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Western Sector In-Situ Chemical Oxidation Project: Additional Injection Pilot Testing Supplemental Results (U)

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LIST OF ABBREVIATIONS AND ACRONYMS

bgs	below ground surface
Cl	chlorine
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
EPA	Environmental Protection Agency
ft	foot, feet
gal	Gallon, gallons
Hg	mercury
HWMF	Hazardous Waste Management Facility
ID	identification
ISCO	in-situ chemical oxidation
J	estimated value
K	potassium
L	liter
LLAZ	Lost Lake Aquifer Zone
µg/L	microgram per liter
µS/cm	microsiemens per centimeter
m	meter, meters
MCL	maximum contaminant level
mg/L	milligram per liter
Mn	manganese
msl	mean sea level
mV	milliVolt
Na	sodium
ND	non-detect
NS	not sampled
ORP	oxidation-reduction potential
PCE	tetrachloroethylene
pH	potential of hydrogen
R	rejected
RCRA	Resource Conservation and Recovery Act
SC	Specific Conductivity
SCDHEC	South Carolina Department of Health and Environmental Control
SRNS	Savannah River Nuclear Solutions, LLC
SRS	Savannah River Site

LIST OF ABBREVIATIONS AND ACRONYMS *(Continued/End)*

TA	temporary authorization
TCE	trichlorethylene
VOCs	volatile organic compounds

1.0 INTRODUCTION

Trichloroethylene (TCE) and tetrachloroethylene (PCE) are persistent at elevated concentrations in the Western Sector of the M-Area Hazardous Waste Management Facility (HWMF) groundwater plume. Migration of these chlorinated ethenes as Dense Non-Aqueous Phase Liquids (DNAPLs) occurred from the M-Area Settling Basin along geologic strata resulting in a high concentration groundwater plume in Western Sector. Pump-and-treat has been active for over 30 years at the M-Area HWMF to hydraulically contain the primary sources of the plume in addition to other remediation strategies throughout the contaminated zone, like soil vapor extraction, dynamic underground stripping, groundwater recirculation wells, and bioremediation. In-situ chemical oxidation (ISCO) has been identified as a viable treatment method for removal of these volatile organic compounds (VOCs) due to the complex lithology and high concentrations in this part of the aquifer. In addition to ISCO, a new recovery well (i.e., RWM018) was also installed in Western Sector to contain the high concentration VOC plume. The ISCO projects have utilized the gradient induced by RWM018 to help plan the injection and monitoring locations. The combination of ISCO and the additional pump and treat in Western Sector with the installation of RWM018 will help to control the plume and maximize remediation efforts.

RWM018 and chemical oxidant solutions of potassium permanganate and sodium persulfate were proposed under a temporary authorization (TA) request for Western Sector (SRNS 2016) and approved by South Carolina Department of Health and Environmental Control (SCDHEC) in March 2016 (SCDHEC 2016). RWM018 was installed in July 2017 and became operational as part of the M-1 Air Stripper recovery well network in May 2018. A first round of oxidant injections, known as ISCO-I, was performed between August and October of 2018 using eight injection wells with 4.6-m (15-ft) screen zones along two horizons of the Lost Lake Aquifer Zone (LLAZ). Groundwater monitoring post injection was accomplished with a series of monitoring wells downgradient from the injection site. This pilot-scale study demonstrated positive results; showing that dual oxidant treatment was able to effectively target the contaminants near the injection, as well as along the migration path (SRNS 2019).

Though this initial round of injections showed ISCO was effective in the destruction of chlorinated ethenes in the Western Sector, results highlighted that the oxidants were not well distributed vertically across all horizons of the aquifer and the injections had little impact on the upper portion of each geologic horizon. The injection strategy was refined to address this limitation in a second injection campaign referred to as ISCO-II. The second injection was proposed as a second TA, submitted to SCDHEC in January 2020 (SRNS 2020a), and approved in March 2020 (SCDHEC 2020a). The revised injection strategy includes new injection wells with shorter screens to better target specific zones of the LLAZ. Screens zones at the four new injection wells are 1.5-m (5-ft) (SRNS 2020b). A similar injection scheme was employed as was used in the 2018 injections (SRNS 2017). However, the volume of each oxidant differed from the 2018 injections. During ISCO-II injections a total of 75,708 liters (L [20,000 gallons {gal}]) of potassium permanganate solution was injected, followed by an injection of 94,635 L (25,000 gal) of sodium persulfate and sodium hydroxide solution. This activity will help in further assessing the viability of a full-scale remediation using ISCO to treat PCE, TCE, and daughter products present in the M-Area groundwater.

2.0 PURPOSE AND OBJECTIVE

The purpose of the Western Sector ISCO project is to inject chemical oxidants (potassium permanganate and sodium persulfate) into a contaminated aquifer zone via a series of injections wells and evaluate the effectiveness of diminishing indiscriminate DNAPL sources that are present in the subsurface of the Western Sector of M-Area. Oxidant injections were repeated using an adapted scheme to address a limitation found during the prior injection activity and more efficiently target all zones of the LLAZ.

This is the third planned interim report to track the performance of the project. The purpose of this document is to report groundwater monitoring data collected after the ISCO-II injections with the revised scheme and compare its effectiveness with ISCO-I. This document will interpret data from March 2020 through December 2020 to illustrate the impacts of each of the injection campaigns. In ISCO-II additional injection wells were installed with shorter screen lengths targeting discrete geologic horizons and the existing network of monitoring wells was used to monitor the effect of the oxidant injections on the VOC plume.

Table 2-1 includes the new injection wells and existing monitoring and recovery wells specifications. Monitoring of ISCO-II specific effects focuses primarily on the area between the injection wells and the WSM003 well cluster. Data collected between ISCO-I and ISCO-II injection activities is also assessed to determine the impact of oxidant introduction on the system between campaigns.

Table 2-1. M-Area Western Sector ISCO Well Locations and Screen Intervals

Station ID	Screen Top *(ft bgs)*	Screen Bottom *(ft bgs)*	Total Depth *(ft bgs)*	Ground Elevation *(ft amsl)*	Well Diameter *(in.)*	Aquifer	SRS Easting *(ft)*	SRS Northing *(ft)*
ISCO-II Injection wells								
WSI005B	197	202	202	346.42	2	LLLAZ	46,691	103,105
WSI005C	173	178	178	346.42	2	ULLAZ	46,691	103,105
WSI006B	197	202	202	346.64	2	LLLAZ	46,716	103,105
WSI006C	173	178	178	346.64	2	ULLAZ	46,716	103,105
Existing Groundwater Recovery (Extraction) Well								
RWM018	170.6	220.6	220.6	349.75	2	ULLAZ_LLLAZ	46,548.4	102,538.2
ISCO Monitoring Wells								
WSM001B	197.4	202.4	202.7	346.31	2	LLLAZ	46,685.0	103,085.2
WSM001BB	206.7	211.7	212.0	346.27	2	LLLAZ	46,694.0	103,083.3
WSM001C	173.2	178.2	178.5	346.31	2	ULLAZ	46,684.9	103,095.2
WSM001CC	182.2	187.2	187.5	346.19	2	ULLAZ	46,695.1	103,093.9
WSM002B	197.3	202.3	202.6	345.94	2	LLLAZ	46,712.0	103,083.9
WSM002BB	206.7	211.7	212.0	345.92	2	LLLAZ	46,721.9	103,084.5
WSM002C	172.9	177.9	178.2	345.97	2	ULLAZ	46,712.0	103,094.0
WSM002CC	180.9	185.9	186.2	345.89	2	ULLAZ	46,722.0	103,094.1
WSM003B	200.0	205.0	205.3	345.99	2	LLLAZ	46,666.9	102,863.0
WSM003BB	212.1	217.0	217.4	345.85	2	LLLAZ	46,677.0	102,862.1
WSM003C	174.1	184.1	184.5	345.89	2	ULLAZ	46,668.2	102,872.2
WSM003CC	189.3	199.3	199.6	345.79	2	ULLAZ	46,676.4	102,871.9
RCRA Permitted Monitoring Wells								
MSB107B	213.0	223.0	225.0	347.24	2	LLLAZ	46,614.4	102,634.7
MSB107C	170.0	180.0	182.0	347.29	2	ULLAZ	46,605.1	102,639.1
MSB107CC	190.0	200.0	227.0	347.65	2	ULLAZ_LLLAZ	46,593.8	102,667.3

bgs = below ground surface
ft = feet
LLLAZ = Lower Lost Lake aquifer zone
amsl = above mean sea level
RCRA = Resource Conservation and Recovery Act
ULLAZ = Upper Lost Lake aquifer zone
in. = inch

3.0 MONITORING AND INJECTION WELL NETWORK

Four new injection wells (WSI005B, WSI005C, WSI006B, and WSI006C) were installed with shorter screen lengths for this activity to better target specific subsurface horizons in the LLAZ. The injection wells were installed as nested wells; two separate injection wells were installed in the same bore hole with a bentonite seal hydraulically separating the two screen intervals. The nested well design was utilized to reduce the overall footprint of the project at the surface while still being able to target specific horizons in the LLAZ. Nested injection wells were installed at two locations with 1.5-meters (m [5-feet {ft}]) screen zones. The injection wells were constructed of polyvinyl chloride, a material not reactive with potassium permanganate and sodium persulfate. The injection wells are located approximately (~) 3.8-m (12.5-ft) downgradient from the previous injection wells and 3.8-m (12.5-ft) upgradient from existing monitoring wells. Monitoring of injection activities will be accomplished through the use of existing groundwater monitoring wells. The locations of both monitoring and injection wells are shown in Figure 3-1.

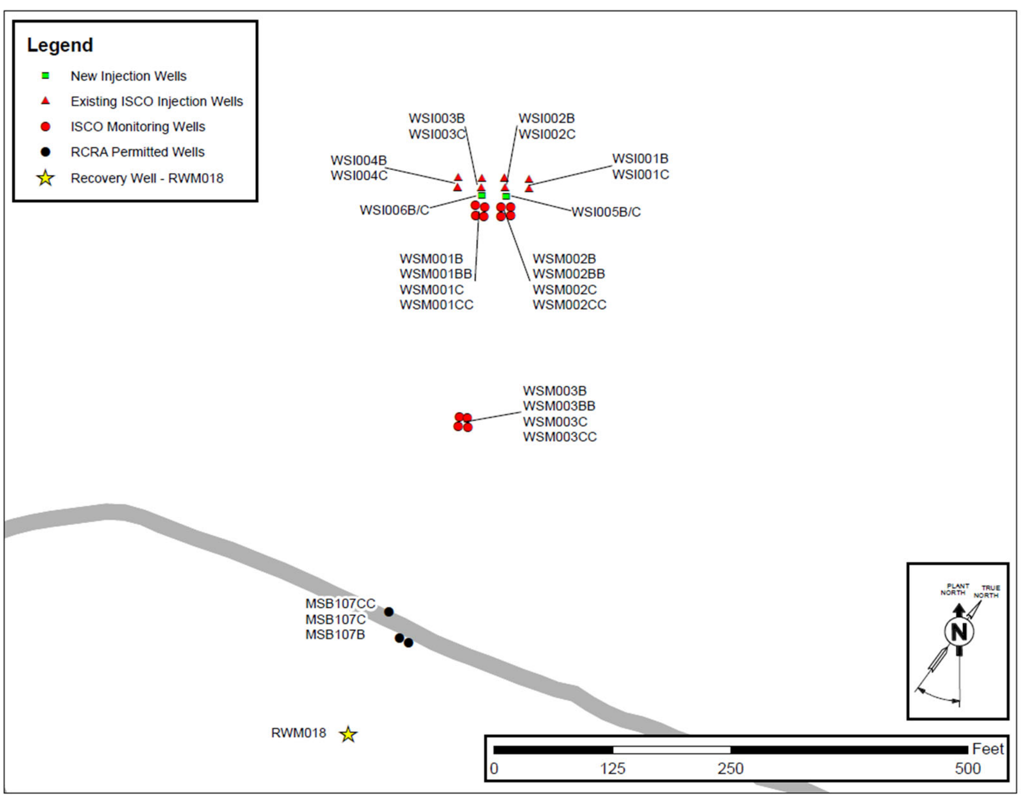

Figure 3-1. Newly Installed ISCO Well Locations in Relation to Existing Network

4.0 INJECTION ACTIVITIES

The strategy used in previous campaigns was altered for this round of injections. Oxidant solutions of potassium permanganate and sodium persulfate were injected into horizons that were not effectively addressed during ISCO-I and where previous monitoring data indicates that higher contaminant concentrations remain (SRNS 2019; SRNS 2020c).

During ISCO-I, injection wells with 4.6-m (15-ft) screens were utilized for injection of oxidants into the LLAZ along two groundwater horizons (i.e., C- and CC-horizons or B- and BB-horizons). However, monitoring results demonstrated that the oxidants were delivered mostly to the lower portion (CC and BB) of the 4.6-m (15-ft) screens utilizing this injection well design. This resulted in an impact to only those zones associated with the lower portion of the injection well's screen zone. In response, ISCO-II injections utilized an alternate well configuration (Figure 4-1). Shorter screens, 1.5-m (5-ft) in length, were used to explicitly target the C- and B-horizons present in the LLAZ. Each of two injection well locations contain two nested injection points, for a total of four injection wells. Throughout and after the injection activities, groundwater was monitored with the existing monitoring wells to evaluate the effects that the amendments have on reducing groundwater concentration of chlorinated ethenes. All four permeable horizons are included in the monitoring activities. The C- and CC-horizons sample the upper LLAZ, while the B- and BB-horizons sample the lower LLAZ. Western Sector ISCO monitoring well locations and screen intervals are included in Table 2-1.

The injection of chemical oxidants for ISCO-II began on August 27, 2020, and was completed on September 8, 2020. Each oxidant was separately prepared using potable water at the surface to make an injection solution prior to injection. A total of 75,708 L (20,000 gal) of potassium permanganate solution was injected equally into the four injection wells, followed by subsequent equal injection scheme of 94,635 L (25,000 gal) of sodium persulfate and sodium hydroxide solution. Sodium hydroxide was used to prevent corrosion of the mixing equipment through pH adjustment.

4.1 Impacts to RWM018 from ISCO-I

RWM018 was installed as a means of providing capture and hydraulic control of the high concentration VOC plume located in Western Sector. The ISCO-I project was oriented to utilize the hydraulic gradients created by pumping at RWM018 to direct oxidants from the injection location through the monitoring zone. The injection activities for ISCO-I were completed in October 2018. Between then and February 2020, oxidants migrated from the injection location to RWM018. As a result, the stannous chloride system within the M-1 Air Stripper was rendered ineffective and mercury levels increased at the A-11 Outfall, a compliance point for the Savannah River Site (SRS) National Pollutant Discharge Elimination System permit. SRS postulates that strong oxidants were delivered to the M-1 Air Stripper via RWM018 and these oxidants consumed the stannous chloride before it could react with mercury, thus preventing mercury from being removed in the stripping process. It was hypothesized that any oxidants within the groundwater would be consumed prior to reaching the M-1 Air Stripper influent due to the load of VOCs within the area. However, this apparently is not the case for RWM018.

Once it was determined that the stannous system was impacted, RWM018 was removed from service in March 2020, and the stannous system returned to effectively removing mercury from the M-1 Air Stripper influent. SRS notified SCDHEC about RWM018 and its continued shutdown during the ISCO-II injections via email on July 24, 2020 (SRNS 2020d). In a response to that email, SCDHEC approved the ISCO-II injections without the operation of RWM018 via email on July 29, 2020 (SCDHEC 2020b). In the email, SCDHEC stated that they look forward to an SRS solution for mercury in the near future. RWM018 has remained off throughout the ISCO-II activities and will remain off until it can be fully evaluated. Since RWM018 is not operational, no samples could be collected and it will not be discussed within this report.

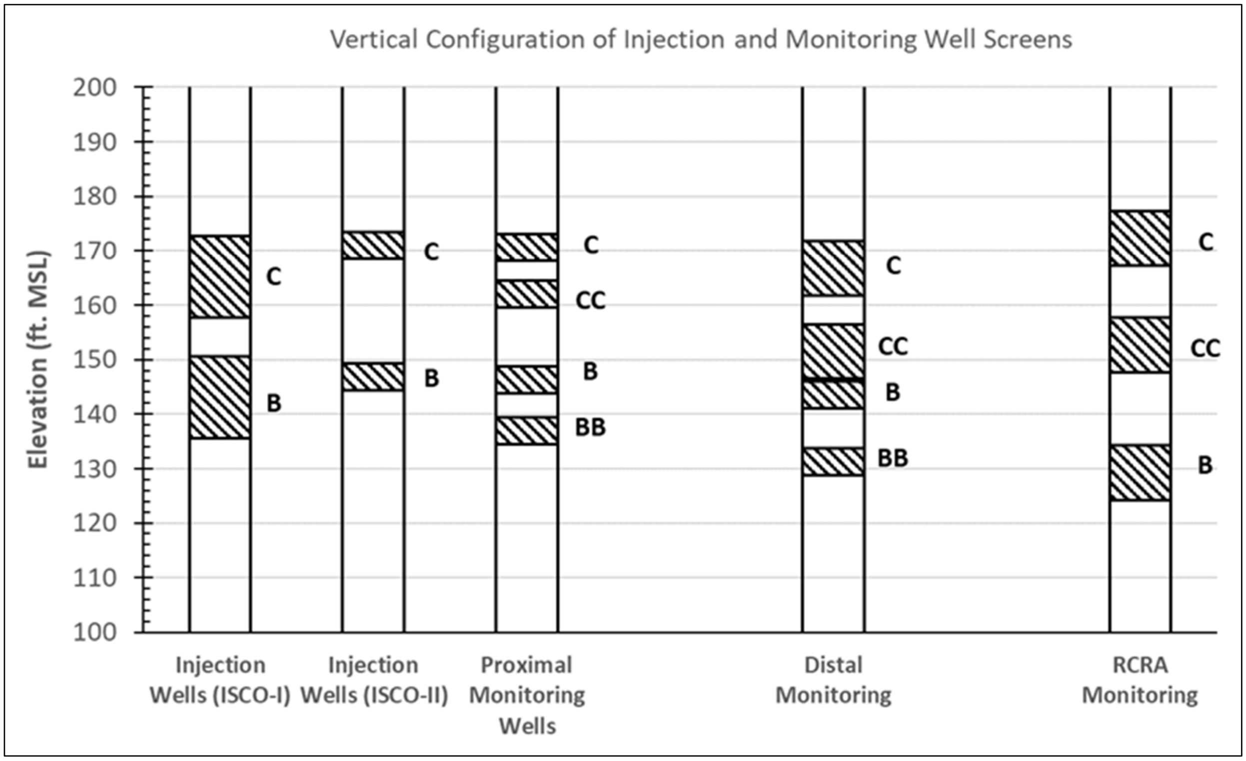

Figure 4-1. Vertical Configuration of Injection and Monitoring Well Screens

5.0 SAMPLING FREQUENCY

As prescribed in the Underground Injection Control permit application, groundwater monitoring is scheduled to occur over a 24-month period after oxidant injection (SRNS 2020b). Field parameters assessed from samples include pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and electrical conductivity. Groundwater samples are analyzed for TCE and PCE and oxidation by-product chloride. Sodium, potassium, sulfate, and manganese were quantified as they are ionic constituents of the two oxidants being employed, potassium permanganate and sodium persulfate. Mercury is included in the monitoring program because of its historic association with DNAPL in the A/M Area. Earlier monitoring activities (SRNS 2019) indicate the presence of dissolved mercury associated with the oxidation of high concentrations of TCE. A sampling schedule for each of these parameters at all monitoring well locations is provided in

Table 5-1.

Table 5-1. Monitoring Well Sampling Frequency by Parameter and Time from Injection

Well ID	cVOCs	Anions	Mercury	Metals	Radionuclides	Field Parameters
Groundwater Monitoring Wells Monitored During and Shortly After Oxidant Injection (First 2 Months)						
ISCO Proximal Wells	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly
ISCO Distal Wells	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
RCRA Monitoring Wells	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
Groundwater Monitoring Wells Monitored During Monitoring Phase (2 – 6 Months)						
ISCO Proximal Wells	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly
ISCO Distal Wells	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
RCRA Monitoring Wells	Semi-annually	Semi-annually	Semi-annually	Not sampled	Semi-annually	Semi-annually
Groundwater Monitoring Wells Monitored After 6 Months						
ISCO Proximal Wells	Quarterly	Quarterly	Quarterly	Quarterly	Not sampled	Quarterly
ISCO Distal Wells	Quarterly	Quarterly	Quarterly	Quarterly	Not sampled	Quarterly
RCRA Monitoring Wells	Semi-annually	Semi-annually	Semi-annually	Semi-annually	Not sampled	Semi-annually

Proximal wells include: WSM001C, WSM001CC, WSM001B, WSM001BB; WSM002C, WSM002CC, WSM002B, and WSM002BB
Distal wells include: WSM003C, WSM003CC, WSM003B, and WSM003BB
RCRA Monitoring Wells include: MSB107B, MSB 107C, and MSB107CC
cVOCs (chlorinated volatile organic compounds) include: TCE, PCE, and daughters

Eight ISCO proximal monitoring wells (WSM001B, WSM001BB, WSM001C, WSM001CC, WSM002B, WSM002BB, WSM002C, WSM002CC), four ISCO distal wells (WSM003B, WSM003BB, WSM003C, WSM003CC), and three Resource Conservation and Recovery Act (RCRA) monitoring wells (MSB107B, MSB107C, MSB107CC) are included as part of the monitoring schedule. The proximal wells are located ~3.8-m (12.5-ft) downgradient of the new injection wells and will be used to assess immediate impacts from injection activities, while the distal wells are located ~76-m (250-ft) downgradient and will be used to evaluate long-term impacts to the plume after oxidant injection. The RCRA monitoring wells are located ~152.4-m (500-ft) downgradient and will be used to further evaluate long-term impacts to the plume expected to occur more than one year after oxidant injections.

Baseline samples were collected prior to the ISCO-I chemical oxidant injections from all 15 monitoring wells associated with the Western Sector ISCO project (July 17 and 18, 2018). From September 16, 2020, to November 4, 2020, weekly sampling was conducted at the eight proximal monitoring wells following oxidant injections associated with ISCO-II. Monthly sampling at the proximal wells started in December 2020 and will continue until March 2021. After March 2021, the proximal wells will be sampled quarterly until 24 months after injections are completed. Quarterly monitoring at the four distal monitoring wells started in December 2020 and will continue for 24 months after injections were completed. The RCRA monitoring wells are being sampled on a semiannual schedule starting in March 2021. Data from these wells are included in this interim report.

6.0 RESULTS

6.1 Field Parameters

Measurements of field parameters (i.e., pH, DO, ORP, and conductance) can be useful in determining the distribution of oxidants and the effectiveness of the remediation. Field parameter data is included in Table 10-1 and Figure 10-1 through Figure 10-4. Included in the top panel of Figure 10-1 through Figure 10-4 is the amount of potassium permanganate and sodium persulfate that was injected into the respective horizon during both injection campaigns. This information is provided to illustrate the two specific injection periods and aid in interpreting responses in monitoring data to ISCO-I or ISCO-II injection campaigns. During ISCO-II, the injection was targeted in the B- and C-horizons. When comparing the field parameters in the B- and C-horizons to those in the BB- and CC-horizons, it can be seen that the impacts are larger in the targeted horizons and smaller in the BB- and CC-horizons (Figure 10-1 through Figure 10-4). A description of changes in each well are detailed below.

The following guidelines were applied in evaluating oxidant injection effectiveness:

- Decreases in pH are expected based on the lower pH of the oxidant solutions,
- Increases in conductivity are frequently observed following oxidant injections and can be indicative of permanganate or persulfate (Petri et al., 2011),
- Increases in DO reflect oxidizing conditions and generally coincide with the presence of active oxidant,
- Positive values (greater than [>] 200 milliVolt [mV]) reflect oxidizing conditions and generally coincide with the presence of oxidant. ORP values in the data set typically mirror the same trends expressed in the DO data.

6.1.1 WSM001

Within the WSM001 well cluster, field parameters around ISCO-II injection activities were impacted in all four horizons indicating the effectiveness of modified injection scheme using two, shorter screened, nested injection wells. Parameters in the B-horizon experienced more of an effect than those in the BB-horizon. Similarly, the C-horizon was impacted more than the CC-horizon. Furthermore, injection activities had a greater effect on both the C- and CC-horizons in comparison to the B- and BB-horizons. A description of each of the trends in the field parameters can be found below.

6.1.1.1 Water Level

There was no major impact to water level within the WSM001 well cluster as a result of ISCO-II activities. This can be seen in panel 2 of Figure 10-1 through Figure 10-4. The gradual increase in water level between March 2020 and October 2020 is due to RWM018 being shut off and no longer pulling water from the aquifer.

6.1.1.2 pH

pH trends can be seen in panel 3 of Figure 10-1 through Figure 10-4. As a result of the ISCO-II injections, the pH in WSM001B is seen to decrease from 4.3 to 3.5 between week 3 (9/30/2020) and week 4 (10/7/2020) of sampling before increasing back to 4.2 by week 5 (10/14/2020) and dropping again to 3.7 in week 6 (10/21/2020). After October, the pH remains relatively constant around 4 through December 2020. WSM001C follows a similar trend with pH decreasing from 4 to 3 between sampling week 2 (9/23/2020) and week 3 (9/30/2020), then increasing to 4.3 by week 4 (10/7/2020) and decreasing to 3.9 in week 5 (10/14/2020) before leveling out to around 4.4 through December 2020 sampling events. While the BB- and CC-horizons were not the targeted injection horizons, changes in pH were observed around the time of injection. WSM001BB is seen to decrease in pH from 4.9 to 3.9 between week 1 (9/16/2020) and week 2 (9/23/2020) and then 3.7 in week 3 (9/30/2020) before increasing to 4.1 by week 5 (10/14/2020) and decreasing to 3.3 in week 6 (10/21/2020). The pH then levels out to 4.2 through the sampling event in December. WSM001CC also had a decrease from 7.6 to 6 between week 1 of sampling

(9/16/2020) and week 2 (9/23/2020). From there, the pH increased to 6.2 by week 4 (10/7/2020) and decreased to 5.3 in week 5 (10/14/2020) before increasing again to 6.2 in week 6 (10/21/2020) and finally decreasing to around 5.3 through December.

6.1.1.3 Conductance

Conductance trends can be seen in panel 4 of Figure 10-1 through Figure 10-4. WSM001B is seen to have a rapid increase from 87 microsiemens per centimeter (µS/cm) in March 2020 to 459 µS/cm during week 1 (9/16/2020) of sampling following ISCO-II. Between weeks 1 and 3 (9/30/2020), the conductance decreases to 122 µS/cm. There was then a rapid increase to 3,078 µS/cm by week 4 (10/7/2020) of sampling before a decrease to 101 µS/cm by week 6 and then a gradual increase through December. Conductance levels in WSM001C also increased quickly from 10 µS/cm to 7,144 µS/cm from March 2020 to week 1 of sampling (9/16/2020). The values stay elevated through December with a dip to 2,710 µS/cm in week 7 of sampling (10/28/2020). The initial rapid increases in conductance at WSM001B and WSM001C indicate that the addition of oxidant impacted those horizons immediately. Readings within WSM001BB do not vary as much following the initial increase from 1,392 µS/cm to 2,388 µS/cm between March 2020 and week 1 of sampling (9/16/2020). WSM001CC conductance values were not as quickly impacted by the oxidant injection. The values increase gradually from 92 µS/cm to 451 µS/cm through week 6 of sampling (10/21/2020). In week 7 (10/28/2020), the value increases rapidly to 3,094 µS/cm. Following this the conductance decreases to 1295 µS/cm in week 8 (11/4/2020) and increases to a maximum of 5,109 µS/cm by December. This could be an indication that the oxidant migrated from the C- or B-horizon causing a delayed impact to the CC-horizon when compared to the others.

6.1.1.4 Dissolved Oxygen

DO trends can be seen in panel 5 of Figure 10-1 through Figure 10-4. WSM001B is seen to have a rapid spike in dissolved oxygen with ISCO-II injection activities. Initially there is a minor decrease from 4.9 mg/L to 4.2 mg/L between sampling week 1 (9/16/2020) and week 2 (9/23/2020) before the large increase from 4.2 mg/L to 9.43 mg/L dissolved oxygen by week 3 (9/30/2020). From there, the DO is seen to decrease to 3.35 by the 6th week of sampling (10/21/2020) and then increased to 5.9 in the 7th week of sampling (10/28/2020) before decreasing to 2.24 through December. WSM001BB is seen to have a similar concentration pattern occur. The DO initially decreased from 5.1 mg/L to 4.4 m/L in the first two weeks of sampling (9/16/2020 and 9/23/2020) before increasing to 8.98 mg/L by sampling week 4 (10/14/2020) then decreasing to 2.87 mg/L by December 2020. The concentration of DO in WSM001C decreased from 8.49 mg/L down to 3.46 mg/L in September 2020, during the first three sampling weeks, and then rapidly increased to 6.15 mg/L by sampling week 4 (10/7/2020) before returning to 4.89 mg/L by sampling week 5 (10/14/2020). After week 5, the DO concentration increased to 8.71 mg/L in sampling week 6 (10/21/2020) and then decreased constantly to 3.0 mg/L in December 2020. WSM001CC is seen to immediately respond to the injection with an increase from 5.38 mg/L to 8.81 mg/L between March 2020 and the second week of sampling (9/23/2020). After this, the DO concentrations are seen to decrease to 3.48 by week 3 of sampling (9/30/2020) before steadily increasing to 6.41 mg/L by week 7 of sampling (10/28/2020) and then steadily decreasing to 2.66 mg/L by December.

6.1.1.5 Oxidation Reduction Potential

ORP trends can be seen in panel 6 of Figure 10-1 through Figure 10-4. The baseline ORP in WSM001B in March 2020 was measured at 381 mV. In sampling week 1 (9/16/2020), the ORP in WSM001B was measured at 608 mV and continually increased to 901 mV by week 5 (10/14/2020) of sampling before steadily decreasing to 796 mV by December 2020. The ORP in WSM001C was 223 mV in March 2020. In week 1 of sampling (9/16/2020), the ORP is 852 mV. After week 1, the ORP increased to 926 mV by week 2 of sampling (9/23/2020) before dipping to 584 mV by week 6 (10/21/2020) of sampling and increasing again to 818 mV by December 2020. The increase in ORP corresponds with the injection of large amounts of oxidants into the system. At WSM001CC, the ORP in March 2020 is 496 mV and decreased to 425 mV for week 1 of sampling (9/16/2020) and increased to 659 mV for week 2 of sampling (9/23/2020). Between week 2 and week 4 (10/7/2020) of sampling, the ORP decreased to 250 mV and then increased to 714 mV by week 7 of sampling (10/28/2020) before dipping to 657 mV in week 8 (11/4/2020) and increasing to 674 mV in December 2020. At WSM001BB, the ORP is 829 mV in week 1 of sampling (9/16/2020). The ORP decreased to 437 mV in week 2 of sampling (9/23/2020) before increasing to 878 mV by sampling week 4 (10/7/2020) and then settling between 865 mV and 871 mV through sampling week 8 (11/4/2020) before decreasing to 832 mV in December 2020.

6.1.2 WSM002

Variations in field parameter trends within the WSM002 well cluster horizons can be seen as a result of ISCO-II injection activities. While water level was not impacted by the injection in any horizon, parameters such as conductance, DO, and pH were affected. This indicates the ability of the new injection strategy to distribute oxidants vertically across the vertical horizons. Parameters in the B-horizon of this well were more largely impacted than those in the BB-horizon and larger fluctuations were seen with time in the C-horizon compared to that in WSM002CC. Each field parameter trend is explained in the corresponding sections below.

6.1.2.1 Water Level

There was no major impact to water level within the WSM002 well cluster as a result ISCO-II activities. This can be seen in panel 2 of Figure 10-1 through Figure 10-4. The gradual increase in water level between March 2020 and October 2020 is due to RWM018 being shut off and no longer pulling water from the aquifer.

6.1.2.2 pH

pH trends can be seen in panel 3 of Figure 10-1 through Figure 10-4. The B- and C-horizons at WSM002 reacted to the injections with similar trends to these horizons at WSM001; generally decreasing in response to oxidant injection initially before ultimately rebounding to a background pH range. The pH in WSM002B, for example, decreased from 5.1 in week 1 of sampling (9/15/2020) to 3.8 by week 3 (9/30/2020). The pH results increased to 5.4 by week 6 (10/21/2020) and decreased to 4.9 in week 7 (11/4/2020) and increased to 5.6 in December. The pH in WSM002BB decreased immediately following the ISCO-II injections from a pH of 5.8 in week 1 of sampling (9/16/2020) to 3.8 by week 5 (10/14/2020). From there, the pH increased back to 5.1 in week 6 (10/28/2020) and settled to 4.9 through December. The pH in WSM002C decreased from 6.5 to 4.8 between week 1 (9/16/2020) and week 2 (9/23/2020) and increased to 5.7 by week 3 (9/30/2020) then fluctuated between 5.5 and 5.0 before decreasing to 4.8 in December. At

WSM002CC, pH increased from 4.4 in week 1 (9/16/2020) to 5.6 by week 5 (10/14/2020) before decreasing to around 4.8 in December. The pH trend at WSM002CC is seen to have a delayed decrease in pH when compared to the other WSM002 horizons. Within the C- and B-horizons, a decrease in pH during week 2 was observed implying immediate impact of oxidant on the aquifer. Decreases in pH in the BB-horizon were observed in week 3, only slightly behind the B-horizon, suggesting that oxidant migrated into this horizon.

6.1.2.3 Conductance

Conductance trends can be seen in panel 4 of Figure 10-1 through Figure 10-4. WSM002B is seen to have a rapid increase from 96 µS/cm in week 1 (9/16/2020) to 2270 µS/cm by week 4 (10/7/2020) as a result of the ISCO-II activities. The conductance then decreased to 438 µS/cm in week 5 (10/14/2020) of sampling before decreasing to 98 µS/cm in December 2020. Conductance in WSM002BB initially decreased from 559 µS/cm in week 1 (9/16/2020) to 485 µS/cm by week 2 of sampling (9/23/2020). The conductance then increased from 566 µS/cm to 2,240 µS/cm between weeks 3 (9/30/2020) and 7 (11/4/2020). pH decreased to 30 µS/cm in week 8 (11/4/2020) of sampling and increased back to 3,000 µS/cm in December 2020. Values in WSM002CC increased from 92 µS/cm to 8,839 µS/cm between March and the week 2 of sampling (9/23/2020). The conductance then decreased to 1,011 µS/cm in week 5 (10/14/2020) of sampling, then increased to 8,868 µS/cm by week 8 (11/4/2020), and then again decreased to 1,931 µS/cm in December 2020. WSM002CC had an initial increase in conductance from 50 µS/cm to 6,112 µS/cm from March to week 1 of sampling (9/16/2020). From there the conductance decreased to 639 µS/cm by sampling week 6 (10/21/2020) before increasing to 2,107 µS/cm in week 8 of sampling (11/4/2020). The conductance measurements at the WSM002 well cluster were variable through December 2020 but indicate the presence of oxidant in all four horizons.

6.1.2.4 Dissolved Oxygen

DO trends can be seen in panel 5 of Figure 10-1 through Figure 10-4. The DO concentration in WSM002B is variable within the ISCO-II sampling period. DO concentrations decrease from 8.86 mg/L to 6.81 mg/L in the first three weeks of sampling (by 9/30/2020) before increasing to 13.05 mg/L in the following week (10/7/2020). DO concentrations then decrease to 8.8 mg/L over the next two weeks (10/21/2020) before increasing to 10.78 mg/L in sampling week 7 (10/28/2020), decrease again to 8.28 mg/L in week 8 (11/4/2020), and finally increase once more to 9.78 mg/L in December 2020. WSM002BB DO concentrations increase from 7.51 mg/L to 10.8 mg/L by sampling week 5 (10/14/2020) and then gradually decrease to 7.5 mg/L by week 7 of sampling (10/28/2020) and then increase to 8.8 mg/L by December sampling. Values in WSM002C are more variable than in other horizons and decrease significantly following the injection activities. The concentration increased from 10.16 mg/L during week 1 sampling (9/16/2020) to 10.58 mg/L in week 2 of sampling (9/23/2020) before it decreased to 4.9 mg/L in week 3 of sampling (9/30/2020), increased to 15.77 mg/L in week 4 of sampling (10/7/2020), decreased to 1.44 mg/L in week 5 of sampling (10/14/2020), increased to 9.46 mg/L (10/28/2020), then decreased to 1.92 mg/L (11/4/2020) before finally increasing to 4.4 mg/L in December 2020. The DO concentration in WSM002CC increased from 7.71 mg/L to 13.32 mg/L between weeks 1 (9/16/2020) and 2 of sampling (9/23/2020), then decreased to 4.94 mg/L in week 4 sampling (9/30/2020), increased to 6.2 mg/L by week 6 sampling (10/21/2020), decreased to 1.86 mg/L in week 8 sampling (11/4/2020), then eventually increased to 3.9 mg/L in December 2020. Similar to conductance, DO measurements at the WSM002 well cluster were variable through December 2020 but indicate the presence of oxidant in all four horizons.

6.1.2.5 Oxidation Reduction Potential

ORP trends can be seen in panel 6 of Figure 10-1 through Figure 10-4. ORP values in WSM002B are seen to increase from 305 mV to 956 mV between week 1 (9/16/2020) and week 4 (10/7/2020) of sampling, then decrease to 593 mV in sampling week 6 (10/21/2020) before rising to 772 mV in week 7 (10/28/2020) and finally decreasing to 545 mV in December 2020. Values in the BB-horizon increased from 515 mV to 781 mV between sampling weeks 1 (9/16/2020) and 5 (10/14/2020) before increasing again to 875 mV in sampling week 6 (10/21/2020) and settling between 837 mV and 862 mV until December. Following ISCO-II, the ORP at WSM002C increased from 597 mV to 754 mV between sampling week 1 (9/16/2020) and 2 (9/23/2020), then decreased to 617 mV in sampling week 3 (9/30/2020) before increasing to 791 mV by sampling week 5 (10/14/2020), decreased to 614 mV in sampling week 6 (10/21/2020), and then increased to 814 mV in sampling week 7 (10/28/2020) before finally decreasing to 605 mV in December

2020. ORP at WSM02CC increased from 797 mV to 812mV between sampling weeks 1 (9/16/2020) and 3 (9/30/2020). From there, the ORP decreased to 449 mV in sampling week 6 (10/21/2020) before increasing to 847 mV in sampling week 7 (10/28/2020) and finally decreasing to 564 mV in December 2020. ORP values in all horizons increased from pre-injection conditions (March 2020) to immediately after the ISCO-II injections (September 16, 2020) and remain elevated (>200mV) through December 2020.

6.1.3 WSM003

The WSM003 well cluster was only sampled twice surrounding the ISCO-II injection activities. This sampling schedule was due to the WSM003 well cluster not being directly involved in the ISCO-II injection activities. Sampling occurred in March 2020 and December 2020. As can be seen from the data described below, the WSM003 well cluster was not directly impacted by the ISCO-II injection activities as was WSM001 and WSM002. This suggests the well cluster is not located in the path of oxidant migration or that the effects of the oxidant are only local and do not migrate away from the injection area.

6.1.3.1 Water Level

There was no major impact to water level within the WSM003 well cluster as a result of ISCO-II activities. This can be seen in panel 2 of Figure 10-1 through Figure 10-4. The gradual increase in water level between March 2020 and October 2020 is due to RWM018 being shut off and no longer pulling water from the aquifer.

6.1.3.2 pH

pH trends can be seen in panel 3 of Figure 10-1 through Figure 10-4. Based on the data collected in December 2020 at the WSM003 well cluster, the pH remained at background levels; therefore, pH was not impacted by the ISCO-II injection activities.

6.1.3.3 Conductance

Conductance trends can be seen in panel 4 of Figure 10-1 through Figure 10-4. Conductance does not fluctuate significantly after the ISCO-II injections within any WSM003 horizon.

6.1.3.4 Dissolved Oxygen

DO trends can be seen in panel 5 of Figure 10-1 through Figure 10-4. The concentration of DO in WSM003B is seen to increase from around 0.98 mg/L up to 9.53 mg/L between March 2020 and December 2020. During this same time frame, concentrations in WSM003BB increased from 1.64 mg/L to 5.85 mg/L. Conversely, DO values in the C-horizon decreased in concentration from 11.34 mg/L to 5.64 mg/L and those in WSM003CC decreased from 11.7 mg/L to 5.55 mg/L. The changes in DO at the WSM003 cluster are likely not directly associated with the ISCO-II injections.

6.1.3.5 Oxidation Reduction Potential

ORP trends can be seen in panel 6 of Figure 10-1 through Figure 10-4. Between March and December 2020, ORP values in all of the WSM003 horizons increased, but the increases are not considered to be significant.

6.2 Analytical Results

Analytical parameters of groundwater samples were measured during well monitoring to assess the presence and effectiveness of the oxidants injected. Parameters measured include TCE and PCE concentrations, as well as concentrations of chloride, manganese, potassium, sulfate, and mercury. Figure 10-5 through Figure 10-16 display chemical data for the sampling period between injection campaigns and prior to ISCO-II injections, while Figure 10-17 and Figure 10-18 focus on the time period associated with ISCO-II activities specifically. VOC data (mg/L) is presented in panel two of Figure 10-5 through Figure 10-16, while chloride concentrations (mg/L) are presented in panel three, potassium and manganese levels (mg/L) in panel four, sodium and sulfate values (mg/L) in panel five, and mercury concentrations (µg/L) in panel six of each of these figures. Oxidant-induced effects on these parameters are discussed by well cluster. In the ISCO-II specific figures (Figure 10-17 and Figure 10-18), analytical data are grouped by well and organized horizontally in panels based upon groundwater monitoring results.

The following guidelines were applied in evaluating oxidant injection effectiveness (SRNS 2019):

- if chloride is above baseline (pre-injection) concentrations, then TCE and PCE have likely been oxidized to the end product,
- when sodium and potassium are above baseline, then the oxidant solution is/was there but it is unknown if it has been consumed or still has oxidizing potential,
- when manganese is above the baseline, then there is active oxidant as permanganate,
- when sulfate is above the baseline, then there is less oxidizing power (less persulfate), and
- increases in mercury concentration in groundwater indicate the presence of DNAPL.

6.2.1 WSM001

Chemical data for well WSM001 is presented in Figure 10-5 through Figure 10-8. Within the WSM001 well cluster, analytical measurements were impacted in all horizons by ISCO-II injection activities. Previous injection activities under ISCO-I were effective at delivering oxidants to the CC- and BB-horizons, with limited effectiveness in the B-horizon, and no affect in the C-horizon (SRNS 2019). As a result, parameters in the C-horizon and B-horizon typically experienced more of an effect during ISCO-II than those in the other horizons. The BB-horizon was most often the least responsive of the four horizons. A description of the impact from each analytical parameter is detailed below.

6.2.1.1 <u>Volatile Organic Compounds</u>

Prior to ISCO-II, TCE and PCE concentrations at WSM001B were relatively stable with concentrations in March 2020 of 24.8 mg/L and 1.2 mg/L, respectively. WSM001C had stable TCE concentrations of 9.0 mg/L in March 2020 while PCE concentrations were less than the detection limits. These results are consistent with the assessment that oxidant injected during ISCO-I had minimal or no impact on the B- and C-horizons. The injection during ISCO-II resulted in the immediate decrease in TCE and PCE concentrations at both WSM001B and WSM001C. At WSM001B, TCE and PCE concentrations were reduced to below detection limits for six of the eight weekly sampling events. During week 2 of sampling (9/23/2020), TCE concentrations were less than detection limits and PCE concentrations increased to 0.67 mg/L, while week 5

(10/14/2020) sampling results had TCE concentrations of 15.8 mg/L and PCE concentrations of 1.1 mg/L. The variability in TCE and PCE concentrations observed at WSM001B are contrasted with results from the shallower WSM001C. In WSM001C, TCE and PCE concentrations were reduced to concentrations less than the detection limits immediately after ISCO-II injections were completed and have remained low or below detection limits from September to December 2020. In WSM001BB and WSM001CC, TCE and PCE concentrations were low or below detection limits leading into the ISCO-II injections indicating oxidant from the ISCO-I injections was effective and that no significant rebound in concentration had occurred yet. After the ISCO-II injections, TCE and PCE concentrations at WSM001BB and WSM001CC remain low. In WSM001BB, TCE concentrations continued to be less than the detection limits, except for the fourth of eight weekly samples when TCE concentrations were 0.0048 mg/L on October 7, 2020. PCE concentrations at WSM001BB were variable ranging from less than 0.001 to 0.26 mg/L. WSM001CC was exhibiting signs of rebound with respect to both TCE and PCE concentrations even after the ISCO-II injections; TCE concentrations ranged from 0.033 to 3.3 mg/L during the first four of eight weeks of sampling and PCE concentrations ranged from 0.003 to 0.029 mg/L during the first six of eight weeks of sampling. After weeks four and six for TCE and PCE respectively, concentrations were reduced to less than the detection limit. The delayed decline in TCE and PCE concentrations likely reflect the time needed for oxidant to migrate from either the C- or B-horizons into the CC-horizon.

6.2.1.2 Inorganic Compounds

6.2.1.2.1 Chloride

The largest changes within this well cluster are seen within the C- and B-horizons. Chloride concentrations in the shallow C-horizon increased from 7.75 mg/L during the first ISCO-II sampling event (9/16/2020) to a maximum of 21.1 mg/L in the fifth sampling event (10/14/2020). Although chloride concentrations fluctuated between September and December 2020, chloride concentrations remained elevated above background concentrations and were 9.38 mg/L on December 2, 2020. Chloride concentrations were similar at WSM001B, increasing in concentration from 2.42 mg/L in March 2020 to 16.9 mg/L in week 1 (9/16/2020). From week 1 sampling to December 2020, chloride concentrations remained above background concentrations. One exception was when chloride concentration declined to 5.51 mg/L during week 6 of sampling (10/14/2020); however, chloride concentrations rebounded the next sampling week to 17.6 mg/L (10/21/2020). The trend in these horizons displays the breakdown of TCE and PCE by chemical oxidation. During in-situ chemical oxidation, the concentration of chloride increases stoichiometrically with the destruction of dissolved VOCs as these compounds are consumed by the oxidants. The response to ISCO-II injections was more subtle within the BB-horizon since chloride concentrations were already elevated as a result of the ISCO-I injections. Chloride concentrations within WSM001BB rose to a maximum of 16.6 mg/L in response to the ISCO-II injections during the second week of sampling (9/23/2020). Values then level out to 10.3 mg/L by December 2020. The direct indication that VOCs have been actively degraded is not as apparent within the chloride concentrations at the CC-horizon. Chloride concentrations remained elevated at WSM001CC after the ISCO-I injections and continued to be stable after the ISCO-II injections. During week 1 of sampling (9/16/2020) chloride concentrations were 10.3 mg/L and were 8.88 mg/L by December 2020 with a maximum chloride concentration of 12.6 mg/L occurring on week 6 of sampling (10/21/2020).

6.2.1.2.2 Potassium and Manganese

Potassium and manganese had similar trends at each horizon and are discussed together because they represent the presence of potassium permanganate, the first oxidant injected during the ISCO-II campaign. The potassium and manganese concentrations spiked between sampling week 1 and 3 at WSM001C and WSM001B. The maximum concentrations of potassium and manganese at WSM001C were 3,140 mg/L during week 1 (9/16/2020) and 2,480 mg/L during week 3 (9/30/2020), respectively. The maximum concentrations of potassium and manganese at WSM001B were 977 mg/L and 1,310 mg/L during week 3 (9/30/2020), respectively. After sampling week 3, concentrations of both constituents decreased in concentration while still remaining well above background concentrations. The elevated concentrations of potassium and manganese is a positive indicator that potassium permanganate was distributed into these two targeted horizons during the ISCO-II injections. There was a delayed response in the CC-horizon where an increase in potassium and manganese concentrations occurred between weeks 8

(November 2020) and 9 (December 2020) of sampling. The delayed increase had concentrations of potassium of 1,840 mg/L and manganese of 1,790 mg/L in December 2020. Similar to other indicator parameters, the delayed increase in potassium and manganese is an indication that oxidant migrated into this horizon although it was not targeted by ISCO-II activities. No significant response to ISCO-II activities was observed in WSM001BB, indicating that oxidant was not delivered to that horizon during the sampling period.

6.2.1.2.3 Sodium and Sulfate

Sodium and sulfate had similar trends at each horizon and are discussed together because they represent the presence of sodium persulfate, the second oxidant injected during the ISCO-II injections. The sodium and sulfate concentrations at WSM001C increased immediately after the ISCO-II injections with a concentrations of 1,110 mg/L and 272 mg/L, respectively, during week 1 sampling (9/16/2020). The increase was short-lived as concentrations steadily declined, starting in week 2 of sampling (9/23/2020) and continuing into November 2020. Sodium and sulfate concentrations did rebound in December 2020 to 384 mg/L and 71 mg/L, respectively. At WSM001B, the sodium and sulfate concentrations were more variable with peaks in concentrations occurring during sampling weeks 3 and 6. The maximum sodium and sulfate concentration occurred in sampling week 3 with concentrations of 314 mg/L for sodium and 31.6 mg/L for sulfate. After week 6 of sampling, concentrations steadily declined through December 2020. Sodium and sulfate concentrations at WSM001CC were similar to WSM001B, experiencing multiple increases in concentration during sampling weeks 5 (10/7/2020) and 8 (10/28/2020) and again in December 2020. At WSM001BB, the sodium and sulfate concentrations were still elevated from the ISCO-I injections at the time ISCO-II injections started. The ISCO-II injections also caused sodium and sulfate concentrations to increase. The increasing concentrations at WSM001BB were variable with time, but continued to remain above pre-ISCO-II concentrations from week 1 sampling to December 2020. In December 2020 at WSM001BB, sodium concentrations were 359 mg/L and sulfate concentrations were 275 mg/L. The sodium and sulfate concentrations show positive impacts of the oxidant, sodium persulfate, at all the horizons at the WSM001 well cluster. This was expected for the B- and C-horizons. Even the CC-horizon had the similar delayed increase in concentrations as observed in other constituents (i.e., TCE, potassium, manganese, etc.). The presence of sodium and sulfate in WSM001BB was not expected based on the low indication of the potassium permanganate oxidant.

6.2.2 WSM002

Analytical parameters were impacted by ISCO-II oxidant injection activities within WSM002C, WSM002CC, WSM002B, and WSM002BB. Within this well cluster, the response of each constituent fluctuated by horizon.

6.2.2.1 Volatile Organic Compounds

Following ISCO-II injections PCE concentrations in WSM002B decreased from 1.19 mg/L in March 2020 to 0.89 mg/L in week 1 of sampling (9/16/2020). From week 2 of sampling (9/23/2020) to week 5 of sampling (10/14/2020), the PCE concentrations were non-detect. Then in week 6 of sampling (10/21/2020), the PCE concentration increased to 0.04 mg/L and increased to 1.06 mg/L through December 2020. WSM002B TCE concentrations were 10.6 mg/L in week 1 of sampling (9/16/2020) and then they decreased to non-detect until sampling week 8 (11/4/2020), when the concentration was measured at 17.8 mg/L. In December 2020, PCE concentrations decreased to 7.83 mg/L. As the VOCs in the groundwater are destroyed, back diffusion of the DNAPL from the sediments into the groundwater resulted in the observed rebounding in the B-horizon. The rebound in TCE and PCE concentration could also be the result of oxidant not being uniformly distributed into the entire B-horizon causing variable sample results. In WSM002BB, the PCE concentration decreased from 0.69 mg/L in March 2020 to 0.42 mg/L in week 1 of sampling (9/16/2020). From there the concentration decreased to non-detect by week 4 of sampling (10/7/2020) and remains non-detect through December. In WSM002C and WSM002CC, the PCE and TCE concentrations were non-detect immediately following the ISCO-II injections and remain non-detect through December 2020. The decrease in PCE and TCE concentrations at these two wells indicates that oxidant was successfully distributed over both horizons. This was not expected in the CC-horizon since it was not targeted during the ISCO-II injections.

6.2.2.2 Inorganic Compounds

6.2.2.2.1 Chloride

Following ISCO-II activities, chloride concentrations at WSM002B increased from 2.6 mg/L from March 2020 to 14.3 mg/L in week 1 of sampling (9/16/2020). Then the concentration continues to fluctuate between 14.8 mg/L and 21.8 mg/L through week 7 of sampling (10/28/2020). In week 8 (11/4/2020) the chloride concentration decreased to 3.75 mg/L before increasing to 15.9 mg/L through December 2020. WSM002BB concentrations initially decreased from 18 mg/L in March to 12.4 mg/L in the week 1 of sampling (9/16/2020). In week 2 of sampling (9/23/2020) the concentration increased to 15.3 mg/L and then increased again to 17.5 through week 4 of sampling (10/7/2020). The concentration remained elevated through December 2020 with a concentration of 15.1 mg/L. Chloride concentrations at WSM002C increased from 3.37 mg/L to 7.62 mg/L by week 1 of sampling (9/16/2020), then in week 2 of sampling (9/23/2020) the concentration increased again to 13.4 mg/L. From there the concentration fluctuates from 6.22 mg/L to 10.5 mg/L through December. WSM002CC concentration increased from 2.53 mg/L to 8.5 mg/L by week 1 of sampling (9/16/2020), then in week 2 of sampling (9/23/2020) the concentration increased again to 12.7 mg/L. From there the concentration fluctuates from 7.89 mg/L to 10.5 mg/L through December. All of the horizons at the WSM002 well cluster experienced an increase in chloride concentration indicating that oxidant was well distributed over all four horizons although only the B- and C-horizons were targeted.

6.2.2.2.2 Potassium and Manganese

Potassium and manganese are breakdown products of the potassium permanganate oxidant that was injected as part of the ISCO-II activities. Increases in potassium and manganese concentrations were anticipated following the ISCO-II injections. WSM002B potassium concentrations immediately increased from 1.92 mg/L in March 2020 to 32.1 mg/L in week 1 of sampling (9/16/2020). Manganese concentrations within WSM002B increased from 0.17 mg/L to 22.2 mg/L from March to week 1 of sampling (9/16/2020). The concentration increased to 801 mg/L by week 3 (9/30/2020). After weeks 3 and 4, potassium and manganese concentrations steadily declined through sampling week 8 (11/4/2020). There was a slight increase in both concentrations in December 2020 to 18.1 mg/L for potassium and 20.8 mg/L for manganese. At WSM002BB, the potassium and manganese concentrations steadily increased during week 1 of sampling (9/16/2020) with concentrations of 37.4 mg/L and 0.8 mg/L, respectively, through December 2020 with potassium concentrations of 503 mg/L and manganese concentrations of 743 mg/L. The potassium and manganese concentrations at WSM002C were elevated immediately after ISCO-II injections. The potassium concentrations ranged from 1,560 to 2,340 mg/L through the first 8 weeks of sampling and then declined to 368 mg/L in December 2020. The manganese concentrations increased slower peaking at 2,430 mg/L in sampling week 4 (10/7/2020) and steadily declined to 526 mg/L in December 2020. In WSM002CC, the potassium concentration increased immediately during sampling week 1 (9/16/2020) to 1,380 mg/L and steadily declined to 312 mg/L by December 2020. The manganese concentration at WSM002CC also increased during week 1 of sampling to 399 mg/L, peaking in concentration during sampling week 3 at 1,230 mg/L. After week 3, manganese concentrations decreased and remained stable through December 2020 with a concentration of 518 mg/L.

6.2.2.2.3 Sodium and Sulfate

Sodium and sulfate are breakdown products of the sodium persulfate oxidant that was injected as part of the ISCO-II activities. Increases in sodium and sulfate concentrations were anticipated following the ISCO-II injections. Sodium and sulfate concentrations in WSM002B increased during week 1 sampling (9/16/2020) to 43.9 mg/L and 22.8 mg/L, respectively. After week 1, sodium and sulfate concentrations continued to increase to sampling week 5 (10/7/2020) when concentrations peaked for sodium at 118 mg/L and for sulfate at 26.4 mg/L. Sodium concentrations at WSM002B steadily declined from week 5 through December 2020 to 13.1 mg/L. Sulfate concentrations immediately declined and remained low through December 2020 to 6.31 mg/L. At WSM002BB, the sodium and sulfate concentrations steadily increased after the ISCO-II injections through December 2020. The sodium concentrations were 127 mg/L in week 1 (9/16/2020) and were 360 mg/L in December 2020. The sulfate concentrations at WSM002BB were 95.6 mg/L in sampling week 1 (9/16/2020) increasing to 113 mg/L in December 2020. The sodium concentration for WSM002C increased immediately during the first week of sampling to a maximum concentration of 1,470 mg/L during sampling week 5 (10/7/2020). After week 5, sodium concentrations declined to187 mg/L in December 2020. The sulfate concentration at WSM002C follow a similar trend, peaking in week 5 at 239 mg/L and decreasing to 54.4 mg/L in December 2020. The sodium and sulfate concentrations at WSM002CC increased immediately during the first week of sampling and steadily declined through December 2020.

6.2.3 WSM003

Distal wells (WSM003C, WSM003CC, WSM003B, and WSM003BB) were sampled quarterly, while proximal wells (WSM001C, WSM001CC, WSM001B, WSM001BB; WSM002C, WSM002CC, WSM002B, and WSM002BB) were sampled weekly. Because distal wells were sampled less frequently, fewer data points associated with ISCO-II activities are available for the WSM003 well cluster.

6.2.3.1 Volatile Organic Compounds

Neither TCE nor PCE levels exhibited a significant response to ISCO-II injections within the WSM003 well cluster, indicating that the oxidant had no impact on this cluster following ISCO-II activities. Following ISCO-II injections, WSM003B PCE concentrations decreased from 2.3 mg/L to 1.97 mg/L, WSM003BB PCE concentrations decreased from 1.29 mg/L to 0.94 mg/L, WSM003C PCE concentrations were non-detect, and PCE concentrations in WSM003CC decreased from 0.8 mg/L to 0.35 mg/L between March 2020 and December 2020. TCE values are consistently elevated from that of PCE throughout the sampling period in all horizons and also vary by horizon. Following ISCO-II injections, TCE concentrations in WSM003B decreased from 31.9 mg/L to 27.4 mg/L, TCE concentrations in WSM003BB decreased from 18.1 mg/L to 16.2 mg/L, TCE concentrations in WSM003C increased from 5.29 mg/L to 7.87 mg/L, and WSM003CC TCE concentrations decreased from 29 mg/L to 18.6 mg/L between March 2020 and December 2020.

6.2.3.2 Inorganic Compounds

6.2.3.2.1 Chloride

No response to the ISCO-II injection activities occurred in the WSM003 well cluster horizons. Increases in chloride concentration would be expected with the breakdown of VOCs; however, concentrations in three of the horizons (B, BB, and CC) decreased from March to December 2020. In WSM003B, the concentration decreased from 2.88 mg/L to 2.81 mg/L. WSM003BB concentration decreased from 2.73 mg/L to 2.47 mg/L. WSM003CC concentration decreased from 3.26 mg/L to 3.01 mg/L. In WSM003C, the chloride concentration increased from 2.93 mg/L to 3.56 mg/L.

6.2.3.2.2 Potassium and Manganese

Potassium concentrations within the WSM003 well cluster remain fairly constant. WSM003BB decreased slightly from 0.90 mg/L to 0.86 mg/L between March (3/16/2020) and December 2020 (12/2/2020). However, levels within the other three horizons of this well increased slightly between those sampling activities. Potassium increased from 0.76 to 0.99 mg/L in the B-horizon, from 1.43 mg/L to 1.71 mg/L in the C-horizon, and from 1.11 mg/L to 1.63 mg/L in the CC-horizon.

Manganese concentrations in the WSM003 well cluster also remain fairly constant throughout the entire ISCO-II sampling period. Prior to ISCO-II injections (3/16/2020), manganese levels were 0.18 mg/L in the B-horizon, 0.16 mg/L in the BB-horizon, 0.71 mg/L in the C-Horizon, and 0.14 mg/L in the CC-horizon. Manganese rose to 0.2 mg/L in WSM003B and to 0.94 mg/L in WSM003C after ISCO-II injections (12/2/2020), while levels slightly decreased to 0.12 mg/L in WSM003BB and to 0.11 mg/L in WSM003CC between March and December.

6.2.3.2.3 Sodium and Sulfate

Small fluctuations also occur in sodium concentrations between March and December 2020, but all changes can be attributed to sampling uncertainty. Sodium in WSM003 well cluster decreased slightly in response to ISCO-II oxidant activities in all horizons except for WSM003B where concentrations increased from 6.21 mg/L to 7.24 mg/L between March 16 and December 2, 2020.

Levels decreased from 4.7 mg/ to 4.09 mg/L in the BB-horizon, from 12 mg/L to 11.1 mg/L in the C-horizon, and from 8.26 mg/L to 7.42 mg/L in the CC-horizon between those same sampling events.

Sulfate values in the WSM003 well cluster are elevated within the C-horizon compared to that of the other three horizons and are also most affected by ISCO-II oxidant activities. Values in WSM003C decreased by 4.05 mg/L (from 13 mg/L to 8.95 mg/L) between March 16, 2020, and December 2, 2020. The same response to injection activities is seen within the BB-horizon where sulfate concentrations decreased slightly from 0.26 to 0.19 mg/L between the March and December 2020 sampling events. An opposite effect is seen in WSM003B and WSM003CC, however. Values increased slightly in the B-horizon from 0.41 mg/L to 0.52 mg/L and from 0.28 mg/L to 0.47 mg/L in the CC-horizon.

6.3 Mercury

Within A/M Area, low levels of mercury are present in the groundwater and are generally associated with DNAPL source areas (Jackson et al., 2006). As VOCs are removed from the system, the concentration gradient causes the DNAPL to dissolve into the groundwater and the dissolved mercury associated with the DNAPL is released into the groundwater. The current paradigm at the Western Sector ISCO project for the presence of mercury is that as VOCs (TCE and PCE) in the aqueous phase are removed through chemical oxidation in the aqueous phase, dissolution rates of these compounds from the non-aqueous phase will increase, reducing the mass (volume) of DNAPL present in the subsurface. As DNAPL mass is removed through dissolution, elemental mercury will become oxidized and form highly soluble mercury chloride complexes in the aqueous phase (Jackson et al. 2006).

Mercury concentrations were observed after ISCO-I but were collected at a low frequency. For ISCO-II, mercury was sampled at a higher frequency to better track changes in concentration with time. Concentrations of mercury are compared to the U.S. Environmental Protection Agency-set maximum contaminant level (MCL) for this constituent in drinking water systems. This threshold for mercury as established under the Safe Drinking Water Drinking Act is 2 µg/L. There were several instances following ISCO-II in which the mercury levels exceed the MCL. Immediate impacts to the mercury concentrations in the B-, C-, and BB-horizons were noticed. The maximum concentration observed following ISCO-II injections was 24.6 µg/L in WSM001B. Minimal impacts were seen in the WSM003 well cluster, which was expected due to the distance of this well cluster from the injection location.

6.3.1 WSM001

Mercury within the WSM001 well cluster varies by horizon. Within the targeted horizons (B- and C-horizons), the ISCO-II injections can be seen to have an immediate impact to the mercury concentrations. The background mercury concentration at WSM001B was 0.2 µg/L in March 2020 and increased to 24.6 µg/L during the first week of sampling following the injections. Mercury concentrations at WSM001B decreased with time to near baseline concentrations conditions with the exception of the December 2020 sampling event, where an increase back to 4.59 µg/L was observed. Within the C-horizon, the concentration in March 2020 was 0.64 µg/L and it increased to 15.6 µg/L immediately following the injections and remained elevated through December 2020. Baseline concentrations within the BB-horizon were elevated prior to ISCO-II in comparison to the other horizons with a concentration of 7.52 µg/L in March 2020. Mercury concentrations increased after the first week of sampling and steadily increased to 20.5 µg/L in December 2020. Impacts to the BB-horizon from ISCO-II injections were not as significant as those seen in response to ISCO-I injections, but continued an upward trend in concentrations suggests a possible second spike (and rebound) could occur at a later date. Similar to the mercury concentration at WSM001BB, the CC-horizon had elevated concentrations of 4.92 µg/L in March 2020. After injections mercury concentrations remained steady until sampling week 5 (10/14/2020) when concentrations increased to 6.34 µg/L and then decreased to 3.11 µg/L by December 2020.

6.3.2 WSM002

Mercury concentrations in the WSM002 horizons were less than 1 µg/L in March 2020 prior to ISCO-II injection activities, with the exception of the BB-horizon with a concentration of 4.91 µg/L. Mercury concentrations increased in response to ISCO-II activities in the B-, C-, and

CC-horizons as VOCs are removed from the system. Mercury concentrations at WSM002B immediately increased to 3.19 µg/L during week 1 of sampling and steadily decreased to pre-injection concentrations by December 2020. Mercury concentrations at the C-horizon increased immediately to 10.7 µg/L after injections and slowly declined to 1.83 µg/L in December 2020. Mercury concentrations in the C-horizon were variable with spikes in concentration during the fourth and seventh weeks of sampling. Mercury concentrations in the CC-horizon immediately increased to 10.8 µg/L following ISCO-II activities, peaking in week 2 with a concentration of 12.5 µg/L and slowly declining to 9.5 µg/L in December 2020. The mercury concentration at WSM002CC sharply declined during week 5 sampling to 1.64 µg/L which was not sustained. The mercury concentration at WSM002BB was relatively stable after ISCO-II injections with concentrations ranging from 3 to 4 µg/L until week eight sampling when concentrations increased slightly to 6.25 µg/L and 7.23 µg/L in December 2020.

6.3.3 WSM003

Mercury concentrations were less than 1 µg/L in all WSM003 horizons after the ISCO-II injection activities. Though minor fluctuations in mercury concentrations did occur within WSM003 horizons, the constituent is overall unaffected by ISCO-II oxidant injection activities.

7.0 DISCUSSION

Impacts from the ISCO-II injections were observed at the targeted B- and C-horizons as well as the non-targeted CC- and BB-horizons. Multiple parameters (i.e., field parameters, inorganic compounds, and VOCs) were used to track the presence or absence of oxidant in these horizons. The field parameters (i.e., water level, pH, conductivity, DO, and ORP) measured experienced changes, indicating the presence of an oxidant after the ISCO-II injections, except for water levels. Water levels were not directly impacted by the ISCO-II injection activities. All changes in water level were associated with the operational status of RWM018. The inorganic compounds (i.e., chloride, potassium, manganese, sodium, and sulfate) were also equally as responsive to the presence of oxidant as the field parameters. With the evaluation of the field parameters and the inorganic compounds it was obvious that there was variability in the trends of each parameter. The variability made it difficult to make concrete correlations on which parameters were more effective at indicating oxidant.

Decreases in VOC concentrations were observed in all four horizons, and those decreases generally correlated to the changes observed in the field parameters and the inorganic compounds. This is a positive indicator that not only was the oxidant successfully distributed into the aquifer, but it was actively degrading the VOCs.

Increases in mercury concentrations were also observed in all four horizons. The mercury concentrations can be used as an indirect indicator that VOCs are being chemically degraded. The concentrations of mercury will continue to be monitored with time, as most wells experienced exceedances of the mercury MCL and concentrations have not yet decreased to less than the MCL.

7.1 WSM001

Impacts from the ISCO-II injections were observed at WSM001 in the targeted B- and C-horizons as well as the non-targeted CC- and BB-horizons. In the C-horizon, PCE and TCE concentrations immediately decreased to non-detect concentrations and remained non-detect for the duration of the reporting period. The decrease in VOCs and the positive indication of oxidant observed in the other indicator parameters, suggest that oxidant was successfully distributed into the C-horizon. Oxidant was not distributed as successfully into the B-horizon. Although PCE and TCE concentrations were reduced to non-detect concentrations, there were also PCE and TCE results that rebounded to pre-ISCO-II concentrations. The variability in the PCE and TCE results in the B-horizon could suggest a couple scenarios: 1) oxidant was not uniformly and fully distributed into this horizon, and/or 2) the diffusion of DNAPL from low permeability sediments within the B-horizon replenished dissolved aquifer concentrations. The B-horizon is ~3.05-m (10-ft) thick at the WSM001 well cluster location. Both the new injection well WSI006B and the monitoring well WSM001B are screened in the bottom half of that 3.05-m (10-ft) thick horizon, so it's possible that the oxidant was not uniformly distributed through the entire thickness of the horizon. The heterogeneity occurring between the mixing of oxidant and groundwater in the

B-horizon may be causing the variable VOC concentrations. Continued monitoring will help to discern how well the oxidant was distributed in the B-horizon.

Oxidant was also distributed into the non-targeted CC- and BB-horizons at WSM001. The presence of oxidant in the CC-horizon was not immediate, suggesting that oxidant migrated into this horizon with time after injection. PCE and TCE concentrations at WSM001CC were impacted during the ISCO-I injections and started rebounding in November 2019. PCE and TCE concentrations continued to rebound through the fourth week of sampling after ISCO-II injections started. Since the fourth week of sampling, PCE and TCE declined to less than the detection limit or were less than the MCL (5 µg/L) and remained at those concentrations through December 2020. The indicator parameters mimic the VOC trends, verifying the delayed presence of oxidant. It is currently unknown which horizon the oxidant came from, but it most likely migrated from the C-horizon. Both of the oxidant solutions injected are denser than water, so the downward vertical migration of oxidant is the most logical conclusion. The C- and CC-horizons were separated in the original injection wells, WSI004C and WSI003C, by a 0.152-m (0.5-ft) thick clay at ~54.86-m (180-ft) below ground surface. This clay unit appears to pinch out toward the WSM001 well cluster creating an ~4.88-m (16-ft) thick massive C- and CC-horizon. The lack of clay separating the two horizons likely allowed the migration of oxidant from the C- to the CC-horizon from the new injection well, WSI006C, to the WSM001 well cluster. The presence of oxidant in the BB-horizon was less pronounced than in the CC-horizon suggesting that less volume of oxidant migrated into this horizon. Rebound of PCE concentrations at WSM001BB started in December 2018 and continued through the fifth week of sampling associated with ISCO-II. After sampling week 5, PCE concentrations slowly declined through December 2020 but were still greater than the MCL. TCE concentrations at WSM001BB have remained less than detection limits since the ISCO-I injections. The ISCO-II induced decrease in PCE concentrations at WSM001BB is collaborated with elevated chloride, sodium, sulfate, and mercury concentrations. It should also be noted that the presence of potassium permanganate was not observed at WSM001BB after the ISCO-II injections, only sodium persulfate. There is currently no explanation for the presence of sodium persulfate in the BB-horizon and not potassium permanganate.

A byproduct of the ISCO injections has been the presence of mercury above the MCL. This was first observed after the ISCO-I injections and continued after the ISCO-II injections. Mercury was detected in all of the horizons at WSM001 well cluster after the ISCO-II injections and remains elevated above the MCL in all horizons. WSM001B was the only well to have mercury concentrations decline to concentrations less than MCL during this reporting period. Mercury is an indicator that VOCs, and more likely DNAPL, have been chemically degraded by oxidant. Mercury will continue to be monitored at the ISCO monitoring wells to observe changes in concentrations with time.

7.2 WSM002

At the WSM002 well cluster, all horizons were observed to be impacted by the ISCO-II injections. In the C-horizon, PCE and TCE concentrations were observed to decline to non-detect concentrations immediately after injections occurred and remained non-detect through December 2020. In similar trends, the indicator parameters were also observed to have a positive response to the presence of oxidant immediately after injections. The combination of decreasing VOC concentrations and the presence of oxidant suggest that oxidant was successfully distributed into the targeted C-horizon. The B-horizon at WSM002 also experienced positive indications that oxidant was successfully delivered to this horizon, but the duration and effects of the oxidants were noticeably shorter. PCE and TCE concentrations at WSM002B started to decline after the first week of sampling and became non-detect concentrations from the second to sixth sampling weeks. After week six, PCE concentrations started to rebound, followed shortly after with TCE concentrations rebounding in week eight. By December 2020, VOC concentrations were similar to background concentrations indicating the absence of oxidant in this horizon. Indicator parameters followed similar trends peaking during week four of sampling, only to decline sharply through weeks six and seven of sampling. The short duration of oxidant and VOC decline in this horizon suggests that only a discrete volume of oxidant entered this horizon.

In the non-targeted CC- and BB-horizons at the WSM002 well cluster, the impacts of oxidant were also observed indicating oxidant migrated from the targeted horizons into these horizons. The CC-horizon was not impacted during the ISCO-II injections. VOC concentrations were stable coming into the ISCO-II injections, and both PCE and TCE concentrations were reduced to non-detect concentrations immediately after injections. PCE and TCE concentrations remain less than the detection limits through December 2020. The indicator parameters show the presence of both oxidants in the CC-horizon immediately after injections. Similar lithology is observed at the WSM002 well cluster, where the C- and CC-horizons coalesce into a massive sandy unit as the low permeability sediments separating them upgradient pinch out. This is the likely connection between the two horizons allowing oxidant to migrate into the CC-horizon. The TCE and PCE concentrations in the BB-horizon were impacted by the ISCO-I injections with concentrations rebounding in September 2019. After the ISCO-II injections, PCE and TCE concentrations decreased to non-detect concentrations after sampling week two. The declining PCE and TCE concentrations in the BB-horizon were slightly delayed indicating that oxidant migrated into this horizon likely from the targeted B-horizon. PCE and TCE concentrations in the BB-horizon have remained less than the detection limits through December 2020. The indicator parameters also had a delayed response with potassium and manganese concentrations increasing after weeks three and four of sampling while sodium and sulfate concentrations increased on a similar time frame. The presence of both oxidants were less pronounced in the above horizons because concentrations of these parameters were still elevated above background concentrations leading into the ISCO-II injections.

An increase in mercury concentrations was also observed in all horizons at the WSM002 well cluster. Mercury concentrations in WSM002B were elevated above the MCL after injections, but decreased to concentrations less than the MCL after week 6 of sampling. These trends coincide with the absence of oxidant and the rebounding of VOC concentrations. Mercury concentrations in the C-, CC-, and BB-horizons all increased after the ISCO-II injections above the MCL and have remained elevated through December 2020. The mercury concentration of WSM001C did decline to less than the MCL; however, continued monitoring will be needed to determine if this trend continues into the future. Mercury will continue to be monitored at the ISCO monitoring wells to observe changes in concentrations with time.

7.3 WSM003

The effects of oxidant after the ISCO-I and ISCO-II injections are not obvious at the WSM003 well cluster. At the more proximal monitoring well clusters (i.e., WSM001 and WSM002), indicator parameters had significant changes in concentrations indicating the presence of oxidant. At the WSM003 well cluster, significant changes in these parameters were not observed. PCE and TCE concentrations were observed to decline steadily over the period of the two injection campaigns in all horizons. These declining concentrations are most prevalent in the BB-horizon and less prevalent in the other three horizons. The BB-horizon was the most impacted horizon in the proximal well locations after the ISCO-I injections. The changes in VOC concentrations at WSM003BB could be an indication of treated groundwater migrating from the injection area toward WSM003BB. It is also possible that the oxidant migrating from the injection area toward RWM018 is not traveling directly through the WSM003 well cluster. RWM018 was temporarily shut down because it is assumed to be introducing oxidant to the M-1 Air Stripper. If oxidant is present at RWM018 and not being observed at any of the WSM003 well clusters, then it is likely WSM003 is not in the migration path and the decreasing VOC concentrations observed at WSM003BB are indirectly related to the ISCO injections.

Mercury has not had a noticeable change in concentrations at the WSM003 well cluster since starting either the ISCO-I or the ISCO-II injections.

8.0 CONCLUSIONS

The ISCO-II injections were able to safely mix 75,708 L (20,000 gal) of potassium permanganate solution and 94,635 L (25,000 gal) of sodium persulfate and sodium hydroxide solution and successfully inject those oxidant solutions equally into four injection wells targeting the B- and C-horizons of the LLAZ. Monitoring of the oxidant at twelve downgradient wells yielded positive results, indicating oxidant distribution and VOC destruction. Conclusions of the monitoring results include:

- Distribution of oxidant in the C-horizon was successfully observed at WSM001C and WSM002C with increases in oxidant indicator parameters (manganese, potassium, sodium, and sulfate), decreases in VOC concentrations to non-detect values, and increases in the VOC destruction parameter chloride.

- Distribution of oxidant into the B-horizon was limited, as observed at WSM001B and WSM002B. Increases in oxidant indicator parameters and decreases in VOCs were short-lived. This indicates that some of the oxidant was dispersed into the overlying CC- or underlying BB-horizons.

- The presence of oxidant in the BB- and CC-horizons was observed to decrease rebounding VOC concentrations at both WSM001 and WSM002 locations and illustrates the complex heterogeneity and interconnection of horizons in the LLAZ.

- Elevated mercury concentrations (>2 μg/L) were observed at all monitoring wells in the WSM001 and WSM002 well clusters, indicating the release of mercury from DNAPL. This likely occurred through the removal of indiscriminate DNAPL sources.

- Direct evidence of oxidant from the ISCO-I or ISCO-II injections were not observed at the downgradient WSM003 well cluster, indicating this well is likely not located in the path of oxidant migration or the effects of oxidant are local to the injection site.

9.0 RECOMMENDATIONS

Mobilization of metals has been identified after both the ISCO-I and ISCO-II injections. Although not included in this report, a thorough evaluation of the metal results in comparison to the respective MCL will be provided in the final report, scheduled to be submitted in calendar year 2023. The metals evaluation will include implications to the M-Area HWMF and any need for future corrective action.

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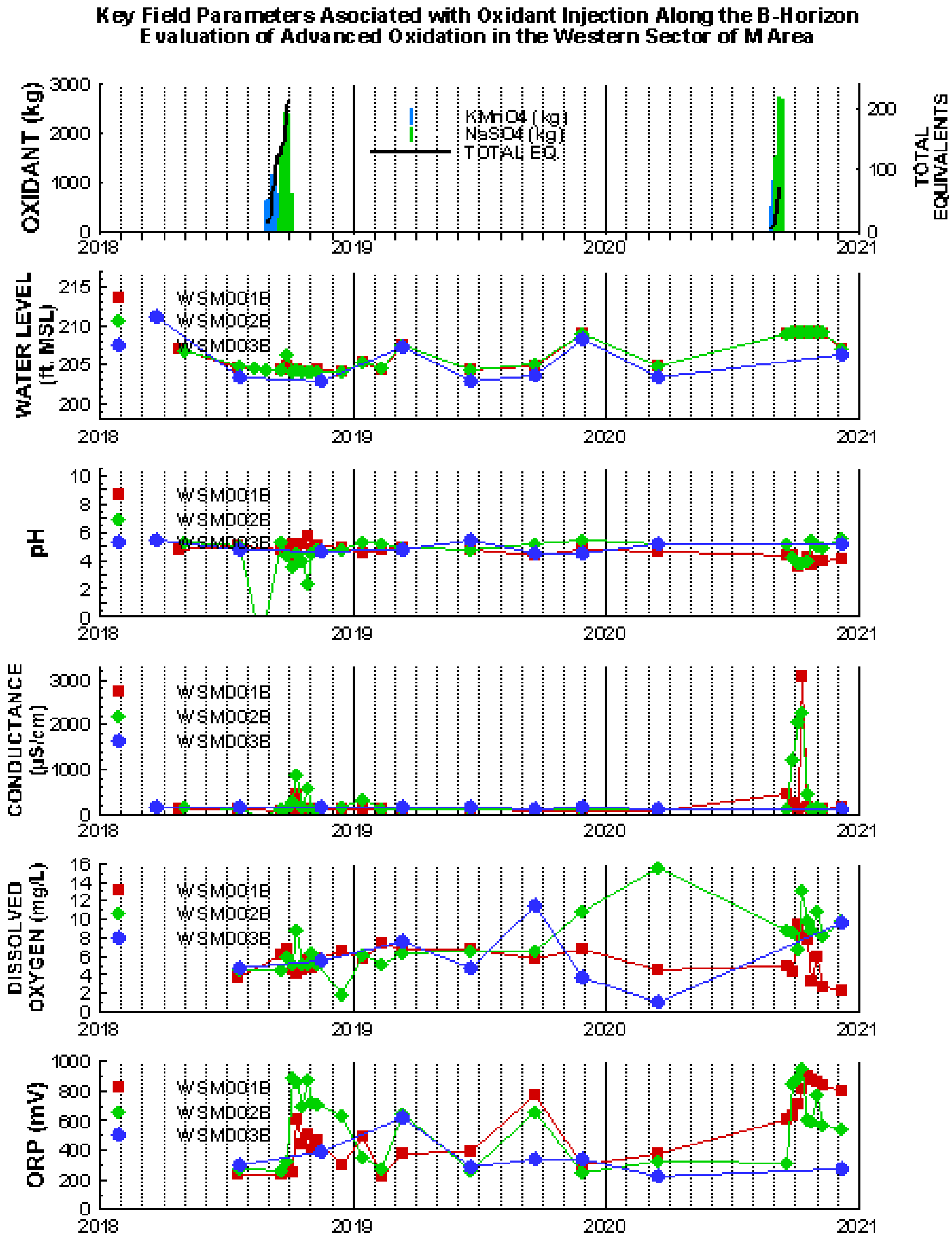

Figure 10-1. Key Field Parameters Associated with Oxidant Injection Along the B-Horizon (Data from Monitoring Wells WSM001B, WSM002B, and WSM003B)

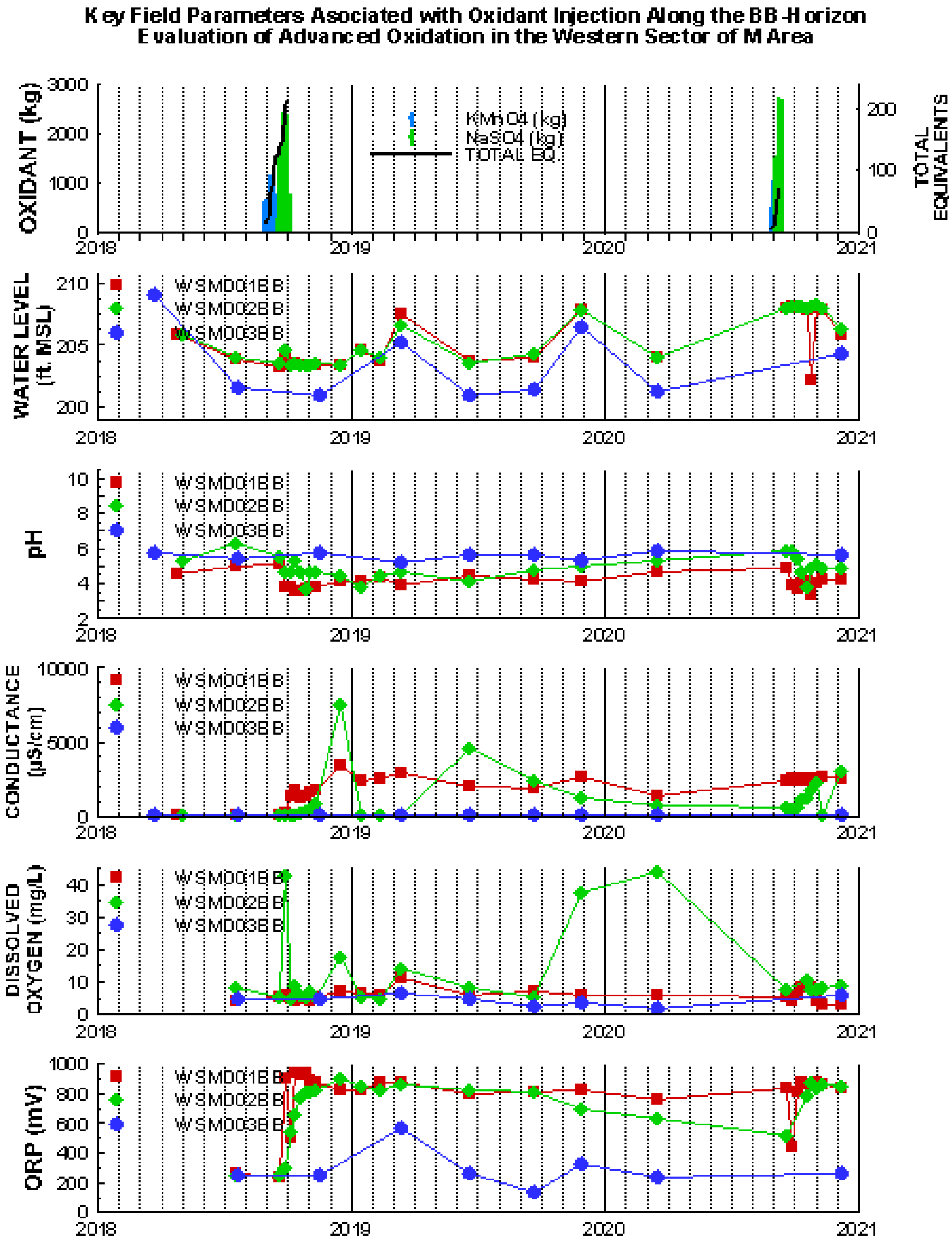

Figure 10-2. Key Field Parameters Associated with Oxidant Injection Along the BB-Horizon (Data from Monitoring Wells WSM001BB, WSM002BB, and WSM003BB)

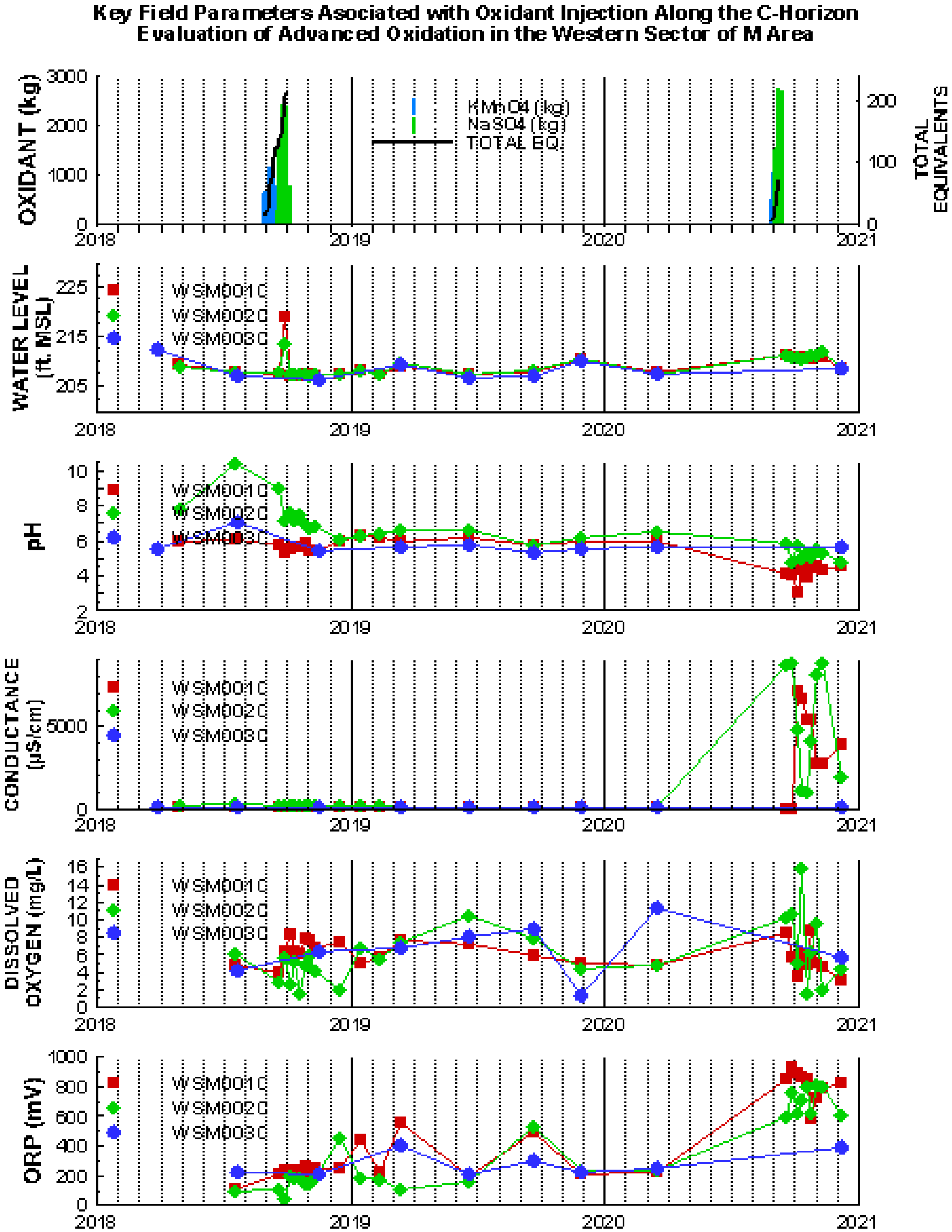

Figure 10-3. Key Field Parameters Associated with Oxidant Injection Along the C-Horizon (Data from Monitoring Wells WSM001C, WSM002C, and WSM003C)

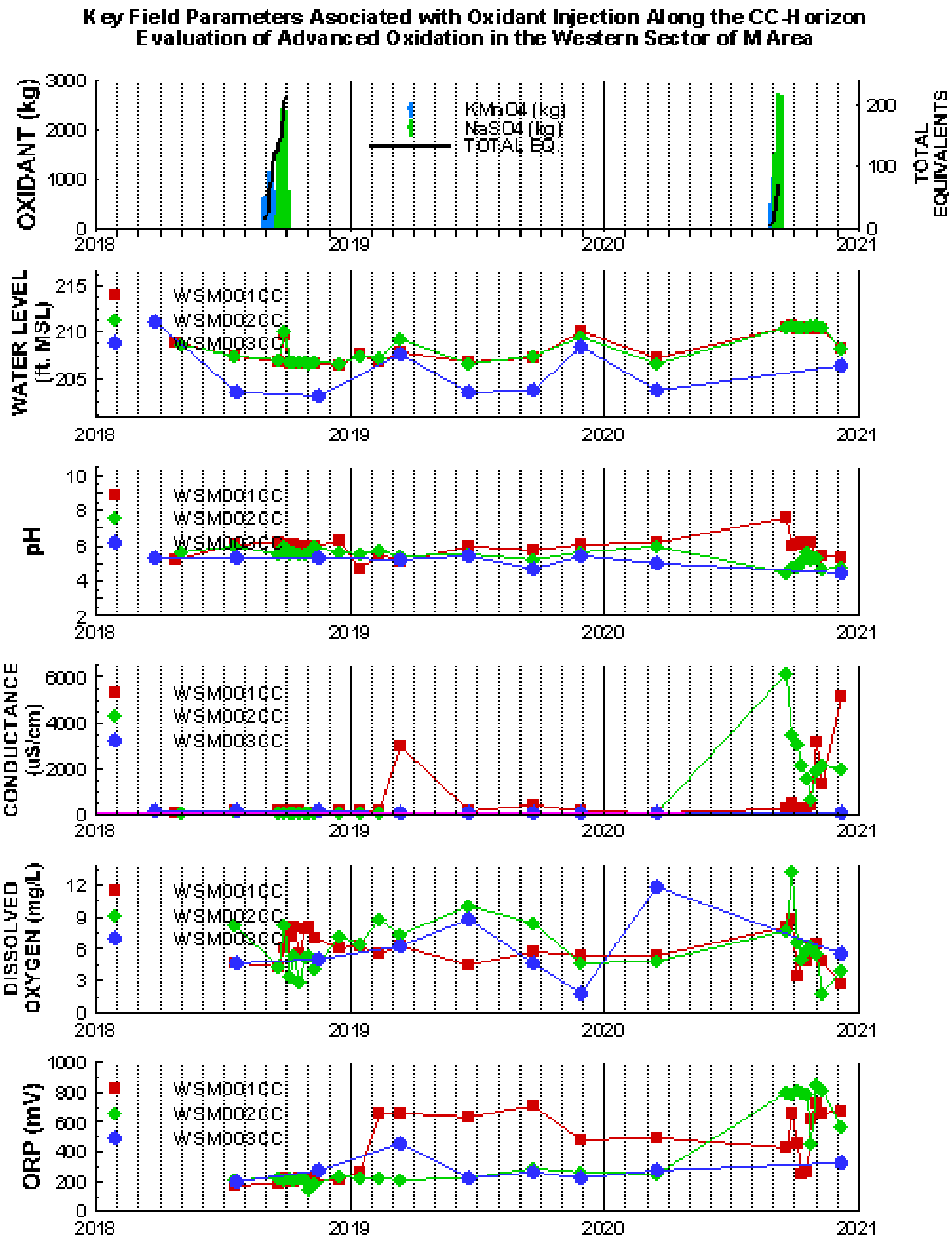

Figure 10-4. Key Field Parameters Associated with Oxidant Injection Along the CC-Horizon (Data from Monitoring Wells WSM001CC, WSM002CC, and WSM003CC)

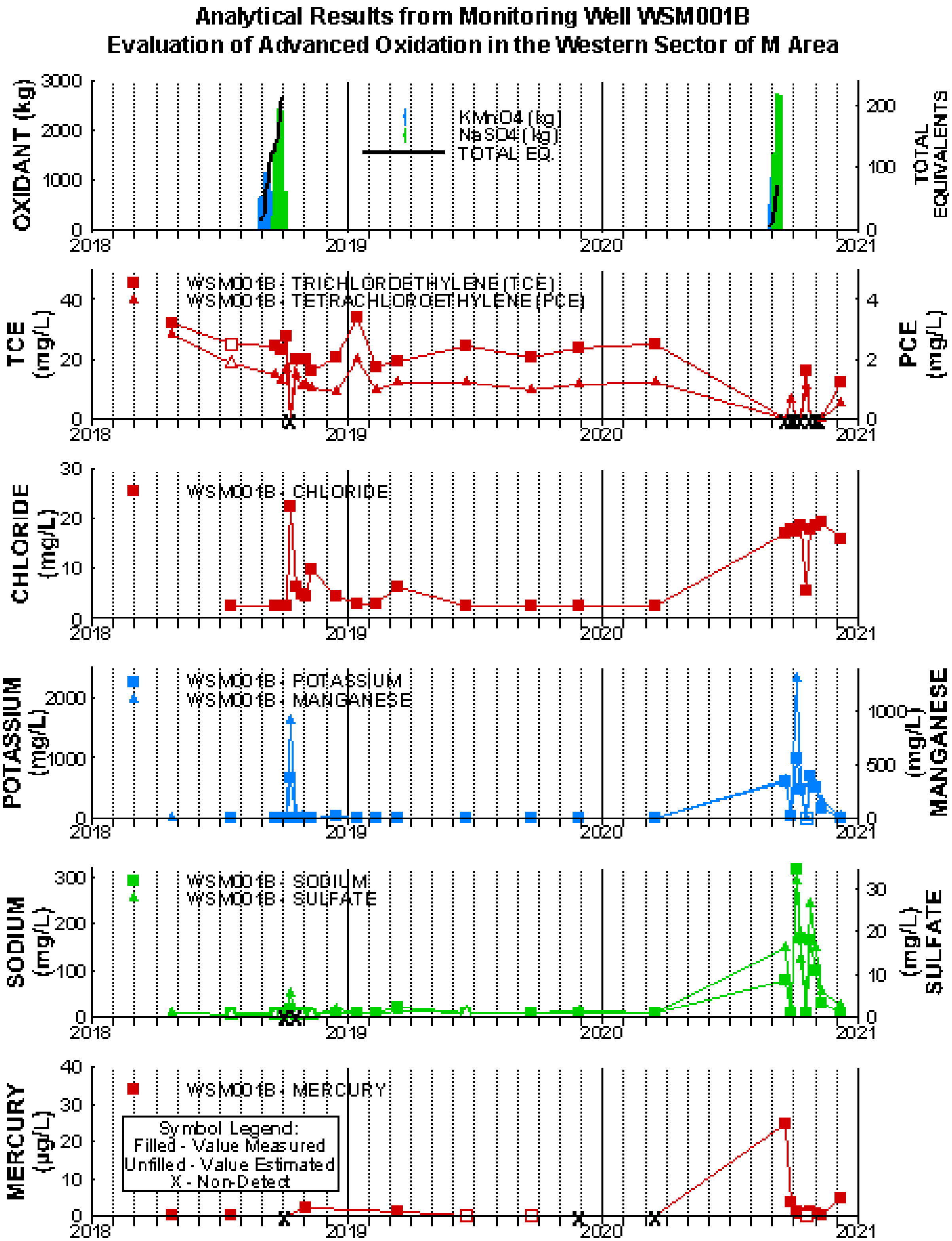

Figure 10-5. Analytical Results from Monitoring Well WSM001B

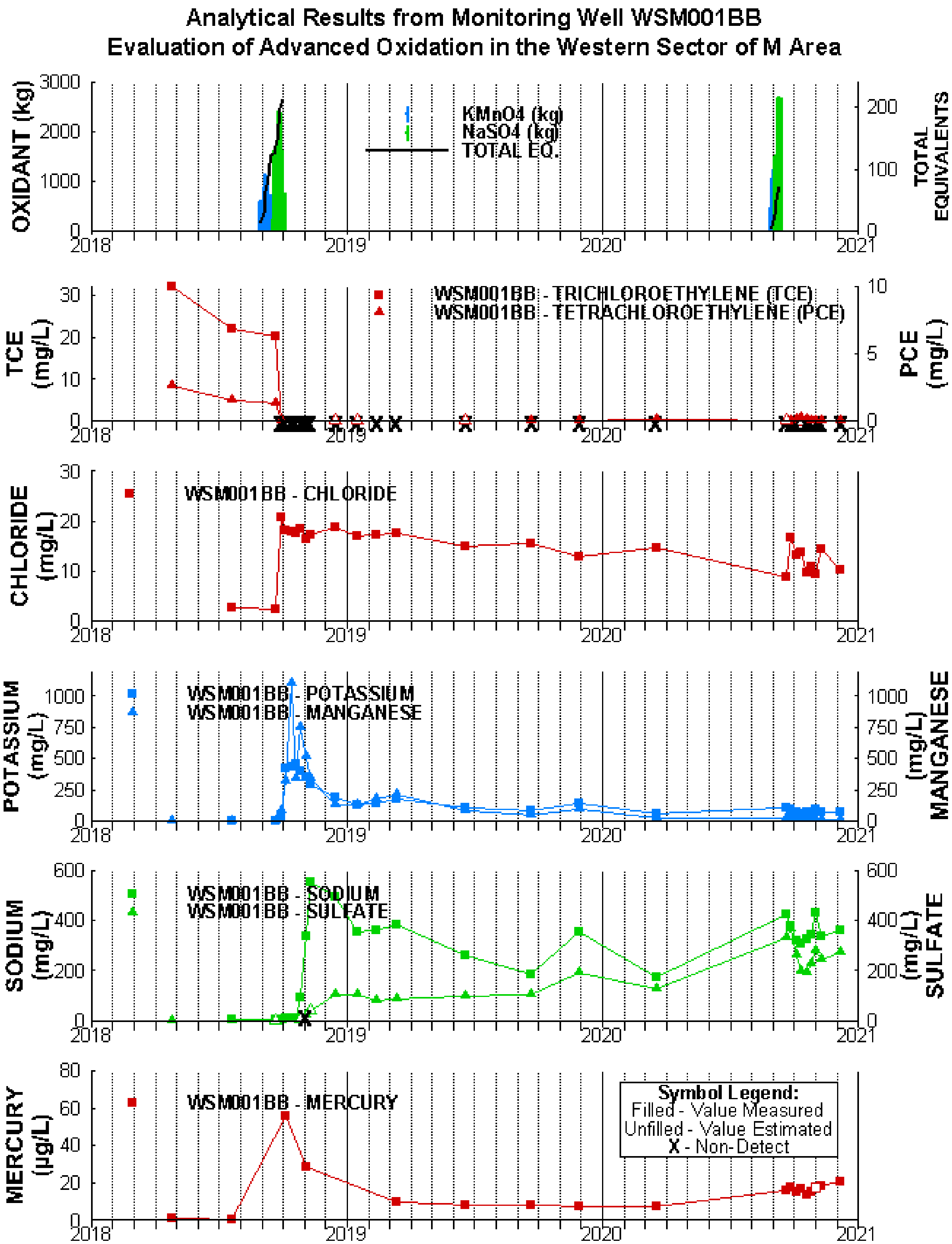

Figure 10-6. Analytical Results from Monitoring Well WSM001BB

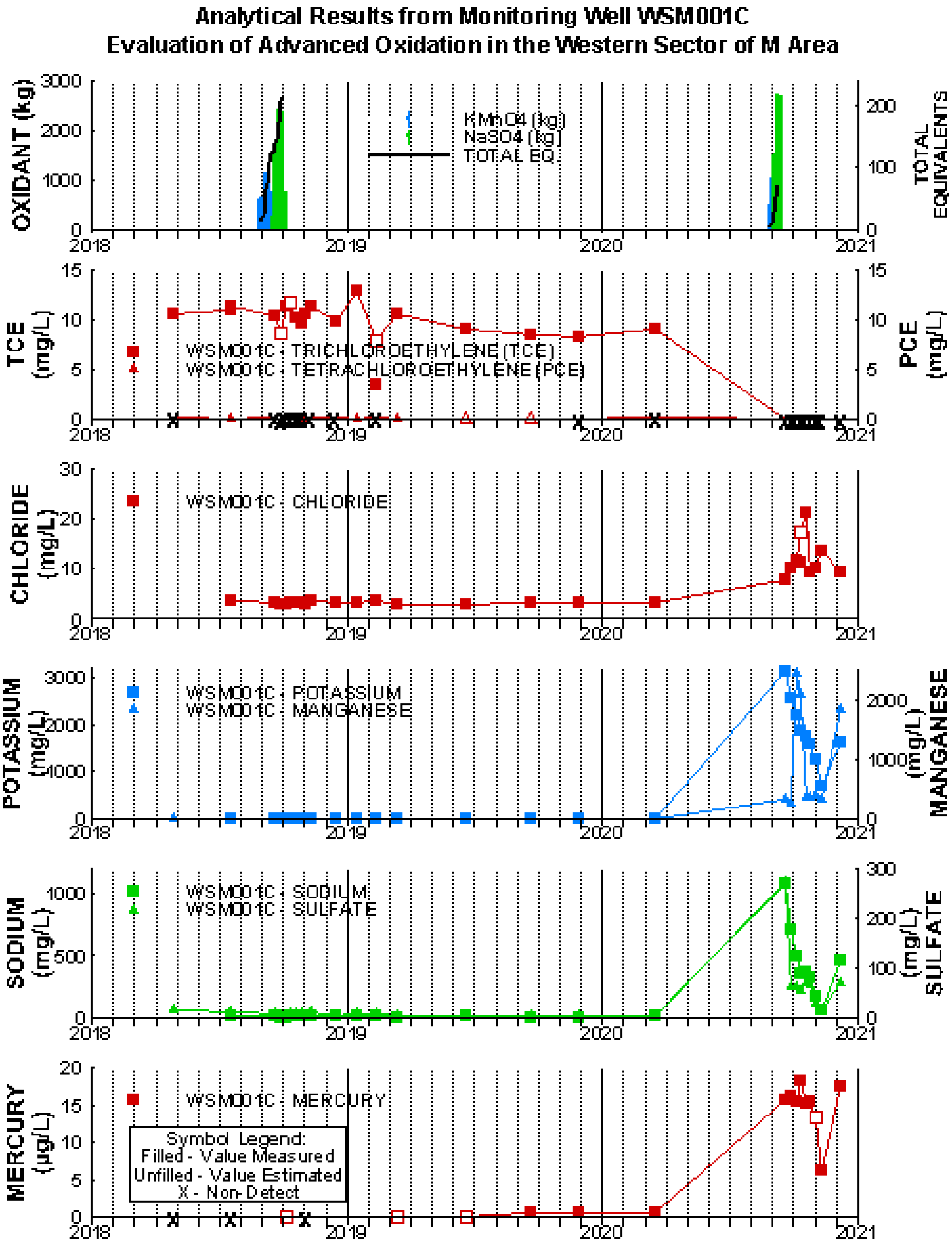

Figure 10-7. Analytical Results from Monitoring Well WSM001C

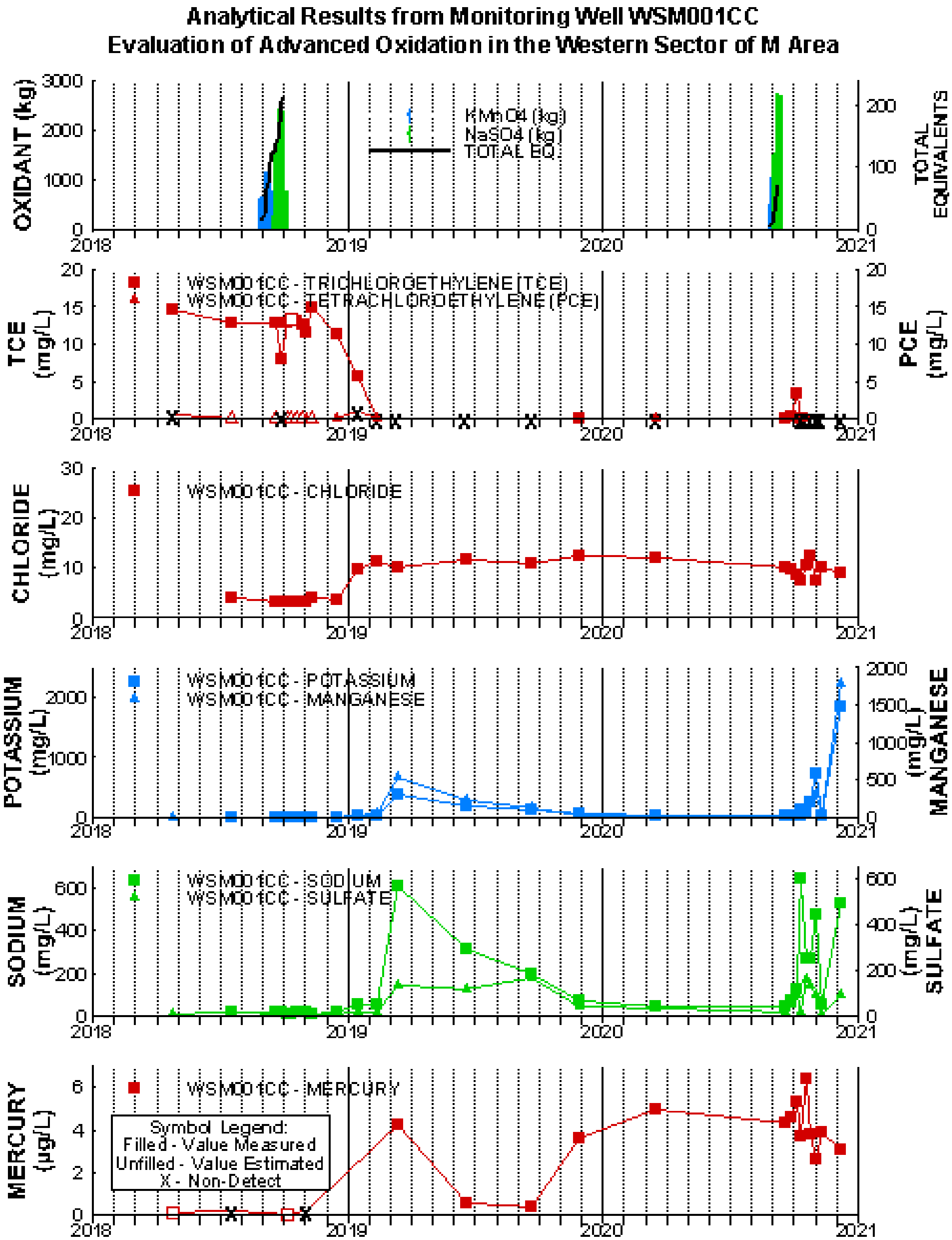

Figure 10-8. Analytical Results from Monitoring Well WSM001CC

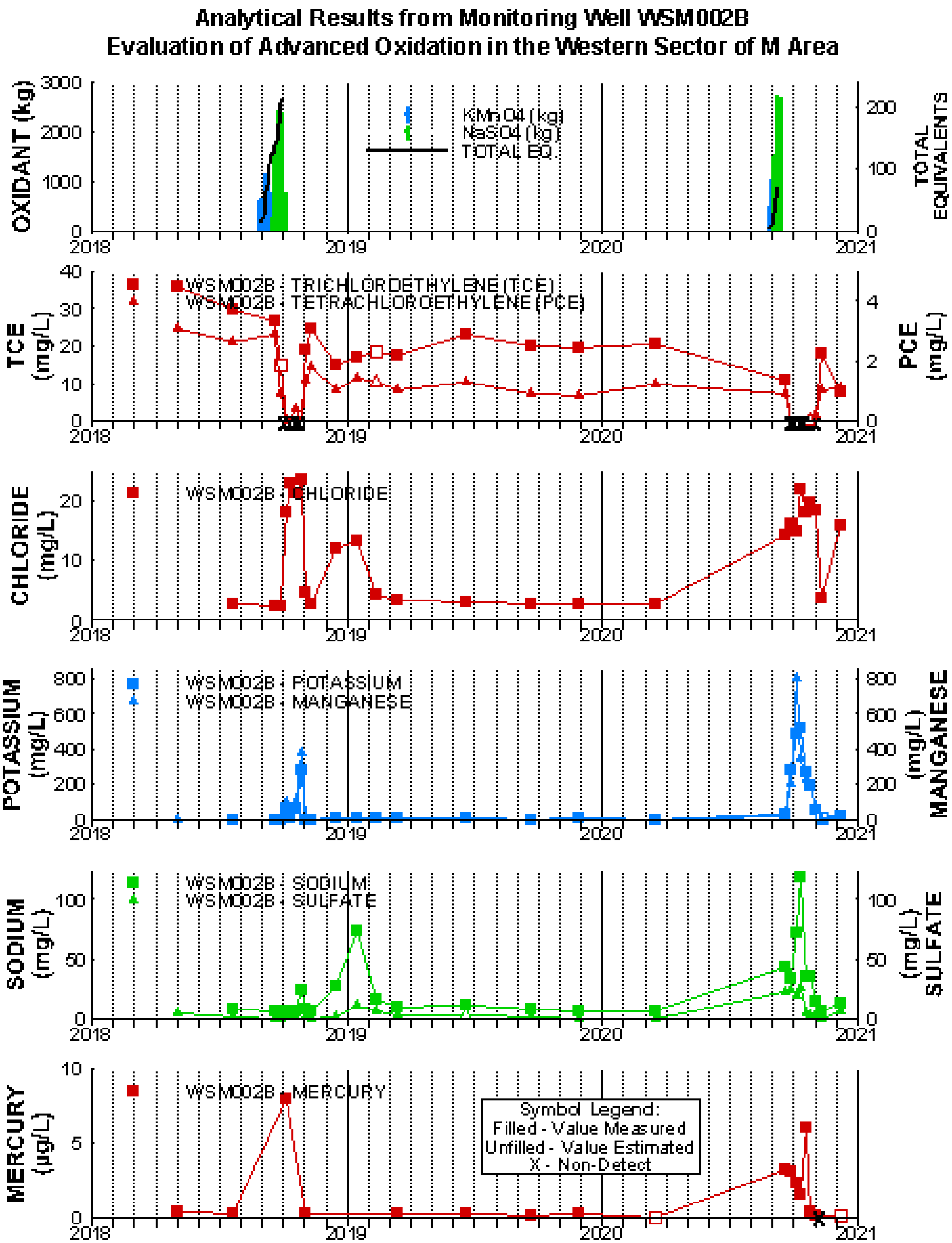

Figure 10-9. Analytical Results from Monitoring Well WSM002B

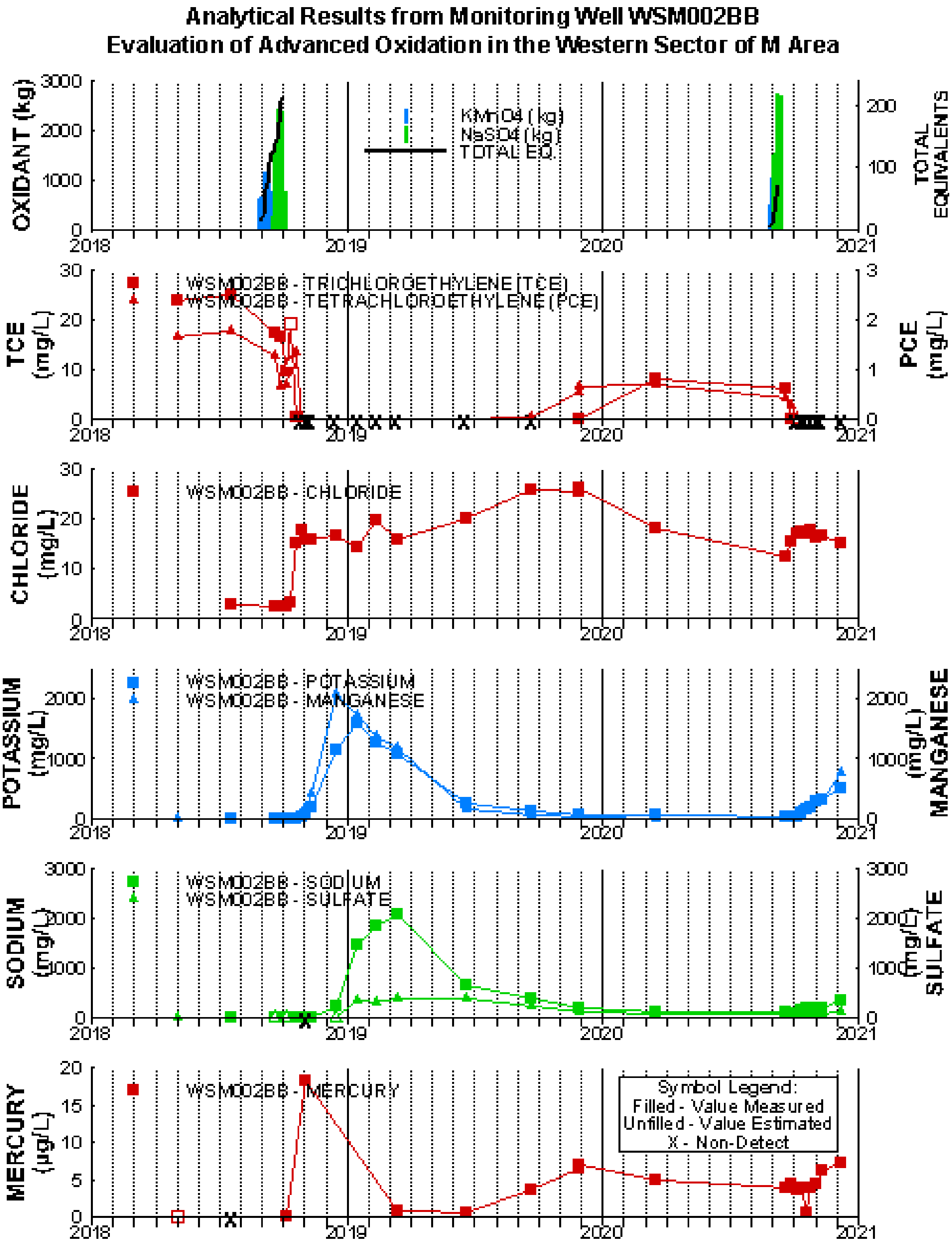

Figure 10-10. Analytical Results from Monitoring Well WSM002BB

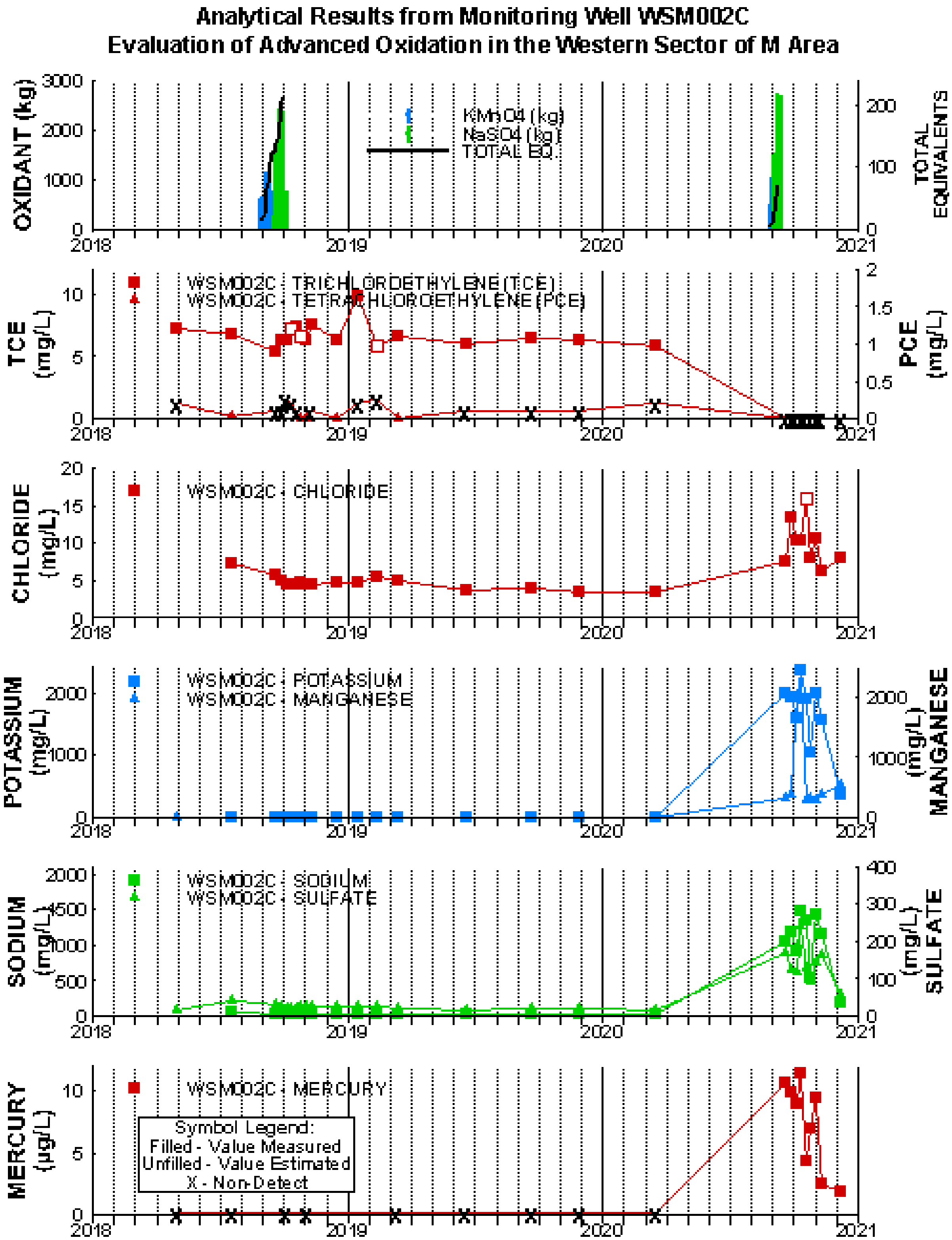

Figure 10-11. Analytical Results from Monitoring Well WSM002C

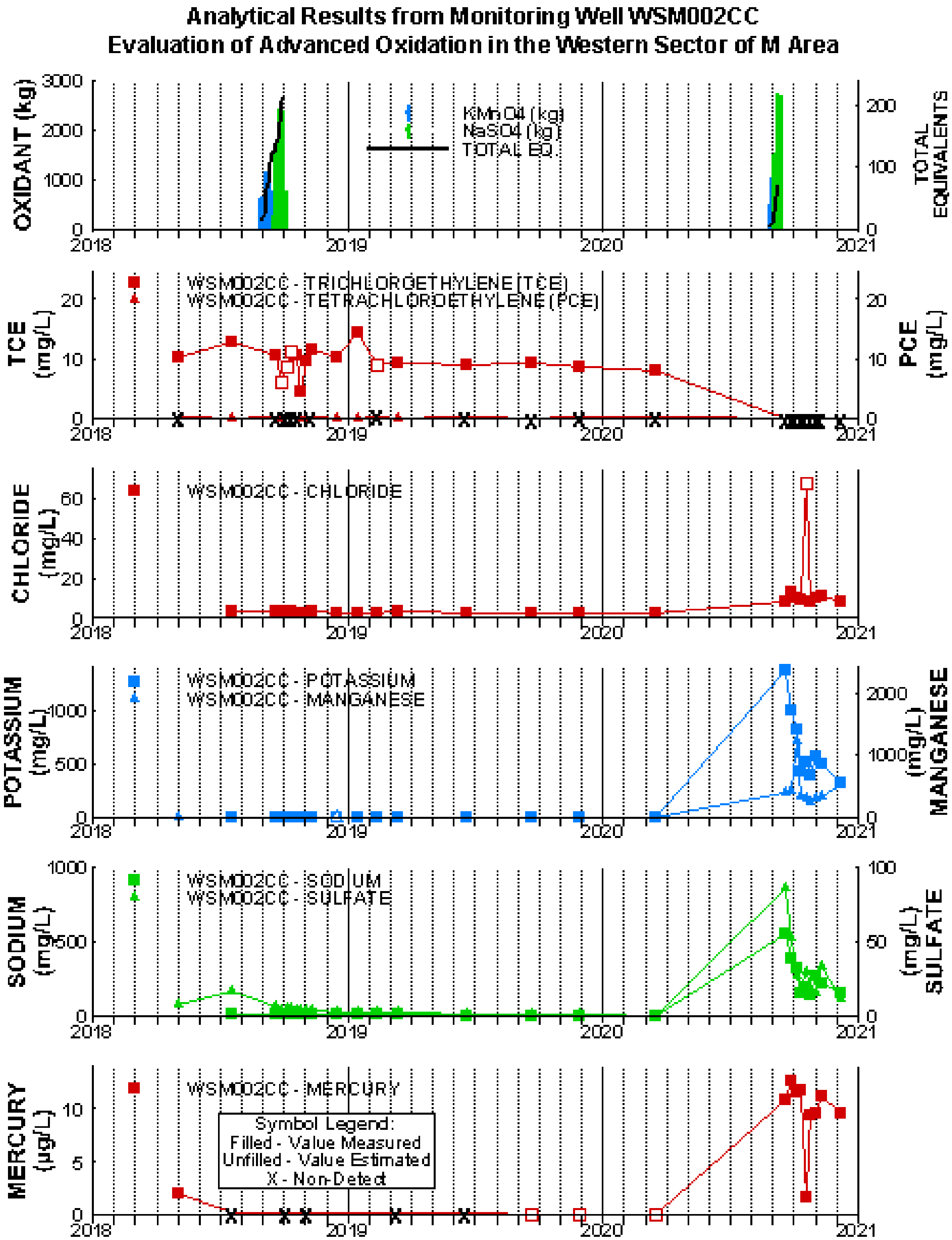

Figure 10-12. Analytical Results from Monitoring Well WSM002CC

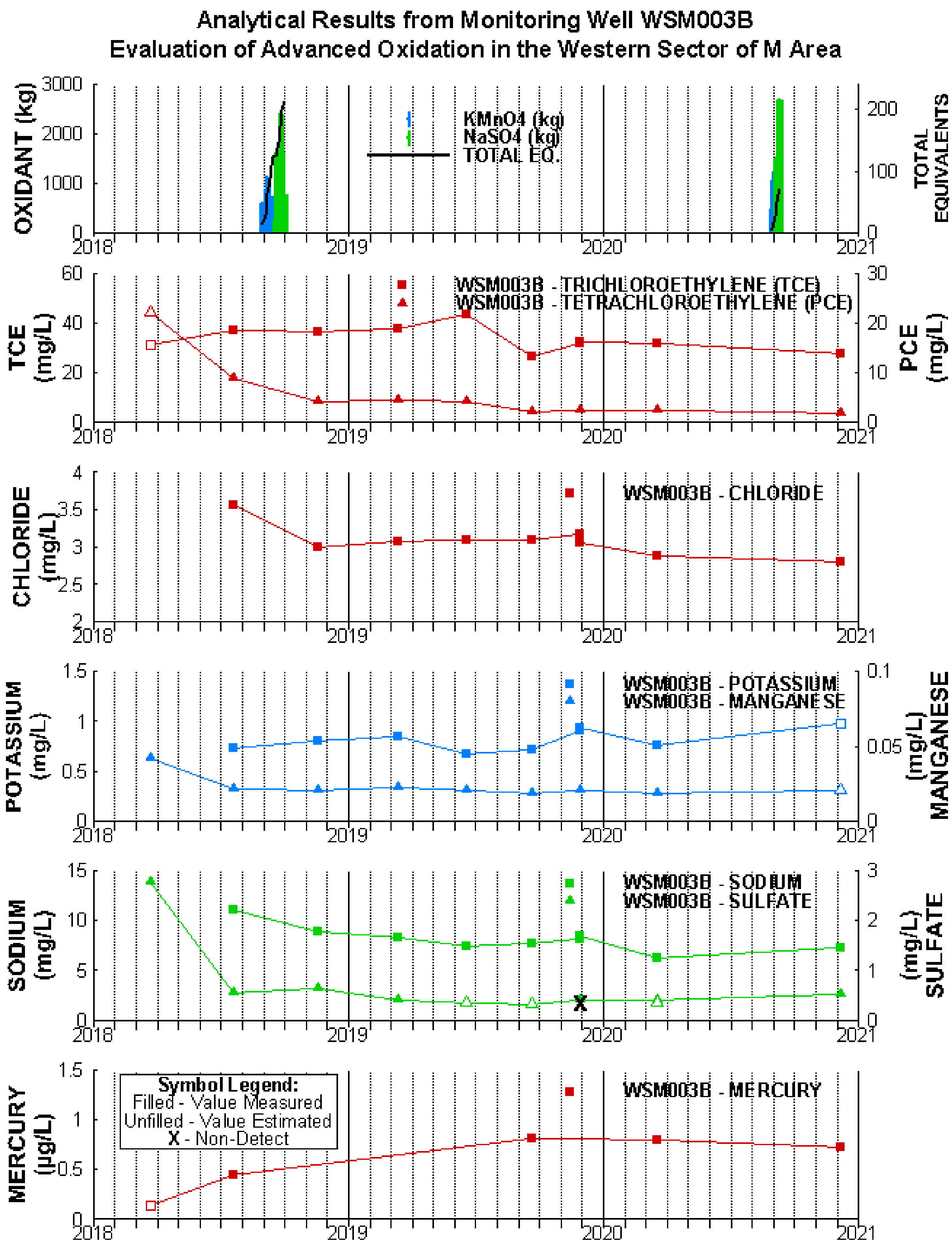

Figure 10-13. Analytical Results from Monitoring Well WSM003B

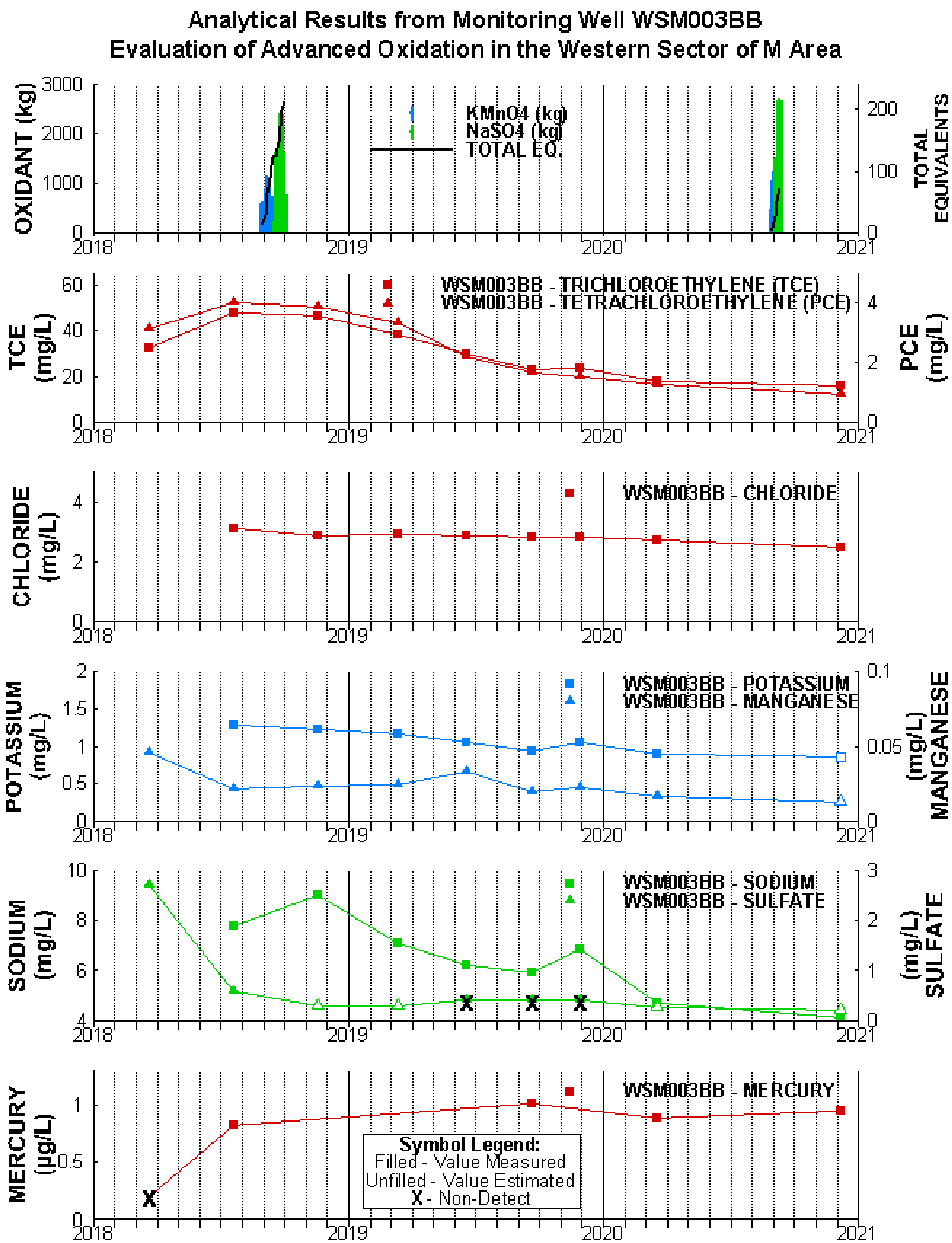

Figure 10-14. Analytical Results from Monitoring Well WSM003BB

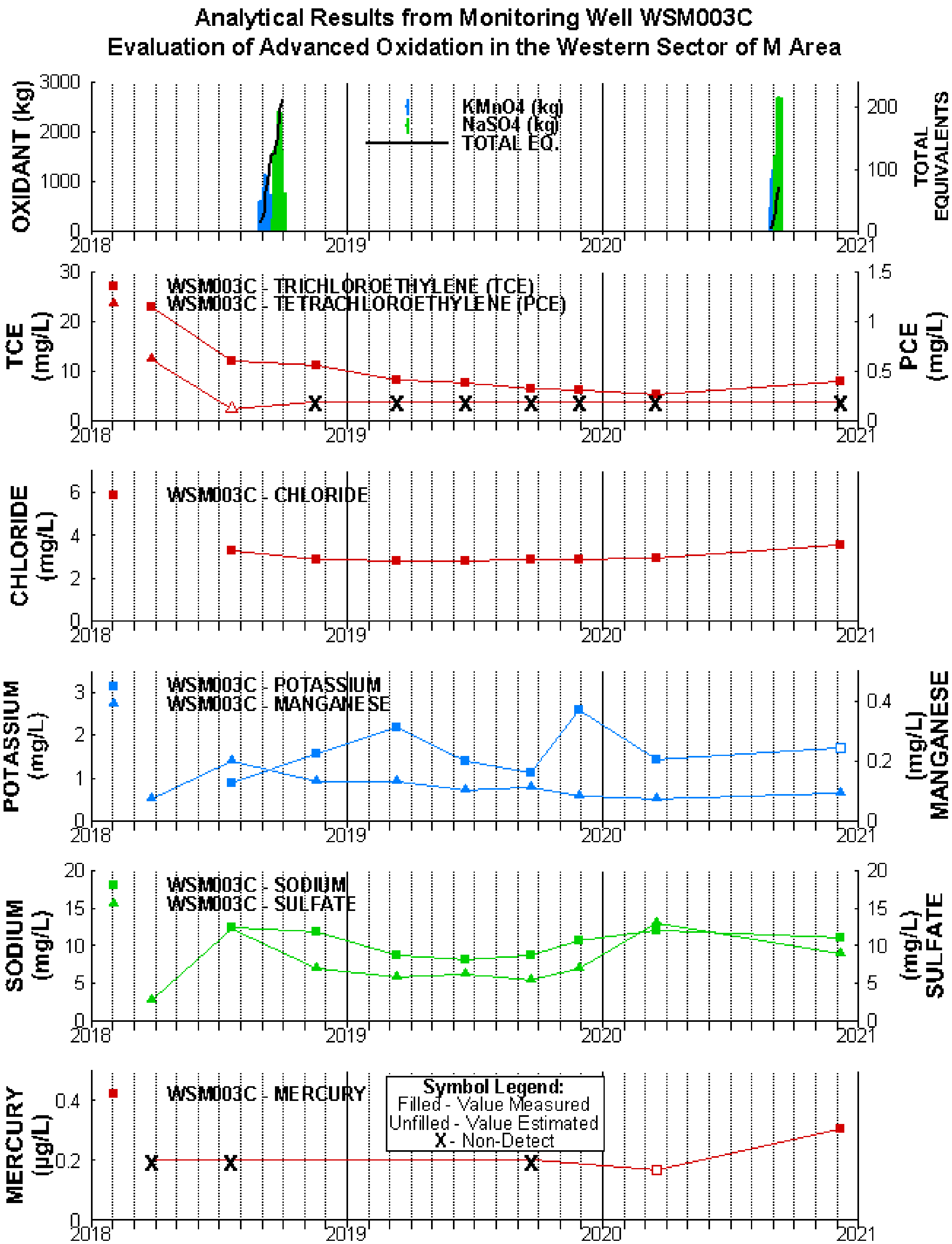

Figure 10-15. Analytical Results from Monitoring Well WSM003C

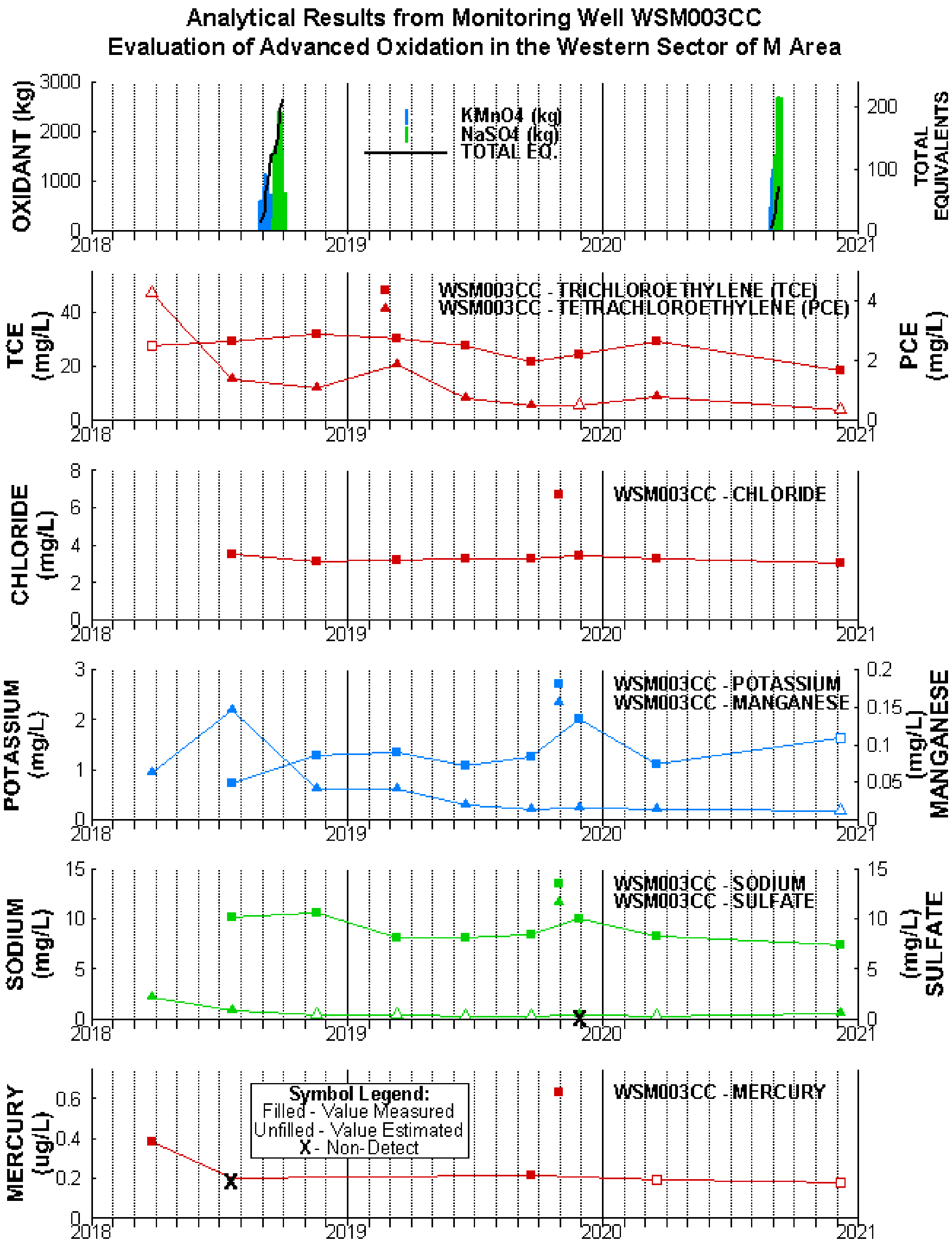

Figure 10-16. Analytical Results from Monitoring Well WSM003CC

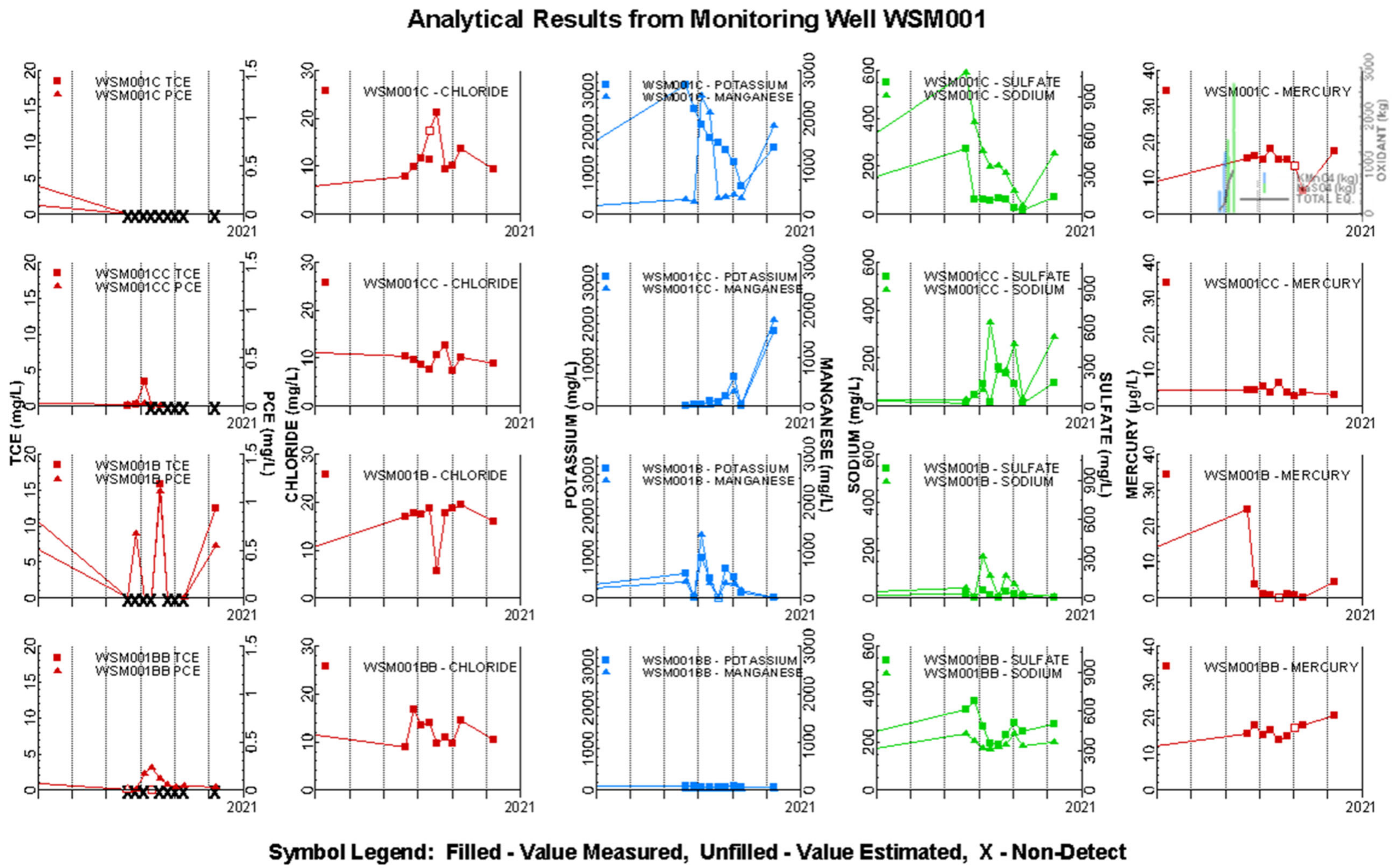

Figure 10-17. ISCO-II Specific Analytical Results for Well WSM001

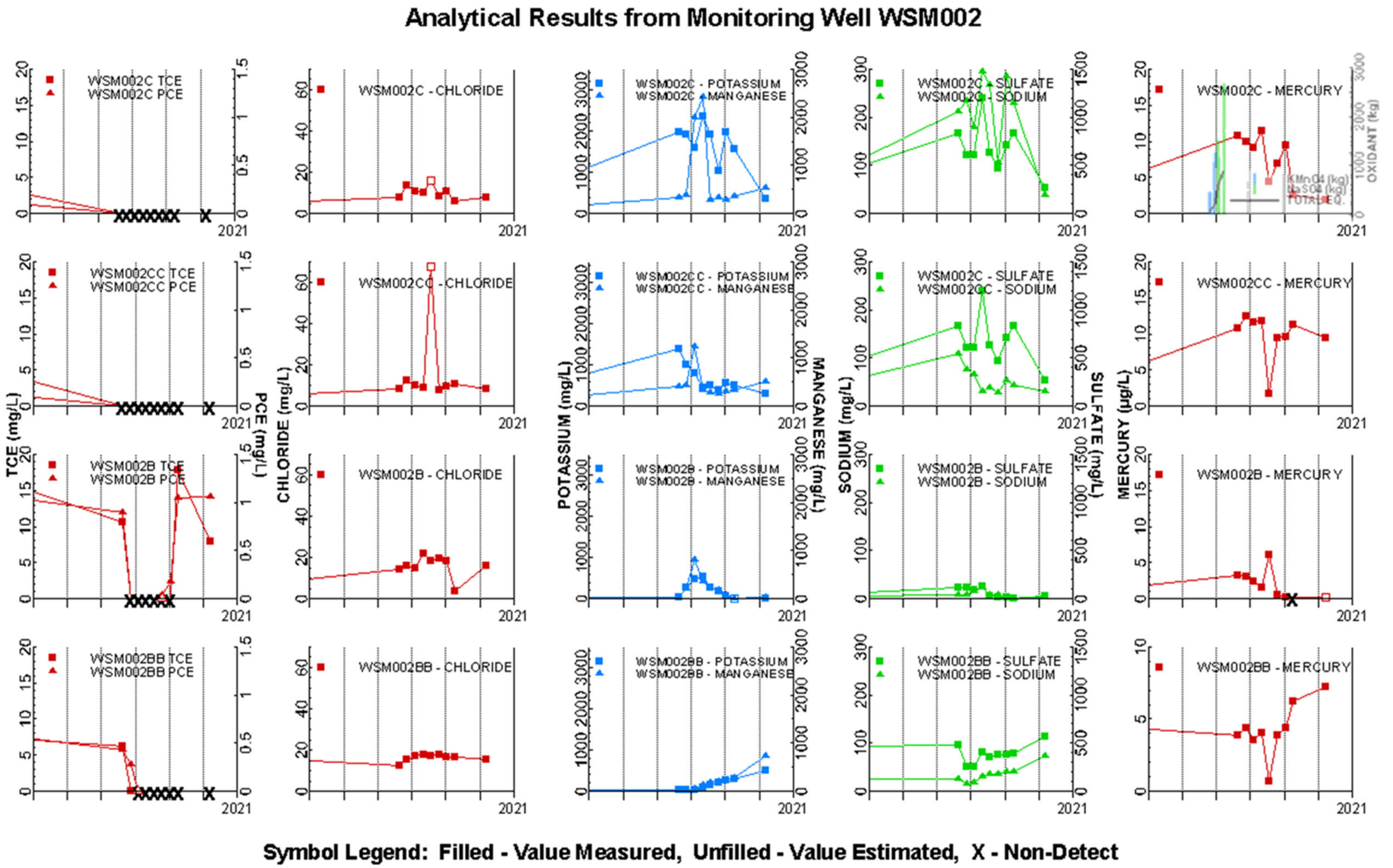

Figure 10-18. ISCO-II Specific Analytical Results for Well WSM002

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM001B												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
25-Apr-18	4.8	117	NS	NS	32,200	2,830	NS	32	NS	NS	0.94	0.42
17-Jul-18	5.0	98	239	3.68	25,200 (J)	1,880 (J)	2.55	18	1,030	6,440	0.33 (J)	0.22
17-Sep-18	4.8	92	234	6.05	24,400	1,470	2.26	11	874	6,520	0.29 (J)	NS
25-Sep-18	4.8	90	267	6.72	22,800	1,290	2.32	11	773	6,280	0.25 (J)	NS
2-Oct-18	5.2	91	246	4.60	27,600	1,660	2.30	70	953	7,080	ND	ND
9-Oct-18	4.4	442	608	4.10	R	R	22.40	902,000	662,000	17,600	5.22	NS
16-Oct-18	5.2	103	440	4.50	20,000	1,470	6.44	5,210	5,250	6,910	ND	NS
23-Oct-18	5.7	93	503	5.60	19,800	1,070	4.77	5,280	6,580	10,300	0.37 (J)	NS
30-Oct-18	4.7	98	400	4.80	19,600	1,160	4.45	928	2,010	7,500	0.43	2.34
6-Nov-18	5.0	122	460	5.80	16,100	1,000	9.61	419	2,900	6,210	0.33 (J)	NS
11-Dec-18	4.9	109	298	6.55	20,300	903	4.36	441	7,310	8,010	1.59	NS
15-Jan-19	4.5	94	494	5.65	33,800	1,960	2.89	413	4,450	7,340	0.83	NS
12-Feb-19	4.8	94	228	7.31	17,200	988	2.67	287	1,830	7,930	0.42	NS
12-Mar-19	4.9	130	378	6.65	18,900	1,250	6.12	549	1,460	18,900	1.44	1.41
17-Jun-19	4.7	94	385	6.82	24,100	1,230	2.52	177	1,000	6,590	1.00 (J)	0.13 (J)
18-Sep-19	4.3	92	768	5.64	20,700	958	2.58	72	760	6,880	0.80	0.10 (J)
25-Nov-19	4.8	92	302	6.68	23,800	1,150	2.58	78	1,780	7,390	1.29	ND
16-Mar-20	4.6	87	381	4.59	24,800	1,190	2.42	102	776	6,520	0.98	ND
16-Sept-20	4.3	459	608	4.90	ND	ND	16.90	345,000	583,000	77,600	16.00	24.60
23-Sept-20	4.3	232	629	4.20	ND	668	17.80	12,500	151,000	8,990	2.09	3.89
30-Sep-20	3.5	122	713	9.43	ND	ND	17.50	1,310,000	977,000	314,000	31.60	1.13
7-Oct-20	3.8	3078	815	8.11	ND	ND	18.60	299,000	482,000	168,000	13.30	0.81
14-Oct-20	4.2	137	901	7.82	15,800	1,110	5.51	2,580	5,830 (J)	8,300	1.61	0.18 (J)

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM001B *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
21-Oct-20	3.7	101	879	3.35	ND	ND	17.70	317,000	704,000	165,000	26.30	0.99
28-Oct-20	4.0	122	855	5.90	ND	ND	18.6	292,000	515,000	100,000	16.00	0.61
4-Nov-20	4.0	135	837	2.56	ND	9.71	19.4	156,000	137,000	28,900	5.62	0.25
2-Dec-20	4.1	143	796	2.24	12,400	539	16.00	4,190	5,980	8,840	2.81	4.59
Monitoring Well WSM001BB												
24-Apr-18	4.5	131	NS	NS	31,900.0	2,640.00	NS	18	NS	NS	0.49	0.78
17-Jul-18	5.0	111	260	4.34	21,900.0	1,560.00	2.76	17	842	5,700	0.51	0.59
17-Sep-18	5.1	104	235	5.46	20,300.0	1,380.00	2.46	16	878	5,660	0.35 (J)	NS
25-Sep-18	3.8	260	896	5.87	ND	2.62	20.80	83,600	24,300	6,860	0.67	NS
2-Oct-18	3.8	1,423	497	4.90	ND	ND	18.20	318,000	419,000	11,300	2.97	56.10
9-Oct-18	3.6	1,761	940	4.30	ND	R	17.80	1,100,000	436,000	11,600	4.88	NS
16-Oct-18	3.6	1,271	922	5.10	ND	ND	17.70	332,000	452,000	10,500	2.92	NS
23-Oct-18	3.7	1,314	934	4.80	ND	ND	18.30	743,000	393,000	92,100	3.92 (J)	NS
30-Oct-18	3.8	1,619	883	4.40	ND	ND	16.50	511,000	346,000	335,000	ND	28.40
6-Nov-18	3.8	1,754	879	5.50	ND	ND	17.20	333,000	290,000	554,000	39.70 (J)	NS
11-Dec-18	4.1	3,353	817	6.94	ND	1.00 (J)	18.60	133,000	186,000	498,000	102.00	NS
15-Jan-19	4.1	2,361	828	6.18	ND	1.00 (J)	17.00	123,000	122,000	353,000	104.00	NS
12-Feb-19	4.3	2,556	874	6.01	ND	ND	17.30	174,000	141,000	363,000	81.40	NS
12-Mar-19	3.9	2,840	875	11.32	ND	ND	17.50	211,000	174,000	385,000	85.10	9.46
17-Jun-19	4.4	2,020	798	5.75	ND	1.00 (J)	14.90	81,700	102,000	260,000	96.40	8.26
18-Sep-19	4.2	1,835	808	6.88	ND	4.00	15.60	49,000	75,700	188,000	105.00	7.87
25-Nov-19	4.1	2,620	817	6.13	ND	10.00	12.80	89,100	137,000	356,000	192.00	7.70
16-Mar-20	4.6	1,392	759	6.08	ND	147	14.60	20,200	62,800	173,000	125.00	7.52

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM001BB *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
16-Sep-20	4.9	2,388	829	5.10	ND	0.96 (J)	8.93	19,400	106,000	425,000	334.00	15.60
23-Sep-20	3.9	2,481	437	4.40	ND	9.13	16.60	20,300	87,500	37,6000	368.00	17.90
30-Sep-20	3.7	2,438	810	6.16	ND	172.00	13.30	17,000	69,300	31,7000	264.00	15.10
7-Oct-20	4.0	2,576	878	8.24	ND	225.00	13.80	14,100	62,500	310,000	195.00	16.50
14-Oct-20	4.1	2,439	865	8.98	ND	120.00	9.74	10,300	69,100	327,000	189.00	13.70
21-Oct-20	3.3	2,551	865	8.28	ND	52.00	10.9	6,470	72,900	345,000	228	15.00
28-Oct-20	4.0	2,535	871	4.35	ND	34.9	9.52	8,470	87,000	429,000	277	17.3 (J)
4-Nov-20	4.2	2,597	865	2.93	ND	40.3	14.4	4,800	70,100	338,000	245	18.00
2-Dec-20	4.2	2,494	832	2.87	ND	27.00	10.30	15,600	74,500	359,000	275.00	20.50
Monitoring Well WSM001C												
26-Apr-18	6.0	127	NS	NS	10,500	ND	NS	54	NS	NS	15.50	ND
17-Jul-18	6.1	94	105	4.80	11,300	42	3.76	53	2,300	13,100	12.40	ND
17-Sep-18	5.7	90	208	3.92	10,300	ND	3.09	23	1,530	10,200	6.99	NS
25-Sep-18	5.3	62	231	6.23	8,590 (J)	ND	2.85	20	882	6,350	3.13	NS
2-Oct-18	5.5	76	233	8.18	11,400	ND	2.78	22	1,250	6,940	2.97	0.08 (J)
9-Oct-18	5.6	88	207	6.30	11,800 (J)	R	3.05	20	1,680	9,620	7.05	NS
16-Oct-18	5.6	93	237	6.01	10,100	ND	3.12	24	1,800	10,200	8.60	NS
23-Oct-18	5.8	98	254	7.72	9,670	ND	3.16	20	2,850	12,800	8.62	NS
30-Oct-18	5.4	82	225	7.70	10,600	44	2.77	23	2,960	10,200	4.37	ND
6-Nov-18	5.4	99	250	6.70	11,400	ND	3.60	17	2,770	11,600	9.87	NS
11-Dec-18	6.0	110	245	7.43	9,710	ND	3.09	18	3,710	10,300	5.46	NS
15-Jan-19	6.3	122	433	4.98	12,800	58	3.17	21	7,500	16,300	9.06	NS
12-Feb-19	6.2	109	220	5.59	7,880 (J)	ND	3.48	17	5,120	12,200	8.13	NS

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM001C *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
12-Mar-19	6.0	94	557	7.51	10,600	39	2.87	19	2,440	7,880	3.41	0.14 (J)
17-Jun-19	6.2	91	200	7.20	8,960	36 (J)	3.00	16	4,650	10,500	4.64	0.16 (J)
18-Sep-19	5.7	75	484	5.96	8,520	41 (J)	3.08	16	1,590	6,630	2.20	0.60
25-Nov-19	6.0	77	211	5.07	8,280	ND	3.20	23	1,930	7,100	2.13	0.66
16-Mar-20	5.9	81	223	4.88	8,990	ND	3.36	14	2,370	8,630	3.55	0.64
16-Sep-20	4.1	13	852	8.49	ND	ND	7.75	318,000	3,140,000	1,080,000	272.00	15.60
23-Sep-20	4.0	10	926.00	5.73	ND	ND	9.97	261,000	2,560,000	704,000	62.00	16.30
30-Sep-20	3.0	7,144	883.00	3.46	ND	ND	11.50	2,480,000	2,190,000	484,000	60.30	15.30
7-Oct-20	4.3	6,652	864.00	6.15	ND	ND	17.40 (J)	2,120,000	1,850,000	360,000	55.50	18.30
14-Oct-20	3.9	5,407	854.00	4.89	ND	ND	21.10	339,000	1,750,000	369,000	67.70	15.10
21-Oct-20	4.4	5,357	584.00	8.71	ND	ND	9.33	349,000	1,570,000	319,000	63.5	15.3
28-Oct-20	4.5	2,710	721.00	4.90	ND	ND	10.2	398,000	1,270,000	173,000	26.2	13.40 (J)
4-Nov-20	4.3	2,776	785.00	4.60	ND	ND	13.7	325,000	692,000	67,000	16.2	6.35
2-Dec-20	4.5	3,877	818.00	3.00	ND	ND	9.38	1,840,000	1,630,000	463,000	71.00	17.50
Monitoring Well WSM001CC												
25-Apr-18	5.2	83	NS	NS	14,500	ND	NS	21	NS	NS	4.40	0.08 (J)
17-Jul-18	6.1	104	174	4.60	12,800	115.0 (J)	3.91	31	1,290	18,100	15.70	ND
17-Sep-18	6.2	120	180	4.33	12,800	92.0 (J)	3.39	14	1,860	17,200	8.81	NS
25-Sep-18	5.7	93	216	6.07	7,920	ND	3.38	15	810	15,200	7.86	NS
2-Oct-18	6.1	108	191	7.13	12,800	95.0 (J)	3.07	20	979	12,800	4.01	0.07 (J)
9-Oct-18	6.1	108	200	8.04	13,200 (J)	95.0 (J)	3.03	19	1,110	11,800	4.85	NS
16-Oct-18	6.0	105	218	5.55	13,100	98.0 (J)	3.36	15	1,800	15,400	8.00	NS
23-Oct-18	5.9	100	225	7.95	12,600	112.0 (J)	3.40	14	2,110	17,400	7.85	NS

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM001CC *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
30-Oct-18	6.0	100	224	8.10	11,600	100.0	3.05	16	2,050	15,100	5.72	ND
6-Nov-18	5.9	96	210	6.96	14,800	112.0 (J)	4.11	16	1,690	11,600	7.93	NS
11-Dec-18	6.3	112	203	6.13	11,200	71.0	3.53	484	4,510	15,500	7.03	NS
15-Jan-19	4.7	116	261	6.34	5,710	ND	9.86	17,900	17,800	49,900	15.30	NS
12-Feb-19	5.5	115	650	5.51	ND	29.0	11.20	45,300	32,100	56,100	14.80	NS
12-Mar-19	5.1	2,980	651	6.30	ND	ND	10.30	541,000	387,000	607,000	135.00	4.22
17-Jun-19	5.9	135	625	4.42	ND	ND	11.70	215,000	196,000	316,000	119.00	0.56
18-Sep-19	5.7	404	711	5.74	ND	ND	10.80	121,000	117,000	201,000	170.00	0.42
25-Nov-19	6.1	119	479	5.38	2	33.0	12.40	29,300	41,500	68,400	45.50	3.64
16-Mar-20	6.2	92	496	5.38	ND	33.0	12.00	2,190	20,000	43,000	32.80	4.92
16-Sep-20	7.6	196	425	7.99	84	19.0	10.30	3,390	10,800	48,000	13.10	4.37
23-Sep-20	6.0	451	659	8.81	167	25.2	9.61	2,600	24,600	75,400	46.90	4.55
30-Sep-20	6.1	206	457	3.48	3,320	28.9	8.58	2,720	31,300	122,000	93.00	5.29
7-Oct-20	6.2	223	250	4.90	33	ND	7.51	4,060	118,000	641,000	13.90	3.72
14-Oct-20	5.3	211	254	4.90	ND	2.6	10.50	66,300	91,600	269,000	162.00	6.34
21-Oct-20	6.2	389	622	6.34	ND	ND	12.60	192,000	231,000	273,000	136.00	3.77
28-Oct-20	5.3	3,094	714	6.41	ND	ND	7.29	307,000	720,000	470,000	92.90	2.67
4-Nov-20	5.4	1,295	657	4.80	ND	ND	10.2	21,800	20,300	55,500	10.30	3.92
2-Dec-20	5.3	5,109	674	2.66	ND	ND	8.88	1,790,000	1,840,000	530,000	94.60	3.11
3-May-18	5.3	152	NS	NS	35,900	3,050	NS	25	NS	NS	4.73	0.48
18-Jul-18	5.0	112	271	4.47	29,700	2,650	2.69	15	1,210	7,580	1.34	0.26
17-Sep-18	5.3	110	264	4.4	26,600	2,890	2.36	14	799	6,910	0.59	NS
25-Sep-18	4.4	104	320	5.93	15,000 (J)	921	2.36	14	695	6,560	0.63	NS

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM002B												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
2-Oct-18	3.5	285	889	5.03	ND	9	17.90	93,000	57,600	6,630	0.86	7.95
9-Oct-18	4.5	861	860	8.80	ND	R	22.70	6,300	5,800	6,860	2.67	NS
16-Oct-18	3.9	145	699	5.08	ND	359	21.30	97,000	65,200	6,730	1.04	NS
23-Oct-18	2.4	566	876	5.19	ND	ND	23.40	372,000	277,000	24,700	6.18	NS
30-Oct-18	4.5	103	726	6.30	19,000	1,330	4.69	2,460	2,200	7,360	0.93	0.31
6-Nov-18	4.8	96	707	5.14	24,600	1,770	2.63	705	944	6,350	0.50	NS
11-Dec-18	4.7	164	625	1.91	14,900	1,020	12.10	784	7,620	26,800	1.34	NS
15-Jan-19	5.3	315	344	6.10	17,000	1,430	13.20	726	12,000	74,300	11.60	NS
12-Feb-19	5.2	123	268	5.10	18,300 (J)	1,310 (J)	4.31	719	5,170	16,700	6.93	NS
12-Mar-19	4.9	112	645	6.40	17,200	1,000	3.17	187	4,650	9,780	3.64	0.36
17-Jun-19	4.8	105	256	6.58	22,800	1,260	2.85	107	2,850	11,700	2.46 (J)	0.29
18-Sep-19	5.1	106	655	6.48	20,000	898	2.53	173	2,270	8,440	0.99	0.23
25-Nov-19	5.4	106	253	10.9	19,400	830	2.57	82	3,950	6,690	0.67	0.29
16-Mar-20	5.1	95	320	15.55	20,400	1,190	2.60	171	1,920	6,800	0.80	0.11 (J)
16-Sep-20	5.1	96	305	8.86	10,600	890	14.30	22,200	32,100	43,900	22.80	3.19
23-Sep-20	4.2	1,223	845	8.60	ND	ND	16.00	203,000	275,000	33,500	24.10	3.09
30-Sep-20	3.8	2,037	891	6.81	ND	ND	14.80	801,000	482,000	71,600	18.50	2.40
7-Oct-20	3.8	2,270	956	13.05	ND	ND	21.80	347,000	518,000	118,000	26.40	1.60
14-Oct-20	3.9	438	608	9.77	ND	ND	18.00	221,000	268,000	34,400	4.38	6.08
21-Oct-20	5.4	117	593	8.80	ND	43.2	19.7	184,000	189,000	34,600	3.66	0.47
28-Oct-20	5.0	154	772	10.78	ND	181	18.2	73,400	55,800	15,000	3.05	0.22
4-Nov-20	4.9	102	570	8.28	17,800	1,040	3.75	1,970	3,920 (J)	6,530	0.50	ND
2-Dec-20	5.6	98	545	9.78	7,830	1,060	15.90	20,800	18,100	13,100	6.31	0.12 (J)

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM002BB												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
1-May-18	5.3	121	NS	NS	23,800.0	1,670	NS	35	NS	NS	0.80	0.08 (J)
17-Jul-18	6.3	105	242	8.48	24,900.0	1,750	2.74	21	896	6,820	0.57	0.20
17-Sep-18	5.5	105	244	5.50	17,400.0	1,250	2.47	18	878	5,770	0.38 (J)	NS
25-Sep-18	4.7	104	293	43.19	16,500.0	673	2.45	20	950	6,310	0.58	NS
2-Oct-18	4.7	104	535	4.82	9,460.0	708	2.51	26	976	6,770	0.37 (J)	0.21
9-Oct-18	5.3	112	661	8.71	19,200.0 (J)	1,110 (J)	3.22	22	1,030	6,210	0.41	NS
16-Oct-18	4.7	156	771	5.97	509.0	1,360	15.20	7,350	1,340	6,480	0.64	NS
23-Oct-18	3.7	295	805	5.34	ND	4	17.70	71,400	11,100	9,410	1.30	NS
30-Oct-18	4.6	522	812	6.97	ND	ND	16.00	188,000	56,600	8,970	2.00	18.20
6-Nov-18	4.6	889	827	5.29	ND	ND	16.00	422,000	169,000	10,700	2.15	NS
11-Dec-18	4.4	7,448	900	17.80	ND	ND	16.80	2,080,000	1,140,000	250,000	20.20	NS
15-Jan-19	3.8	90	853	5.20	ND	ND	14.30	1,730,000	1,590,000	1,440,000	341.00	NS
12-Feb-19	4.4	84	824	4.90	ND	ND	19.80	1,380,000	1,260,000	1,860,000	295.00	NS
12-Mar-19	4.6	111	855	14.30	ND	ND	15.70	1,160,000	1,080,000	2,060,000	398.00	0.79
17-Jun-19	4.1	4,565	821	8.25	ND	ND	20.00	149,000	248,000	662,000	389.00	0.62
18-Sep-19	4.8	2,347	807	5.03	ND	26	25.90	57,700	119,000	379,000	217.00	3.63
25-Nov-19	5.0	1,274	689	37.65	10	653	26.30	19,100	70,200	207,000	131.00	7.10
16-Mar-20	5.3	730	626	44.23	8,230	688	18.00	1,340	42,600	118,000	92.90	4.91
16-Sep-20	5.8	559	515	7.51	6,290	423	12.40	801	37,400	127,000	95.60	3.86
23-Sep-20	5.8	485	ND	ND	14.4	276	15.30	4,630	28,500	72,600	49.90	4.34
30-Sep-20	5.4	566	ND	ND	ND	1 (J)	17.00	65,200	35,200	94,100	49.70	3.56
7-Oct-20	4.7	1,097	ND	ND	ND	ND	17.50	141,000	796,00	150,000	79.80	4.02
14-Oct-20	3.8	1,260	781	10.80	ND	ND	17.00	185,000	154,000	179,000	69.60	0.71

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM002BB *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
21-Oct-20	4.9	1,720	875	7.54	ND	ND	17.6	208,000	195,000	178,000	76.20	3.89
28-Oct-20	5.1	2,240	837	7.50	ND	ND	16.3	236,000	266,000	201,000	75.50	4.40
4-Nov-20	4.9	30	862	7.95	ND	ND	16.7	288,000	300,000	199,000	79.20	6.25
2-Dec-20	4.9	3,000	853	8.80	ND	ND	15.10	743,000	503,000	360,000	113.00	7.23
Monitoring Well WSM002C												
30-Apr-18	7.8	157	NS	NS	7,260	200	NS	59	NS	NS	14.10	ND
17-Jul-18	10.4	317	95	6.07	6,720	15	7.21	28	2,850	42,700	40.90	ND
17-Sep-18	9.0	213	112	2.76	5,310	100	5.81	24	2,120	32,900	32.90	NS
25-Sep-18	7.2	178	40	5.60	6,350	100	4.89	23	1,550	27,100	24.40	NS
2-Oct-18	7.6	170	198	2.52	6,250	250	4.56	24	1,480	26,800	21.40	ND
9-Oct-18	7.2	166	189	5.13	7,210 (J)	R	4.54	36	1,520	23,800	21.20	NS
16-Oct-18	7.5	169	186	1.53	7,420	100	4.47	36	1,320	22,600	21.80	NS
23-Oct-18	6.9	175	150	4.70	6,580 (J)	12	4.77	40	1,570	28,500	26.80	NS
30-Oct-18	6.7	173	147	5.95	6,330	12	4.37	42	1,390	25,100	23.30	ND
6-Nov-18	6.8	166	179	4.13	7,520	100	4.54	35	1,240	22,500	24.70	NS
11-Dec-18	6.1	149	452	1.92	6,260	9	4.76	29	1,930	33,700	28.20	NS
15-Jan-19	6.3	150	180	6.73	9,810	200	4.66	30	1,350	26,900	25.20	NS
12-Feb-19	6.4	143	168	5.33	5,820 (J)	250	5.58	40	1,340	23,100	26.70	NS
12-Mar-19	6.6	131	112	7.40	6,610	13	4.92	44	1,180	17,200	18.30	ND
17-Jun-19	6.6	117	160	10.51	6,030	100	3.76	42	1,060	15,600	17.80	ND
18-Sep-19	5.7	91	527	7.86	6,500	100	3.82	44	1,110	15,500	18.70	ND
25-Nov-19	6.2	94	230	4.30	6,360	100	3.55	49	1,510	18,200	18.70	ND

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM002C *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
16-Mar-20	6.5	92	231	4.70	5,840	ND	3.37	48	2,960	15,300	17.30	ND
16-Sep-20	5.8	8,722	597	10.16	ND	ND	7.62	323,000	1,970,000	1,060,000	167.00	10.70
23-Sep-20	4.8	8,839	754	10.58	ND	ND	13.40	380,000	1,910,000	1,170,000	121.00	9.92
30-Sep-20	5.7	4,786	617	4.90	ND	ND	10.40	2,000,000	1,580,000	900,000	120.00	9.02
7-Oct-20	5.0	1,070	712	15.77	ND	ND	10.30	2,430,000	2,340,000	1,470,000	239.00	11.40
14-Oct-20	5.3	1,011	791	1.44	ND	ND	16.00 (J)	291,000	1,900,000	1,340,000	127.00	4.39
21-Oct-20	5.1	4,063	614	6.40	ND	ND	8.10	323,000	1,040,000	529,000	92.3	6.88
28-Oct-20	5.5	8,134	814	9.46	ND	ND	10.5	290,000	1,980,000	1,430,000	142	9.40
4-Nov-20	5.3	8,868	791	1.92	ND	ND	6.22	364,000	1,560,000	1,150,000	166	2.52
2-Dec-20	4.8	1,931	605	4.40	ND	ND	7.99	526,000	368,000	187,000	54.40	1.83
Monitoring Well WSM002CC												
2-May-18	5.6	88	NS	NS	10,400	ND	NS	39	NS	NS	7.43	2.02
17-Jul-18	5.9	103	203	8.21	12,700	46.00	3.59	39	736	15,400	16.30	ND
17-Sep-18	5.5	76	221	4.35	10,600	ND	2.83	24	674	9,330	5.84	NS
25-Sep-18	5.9	63	214	8.32	6,140	37.00	2.77	22	571	7,140	3.59	NS
2-Oct-18	5.5	71	216	3.37	8,750	250	2.82	21	741	9,600	5.30	ND
9-Oct-18	5.6	73	206	5.34	11,300	R	2.79	22	660	8,770	4.91	NS
16-Oct-18	5.5	71	221	2.88	10,600	ND	2.77	21	689	8,620	4.30	NS
23-Oct-18	5.5	65	203	5.14	4,520	34.00	2.75	23	815	9,700	4.09	NS
30-Oct-18	5.6	70	151	5.33	9,620	34.00	2.63	23	699	9,190	4.14	ND
6-Nov-18	5.9	69	185	4.05	11,500	ND	2.86	19	688	7,900	4.07	NS
11-Dec-18	5.6	66	231	7.19	10,200	27.00	2.60	20	828	9,050	2.96	NS
15-Jan-19	5.5	64	226	6.48	14,300	46.00	2.60	17	661	8,590	2.52	NS

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM002CC *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
12-Feb-19	5.7	62	223	8.84	8,830	500.00	2.67	19	646	7,730	2.57	NS
12-Mar-19	5.4	62	215	7.38	9,290	26.00	3.05	22	643	7,330	2.07	ND
17-Jun-19	5.5	56	218	9.96	9,040	ND	2.62	18	494	6,490	1.35	ND
18-Sep-19	5.2	50	287	8.44	9,320	ND	2.57	14	510	6,390	0.93	0.12 (J)
25-Nov-19	5.6	53	258	4.60	8,610	ND	2.72	15	655	6,400	0.95	0.09 (J)
16-Mar-20	5.9	50	247	4.90	8,060	ND	2.53	12	545	5,590	0.66	0.14 (J)
16-Sep-20	4.4	6,112	797	7.71	ND	ND	8.50	399,000	1,380,000	548,000	86.20	10.80
23-Sep-20	4.8	3,488	780	13.32	ND	ND	12.70	424,000	999,000	379,000	53.00	12.50
30-Sep-20	4.8	3,011	812	6.69	ND	ND	9.98	1,230,000	810,000	324,000	27.30	11.60
7-Oct-20	5.1	2,133	799	4.94	ND	ND	8.70	335,000	431,000	157,000	17.30	11.70
14-Oct-20	5.6	1,550	790	5.96	ND	ND	67.40 (J)	286,000	505,000	195,000	29.30	1.64
21-Oct-20	5.2	639	449	6.20	ND	ND	7.89	244,000	385,000	145,000	19.70	9.35
28-Oct-20	5.3	1,874	847	5.55	ND	ND	9.65	295,000	575,000	267,000	15.80	9.62
4-Nov-20	4.7	2,107	812	1.86	ND	ND	10.5	332,000	491,000	216,000	33.40	11.20
2-Dec-20	4.8	2,001	564	3.90	ND	ND	8.12	518,000	312,000	151,000	11.50	9.50
Monitoring Well WSM003B												
22-Mar-18	5.4	174	NS	NS	30,900 (j)	21,900 (J)	NS	42	NS	NS	2.77	0.14 (J)
18-Jul-18	4.7	150	296	4.68	37,000	8,810	3.56	21	732	11,000	0.53	0.44
13-Nov-18	4.6	156	383	5.58	36,200	4,250	2.99	21	806	8,930	0.65	NS
13-Mar-19	4.7	147	613	7.64	37,600	4,590	3.07	22	842	8,240	0.41	NS
17-Jun-19	5.4	145	288	4.70	43,200	4,290	3.09	20	667	7,400	0.35 (J)	NS
18-Sep-19	4.5	128	336	11.47	26,400	2,100	3.10	18	714	7,640	0.31 (J)	0.81
25-Nov-19	4.5	155	342	3.74	32,200	2,360	3.18	20	936	8,470	ND	NS

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM003B *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
16-Mar-20	5.1	123	225	0.98	31,900	2,300	2.88	18	758	6,210	0.41	0.80
23-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
30-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
7-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
14-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
21-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
28-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4-Nov-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Dec-20	5.2	123	276	9.53	27,400	1,970	2.81	20 (J)	985 (J)	7,240	0.52	0.72
Monitoring Well WSM003BB												
21-Mar-18	5.7	96	NS	NS	32,500	3,140	NS	46	NS	NS	2.71	ND
18-Jul-18	5.4	153	247	4.75	47,600	4,010	3.12	21	1,290	7,760	0.58	0.81
13-Nov-18	5.7	152	251	4.60	46,500	3,880	2.89	23	1,220	9,020	0.28 (J)	NS
13-Mar-19	5.2	152	561	6.71	38,200	3,320	2.95	24	1,160	7,060	0.28 (J)	NS
17-Jun-19	5.6	150	258	4.8	29,900	2,230	2.90	33	1,050	6,190	ND	NS
18-Sep-19	5.6	136	135	2.64	22,700	1,650	2.84	19	929	5,900	ND	1.01
25-Nov-19	5.3	134	319	3.78	23,500	1,540	2.82	22	1,060	6,860	ND	NS
16-Mar-20	5.8	116	233	1.64	18,100	1,290	2.73	16	903	4,700	0.26 (J)	0.88
23-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
30-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
7-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
14-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM003BB *(cont'd)*												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
21-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
28-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4-Nov-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Dec-20	5.6	103	264	5.85	16,200	935	2.47	12 (J)	855 (J)	4,090	0.19 (J)	0.94
Monitoring Well WSM003C												
27-Mar-18	5.5	117	NS	NS	22,900	615	NS	70	NS	NS	2.57	ND
18-Jul-18	7.0	109	216	4.12	12,100	123 (J)	3.28	200	877	12,400	12.30	ND
13-Nov-18	5.4	82	206	6.21	11,100	ND	2.86	133	1,560	11,800	6.91	NS
13-Mar-19	5.6	56	406	6.70	8,160	ND	2.80	131	2,190	8,630	5.86	NS
17-Jun-19	5.7	56	207	8.04	7,640	ND	2.80	102	1,400	8,140	6.26	NS
18-Sep-19	5.3	66	303	8.87	6,550	ND	2.85	112	1,130	8,750	5.47	ND
25-Nov-19	5.5	64	220	1.20	6,360	ND	2.89	81	2,580	10,700	6.88	NS
16-Mar-20	5.6	52	250	11.34	5,290	ND	2.93	71	1,430	12,000	13.00	0.17 (J)
23-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
30-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
7-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
14-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
21-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
28-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4-Nov-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Dec-20	5.6	71	386	5.64	7,870	ND	3.56	94	1,710 (J)	11,100	8.95	0.30

Table 10-1. M-Area Western Sector ISCO Field and Analytical Results *(Continued/End)*

Sample Results for M-Area Western Sector ISCO												
Monitoring Well WSM003CC												
Date	**pH**	**SC** *(µS/cm)*	**ORP** *(mV)*	**DO** *(mg/L)*	**TCE** *(µg/L)*	**PCE** *(µg/L)*	**Cl** *(mg/L)*	**Mn** *(µg/L)*	**K** *(µg/L)*	**Na** *(µg/L)*	**Sulfate** *(mg/L)*	**Hg** *(µg/L)*
26-Mar-18	5.3	150	NS	NS	27,400 (J)	4,260 (J)	NS	63	NS	NS	2.17	0.39
18-Jul-18	5.3	110	197	4.61	28,900	1,380	3.54	146	714	10,200	0.82	ND
13-Nov-18	5.3	102	271	5.06	31,700	1,090	3.14	41	1,280	10,600	0.35 (J)	NS
13-Mar-19	5.2	97	449	6.2	30,100	1,880	3.19	40	1,330	8,150	0.35 (J)	NS
17-Jun-19	5.4	98	227	8.71	27,500	755	3.31	19	1,080	8,200	0.27 (J)	NS
18-Sep-19	4.7	94	256	4.58	21,700	505	3.26	14	1,240	8,450	0.25 (J)	0.22
25-Nov-19	5.4	94	225	1.87	24,300	480	3.46	15	2,020	9,980	ND	NS
16-Mar-20	5.0	93	279	11.78	29,000	800	3.26	14	1,110	8,260	0.28 (J)	0.20 (J)
23-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
30-Sep-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
7-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
14-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
21-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
28-Oct-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4-Nov-20	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2-Dec-20	4.4	87	330	5.55	18,600	350 (J)	3.01	11 (J)	1,630 (J)	7,420	0.47	0.18 (J)

ND = Non-detect
µS/cm = microsiemens per centimeter
R = Rejected
mg/L = milligram per liter
NS = Not Sampled
mV = millivolt
(J) = Estimated
µg/L = microgram per liter

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