period of record evaluated for this report (January 2009 through December 2018) is provided as Appendix A. Over time, the relation between water levels (e.g., drawdown or mounding) and changes in chromium and other key constituents in the plume may provide a useful line of evidence into performance of the IM.

Tracers that have been used in the project area are also sampled for in performance monitoring wells. One of the two tracers deployed into the injection wells in 2017 is now being detected in R-50 S1 and in extraction well CrEX-1. Sodium-1,5 naphthalenedisulfonate (Na-1,5 NDS) deployed into CrIN-4 has been increasing in concentration in R-50 S1 and CrEX-1 since August 2018 (Figure 3.2-21). Tracers deployed into CrIN-3, CrIN-4, and CrIN-5 in September 2018 have not yet been detected in any of the performance monitoring or extraction wells.

Concurrent with the increase in concentrations of Na-1,5 NDS, time-series data from R-50 S1 are showing steadily decreasing chromium concentrations. In addition to the Na-1,5 NDS, other constituents that can be considered “opportunistic” tracers are also increasing in R-50 S1, including sulfate and chloride. The increase in sulfate concentrations at R-50 S1 is related to higher concentrations of sulfate from extraction wells passing untreated (as expected) though the ion exchange treatment system and entering the aquifer via injection wells in areas with lower sulfate concentrations, thus creating a sulfate tracer signature in the injection water. Similarly, chloride is being exchanged with chromium on the ion exchange resins and entering the aquifer in concentrations distinct from the chloride concentrations previously in the aquifer near the injection wells, also creating a discernable tracer signature. Both sulfate and chloride concentration trends correlate well with the increasing concentration of Na-1,5 NDS at R-50 S1 (Figure 3.2-21). No tracer breakthrough is being detected in R-50 S2 (Figure 3.2-22). This is an indication that the Na-1,5 NDS tracer and injection water is moving laterally away from CrIN-4 along preferential strata with no discernable downward component that may have been created by groundwater gradients associated with injection.

Significant temporal variability is observed in many of the wells (e.g., R-50 S1), making relatively short-term changes in chromium concentrations difficult to assign specifically to IM performance. However, the relation of the tracer detections at R-50 S1 and the corresponding steady decrease in chromium concentrations is an indication that hydraulic capture combined with the effective flooding radius from injection at CrIN-4 have established the 50-ppb edge of the plume close to and just downgradient of R-50. Chromium concentrations are also showing a steady decline at R-44 S1, along with increasing concentrations of sulfate and chloride, indicating that the flooding radius likely from CrIN-3 reached the R-44 area in the August/September 2018 timeframe (Figure 3.2-23). The absence of detections of tracer (Na-1,3,6 NTS) at R-44 S1 from the September 2018 deployment into CrIN-3 could be because the tracer is lagging behind the chloride and sulfate tracer signal which entered the aquifer earlier in 2018, many months before the September 2018 deployment. Similar to R-50, no tracers are being detected in R-44 S2 (Figure 3.2-24), indicating that injection water is moving along preferential strata with no discernable downward migration component.

3.3 Flow Inferences from 2016 Tracer/Chemical Injections and from 2017 Amendments Injections

This section summarizes inferences about regional aquifer flow velocities and directions within the plume area derived from cross-hole observations of tracers or other chemicals after large-mass/volume injections into CrPZ-2a, CrPZ-2b, and R-28 in 2016, and after the 2017 amendment injections into R-42 and R-28. Inferences about flows from tracer and/or treated-water injections into CrIN wells is discussed in section 3.2. Figure 3.3-1 provides a map-view summary of the large mass/volume injections of 2016, 2017, and 2018 and Table 3.3-1 provides additional details of these injections.

Figure 3.3-2 provides a graphical depiction of all the inferences derived so far from cross-hole observations of tracers or other injected chemicals, including the inferences from CrIN well injections (discussed in section 3.2). The only well-defined cross-hole response observed from any of the non-injection well injections was a rapid response of the tracers injected into CrPZ-2a in June 2016 at CrEX-3 starting in September 2016, almost as soon as CrEX-3 began extraction operations. The tracers were detected within a few days of starting to pump CrEX-3, which suggests that they migrated a significant portion of the distance between CrPZ-2a and CrEX-3 during the approximately 3 mo that followed the end of the injection into CrPZ-2a and before the start of pumping CrEX-3 (a linear flow velocity of approximately 3 ft/day under natural flow conditions is estimated). In the ensuing approximately 2 mo that CrEX-3 was pumped, approximately 35% of the tracer mass injected into CrPZ-2a was recovered at CrEX-3. Additional details of this tracer response are provided in the “Compendium of Technical Reports Conducted Under the Work Plan for Chromium Plume Center Characterization,” Attachment 1 (LANL 2018, 602964).

The tracers that were injected into CrPZ-2b and into R-28 in 2016 never definitively appeared in CrEX-3 or any other potential observation wells (including R-28 for the tracers injected into CrPZ-2b). Also, the tracers injected into CrPZ-2a were never definitively observed in any other well besides CrEX-3, and the large volume injection of a sodium bicarbonate/sodium carbonate ($NaHCO_3$/Na_2CO_3) solution into R-42 in July 2016 was never observed at any monitoring or extraction location. Finally, the 2017 amendment solutions injected into both R-42 (sodium dithionite + sodium sulfite + bromide tracer) and R-28 (molasses + ethanol + bromide tracer) have not definitively appeared in any monitoring or extraction well. However, in the case of R-42, over 90% of the amendment solution was pumped back from R-42 in the weeks immediately following the injection. Also, there is a possibility that a weak signature related to the molasses amendment injection into R-28 may have appeared or is appearing in CrEX-3 in 2018. The evaluation of the geochemistry at CrEX-3 is underway and will be further discussed in a forthcoming quarterly report on the pilot-scale amendments testing currently underway. Collectively, the observations mentioned above suggest the following:

- Water within and in the vicinity of the CrPZ-2b well screen is not significantly affected by pumping of CrEX-3, nor is it reaching R-28 in detectable proportions, even when CrEX-3 is pumping. This water is either flowing off to the northeast of R-28 or perhaps it is staying deep in the Tjfp formation (the stratigraphic interval in which the well screen of CrPZ-2b sits), below the stratigraphy in the well screens of both R-28 [Tfp and Tfp(p)] and CrEX-3 (Tfp).
- Water within and in the vicinity of the R-28 well screen is flowing rapidly enough to the east or northeast and is not being drawn substantially into CrEX-3, even when CrEX-3 is actively being pumped. To date, no signature of tracer injected into R-28 is detectable in R-45. Future sampling at CrIN-1, CrIN-2, and CrEX-5 and ongoing sampling at R-45 will include R-28 tracers in the analyte suite.

- Traced water within and in the vicinity of the R-42 well screen has not been detected in any monitoring wells or extraction wells, to date. This result is not surprising given the distance from R-42 to potential observation wells. It is perhaps also not surprising given that the signal from the $NaHCO_3/Na_2CO_3$ solution injected in 2016 would be rather weak (no tracers), and most of the dithionite solution injected in 2017 was pumped back from R-42 after it was injected. Future sampling at CrEX-4 (when CrEX-4 is incorporated in the IM operations) will include R-42 tracers in the analyte suite.

3.4 Water-Table Map

Water-table maps are presented as an additional line of evidence in evaluating IM performance and interpreting potential changes in concentrations of key constituents in performance monitoring wells and piezometers. Long-term pumping and injection at IM infrastructure wells may affect the structure of the water table over time in the form of drawdown around extraction wells and mounding around injection wells. The relation of changes in the water table, chromium concentrations, and tracer breakthrough provide insights into overall IM performance.

For this semiannual report, a water-table map depicting average water levels for November 2018 is provided (Figure 3.4-1). For comparison, a map showing the water table for May 1, 2018, is provided as a baseline condition with little to no influence from IM operational pumping or injection (Figure 3.4-2). These maps do not include data from the injection and extraction wells because there is no way to extrapolate in-well transducer data to a water level elevation in the aquifer around the wells. A comparison of the two maps shows that a small depression in the water table is forming around the three IM extraction wells (CrEX-1, CrEX-2, and CrEX-3) that have been pumping continuously since May 2018 (CrEX-1 and CrEX-2) or discontinuously since May 2018 (CrEX-3, see section 2.1.1). The decline in the water-table elevation and its location and configuration is an interpretation based on head data from surrounding monitoring wells that are used in the water-table map.

Table 3.4-1 presents water levels and head difference for dual-screen locations within the chromium project area. All dual screen locations near where extraction and injection is occurring display subtle changes in water levels. These changes are currently too small to discern whether they are because of the effects of the IM pumping and extraction or water-supply pumping. These data and evaluation will be included in future reports.

4.0 DISCUSSION

Multiple lines of evidence are being used to evaluate the performance of the IM and the cause for effectiveness. These same data can also be used to inform adaptive management strategies that may need to be considered if the IM objectives are not being met. The primary line of evidence for IM performance will be trends in chromium concentrations in performance monitoring wells that indicate hydraulic capture compared with the long-term trend before IM operations. Additional lines of evidence that help interpret changes in chromium concentration include water-level data and tracer data from the injection well tracer tests.

It was stated in the IMWP (LANL 2015, 600458) that it may require up to 1 yr of continuous IM operation to see clear indication of plume response at performance monitoring wells. Based on the trends in chromium and various tracers in performance monitoring wells, it appears that IM operations along the southern portion of the plume have begun to establish hydraulic capture. Based on data presented for R-50 S1 in section 3.2, an approximation of the current location of the 50-ppb chromium plume edge is provided in Figure 4.0-1.

5.0 RECOMMENDATIONS

There are no indications at this point that the operational approach of the IM at the southern boundary should be changed. Reconfiguration of CrIN-6 to CrEX-5 and tie-in to the central treatment system is expected to occur in the late spring to early summer 2019 timeframe and will enable start-up of the entire IM. A new monitoring well, R-70, will also be installed in the spring 2019 timeframe and will be added to the list of performance monitoring wells sampled on a monthly basis for a suite consistent with other performance monitoring wells.

6.0 REFERENCES AND MAP DATA SOURCES

6.1 References

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

LANL (Los Alamos National Laboratory), May 2015. "Interim Measures Work Plan for Chromium Plume Control," Los Alamos National Laboratory document LA-UR-15-23126, Los Alamos, New Mexico. (LANL 2015, 600458)

LANL (Los Alamos National Laboratory), March 2018. "Compendium of Technical Reports Conducted Under the Work Plan for Chromium Plume Center Characterization," Los Alamos National Laboratory document LA-UR-18-21450, Los Alamos, New Mexico. (LANL 2018, 602964)

LANL (Los Alamos National Laboratory), April 2018. "Chromium Plume Control Interim Measure Performance Monitoring Work Plan," Los Alamos National Laboratory document LA-UR-18-23082, Los Alamos, New Mexico. (LANL 2018, 603010)

LANL (Los Alamos National Laboratory), April 2018. "Evaluation of Chromium Plume Control Interim Measure Operational Alternatives for Injection Well CrIN-6," Los Alamos National Laboratory document LA-UR-18-23385, Los Alamos, New Mexico. (LANL 2018, 603032)

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), May 2018. "Interim Facility-Wide Groundwater Monitoring Plan for the 2019 Monitoring Year, October 2018-September 2019," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2018-0004, Los Alamos, New Mexico. (N3B 2018, 700000)

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), September 2018. "Annual Progress Report on Chromium Plume Control Interim Measure Performance," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2018-0028, Los Alamos, New Mexico. (N3B 2018, 700088)

NMED (New Mexico Environment Department), June 6, 2018. "Evaluation of Chromium Plume Control Interim Measure Operational Alternatives," New Mexico Environment Department letter to D. Hintze (DOE-EM-LA) and J. Legare (N3B) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico. (NMED 2018, 700011)

6.2 Map Data Sources

Hillshade; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\Data\HYP\LiDAR\2014\Bare_Earth\BareEarth_DEM_Mosaic.gdb; 2014.

Unpaved roads; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\14-Projects\14-0062\project_data.gdb\digitized_site_features\digitized_roads; 2017.

Drainage channel; Los Alamos National Laboratory, ER-ES, As published, GIS projects folder; \\slip\gis\GIS\Projects\15-Projects\15-0080\project_data.gdb\correct_drainage; 2017.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Paved Road Arcs; Los Alamos National Laboratory, FWO Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Chromium plume > 50 ppb; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\13-Projects\13-0065\shp\chromium_plume_2.shp; 2018.

Regional groundwater contour May 2017, 4-ft interval; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\16-Projects\16-0027\project_data.gdb\line\contour_wl2017may_2ft; 2017.

Regional groundwater contour November 2017, 2-ft interval; Los Alamos National Laboratory, ER-ES, As published; \\slip\gis\GIS\Projects\16-Projects\16-0027\project_data.gdb\line\contour_wl2017nov_2ft; 2017.

Point features; As published; EIM data pull; 2017.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010.

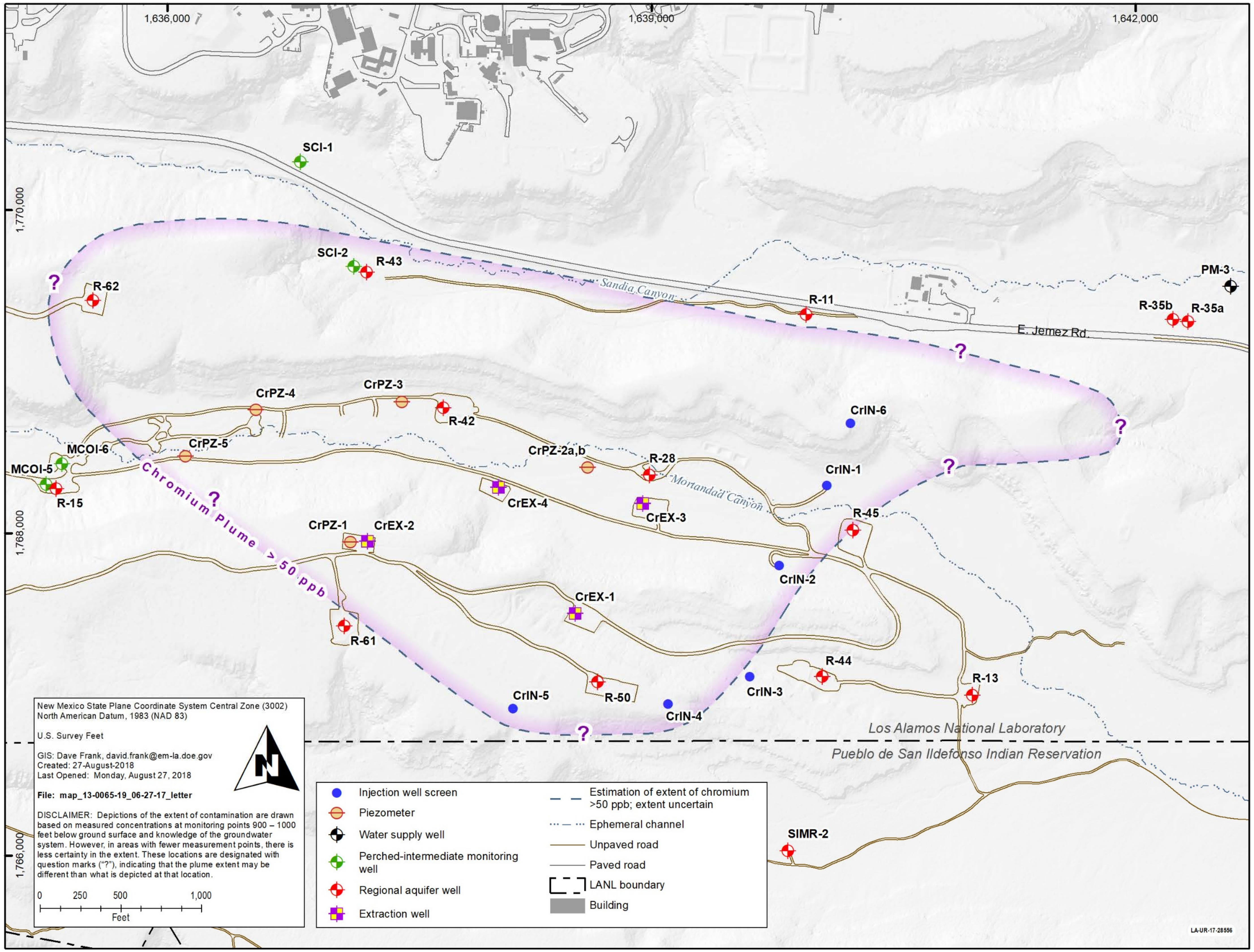
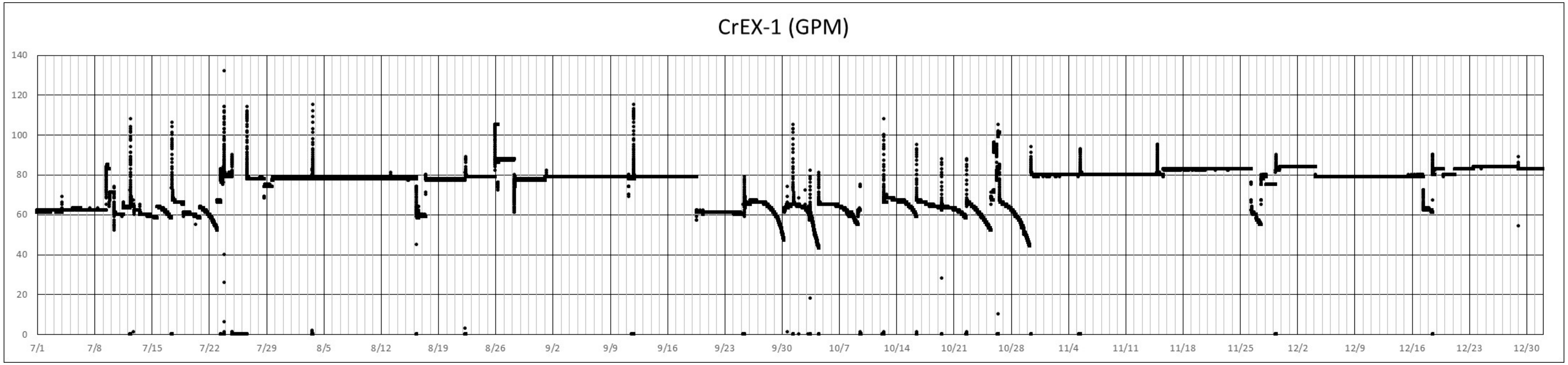


Figure 1.0-1 Chromium project area map



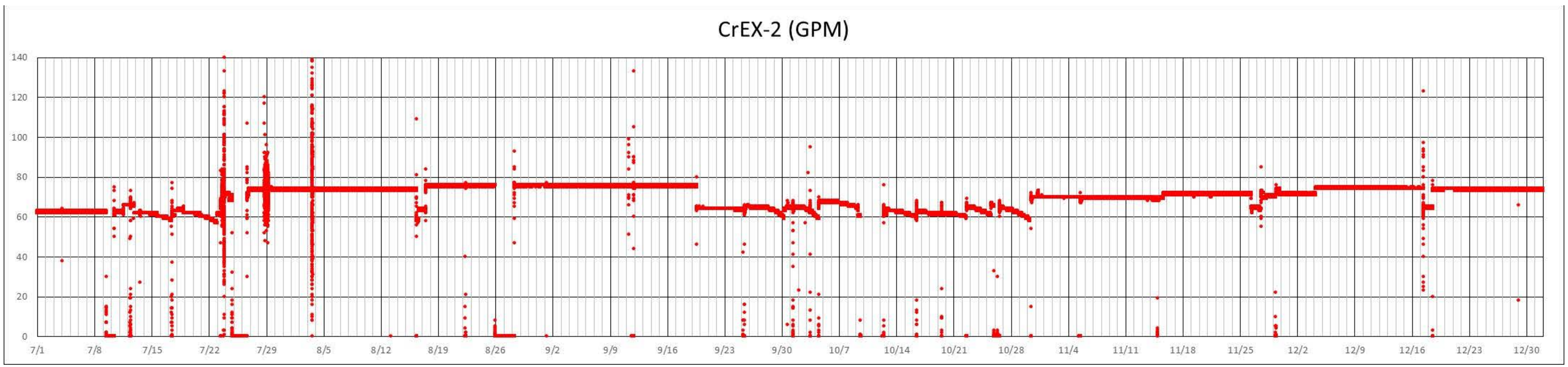


Figure 2.1-1 Flow rates for the CrEX wells July 1 through December 31, 2018

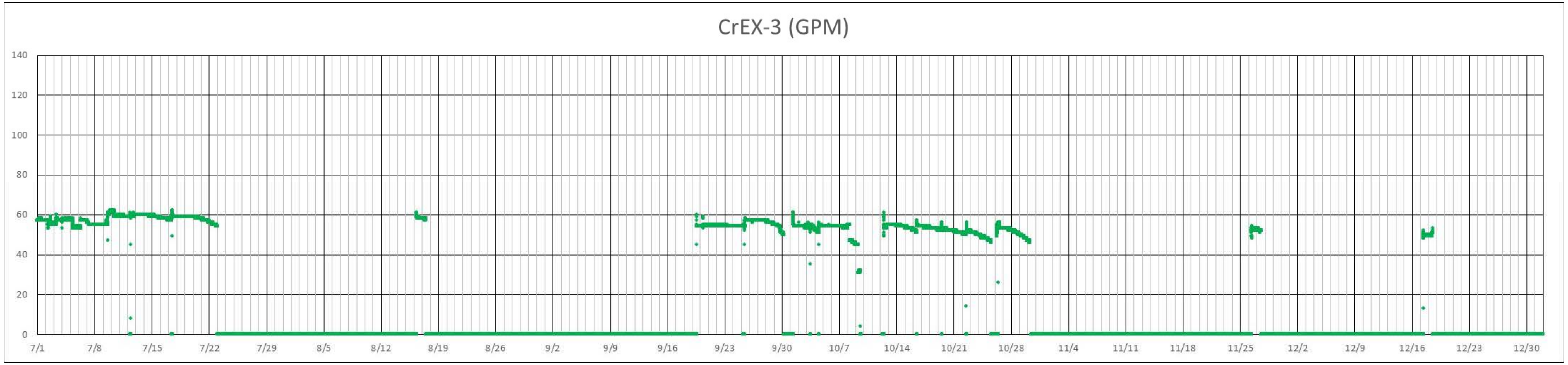
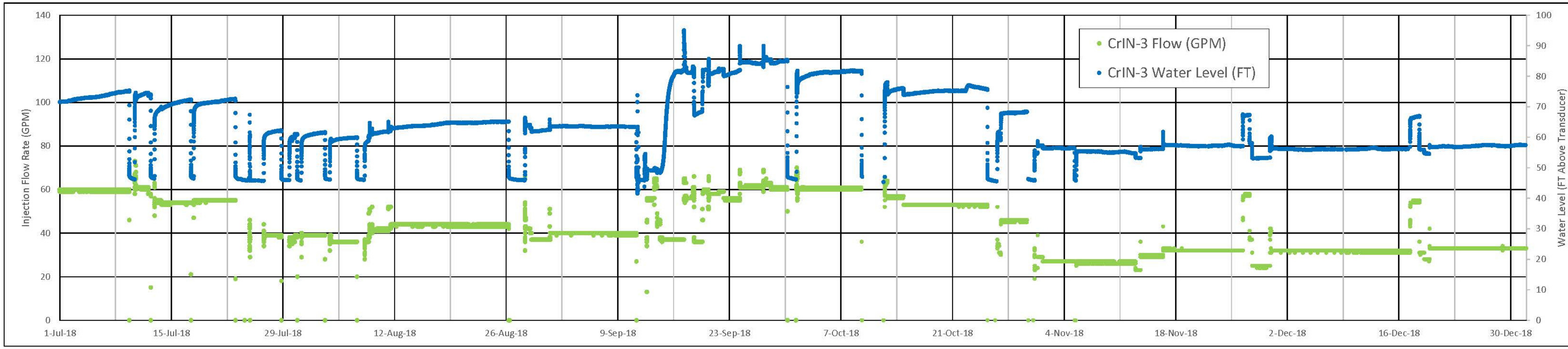


Figure 2.1-1 (continued) **Flow rates for the CrEX wells July 1 through December 31, 2018**



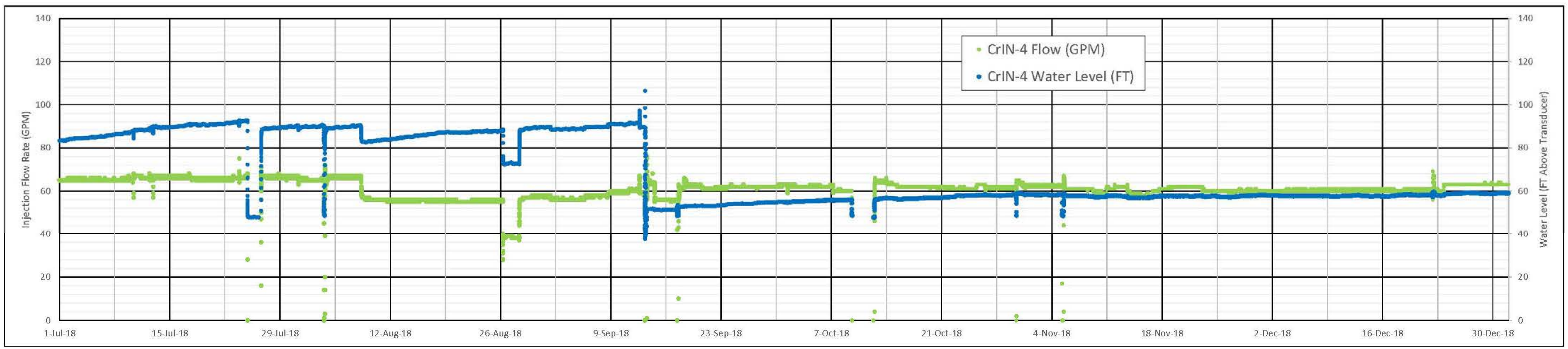


Figure 2.1-2 Injection well flow rates and water levels for CrIN-3, CrIN-4, and CrIN-5

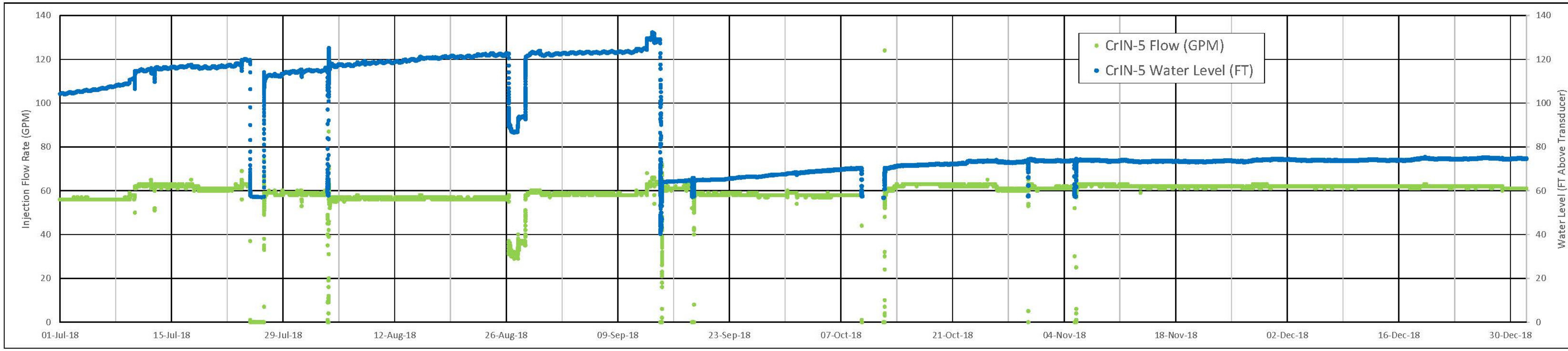


Figure 2.1-2 (continued) **Injection well flow rates and water levels for CrIN-3, CrIN-4, and CrIN-5**

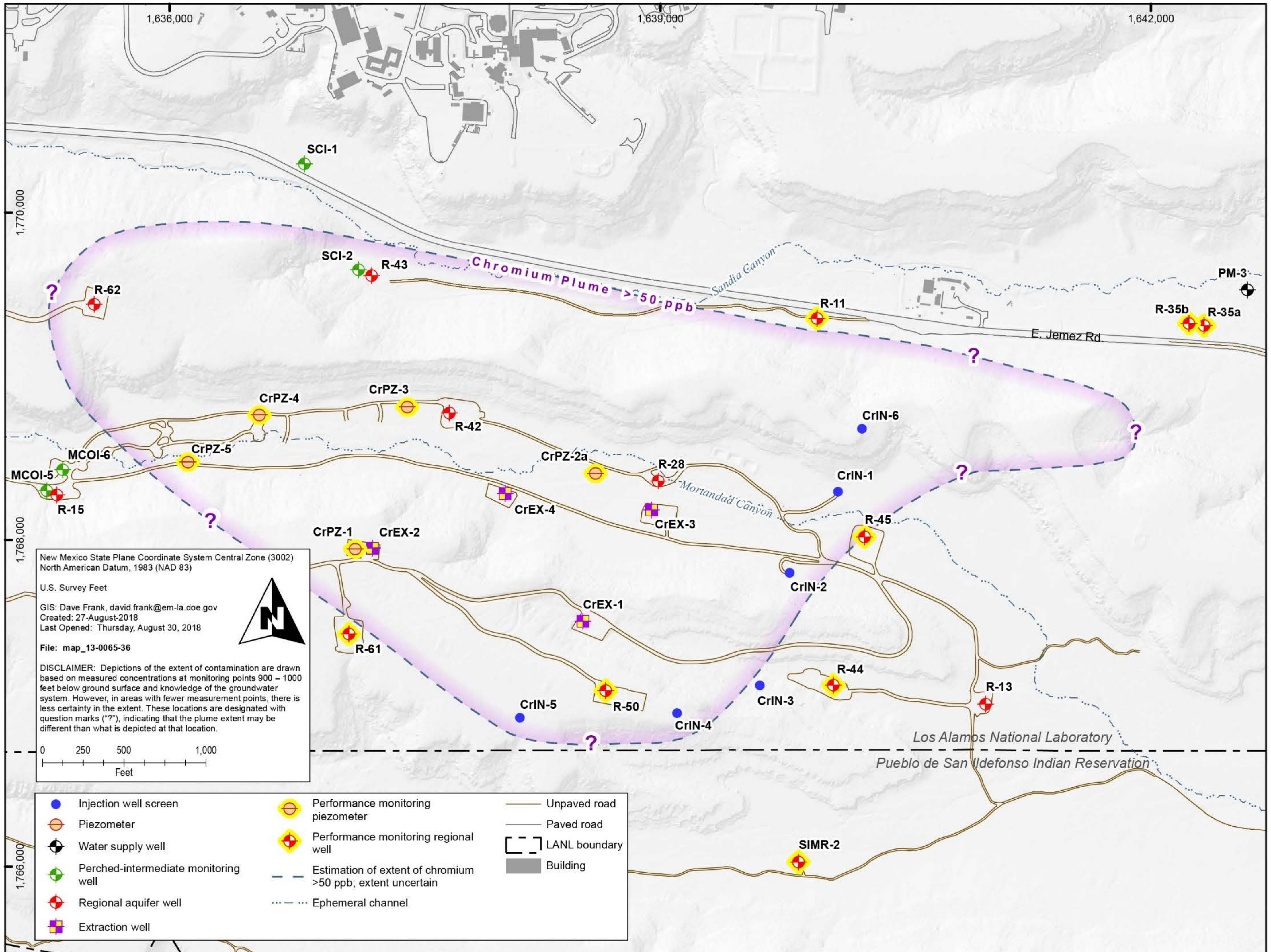
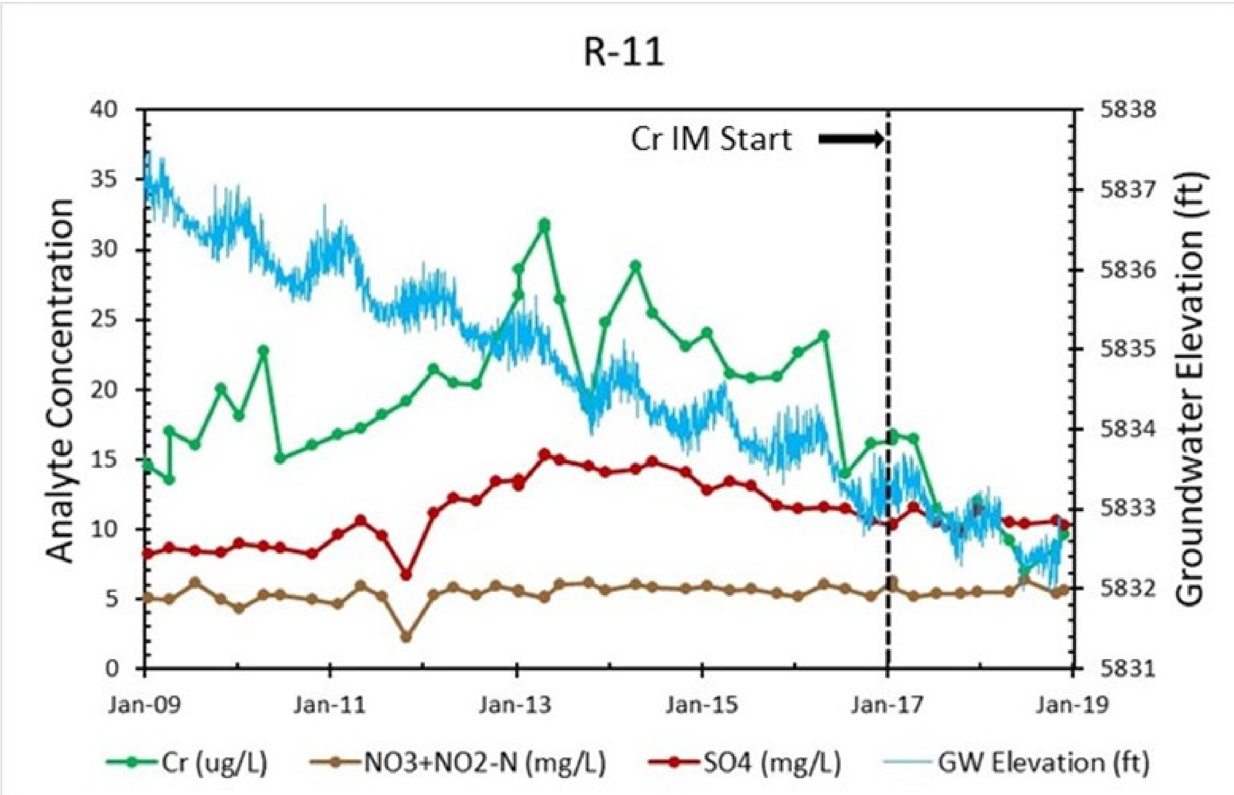


Figure 3.1-1 Locations of all wells in the chromium plume area, including performance monitoring wells and piezometers



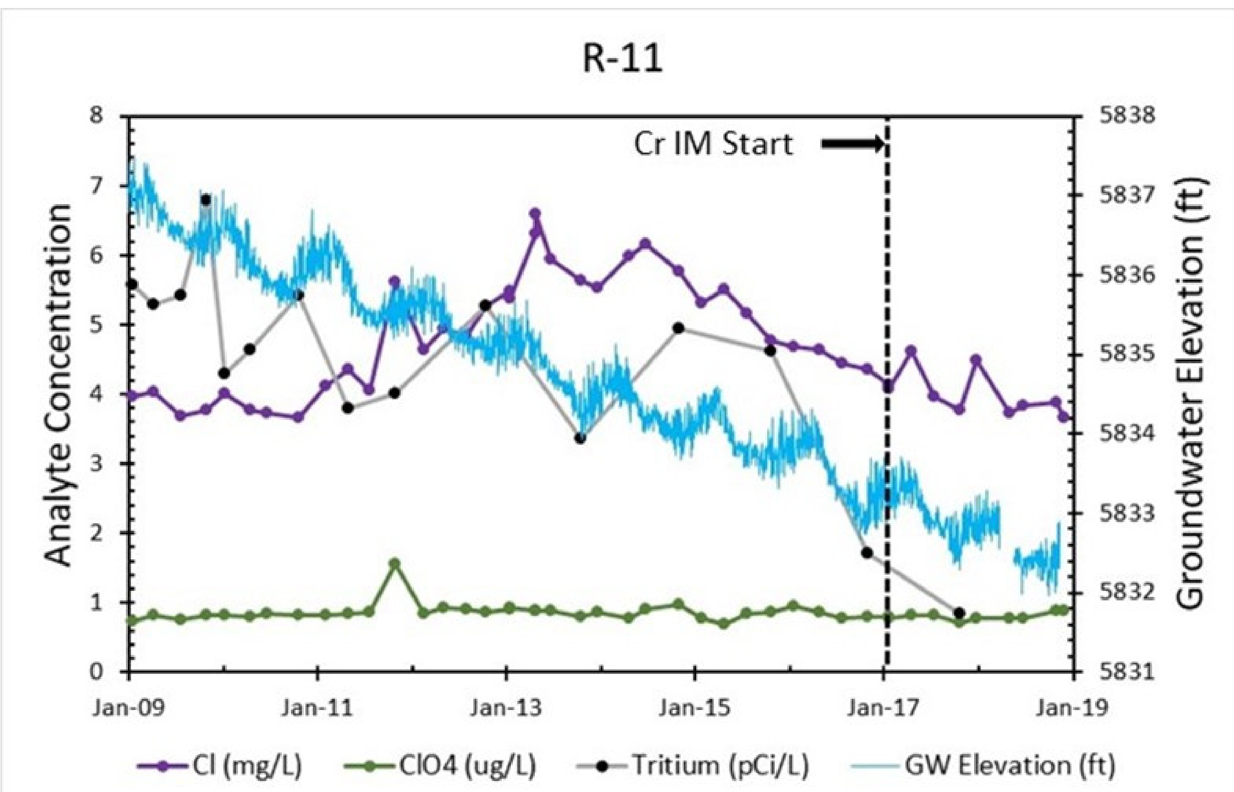
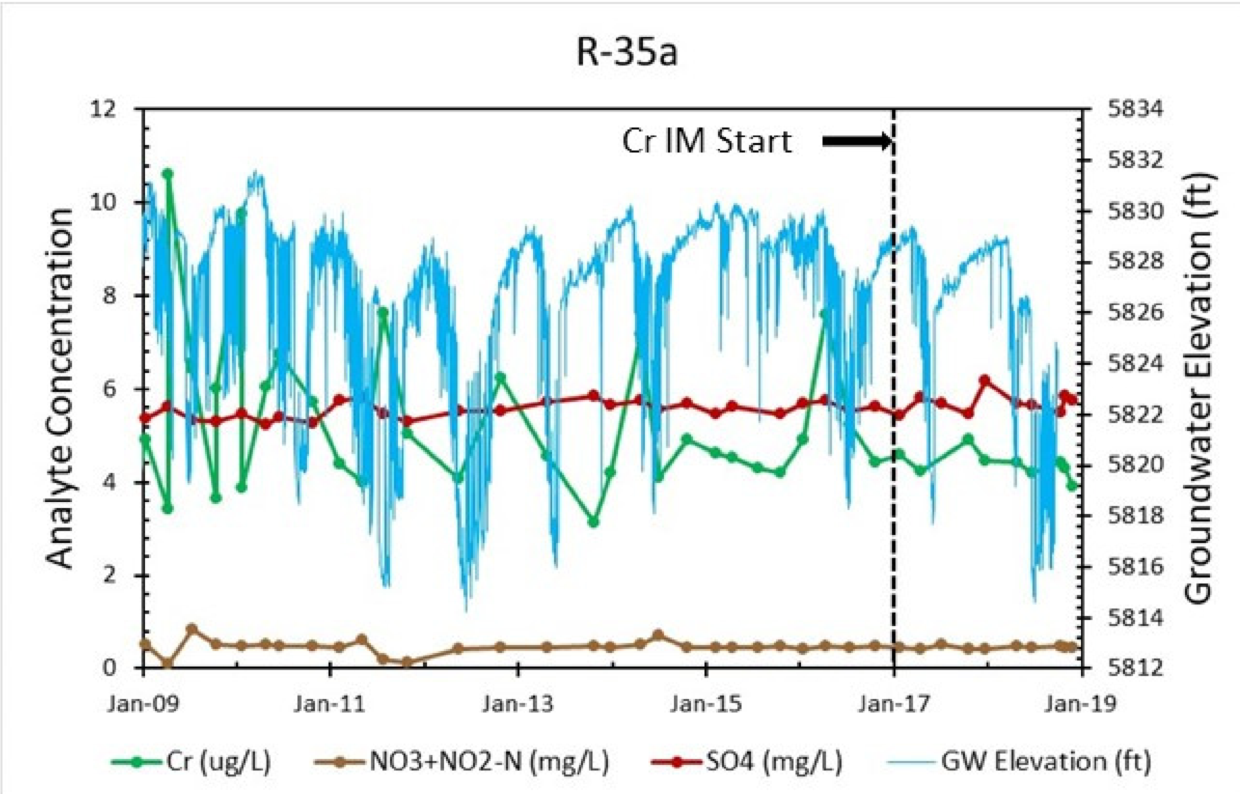
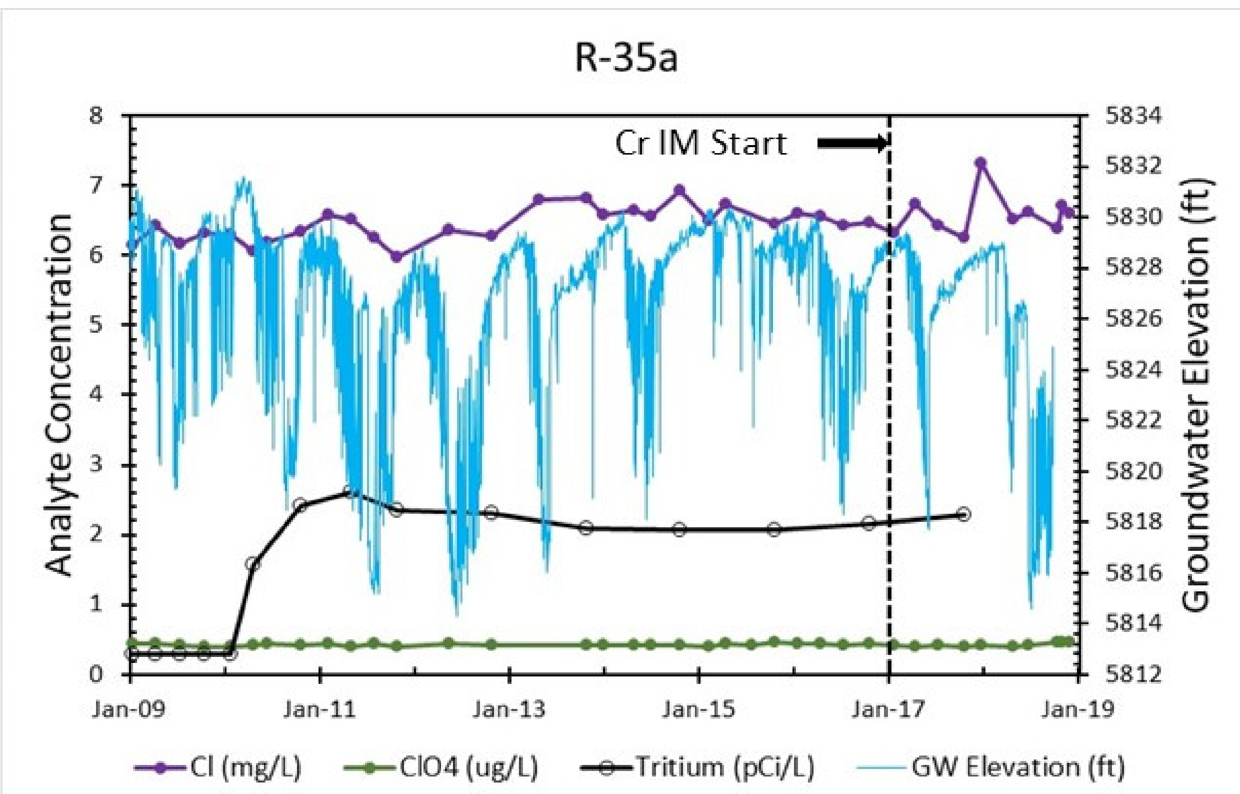


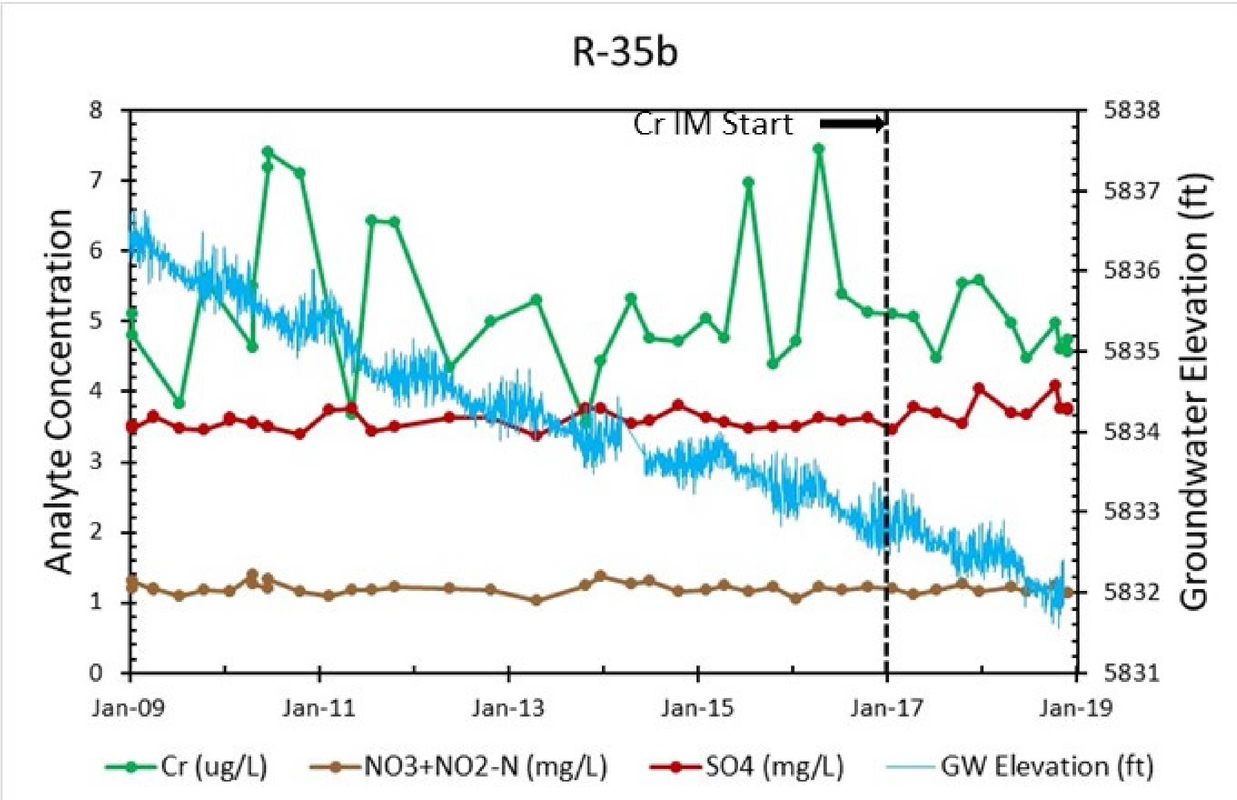
Figure 3.2-1 Time-series plots for R-11

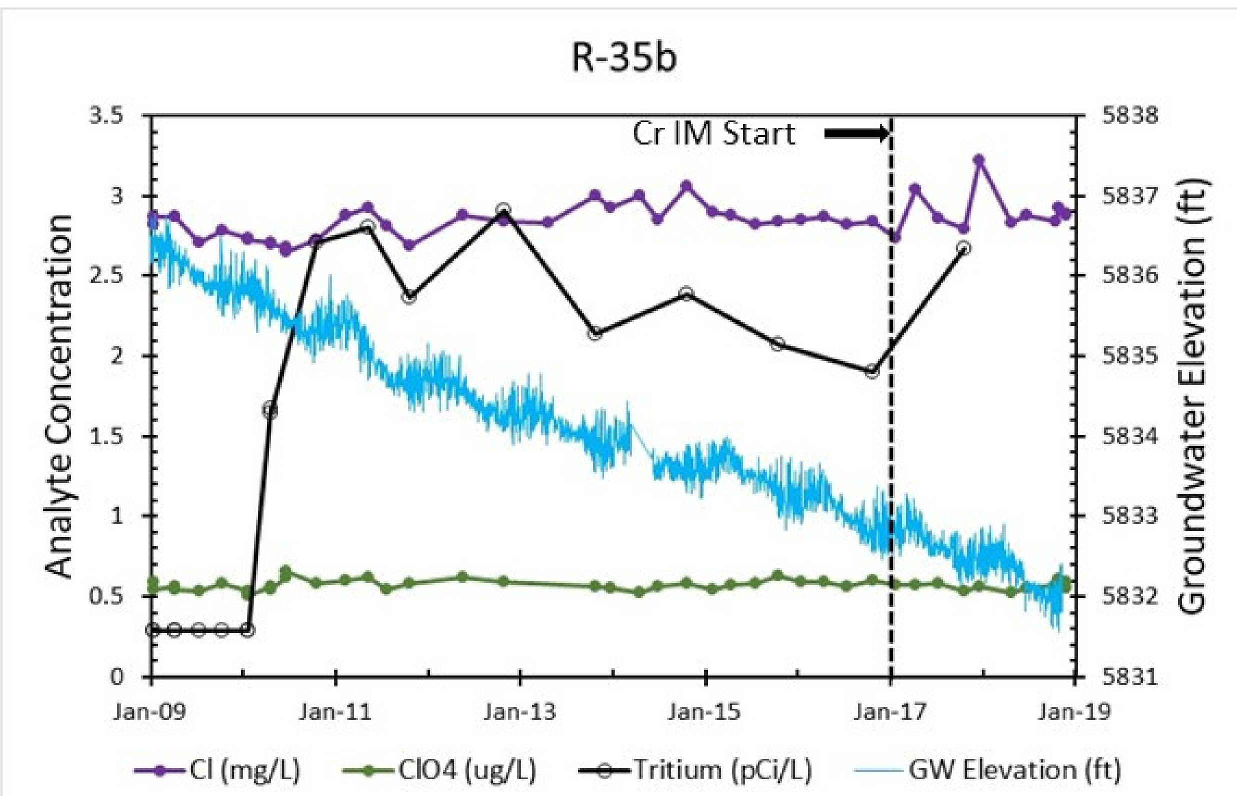




Note: Data represented by open circles are nondetect at the plotted value.

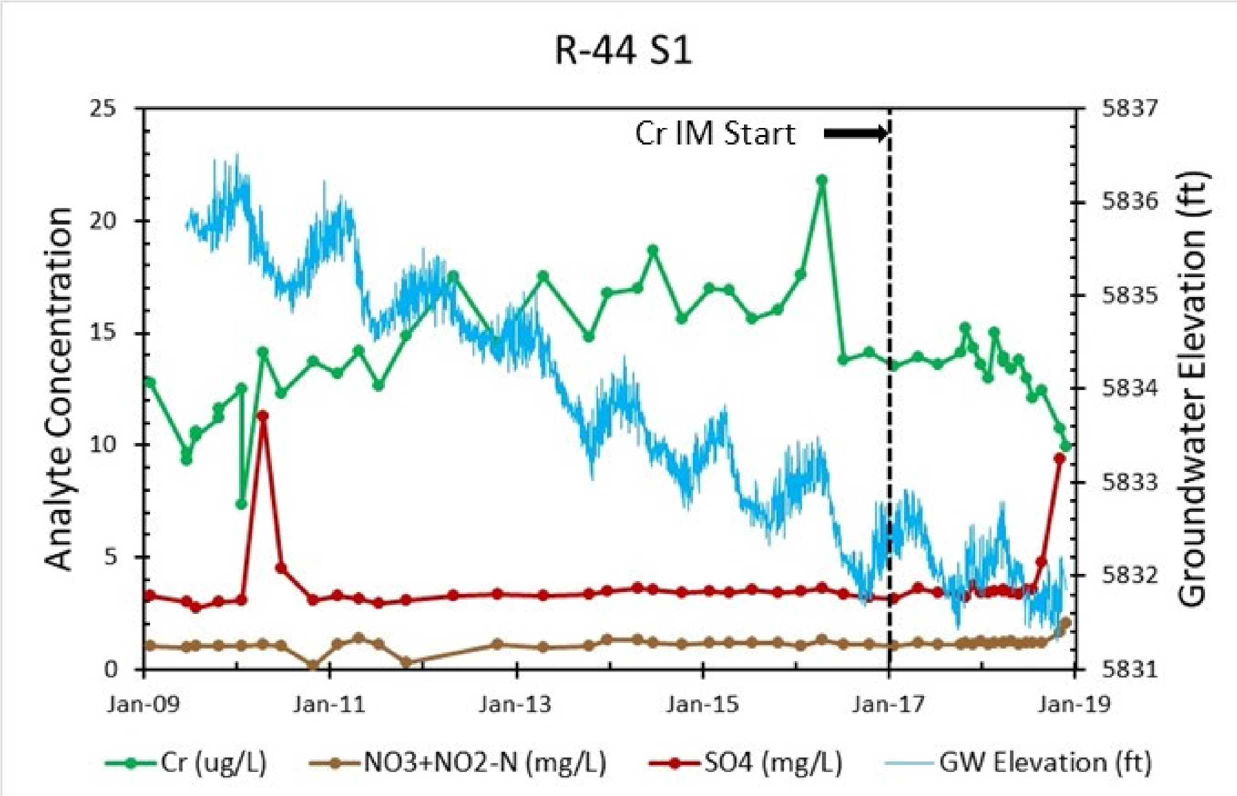
Figure 3.2-2 Time-series plots for R-35a

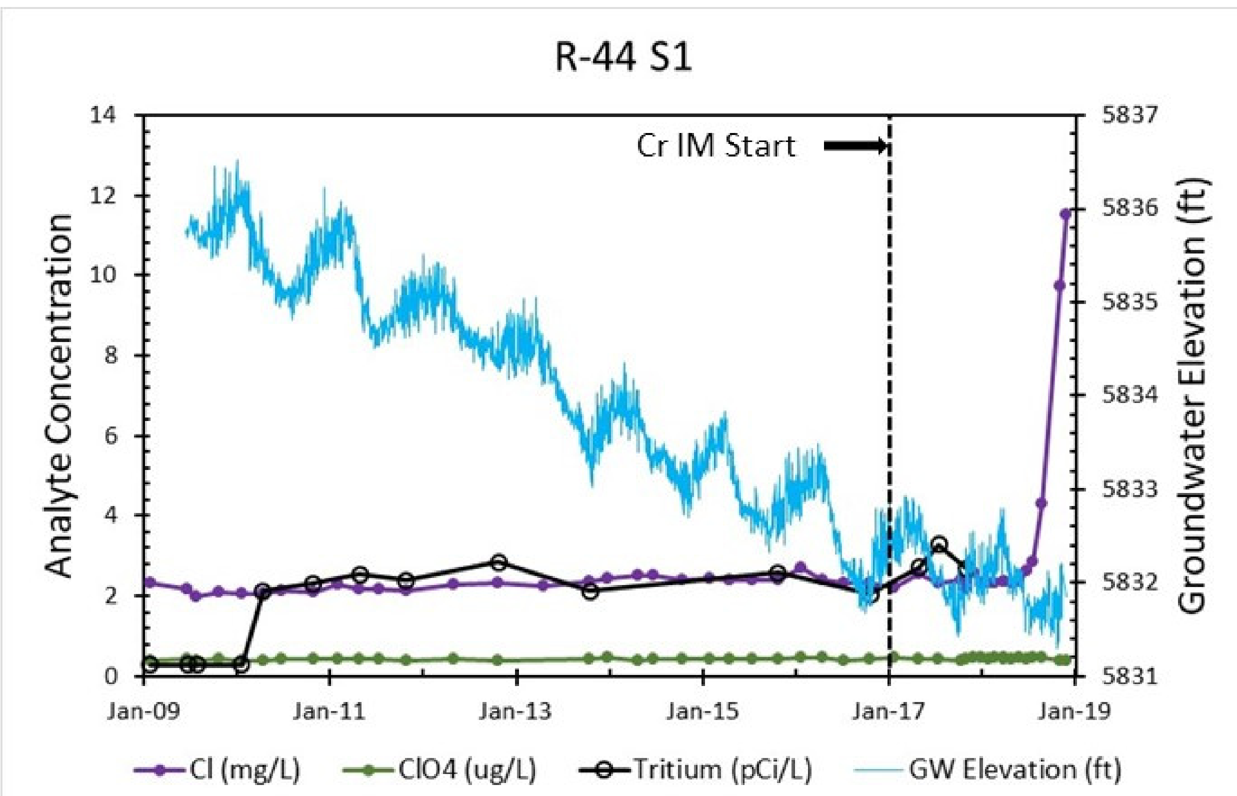




Note: Data represented by open circles are nondetect at the plotted value.

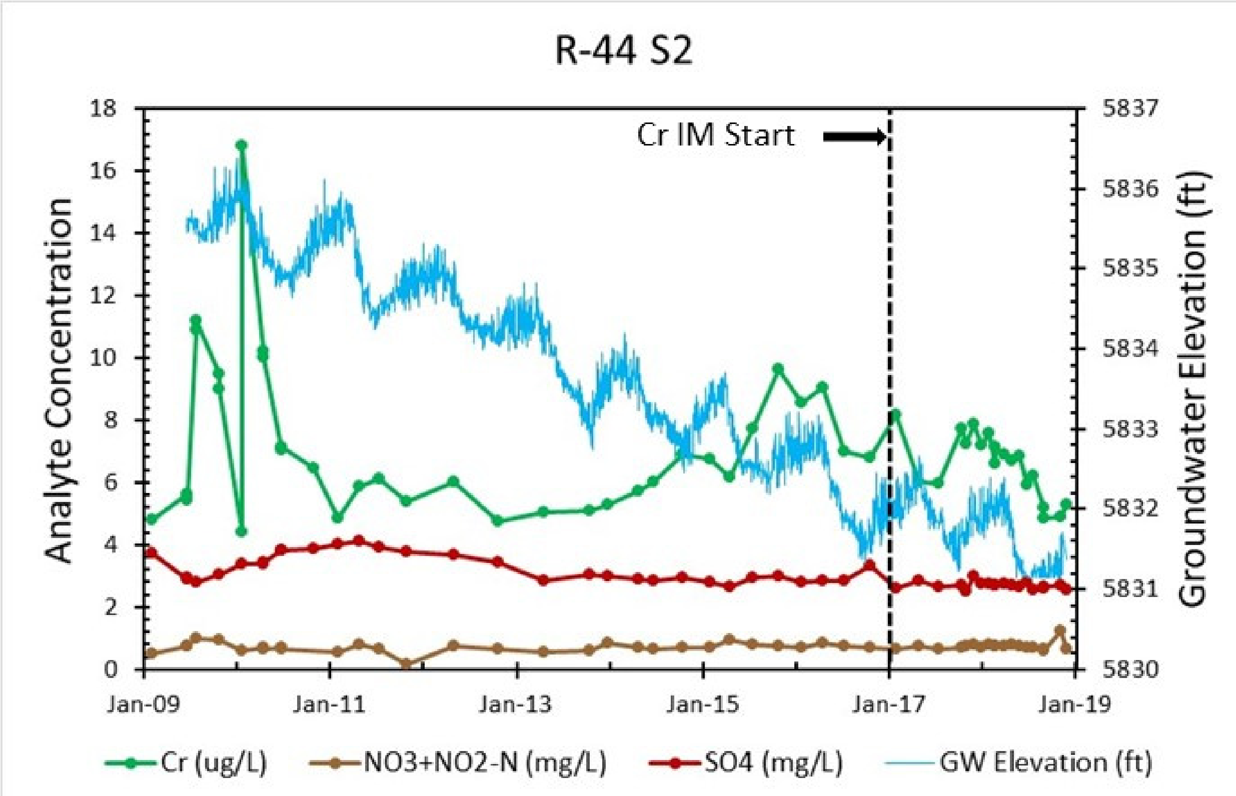
Figure 3.2-3 Time-series plots for R-35b

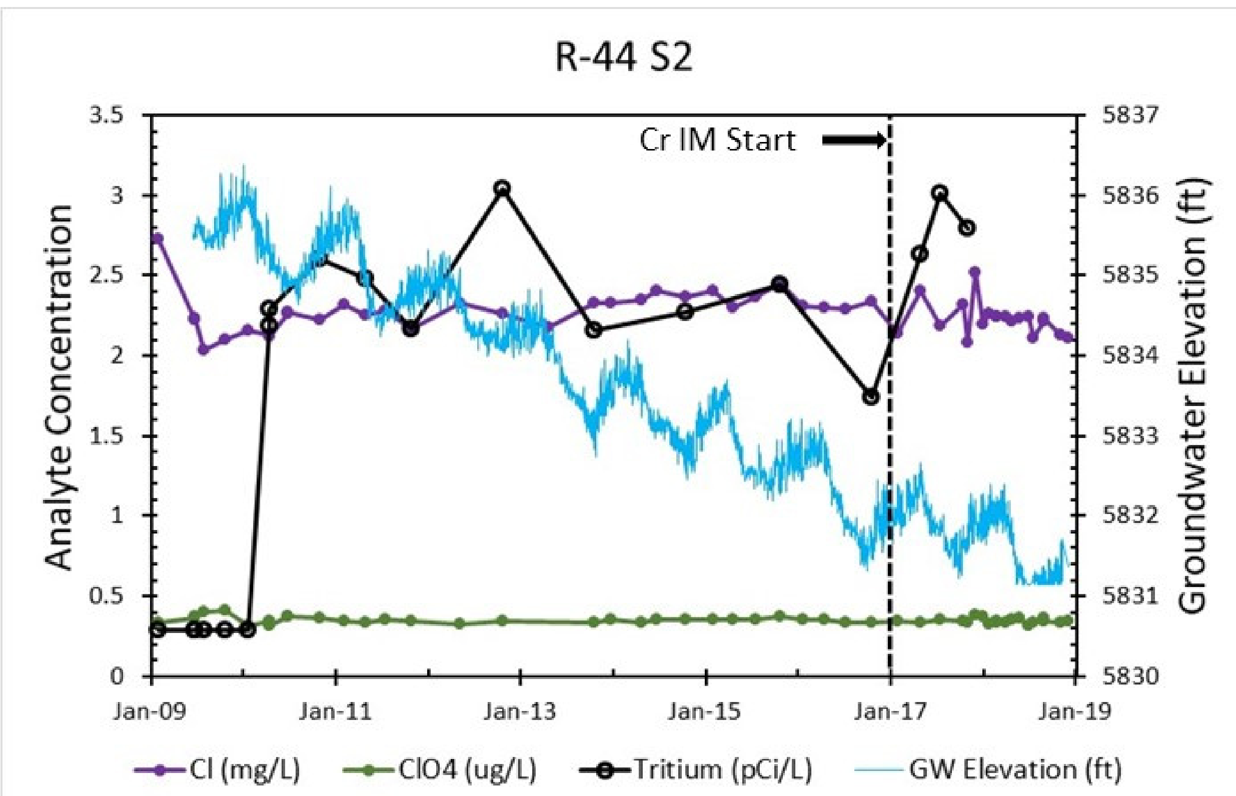




Note: Data represented by open circles are nondetect at the plotted value.

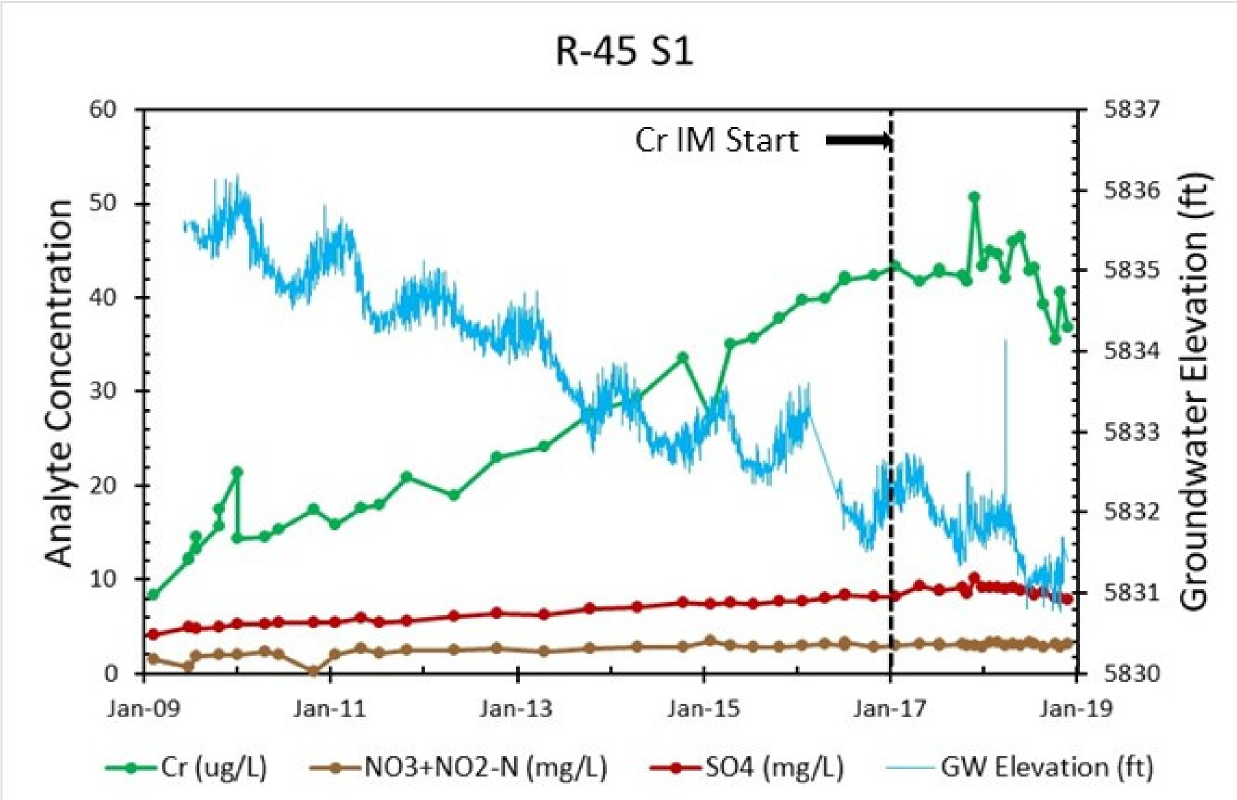
Figure 3.2-4 Time-series plots for R-44 S1

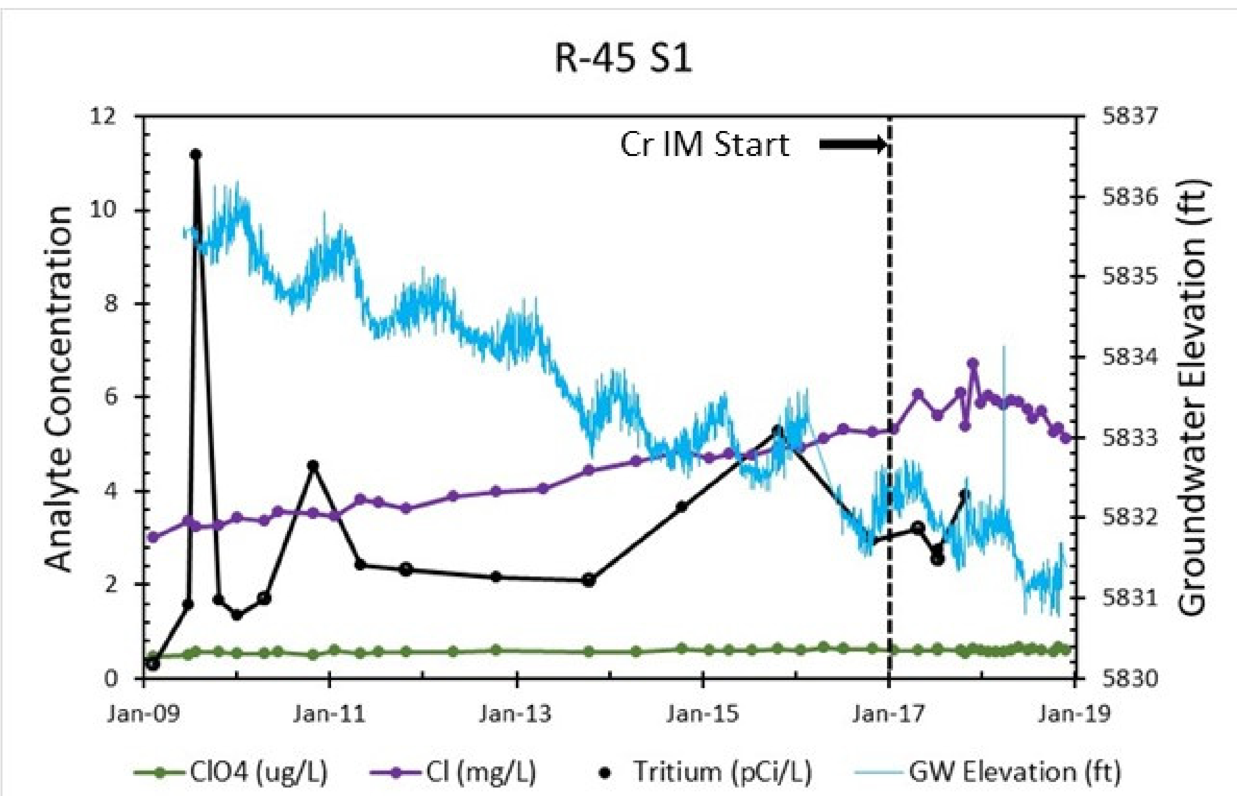




Note: Data represented by open circles are nondetect at the plotted value.

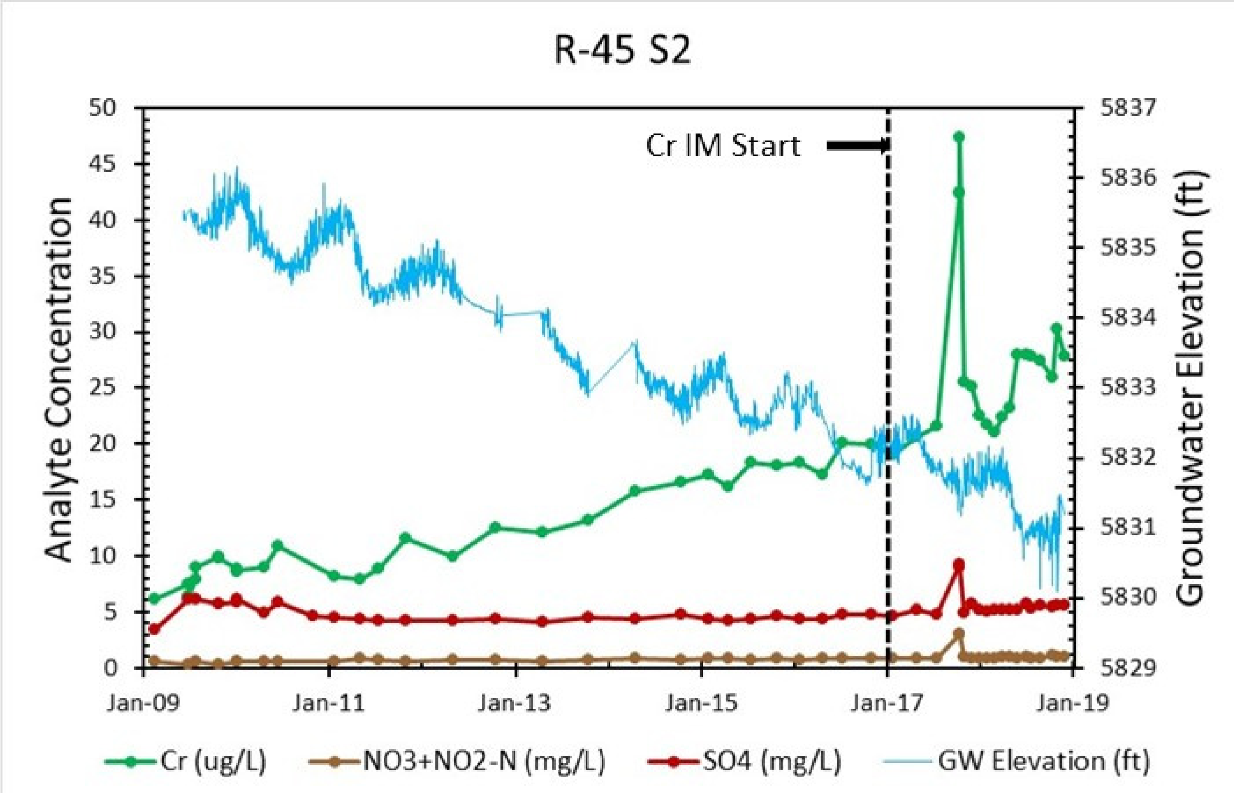
Figure 3.2-5 Time-series plots for R-44 S2

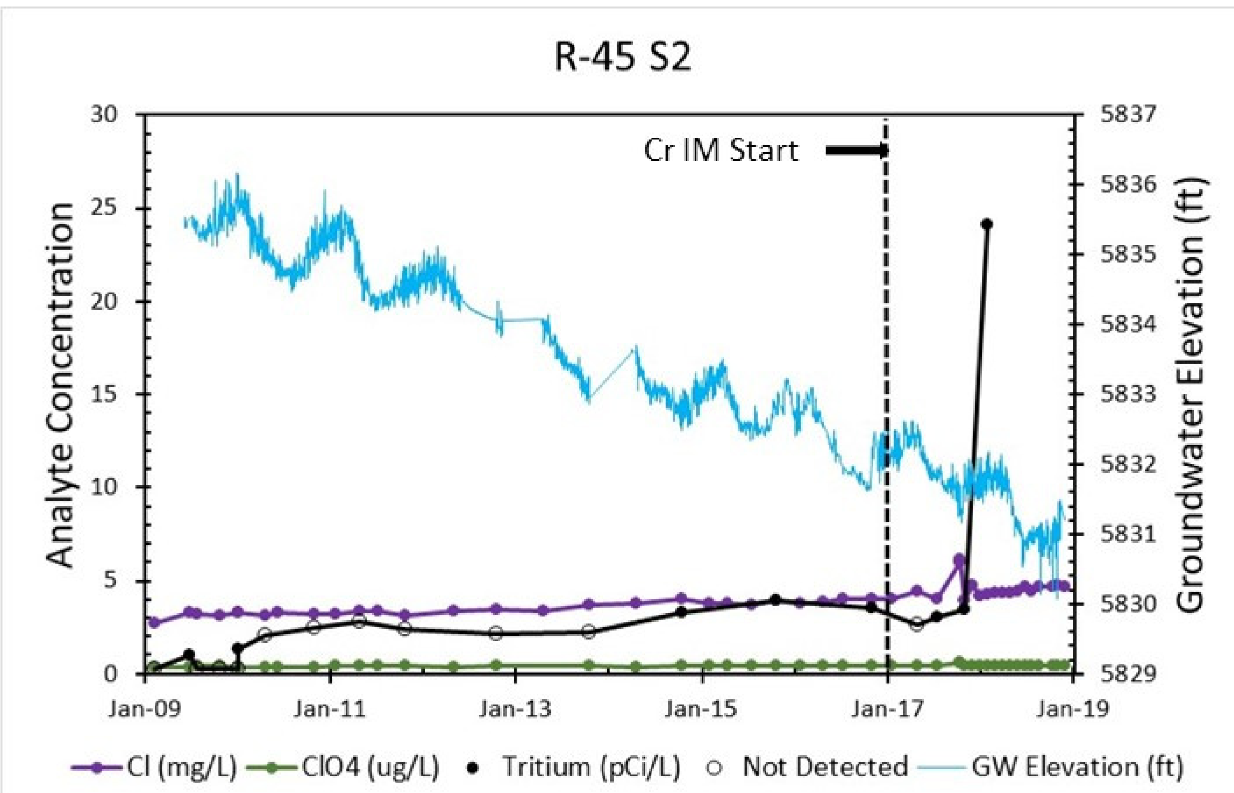




Note: Data represented by open circles are nondetect at the plotted value.

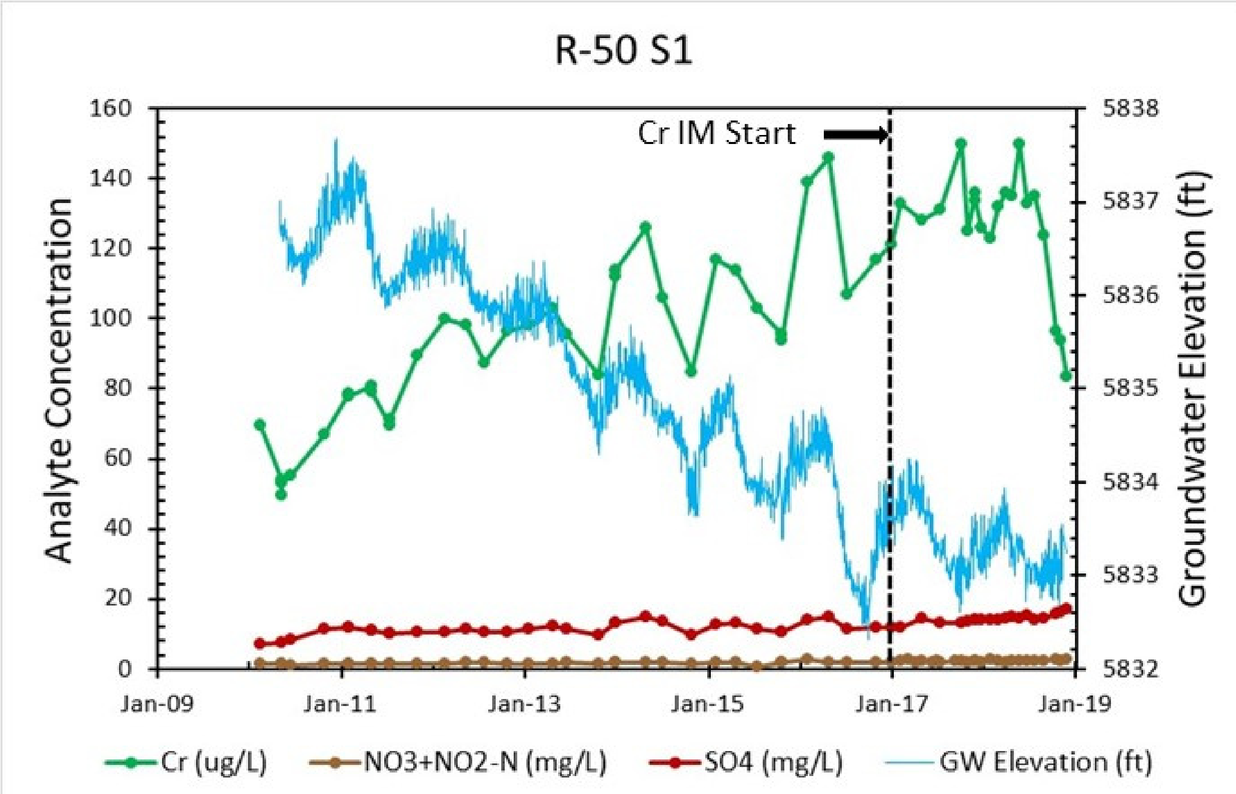
Figure 3.2-6 Time-series plots for R-45 S1





Note: Data represented by open circles are nondetect at the plotted value.

Figure 3.2-7 Time-series plots for R-45 S2



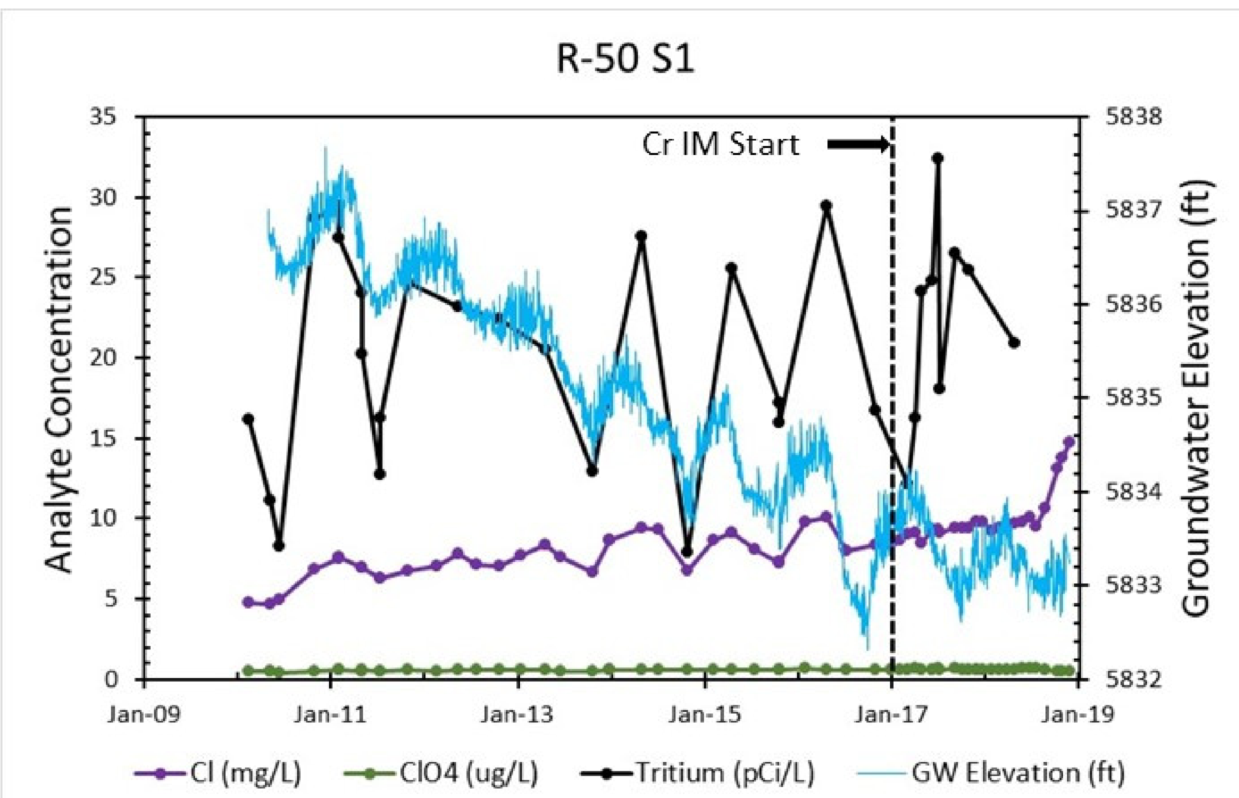
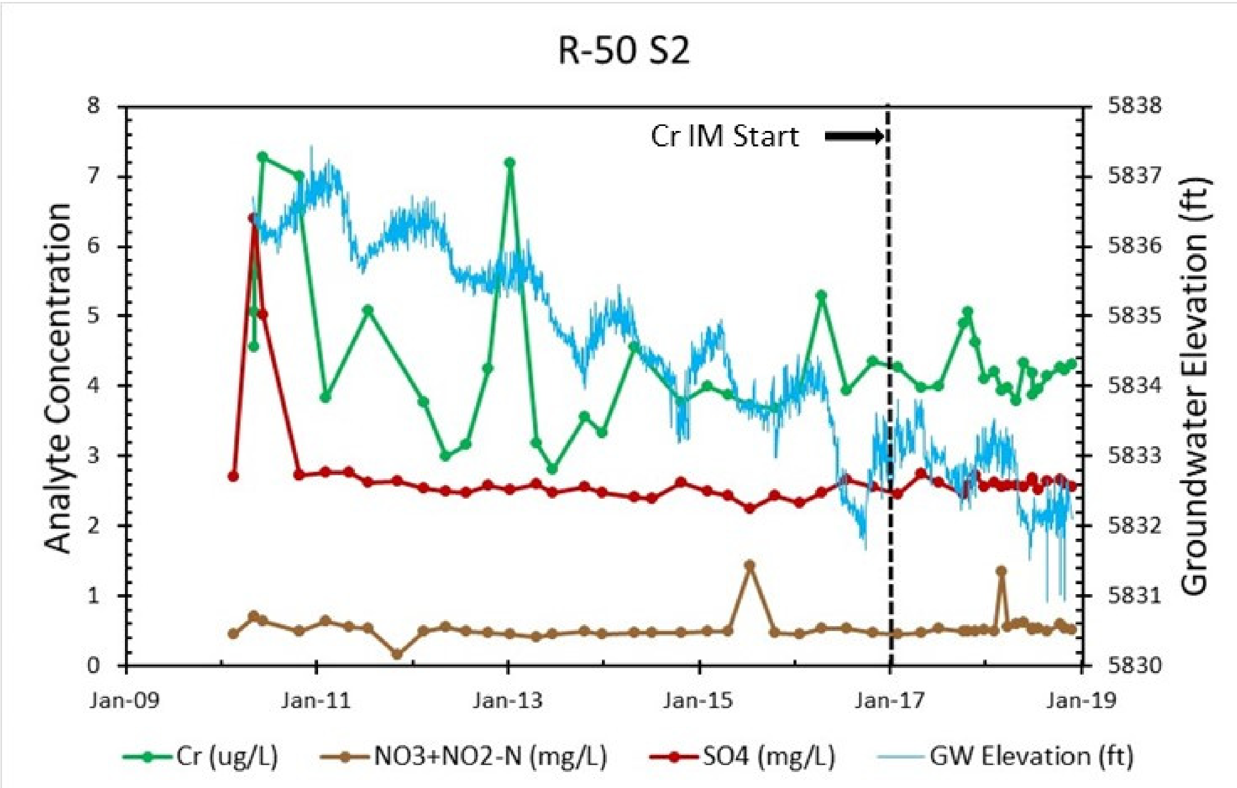
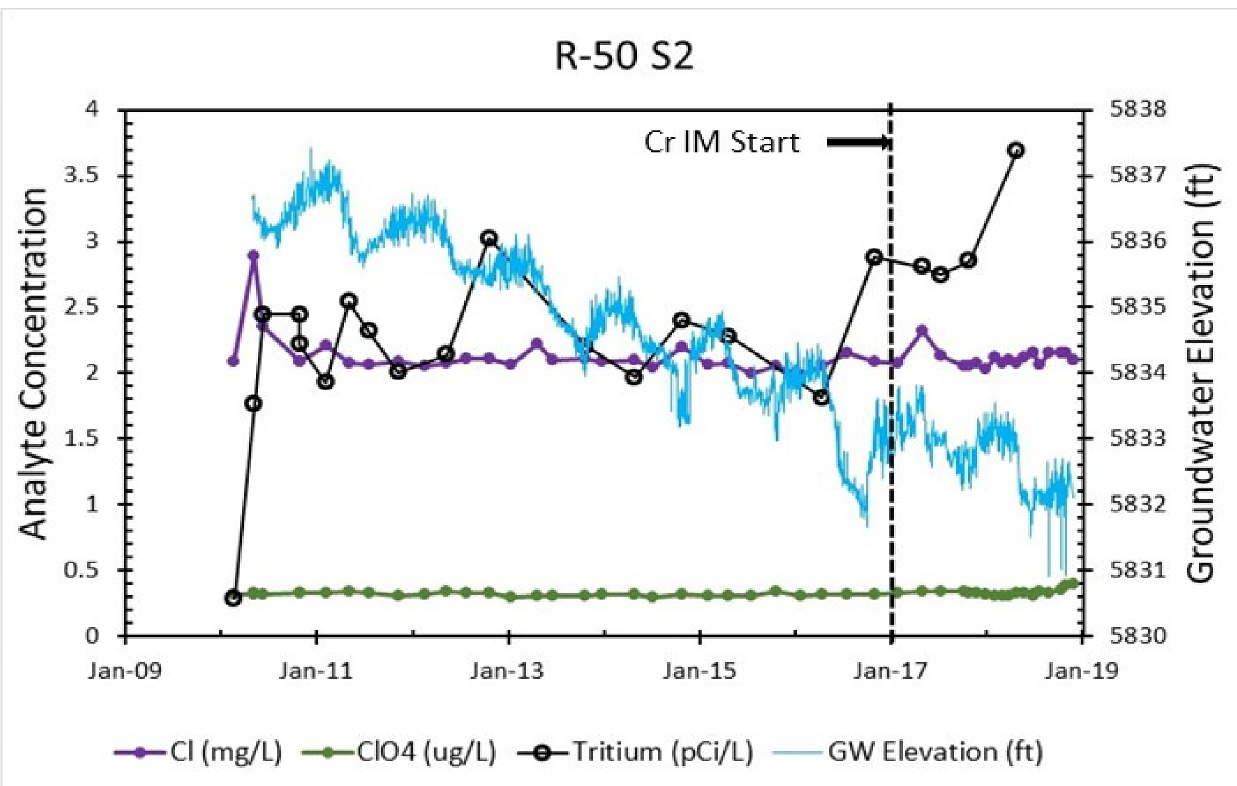


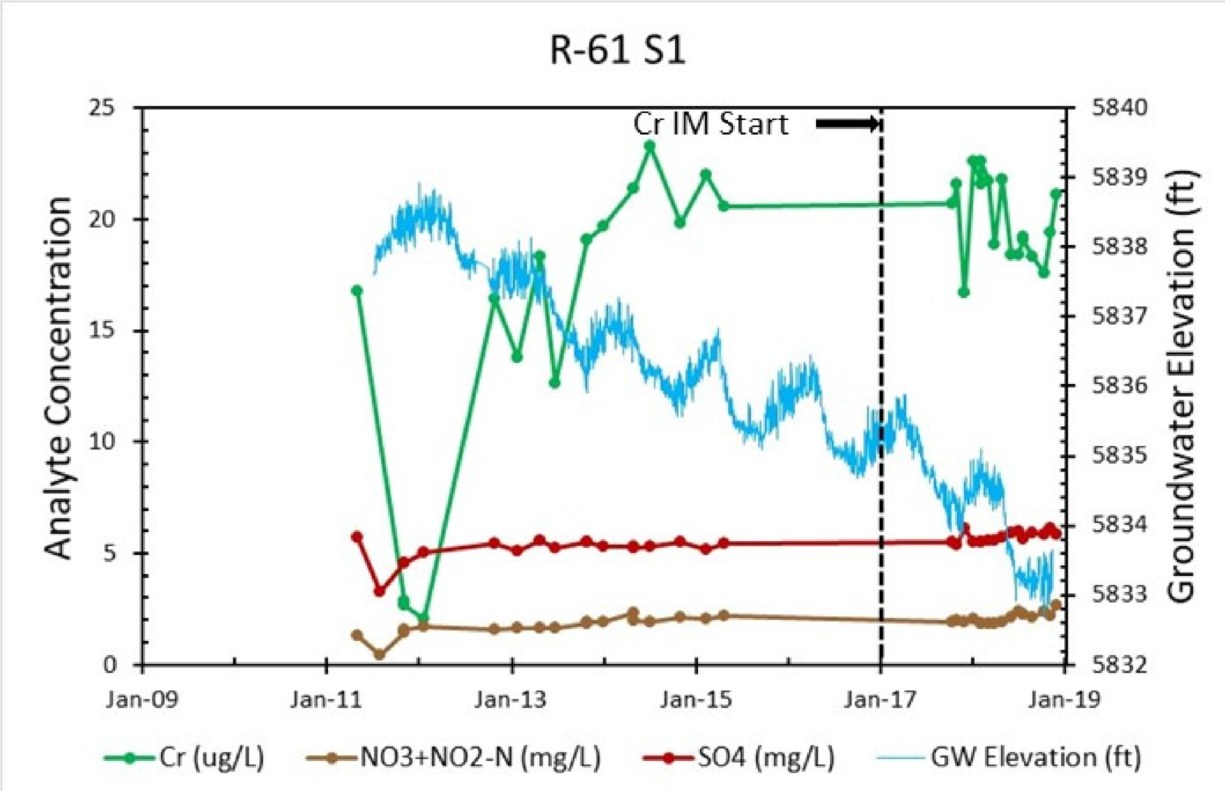
Figure 3.2-8 Time-series plots for R-50 S1

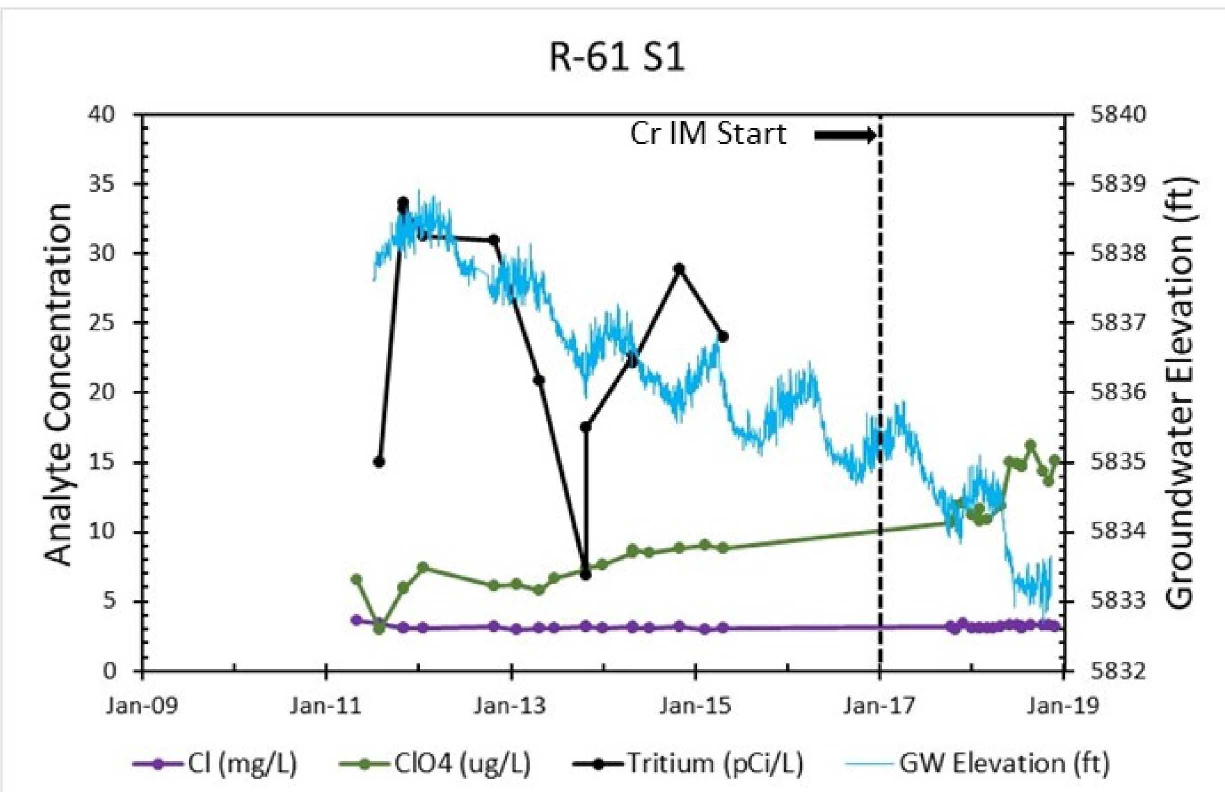




Note: Data represented by open circles are nondetect at the plotted value.

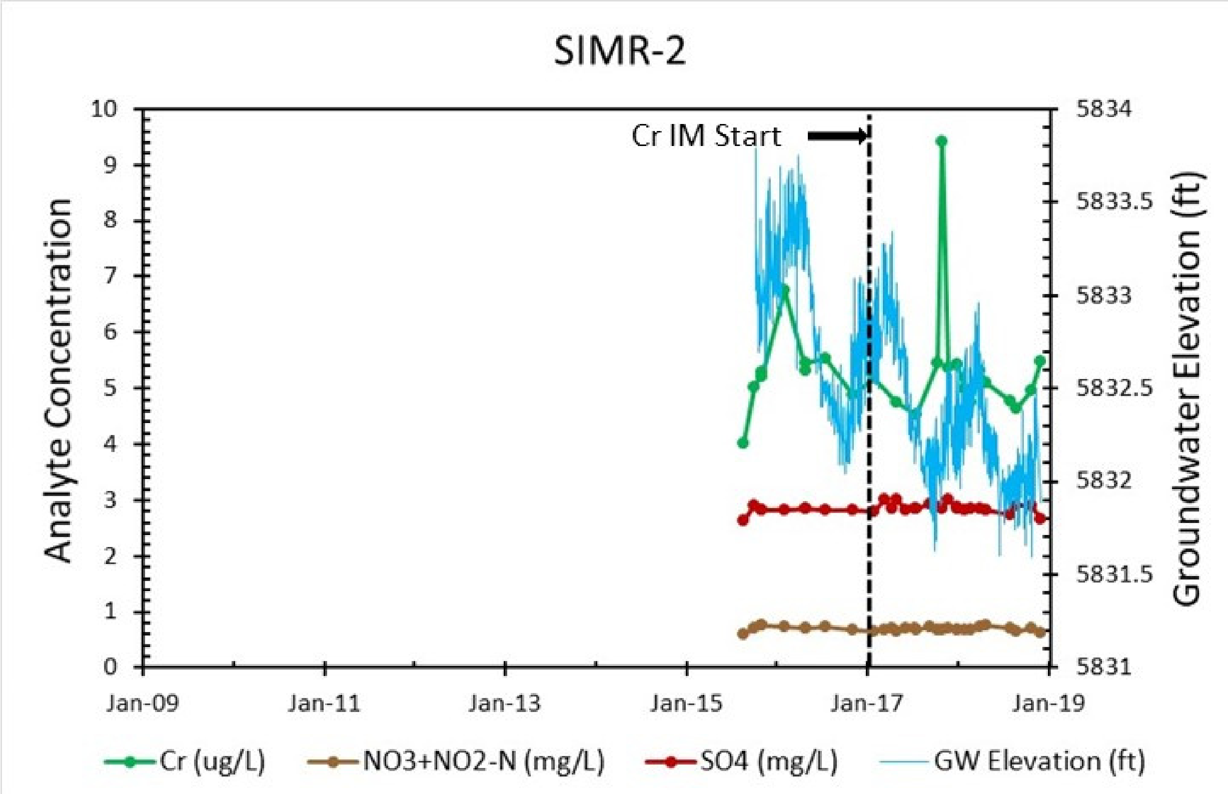
Figure 3.2-9 Time-series plots for R-50 S2

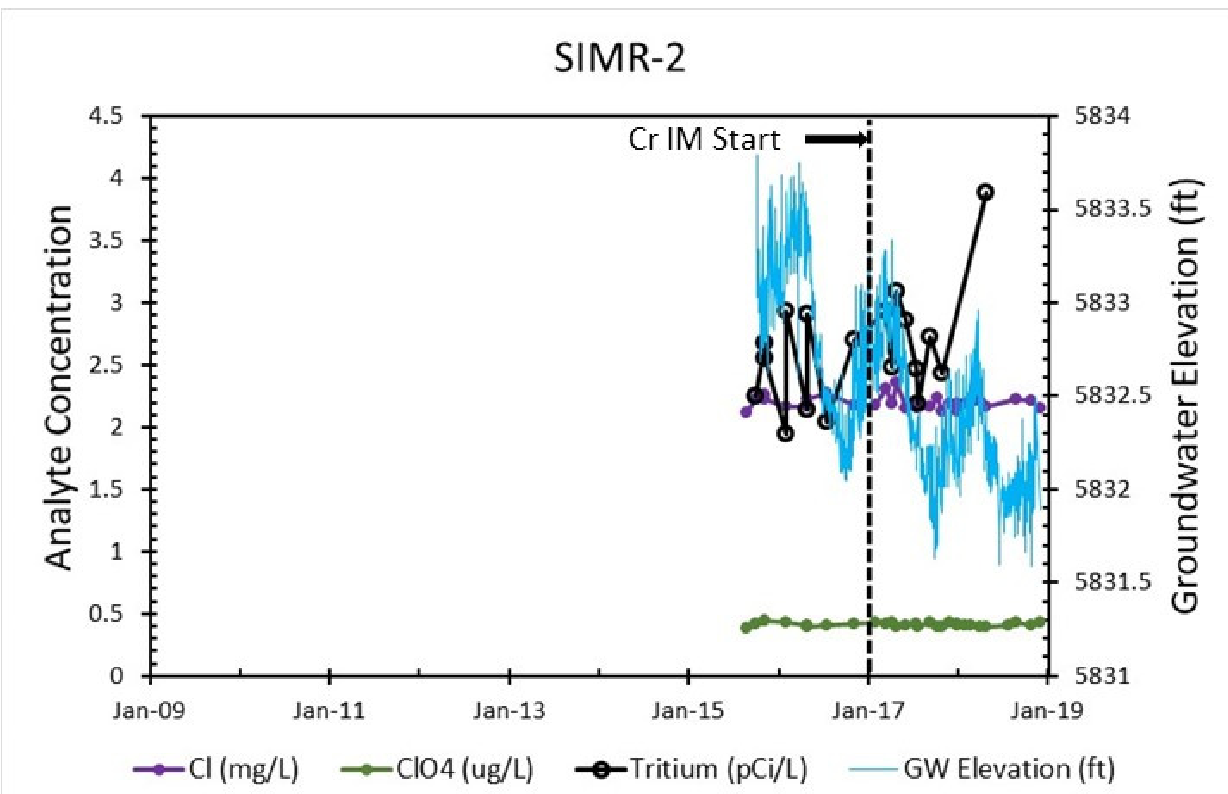




Note: Data for certain constituents at R-61 S1 have historically been nonrepresentative of aquifer conditions because of locally reducing conditions around the well. Current data are considered useful for the purposes of this performance monitoring report.

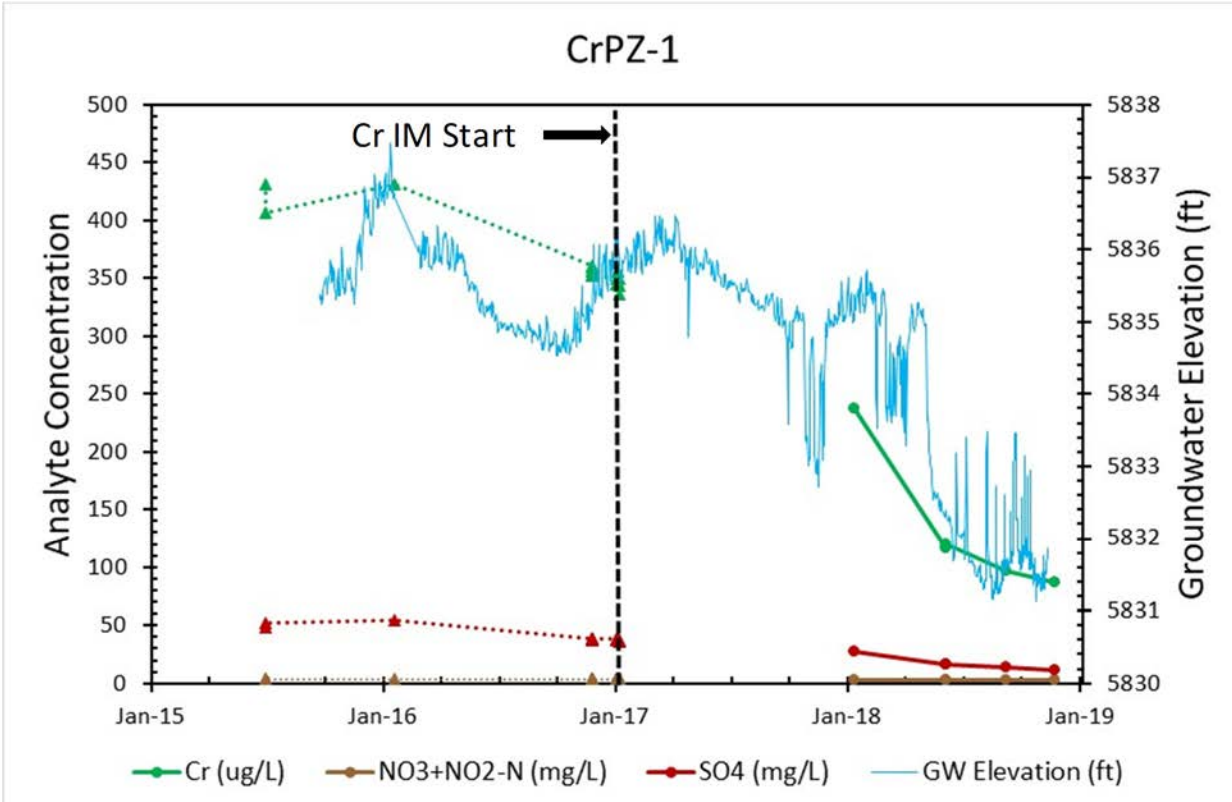
Figure 3.2-10 Time-series plots for R-61 S1

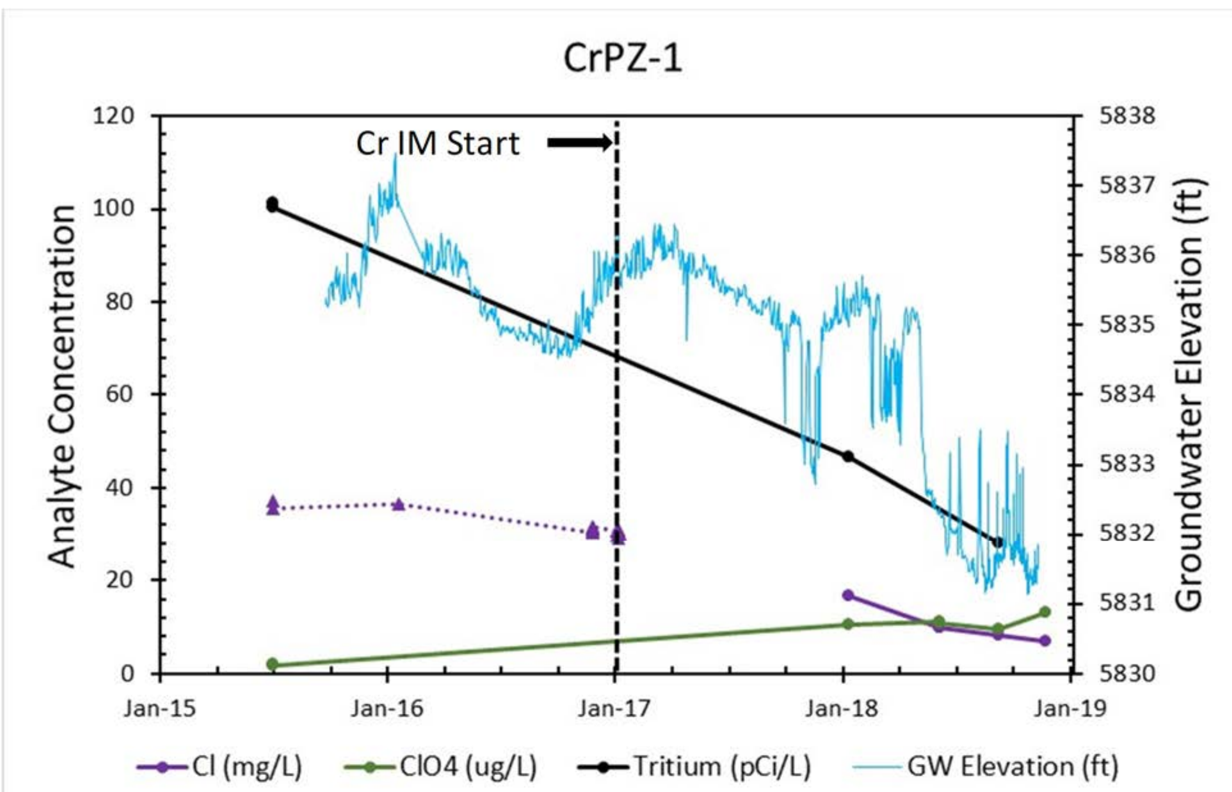




Note: Data represented by open circles are nondetect at the plotted value.

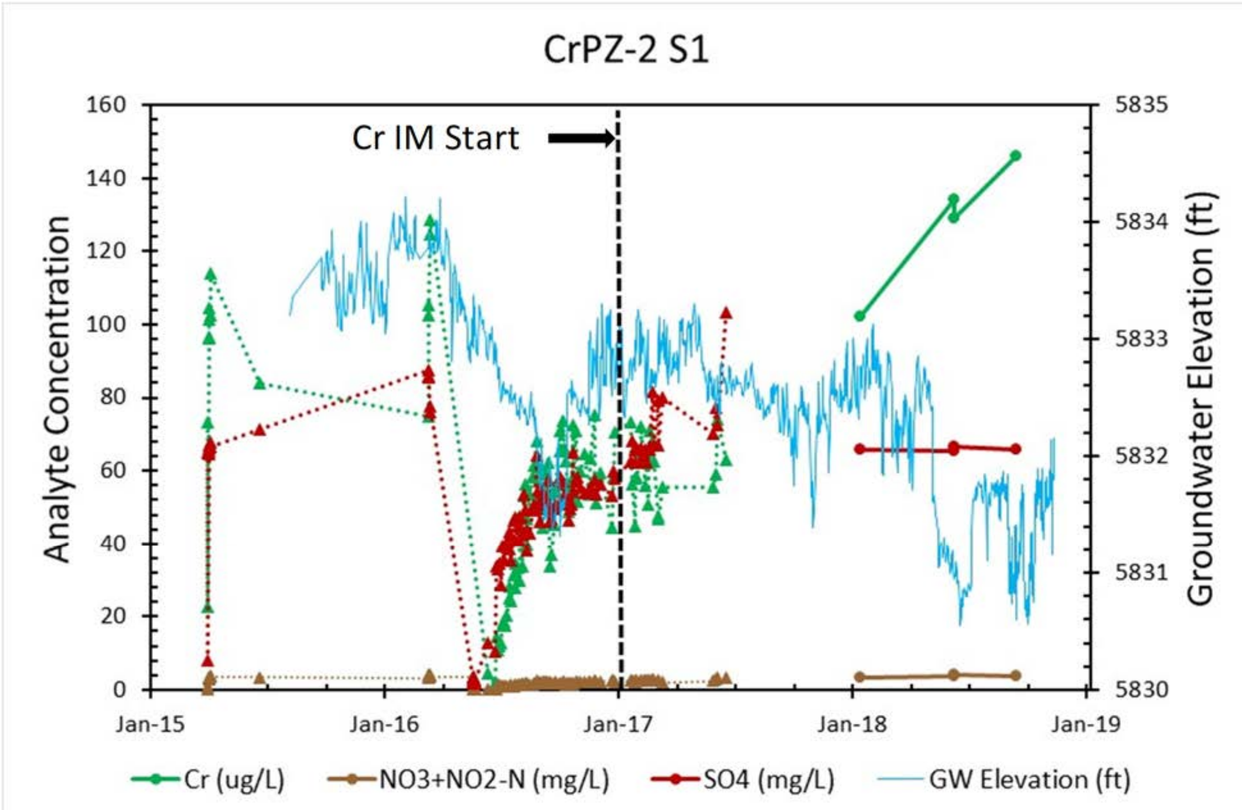
Figure 3.2-11 Time-series plots for SIMR-2

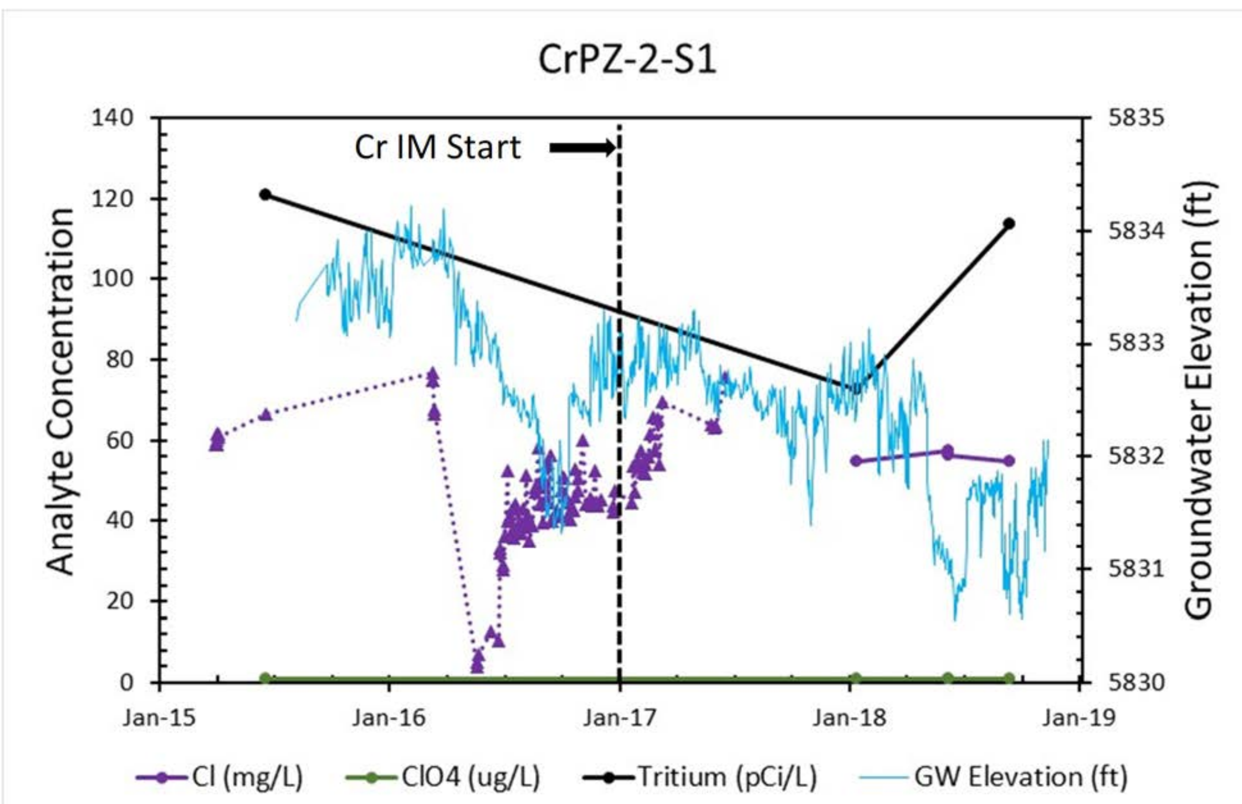




Note: Data represented by triangles and dashed lines are from screening level analyses.

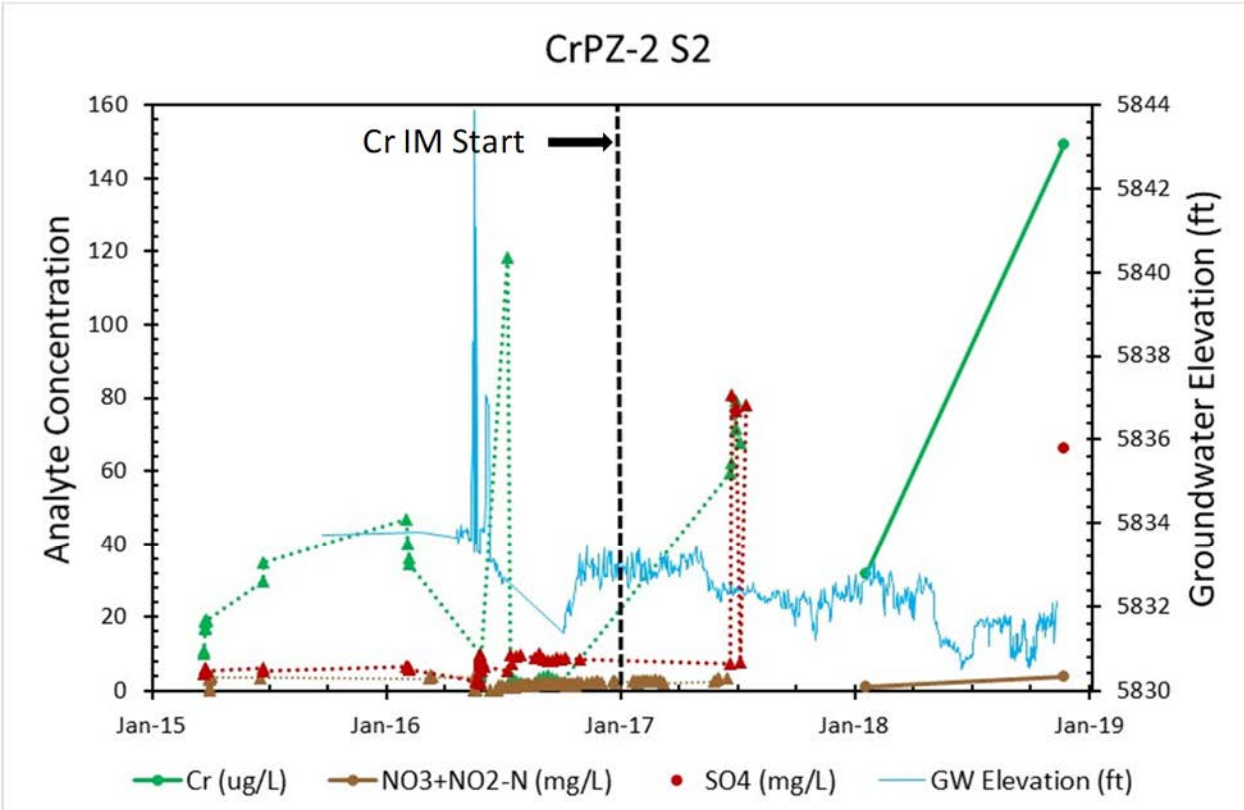
Figure 3.2-12 Time-series plots for CrPZ-1

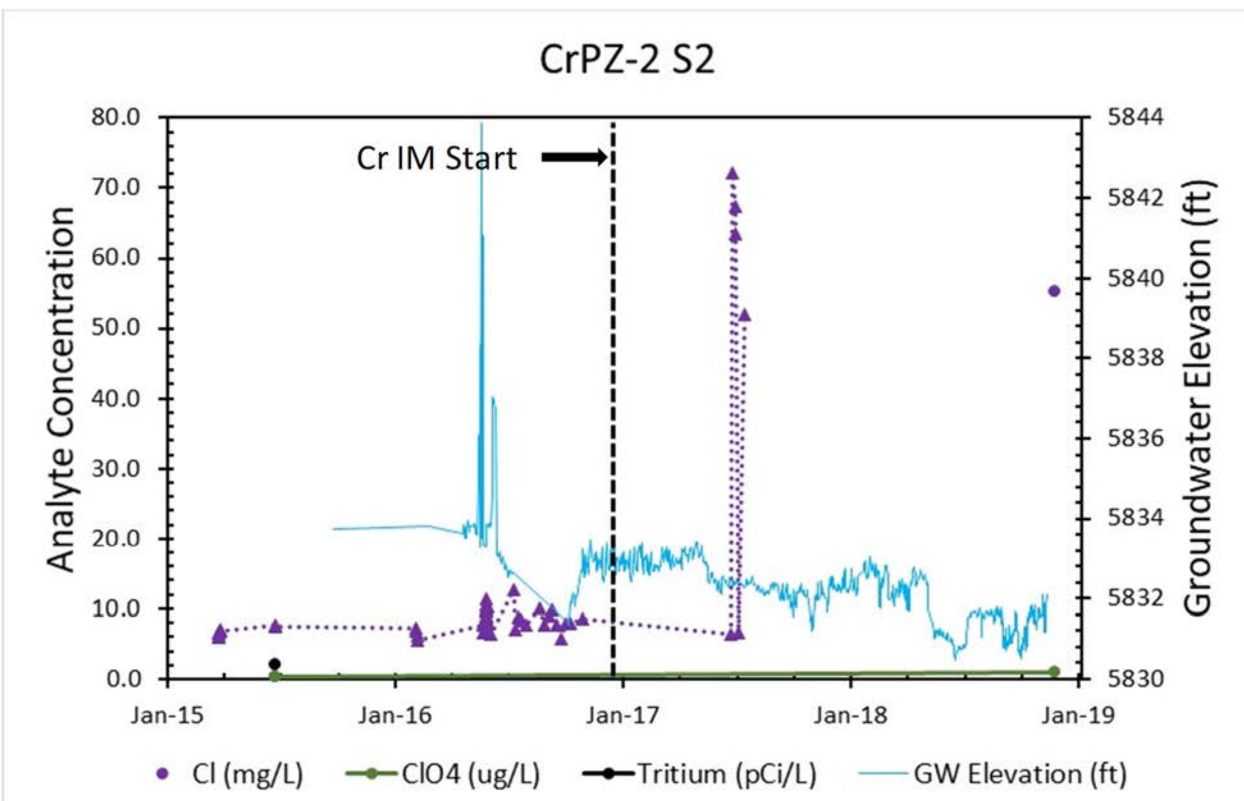




Note: Data represented by triangles and dashed lines are from screening level analyses.

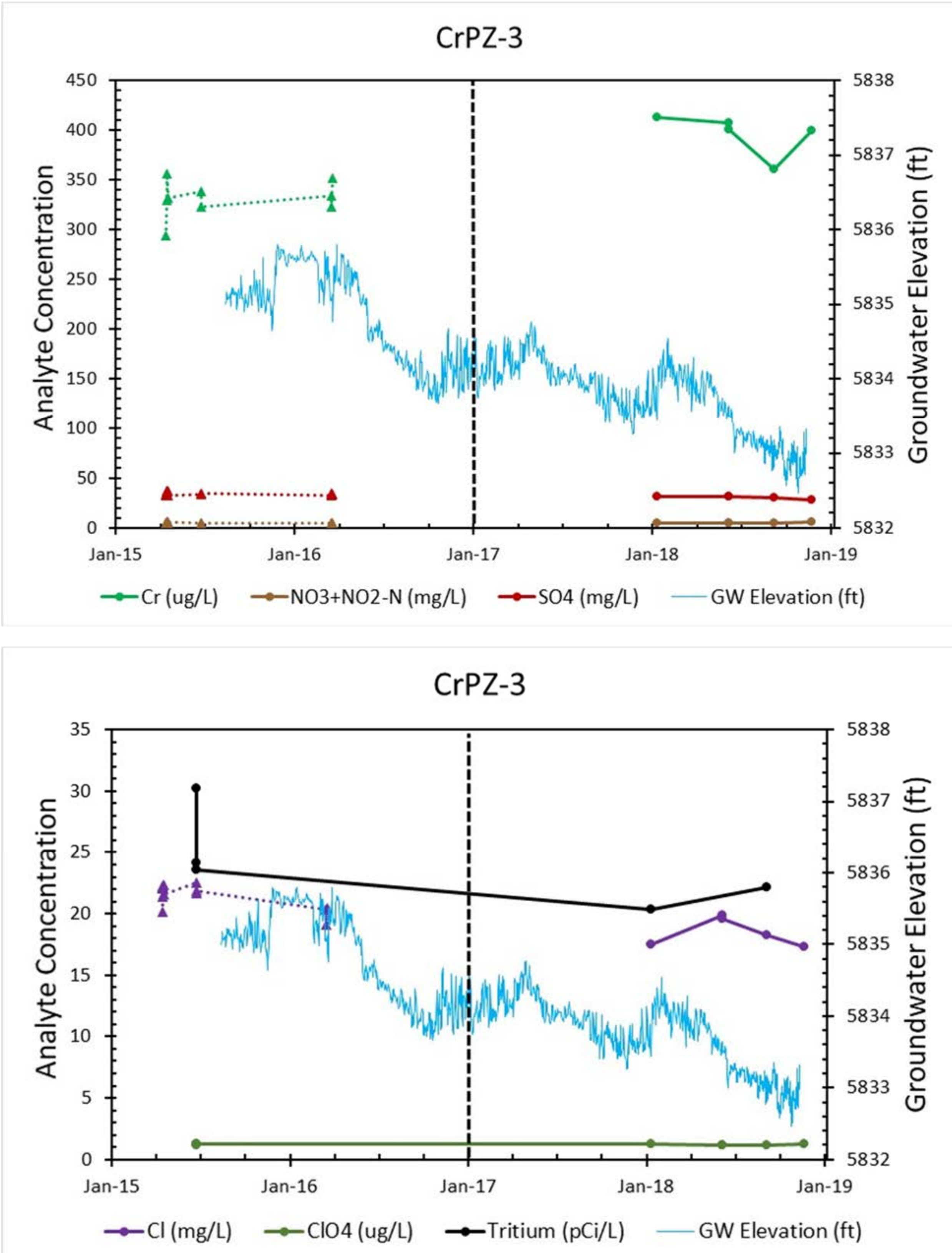
Figure 3.2-13 Time-series plots for CrPZ-2-S1





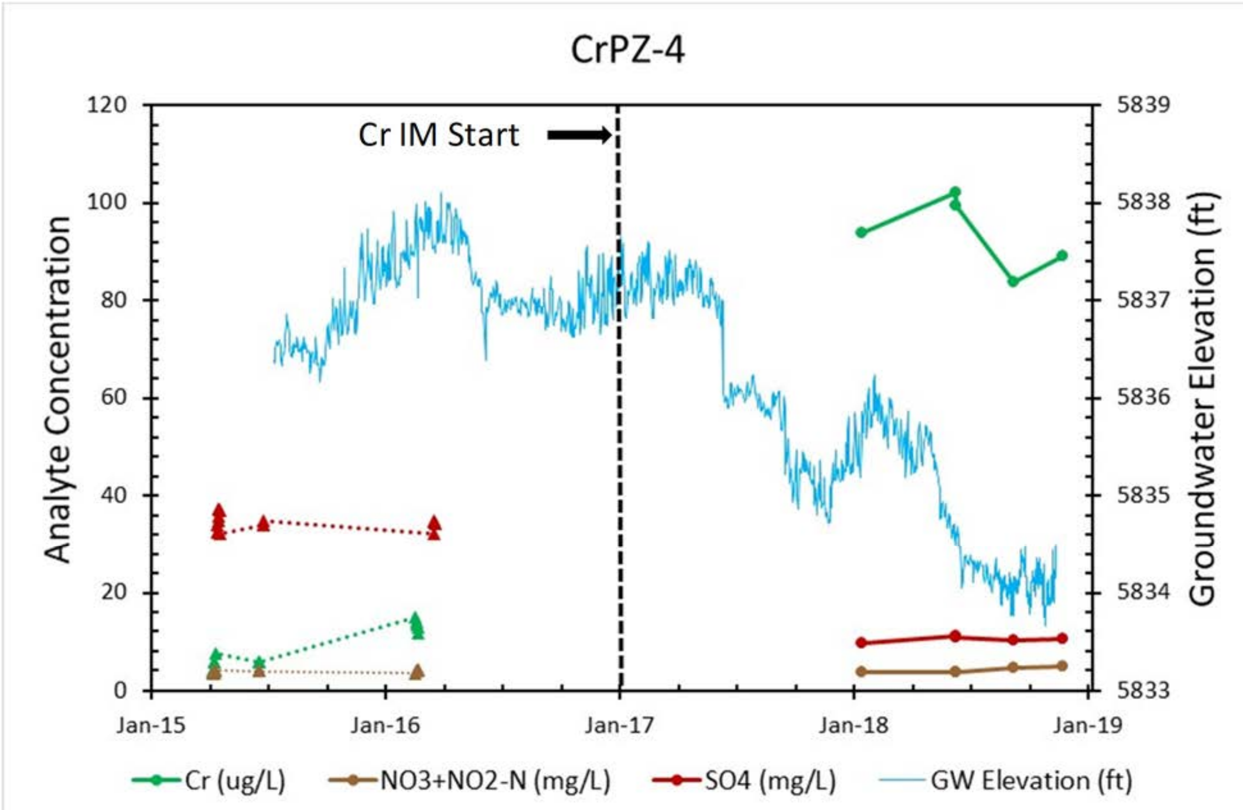
Note: Data represented by triangles and dashed lines are from screening level analyses.

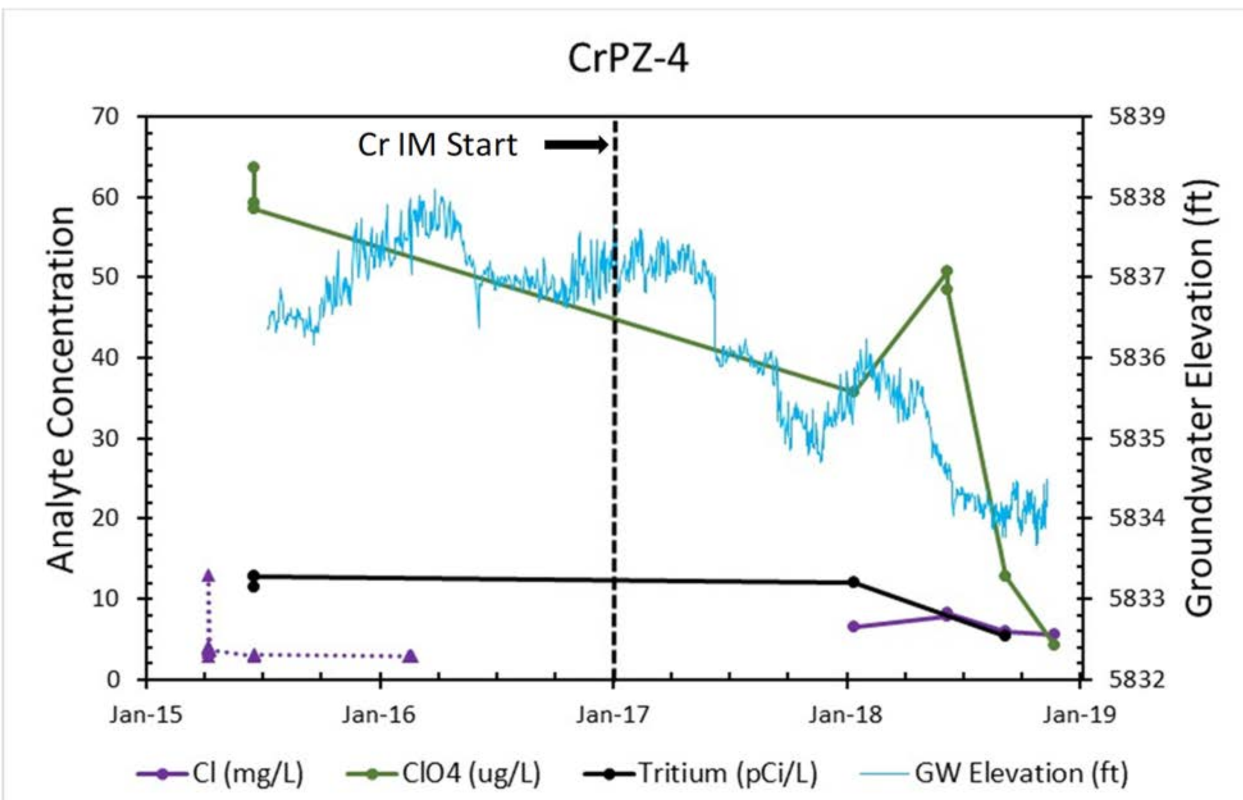
Figure 3.2-14 Time-series plots for CrPZ-2-S2



Note: Data represented by triangles and dashed lines are from screening level analyses.

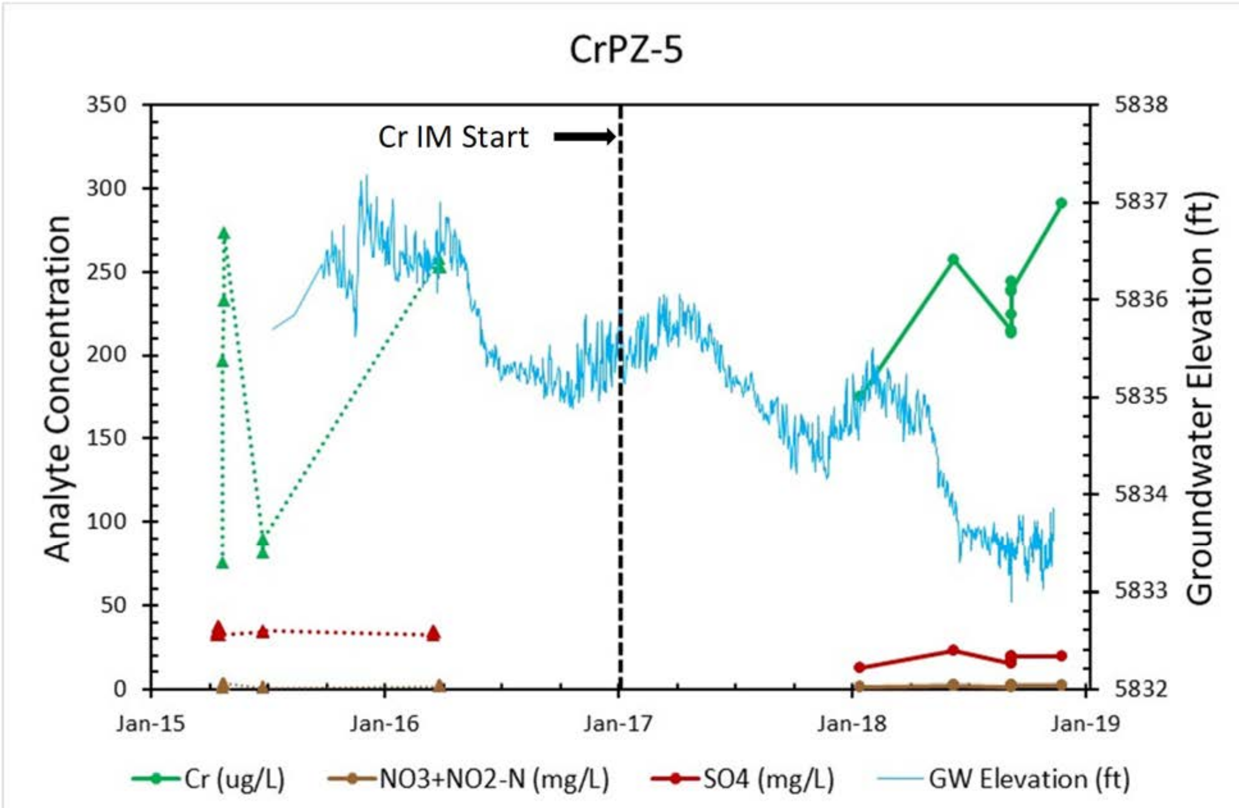
Figure 3.2-15 Time-series plots for CrPZ-3

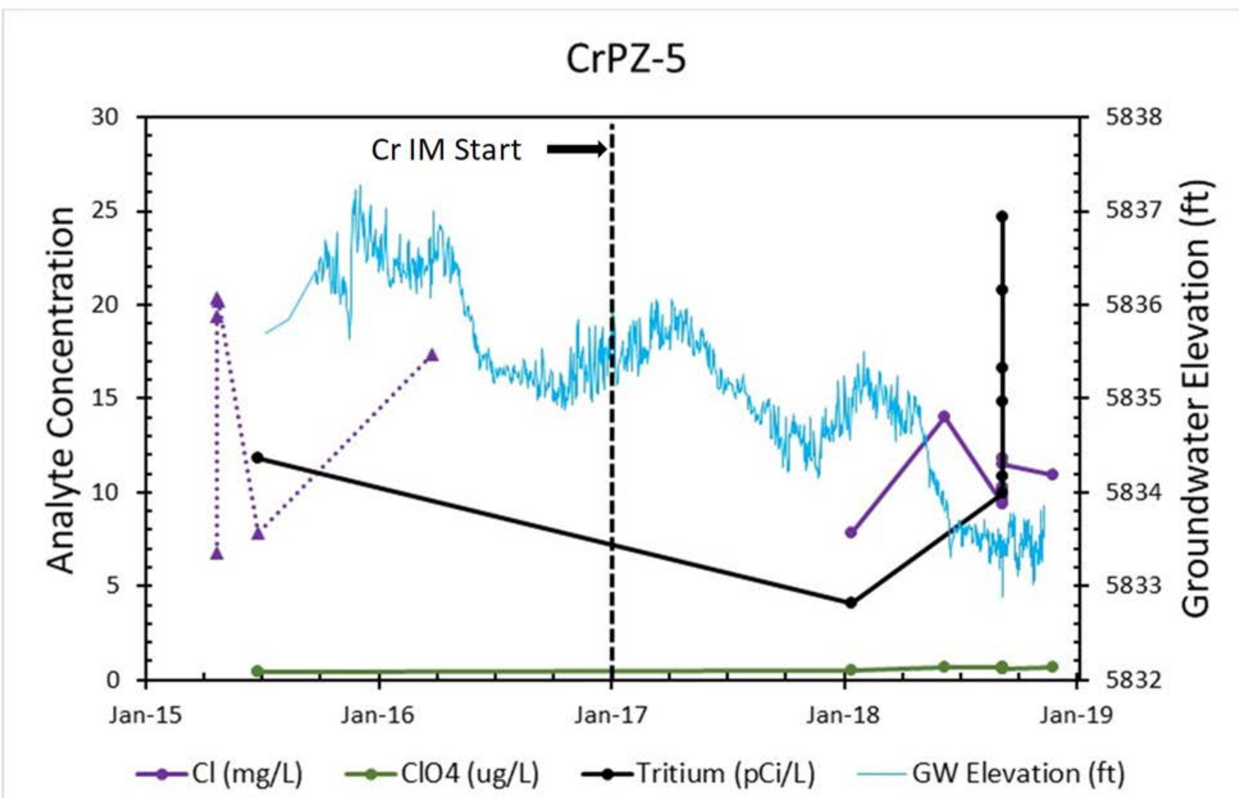




Note: Data represented by triangles and dashed lines are from screening level analyses.

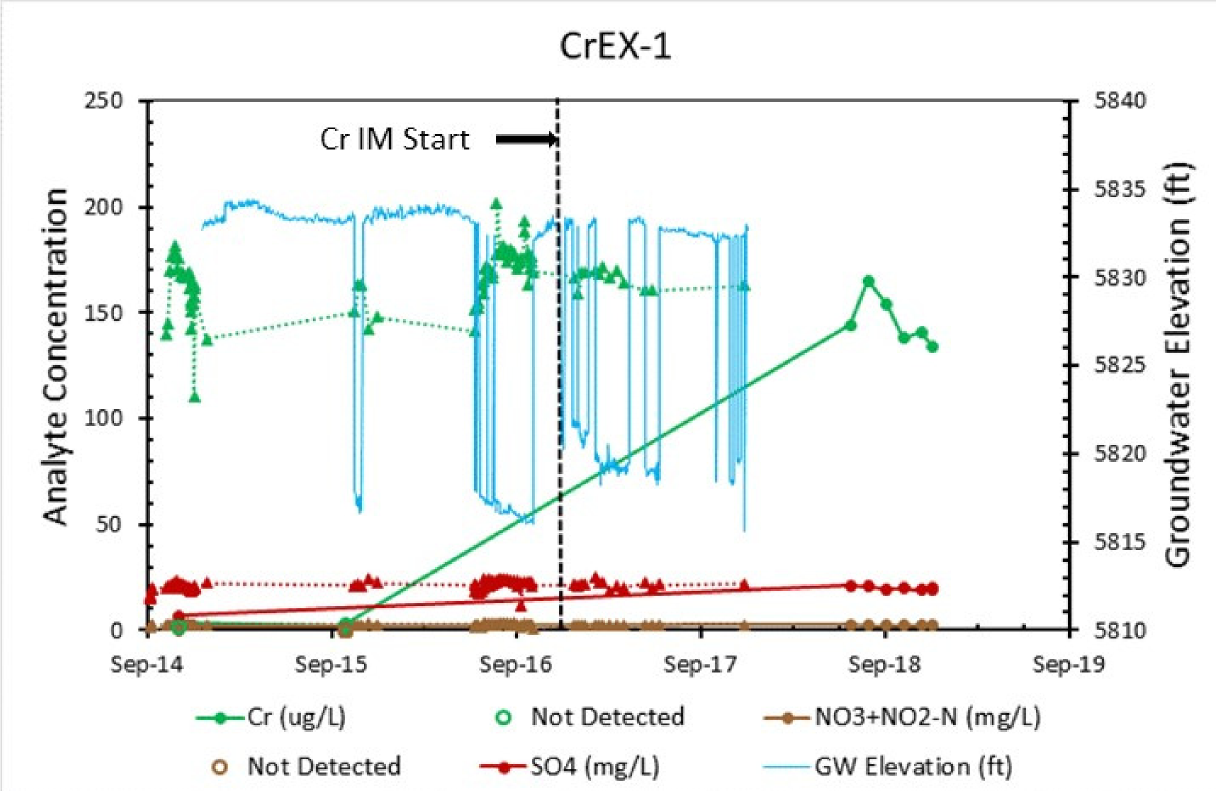
Figure 3.2-16 Time-series plots for CrPZ-4

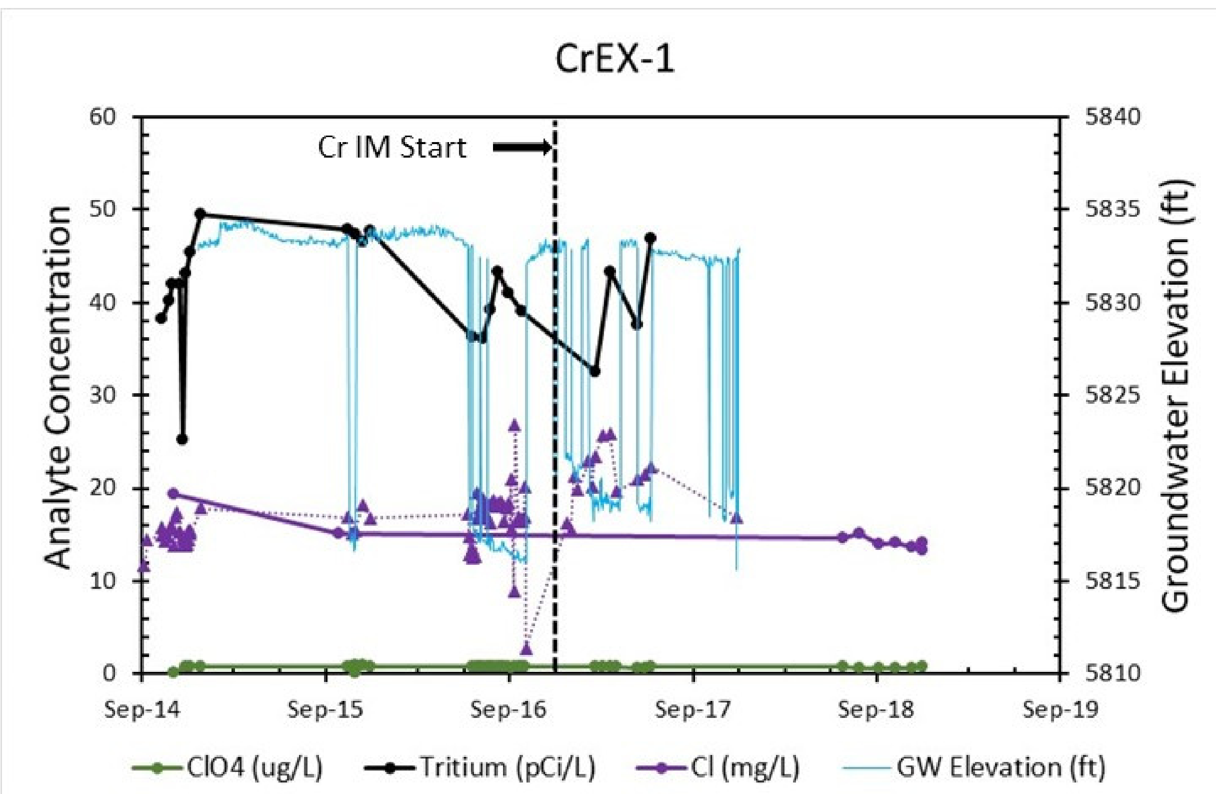




Note: Data represented by triangles and dashed lines are from screening level analyses.

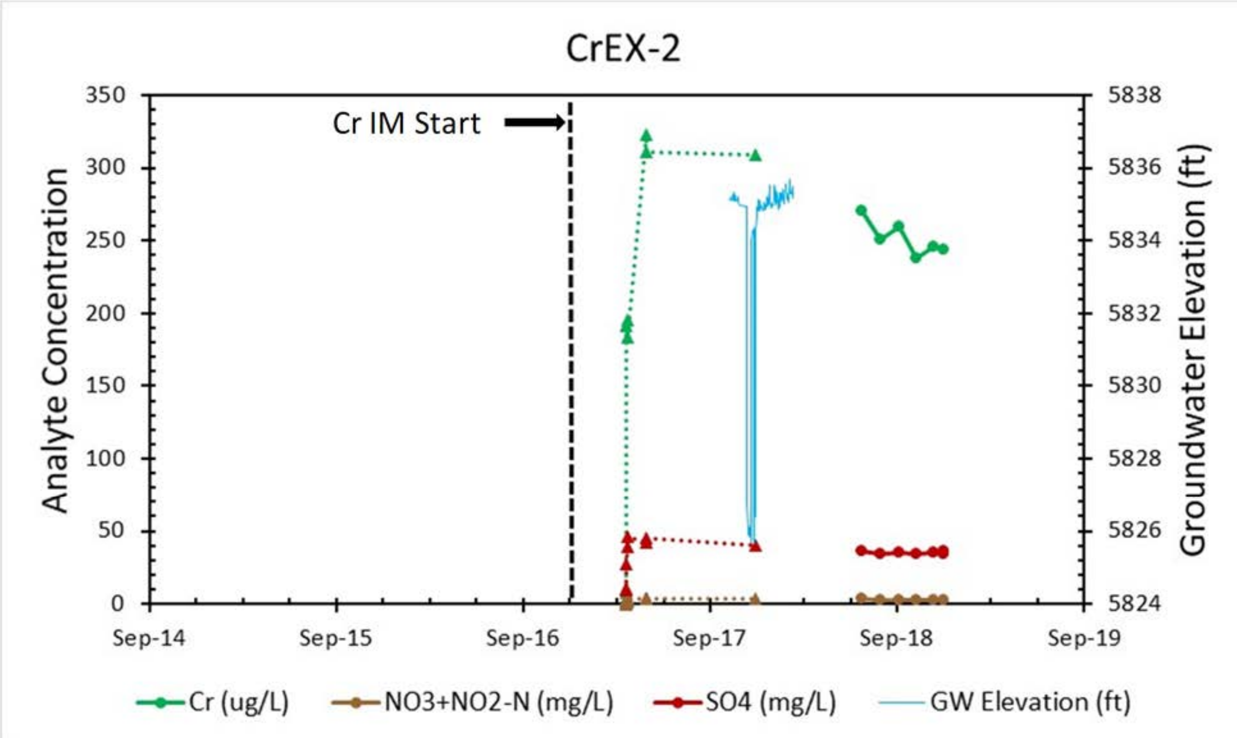
Figure 3.2-17 Time-series plots for CrPZ-5

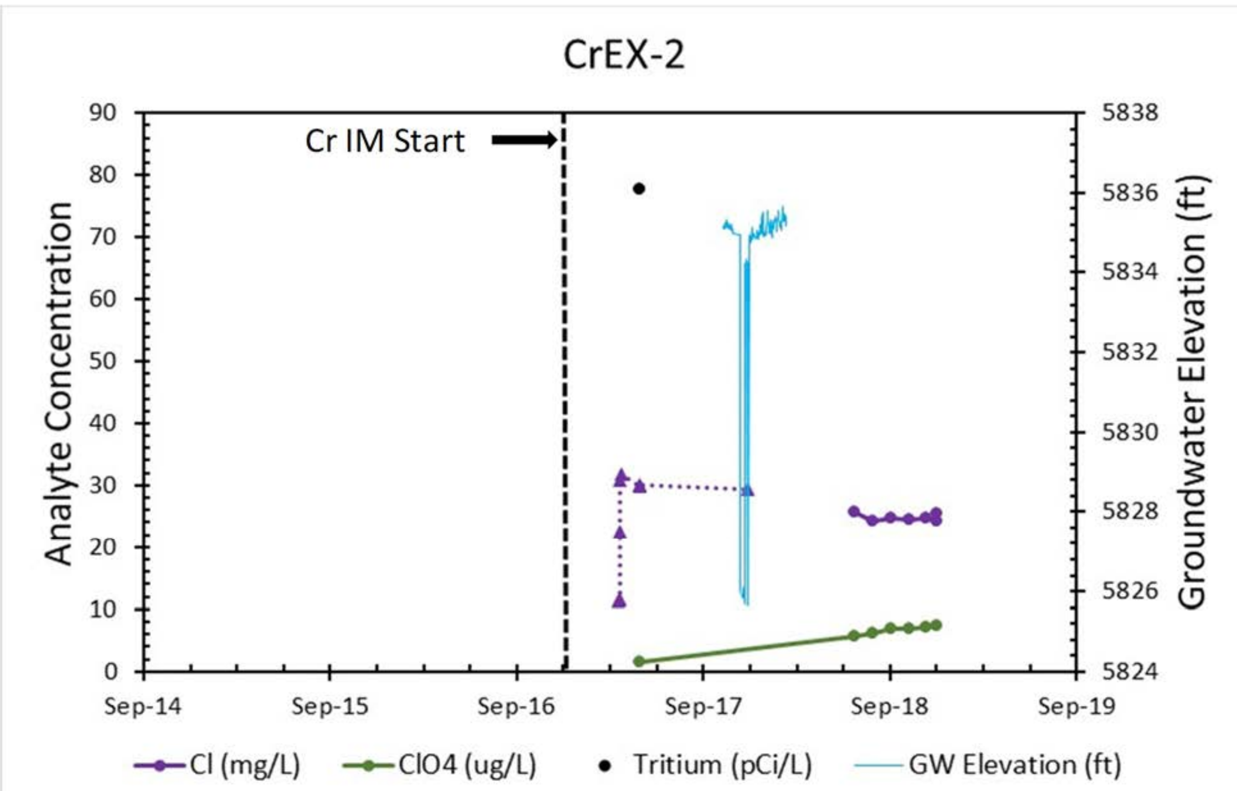




Notes: Data represented by triangles and dashed lines are from screening level analyses. Data represented by open circles are nondetect at the plotted value.

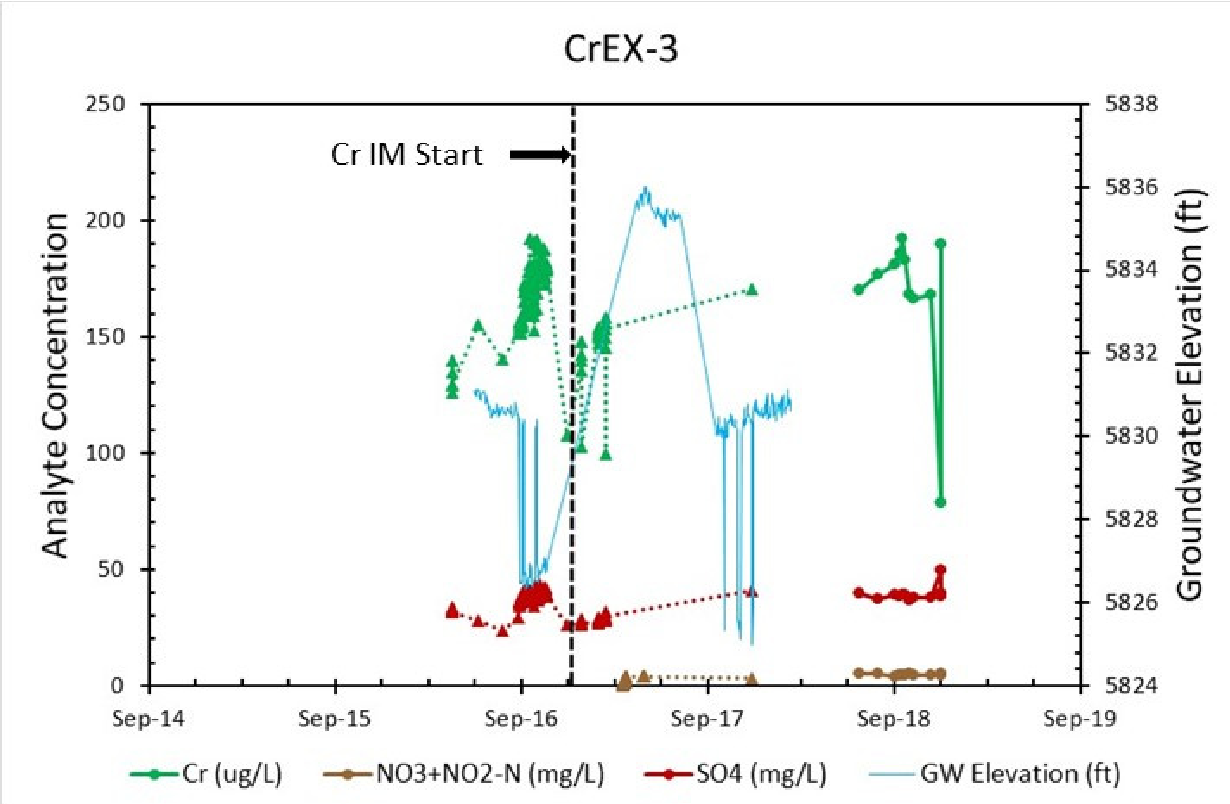
Figure 3.2-18 Time-series plots for CrEX-1

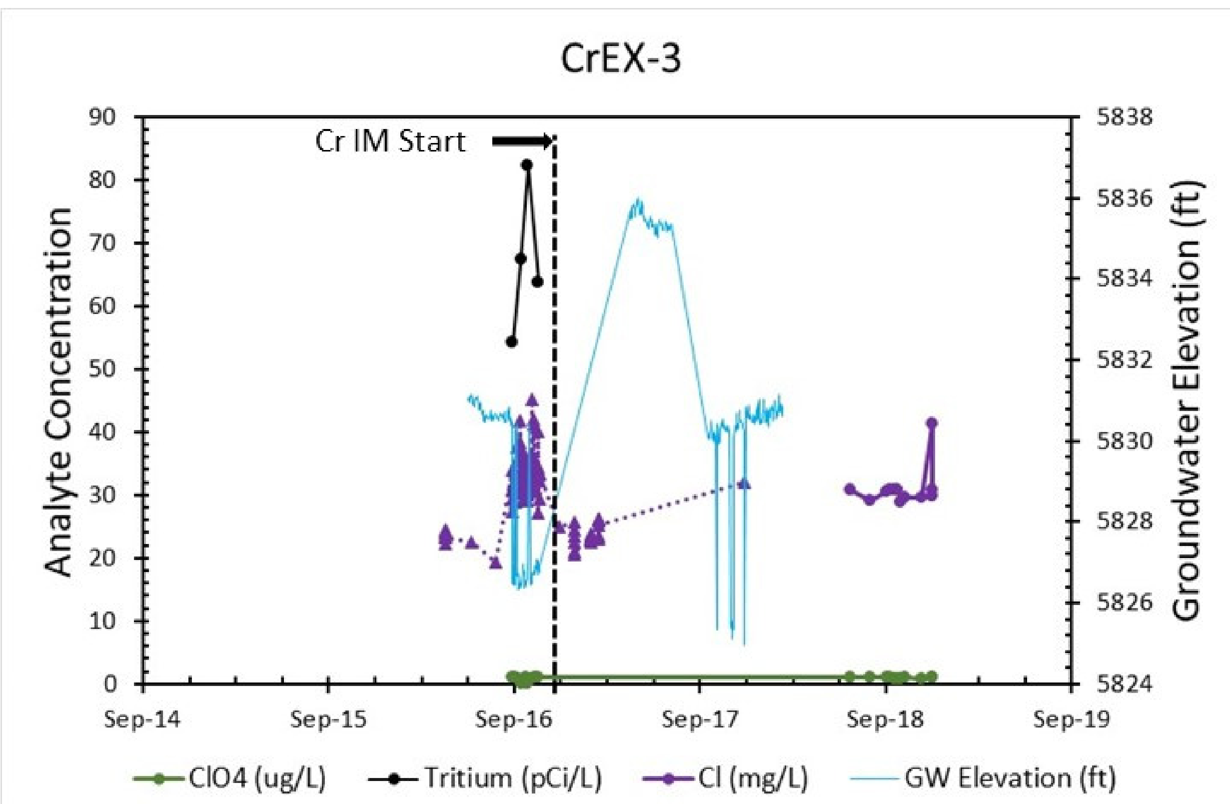




Note: Data represented by triangles and dashed lines are from screening level analyses.

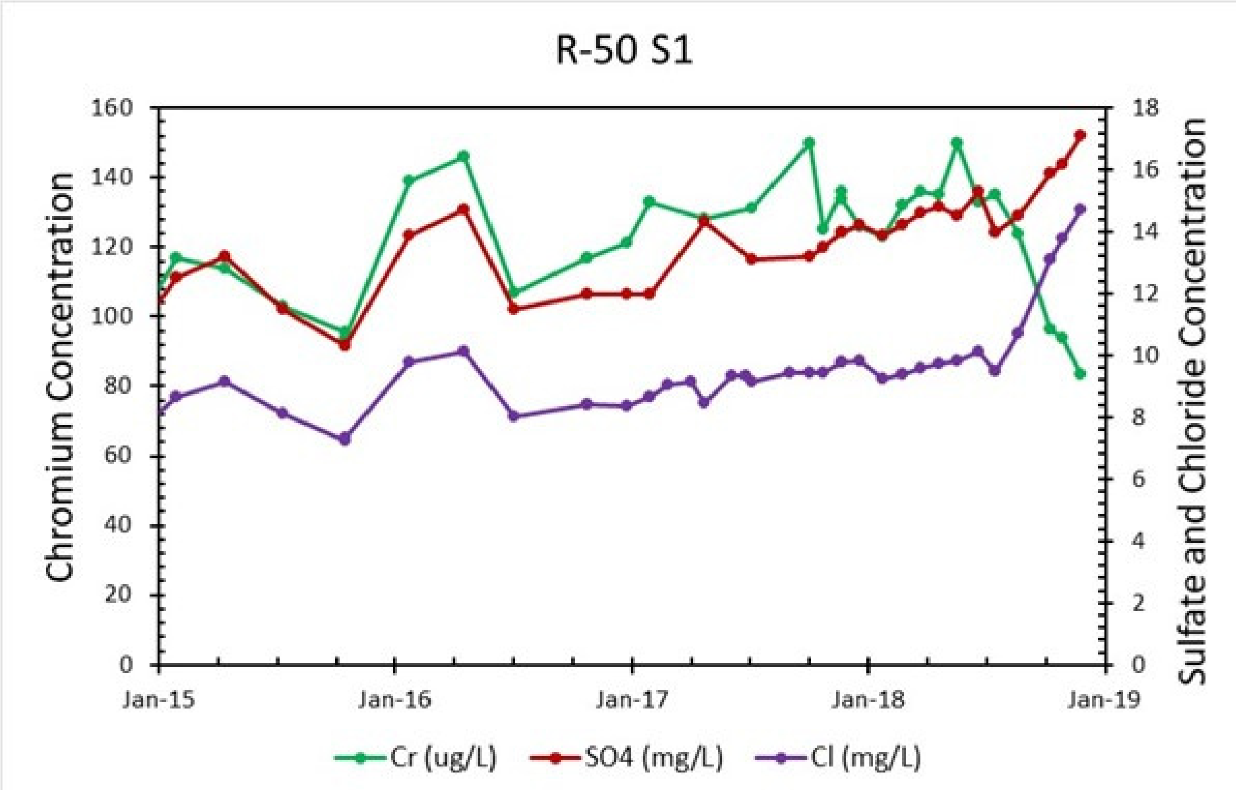
Figure 3.2-19 Time-series plots for CrEX-2





Note: Data represented by triangles and dashed lines are from screening level analyses.

Figure 3.2-20 Time-series plots for CrEX-3



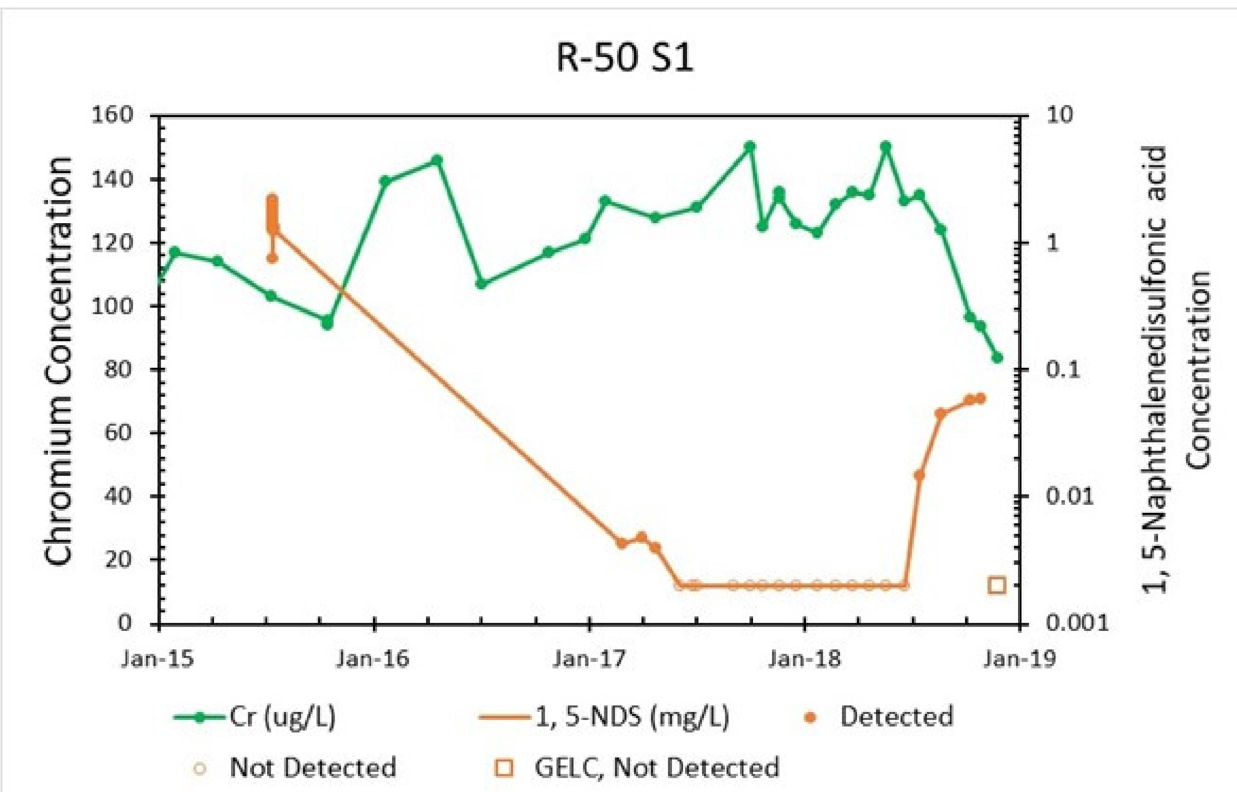
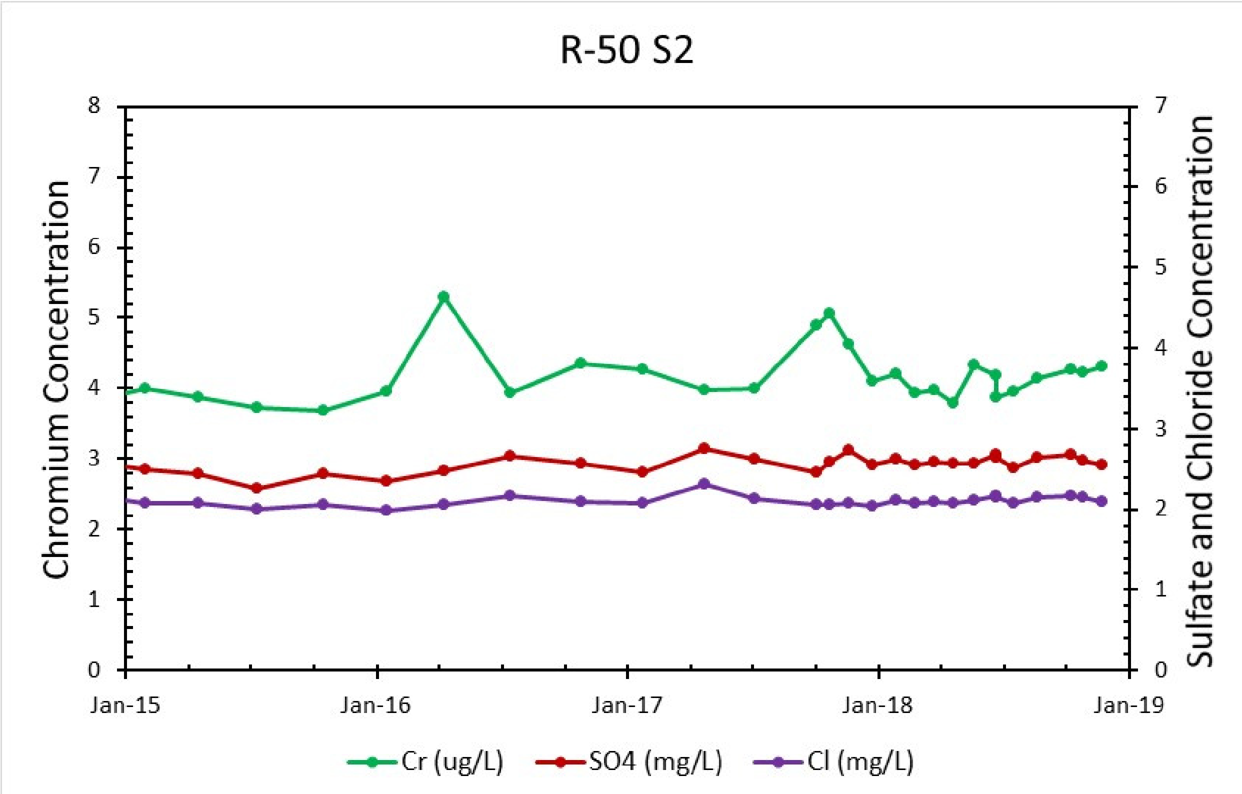


Figure 3.2-21 Time series plots of tracer detections for R-50 S1



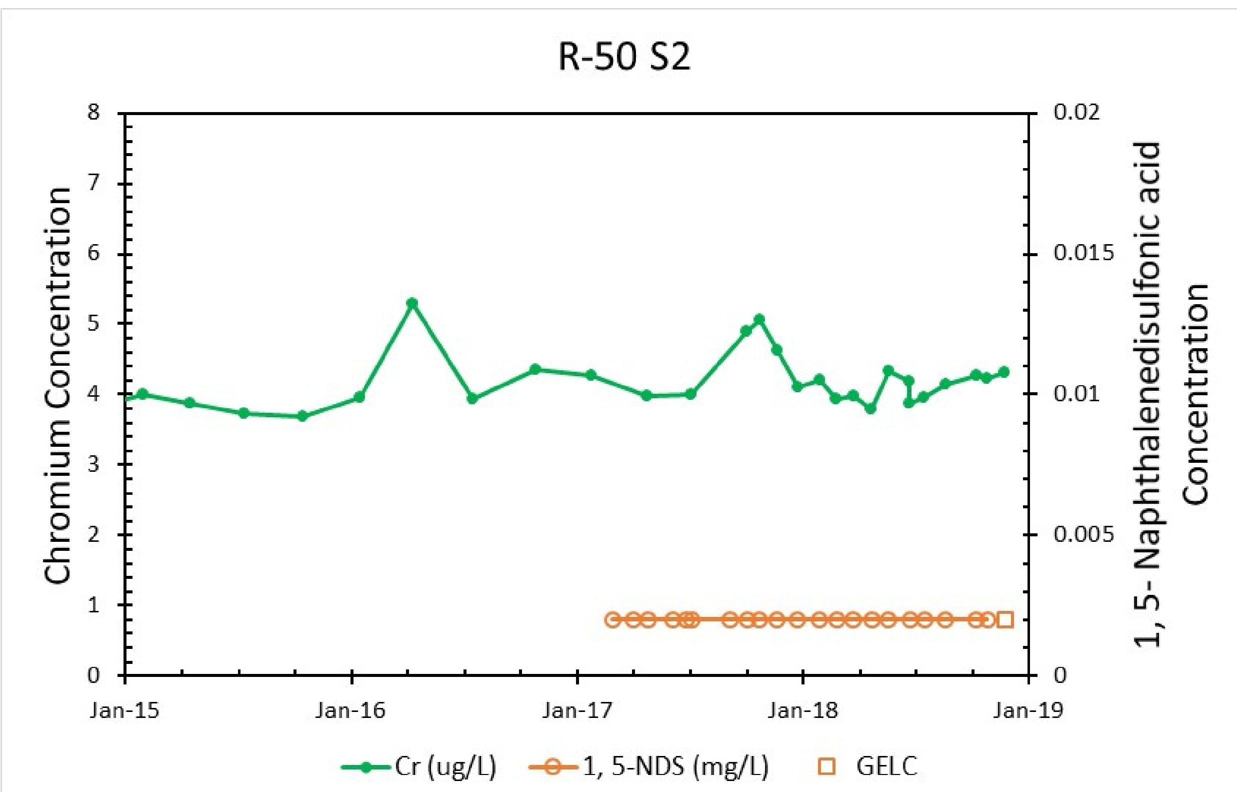
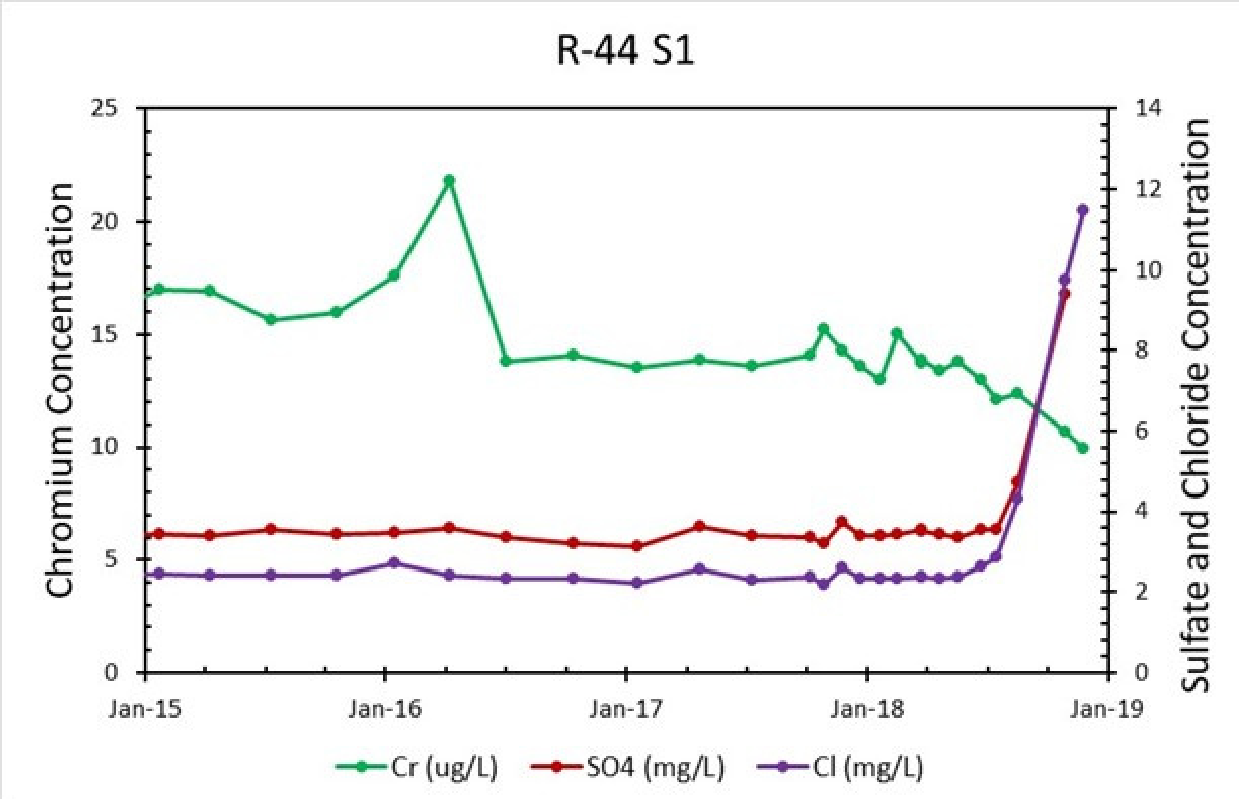


Figure 3.2-22 Time series plots of tracer detections for R-50 S2



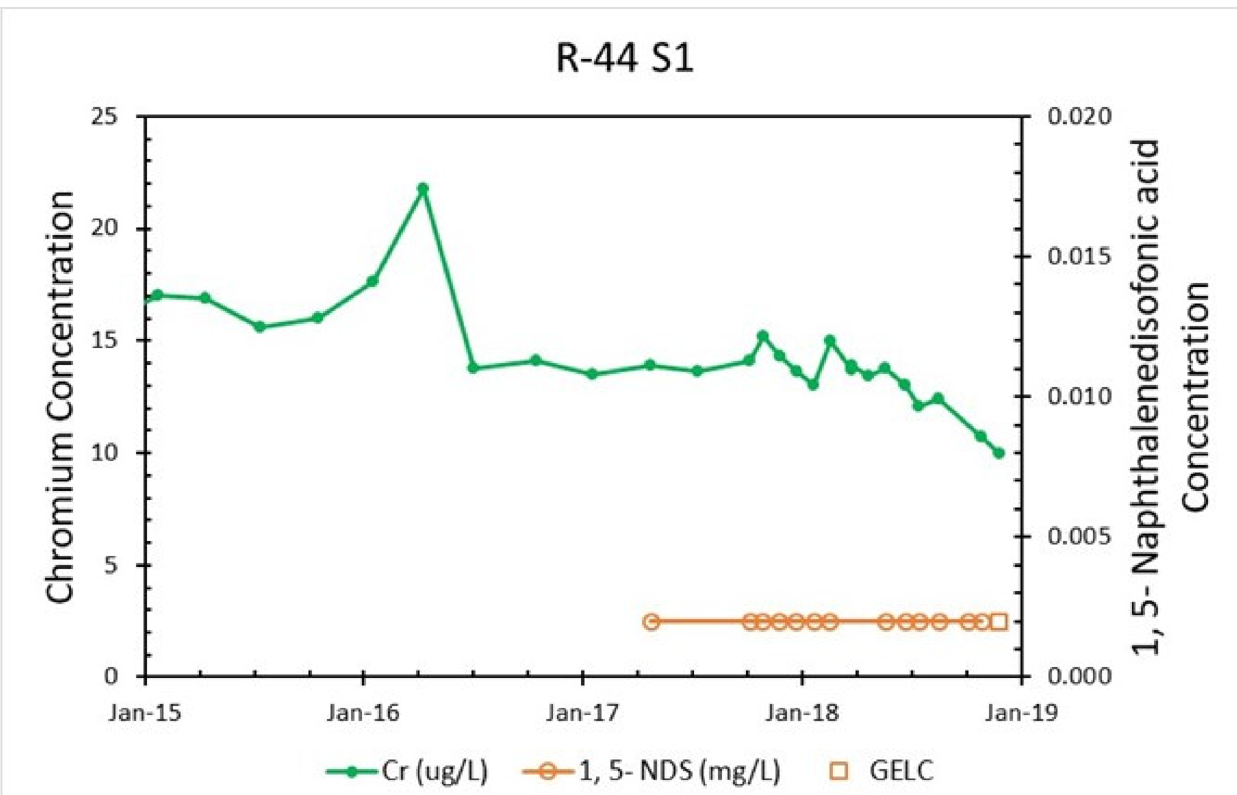
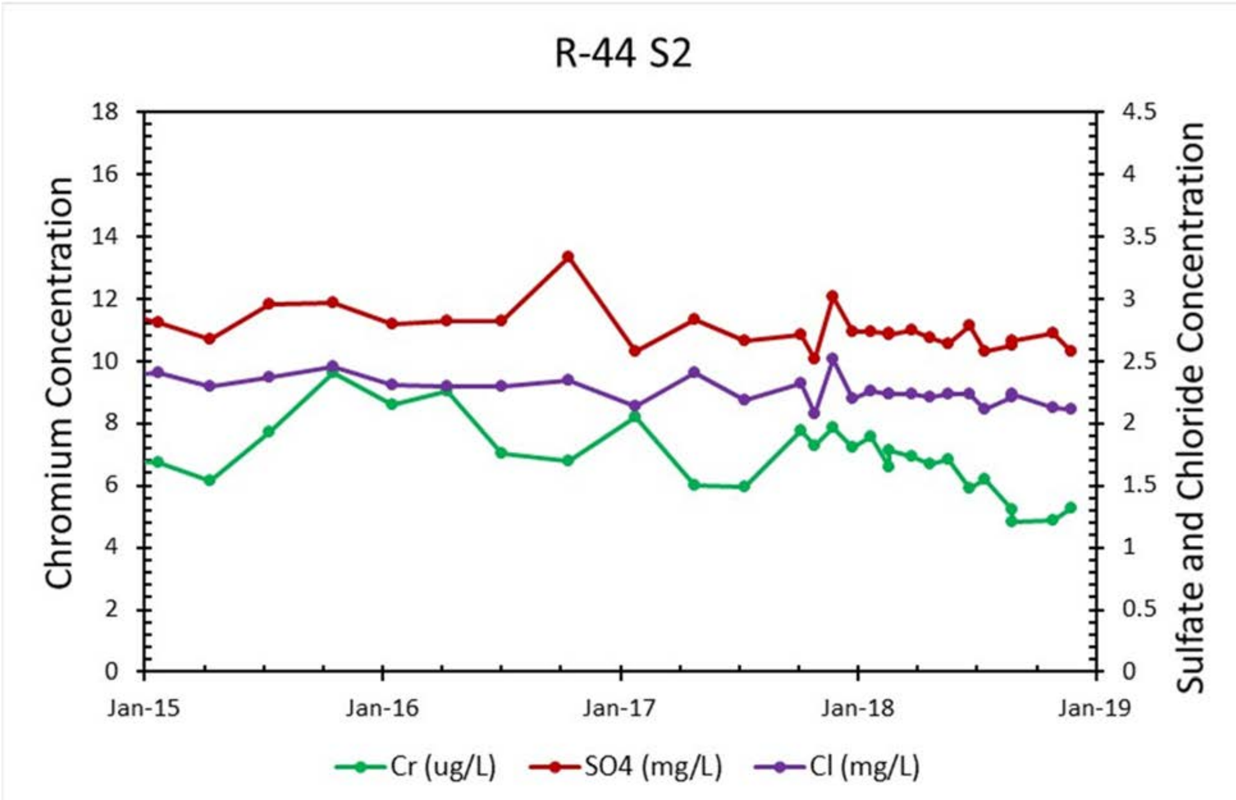


Figure 3.2-23 Time series plots of tracer detections for R-44 S1



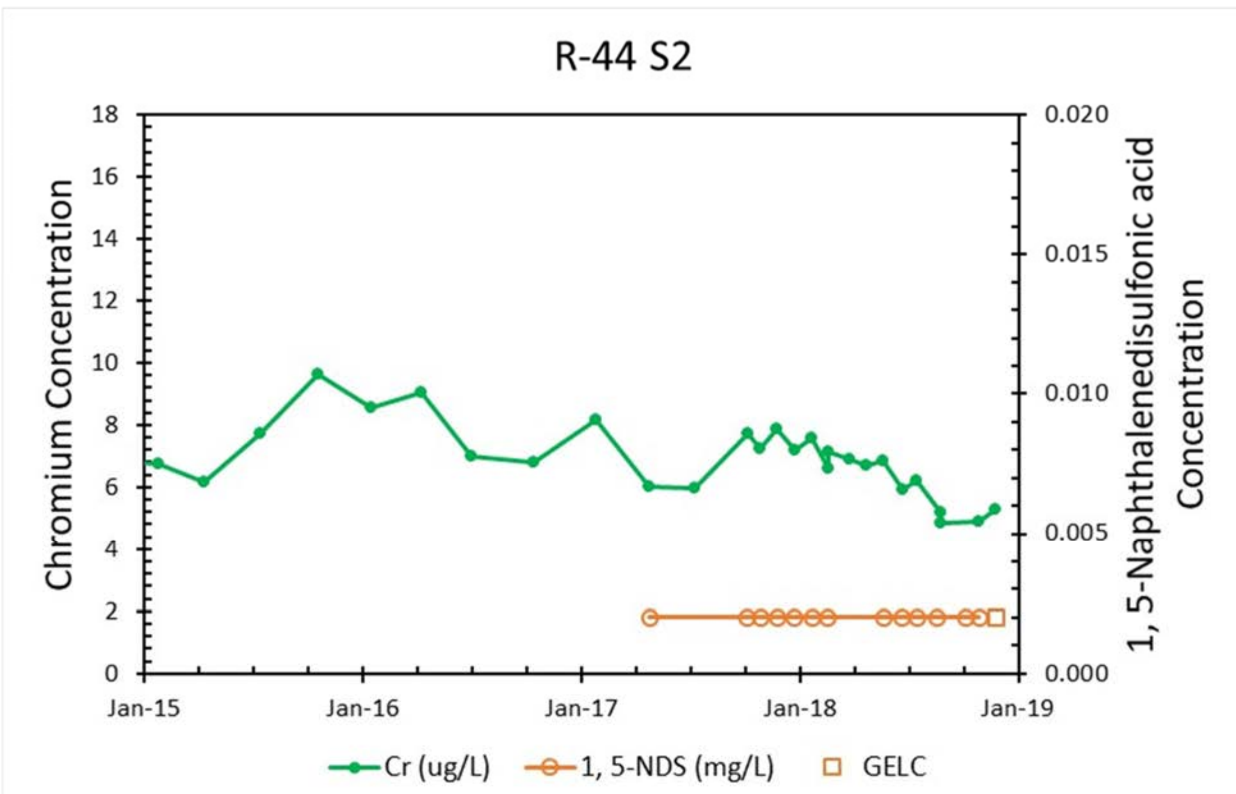


Figure 3.2-24 Time series plots of tracer detections for R-44 S2

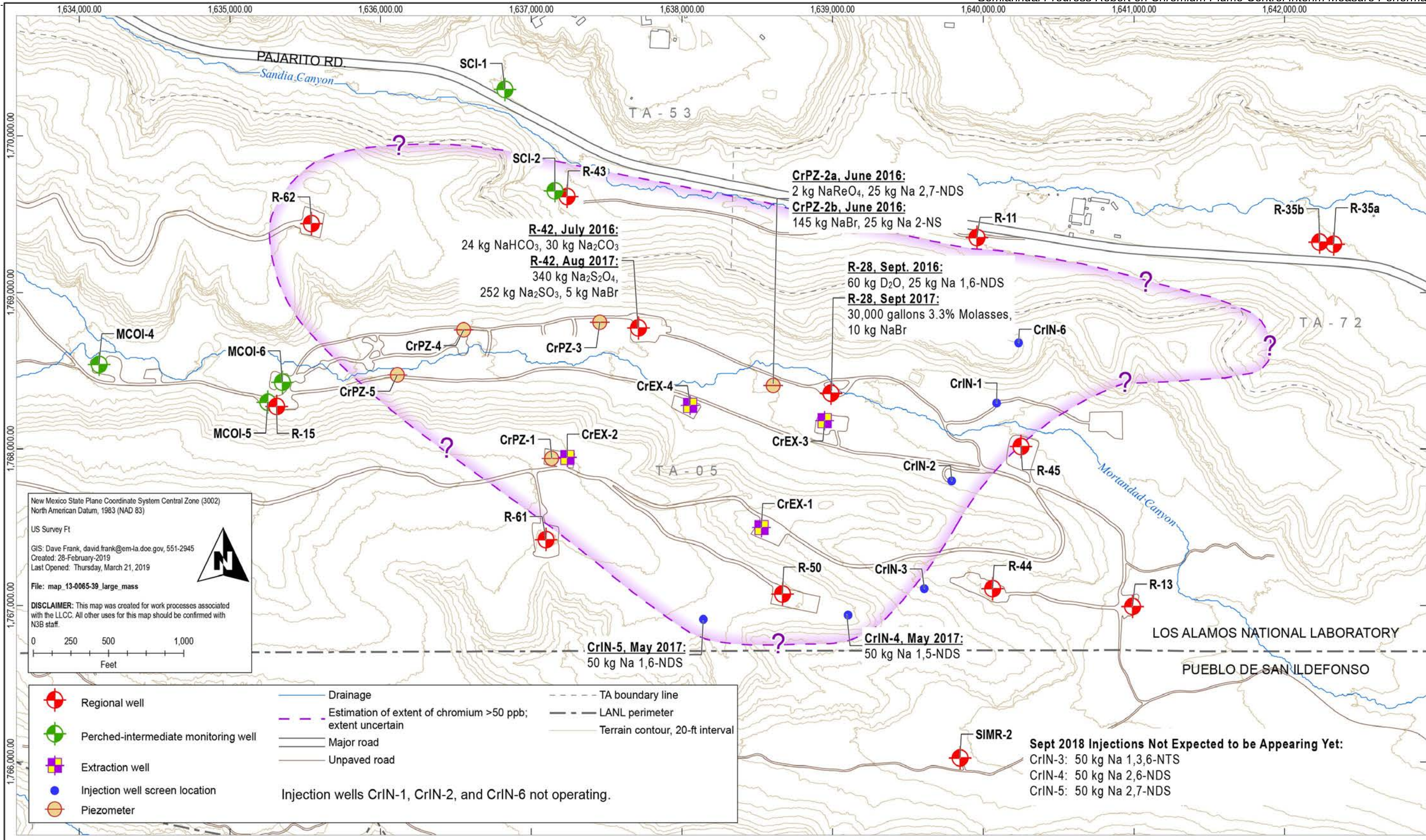


Figure 3.3-1 Summary of large mass/volume injections in 2016, 2017, and 2018

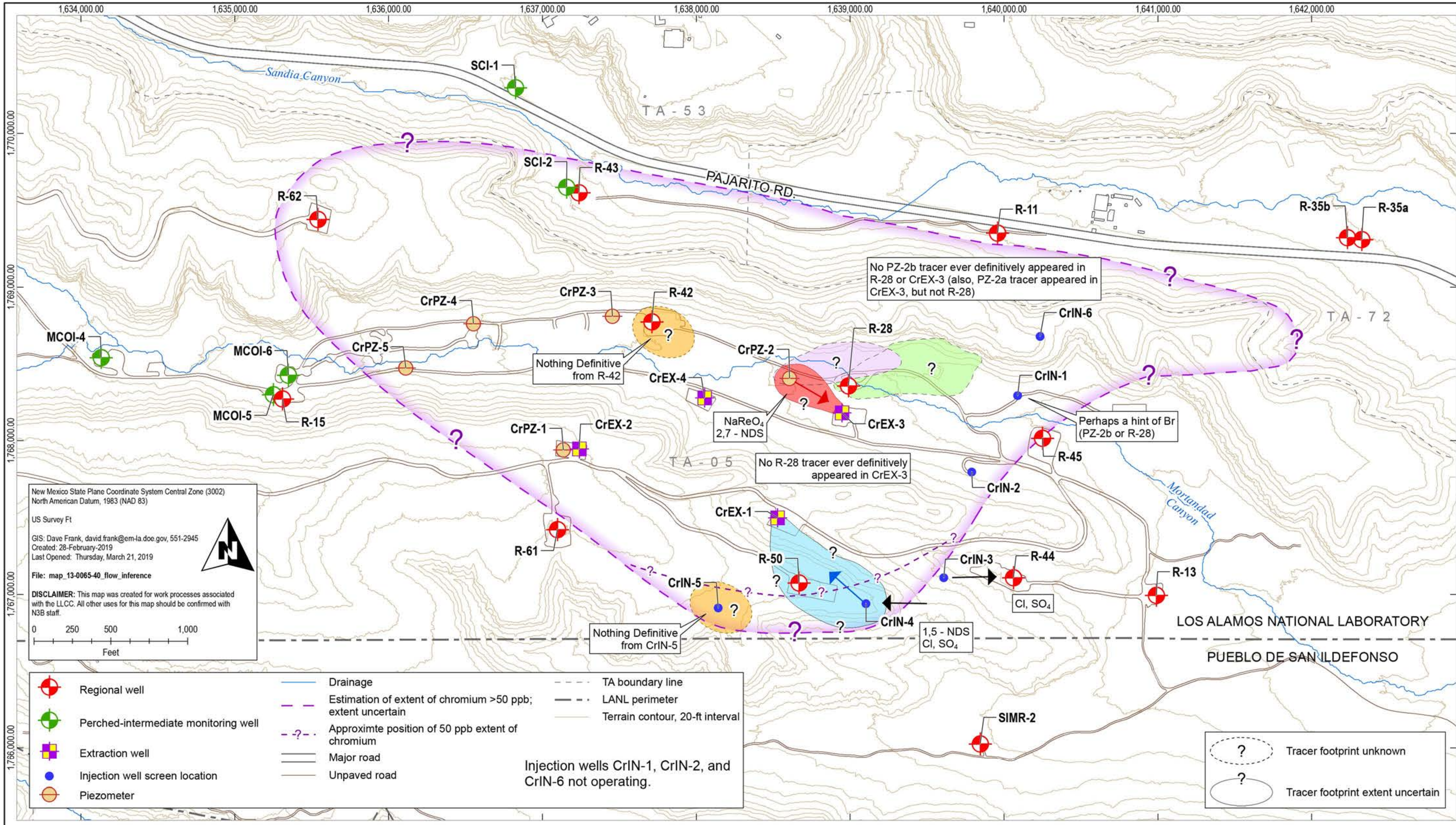


Figure 3.3-2 Inferences derived from cross-hole observations of tracers or other injected chemicals

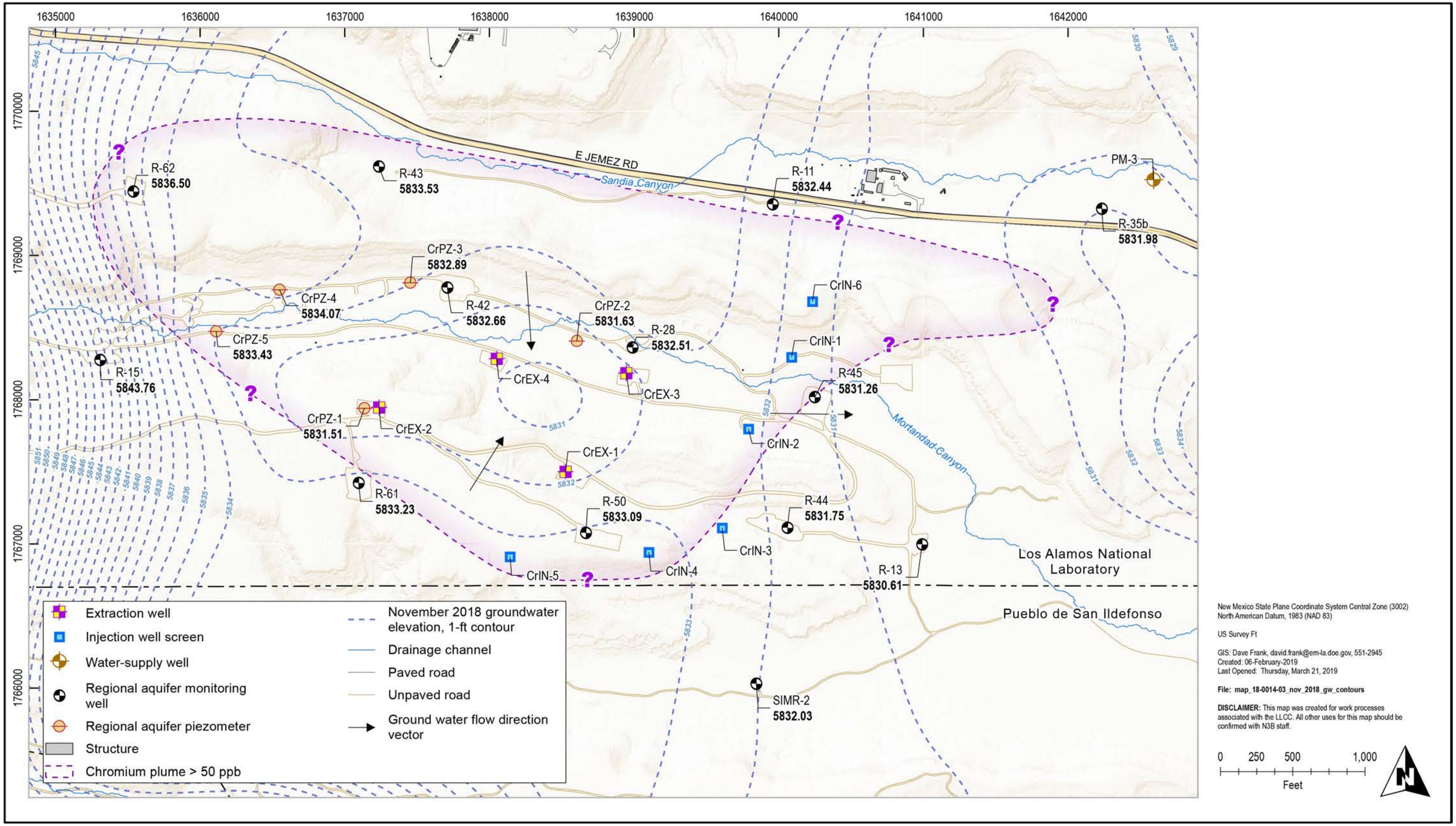


Figure 3.4-1 **Water table showing average water levels for November 2018**

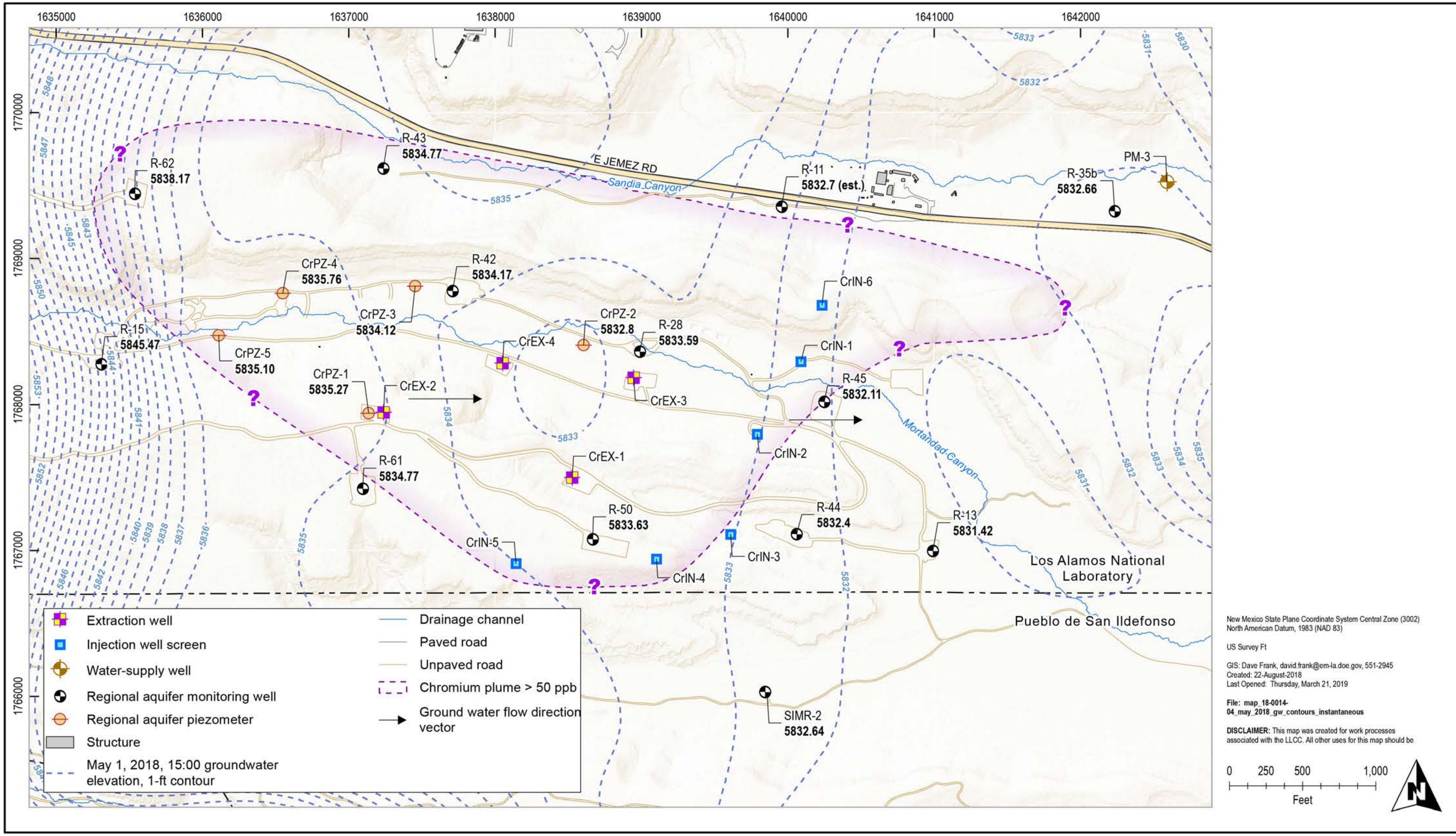


Figure 3.4-2 Baseline water table for May 1, 2018

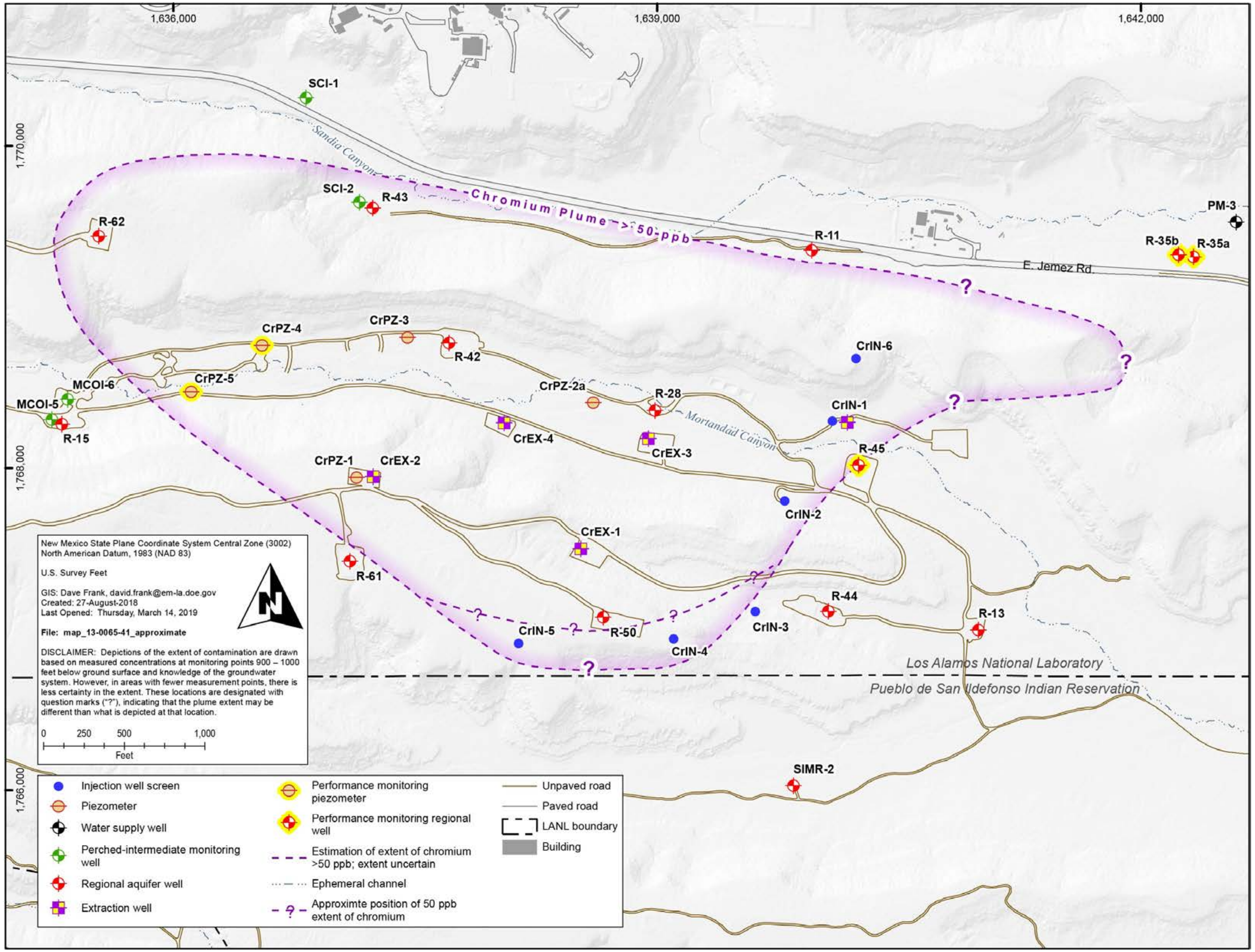


Figure 4.0-1 Current estimate of location of the 50-ppb chromium plume edge

Table 2.1-1
Operations and Maintenance Activity Summary

Maintenance Date	Elements Impacted	Operation/Maintenance Description
7/1/18 through 7/22/18	CrEX-1, CrEX-2, CrEX-3, CTUA[a], CrIN-3, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
7/12/18	CTUA[b]	IX vessel exchanges were completed as follows: Treatment train A – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed.
7/17/18	CTUA[b]	IX vessel exchanges were completed as follows: Treatment train B – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train C – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Both influent and all three effluent filter bags replaced.
7/22/18 through 8/16/18	CrEX-1, CrEX-2, CTUA, CrIN-3, CrIN-4, CrIN-5	CrEX-3 shut down because of observed high pressure in system. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
7/23/18	CTUA[b]	Both influent filter bags replaced.
8/16/18	CTUA[b]	IX vessel exchanges were completed as follows: Treatment train A – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed.
8/16/18 through 8/17/18	CrEX-1, CrEX-2, CrEX-3, CTUA, CrIN-3, CrIN-4, CrIN-5	CrEX-3 turned on for 24-hr period to allow wellhead sample collection. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
8/17/18 through 9/19/18	CrEX-1, CrEX-2, CTUA, CrIN-3, CrIN-4, CrIN-5	CrEX-3 shut down because of observed high pressure in system. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
8/22/18	CTUA[b]	IX vessel exchanges were completed as follows: Treatment train B – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train C – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Both influent filter bags replaced.
9/11/18 and 9/12/18	CrIN-3	Tracer deployed to CrIN-3. Approximately 15,000 gal. of water was pumped from well, mixed with tracer, and reinjected into the well.
9/13/18 and 9/17/18	CrIN-4	Tracer deployed to CrIN-4. Approximately 15,000 gal. of water was pumped from well, mixed with tracer, and reinjected into the well.
9/14/18 and 9/18/18	CrIN-5	Tracer deployed to CrIN-5. Approximately 15,000 gal. of water was pumped from well, mixed with tracer, and reinjected into the well.

Table 2.1-1 (continued)

Maintenance Date	Elements Impacted	Maintenance Description
9/19/18 through 9/30/18	CrEX-1, CrEX-2, CrEX-3, CTUA, CrIN-3, CrIN-4, CrIN-5	CrEX-3 turned back on. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
9/25/18	CTUA[b]	IX vessel exchanges were completed as follows: Treatment train A – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train B – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train C – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Both influent filter bags replaced.
9/30/18	CrEX-1, CrEX-2, CTUA, CrIN-3, CrIN-4, CrIN-5	CrEX-3 shut down because of observed high pressure in system. Extraction, treatment, and injection of treated groundwater occurred per operational plan.
10/1/18	CTUA[b]	Both influent filter bags replaced.
10/1/18 through 10/9/18	CrEX-1, CrEX-2, CrEX-3, CTUA, CrIN-3, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
10/3/18	CTUA	All effluent filter bags replaced because of observed imbalance of flow through CTUA treatment trains.
10/4/18	CTUA	Both influent filter bags replaced because of system high pressure.
10/9/18 through 10/12/18	CrEX-1, CrEX-2, CrEX-3, CTUA, CrIN-3, CrIN-4, CrIN-5	System shutdown occurred for SCADA[c] computer reprogramming. Both influent filter bags replaced because of system high pressure.
10/12/18 through 10/30/18	CrEX-1, CrEX-2, CrEX-3, CTUA, CrIN-3, CrIN-4, CrIN-5	Extraction, treatment, and injection of treated groundwater occurred per operational plan.
10/16/18	CTUA	Both influent filter bags replaced because of system high pressure.
10/19/18	CTUA	Both influent filter bags replaced because of system high pressure.
10/22/18	CTUA	Both influent filter bags replaced because of system high pressure.
10/26/18	CTUA	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via HACH: Treatment train A – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train B – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train C – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Both influent and all three effluent filter bags replaced.
10/30/18	CTUA	Both influent filter bags replaced because of system high pressure.
10/30/18 through 12/31/18	CrEX-1, CrEX-2, CTUA, CrIN-3, CrIN-4, CrIN-5	CrEX-3 operation permanently shut down because of filter plugging. Extraction, treatment, and injection of treated groundwater occurred per operational plan using CrEX-1 and CrEX-2.

Table 2.1-1 (continued)

Maintenance Date	Elements Impacted	Maintenance Description
10/31/18	Booster Pumps	Periodic maintenance performed on booster pump motors.
11/5/18	CrEX-1, CrEX-2, CTUA, CrIN-3, CrIN-4, CrIN-5	System shutdown occurred briefly for SCADA computer replacement with backup SCADA computer.
11/26/18 through 11/27/18	CrEX-3	CrEX-3 turned on for a 24-hr period to allow for monthly sample collection.
11/29/18	CTUA	IX vessel exchanges were completed as follows because of an increase in the amount of hexavalent chromium at the primary IX vessel effluent as determined via HACH: Treatment train A – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train B – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Treatment train C – replaced primary IX vessel with the secondary IX vessel; new secondary IX vessel installed. Both influent and all three effluent filter bags replaced.
12/17/18 through 12/18/18	CrEX-3	CrEX-3 turned on for a 24-hr period to allow for monthly sample collection.

[a] CTUA = Chromium treatment unit A.

[b] CTUA contains three treatment trains: train A, train B, and train C.

[c] SCADA = Supervisory Control and Data Acquisition.

Table 2.1-2
Interim Measure Chromium Mass Removal Estimates

Quarter	Average HACH Cr(VI)* (ppb)	Extracted and Treated Volume (gal.)	Chromium Removed (kg)	Chromium Removed (lb)
1st Qtr 2017	181	6,226,097	4.3	9.4
2nd Qtr 2017	184	4,952,226	3.4	7.6
3rd Qtr 2017	284	95,471	0.1	0.2
4th Qtr 2017	237	5,599,138	5.0	11.1
1st Qtr 2018	237	3,045,820	2.7	6.0
2nd Qtr 2018	227	13,360,000	11.5	25.3
3rd Qtr 2018	223	20,776,913	17.5	38.7
4th Qtr 2018	206	20,442,977	15.9	35.1
Total		**75,163,909**	**61.0**	**134.4**

* Cr(VI) = Hexavalent chromium.

Table 3.1-1
Performance Monitoring Locations and Analyte Suite, Including Tracers That Have Been or Will Be Deployed in Monitoring Wells, Piezometers, and Injection Wells in the Project Area

Location	Metals	Low-Level Tritium	General Inorganics[a]	Naphthalene Sulfonate Tracers	Sodium Bromide Tracer	Sodium Perrhenate Tracer	Deuterated Water Tracer
R-11	M[b]	Q[c]	M	M	M	M	M
R-35a	M	Q	M	M	—[d]	M	M
R-35b	M	Q	M	M	—	M	M
R-44 S1	M	Q	M	M	—	M	—
R-44 S2	M	Q	M	M	—	M	—
R-45 S1	M	Q	M	M	M	M	M
R-45 S2	M	Q	M	M	M	M	M
R-50 S1	M	Q	M	M	—	—	—
R-50 S2	M	Q	M	M	—	—	—
R-61 S1	M	Q	M	M	—	—	—
SIMR-2	M	Q	M	M	—	—	—
CrPZ-1	Q	Q	Q	—	—	—	—
CrPZ-2a	Q	Q	Q	—	—	—	—
CrPZ-2b	Q	Q	Q	—	—	—	—
CrPZ-3	Q	Q	Q	—	—	—	—
CrPZ-4	Q	Q	Q	—	—	—	—
CrPZ-5	Q	Q	Q	—	—	—	—

[a] Includes nitrate, sulfate, and perchlorate.

[b] M = Monthly.

[c] Q = Quarterly.

[d] — = Not analyzed at the noted location.

Table 3.3-1
Summary of Large Mass/Volume Deployments of Tracers and other Chemicals in 2016 and 2017 in the Hexavalent Chromium Plume Area (listed in chronological order)

Well	Deployment Date(s)	Tracer/Chemical	Mass (g)	Volume[a] (gal)	Stratigraphy of Screen
CrPZ-2b	6/1/2016 to 7/2016	NaBr Na-2 NS	144,800 25,150	42,000 21,000 chase	Tjfp
CrPZ-2a	6/15/2016 to 6/18/2016	$NaReO_4$ Na 2,7-NDS	2000 24,870	10,000 10,000 chase	Tpf
R-42	7/11/2016 to 7/14/2016	$NaHCO_3$ Na_2CO_3	23,840 30,090	15,000 500 chase	Tjfp
R-28	9/29/2016	D_2O Na-1,6 NDS	60,000 24,960	15,000 15,000 chase	Tpf and Tpf(p)
CrIN-4	5/17/2017 to 5/18/2017	Na-1,5 NDS	50,000	15,000	Tpf
CrIN-5	5/22/2017 to 5/23/2017	Na-1,6 NDS	50,000	15,000	Tpf
R-42[b]	8/24/2017 to 8/25/2017	$Na_2S_2O_4$ Na_2SO_3 NaBr	340,350 251,859 5003	9000 1000 chase	Tjfp
R-28	9/9/2017	Molasses NaBr Ethanol (chase)	3.3% by volume 10,000 10% by volume	30,000 1500 chase	Tpf and Tpf(p)
CrIN-3	9/12/2018	Na-1,3,6 NTS	50,000	15,000	Tpf
CrIN-4	9/17/2018	Na-2,6 NDS	50,000	15,000	Tpf
CrIN-5	9/18/2018	Na-2,7 NDS	50,000	15,000	Tpf

[a] Makeup water in all tests was potable water, except for R-42 and R-28 amendment injections, in which pre-collected R-42 and R-28 water, respectively, were used as makeup water. Chase water in all tests was potable water (with 10% ethanol added to chase in R-28 amendment test).

[b] Over 90% of the dithionite amendment solution injected into R-42 on 8/24-25/2017 was pumped back from R-42 in the weeks immediately following the injection.

Table 3.4-1
Water Levels and Head Difference for
Dual-Screen Locations within the Chromium Project Area

Monitoring Well	Average Head Jul 2018 (ft)	Average Head Aug 2018 (ft)	Average Head Sep 2018 (ft)	Average Head Oct 2018 (ft)	Average Head Nov 2018 (ft)	Average Head Dec 2018 (ft)
CrPZ-2a	5831.05	5831.69	5831.43	5831.06	5831.67	5831.72
CrPZ-2b	5830.99	5831.61	5831.37	5831.02	5831.63	5831.69
CrPZ 2a - 2b	0.06	0.08	0.06	0.04	0.04	0.03
R-43 S1	5833.83	5833.80	5833.65	5833.55	5833.53	5833.50
R-43 S2	5832.95	5832.94	5832.81	5832.75	5832.78	5832.79
R-43 S1 - S2	0.88	0.86	0.84	0.80	0.74	0.71
R-44 S1	5831.72	5831.72	5831.72	5831.72	5831.75	5831.81
R-44 S2	5831.07	5831.20	5831.17	5831.16	5831.28	5831.33
R-44 S1 - S2	0.65	0.52	0.55	0.57	0.47	0.48
R-45 S1	5831.13	5831.23	5831.19	5831.14	5831.26	5831.30
R-45 S2	5830.88	5831.01	5830.94	5830.89	5831.04	5831.08
R-45 S1 - S2	0.25	0.22	0.24	0.24	0.21	0.22
R-50 S1	5833.05	5833.03	5833.03	5833.08	5833.09	5833.13
R-50 S2	5831.98	5832.14	5832.13	5832.21	5832.22	5832.27
R-50 S1 - S2	1.07	0.89	0.90	0.88	0.86	0.86
R-61 S1	5833.26	5833.25	5833.15	5833.27	5833.23	5833.18
R-61 S2	5833.18	5833.14	5833.04	5833.20	5833.13	5833.07
R-61 S1 - S2	0.08	0.11	0.11	0.06	0.10	0.11

Appendix A

Analytical Data Collected under the
Interim Facility-Wide Groundwater Monitoring Plan
(on CD included with this document)