Technical Memorandum

Third Quarter 2019 Groundwater Monitoring Summary
National Aeronautics and Space Administration
Jet Propulsion Laboratory, Pasadena, California

Final October 2019

This technical memorandum summarizes the results of the third quarter 2019 groundwater sampling event completed as part of the groundwater monitoring program at the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL). The third quarter 2019 groundwater sampling event was conducted from July 19 through August 2, 2019.

INTRODUCTION

During the third quarter 2019 sampling event, groundwater samples were collected from 23 JPL monitoring wells (MWs), both on- and off-facility and analyzed for volatile organic compounds (VOCs), total chromium, hexavalent chromium [Cr(VI)], and perchlorate. In select wells, chloride, nitrate, sulfate, nitrite, and orthophosphate were also analyzed. Figure 1 shows the locations of the groundwater monitoring wells.

Groundwater samples were shipped to BC Laboratories, Inc., in Bakersfield, California, for chemical analysis. BC Laboratories, Inc. is certified by the SWRCB. Sample collection procedures and sample analyses were conducted in accordance with the approved *Work Plan for Performing a Remedial Investigation/Feasibility Study*[1]. No reported data were rejected for non-compliance with method requirements during validation and no reported data were deemed unusable.

Table 1 summarizes analytical results for VOCs and perchlorate and Table 2 summarizes analytical results for metals from the last five sampling events. Table 3 summarizes VOC and perchlorate concentrations in production wells located near the JPL facility from the last five sampling events. No tentatively identified compounds (TICs) were detected in the samples collected during the third quarter of 2019.

Figures summarizing the results from the third quarter 2019 sampling event are included in this technical memorandum. Figure 2 shows the lateral extent of carbon tetrachloride concentrations in groundwater and Figure 3 provides a cross-section detailing the horizontal and vertical extent of carbon tetrachloride. Figure 4 shows the lateral extent of perchlorate concentrations in groundwater and Figure 5 provides a cross-section detailing the horizontal and vertical extent of perchlorate in groundwater. Figure 6 shows the lateral extent of tetrachloroethene (PCE) concentrations in groundwater. Figure 7 shows the lateral extent of trichloroethene (TCE) concentrations in groundwater and Figure 8 shows groundwater elevation contours from the third quarter 2019 event and groundwater flow directions.

Attachment 1 summarizes the field and laboratory quality assurance (QA), data verification and data validation procedures utilized for the JPL groundwater monitoring program. Attachment 2 contains

[1] Ebasco. 1993. *Work Plan for Performing a Remedial Investigation/Feasibility Study*, National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California. December.

the data validation reports performed by an independent subcontractor, Laboratory Data Consultants, Inc. (LDC). Attachment 3 contains the laboratory analytical reports prepared by BC Laboratories, Inc. Attachment 4 contains the groundwater sample collection field logs for the JPL groundwater monitoring wells. Attachment 5 contains water level field measurement log sheets. Attachment 6 presents time series plots for select wells and analytes. Attachment 7 presents historical perchlorate, VOC and metals concentrations from 1996 to present. A summary of the well construction details for the JPL groundwater monitoring wells is included in Attachment 8.

The groundwater monitoring wells have been grouped into four categories:

- On-facility source area wells (MW-7, MW-13, MW-16 and MW-24);
- Other on-facility wells (MW-6, MW-8, MW-11, MW-22 and MW-23);
- Perimeter off-facility wells (MW-1, MW-3, MW-4, MW-5, MW-9, MW-10, MW-12, MW-14 and MW-15 [MW-1 and MW-9 are only sampled during the second and fourth quarter events]); and
- Off-facility wells (MW-17, MW-18, MW-19, MW-20, MW-21, MW-25 and MW-26).

MW-2 was decommissioned in July 2018. Well MW-2 had not been sampled during the groundwater monitoring program since it was replaced with well MW-14.

ON-FACILITY SOURCE AREA WELLS

On-facility source area wells consist of wells that have historically contained the highest concentration of site-related chemicals. This group of wells is located within the JPL facility (on-facility) and consists of monitoring wells MW-7, MW-13, MW-16 and MW-24.

The source area treatment system has been operating since 2005 and addresses groundwater beneath the JPL facility, which has historically contained the highest concentrations of perchlorate and VOCs (i.e., the source area). Operation of the source area treatment system appears to have resulted in a significant reduction of chemicals of interest in wells MW-7, MW-16 and MW-24, which are located within the treatment zone. Additional details regarding chemical concentrations in the on-facility source area wells are presented below.

PERCHLORATE ANALYTICAL RESULTS

- During the third quarter 2019, perchlorate was detected above the state MCL (6.0 µg/L) in wells MW-13 (29.0 µg/L) and MW-24 (Screen 1 [17.0 µg/L]).
- Perchlorate was detected below the state MCL (6.0 µg/L) in MW-7 (4.3 µg/L), MW-16 (2.9J µg/L) and MW-24 (Screen 2 [4.5 µg/L]). 'J' qualifier indicates an estimated concentration. No other perchlorate detections occurred in the on-facility wells during the third quarter 2019 with a reporting limit of 4.0 µg/L.
- Perchlorate concentrations increased from the second quarter 2019 to the third quarter 2019 in MW-16 (non-detect to 2.9J µg/L) and MW-24 (Screens 1 and 2 [9.3 µg/L to 17.0 µg/L and 3.0J µg/L to 4.5 µg/L]).
- Perchlorate concentrations decreased from the second quarter 2019 to the third quarter 2019 in MW-7 (21.0 µg/L to 4.3 µg/L) and MW-13 (39.0 µg/L to 29.0 µg/L).

- Perchlorate concentrations remained non-detect in MW-24 (Screen 3).

VOC Analytical Results

- During the third quarter 2019 carbon tetrachloride was not detected in the on-facility wells with a reporting limit of 0.5 µg/L.
- During the third quarter 2019 TCE was not detected in the on-facility wells with a reporting limit of 0.5 µg/L.
- During the third quarter 2019 PCE was not detected in the on-facility wells with a reporting limit of 0.5 µg/L.

Other Notable Analytical Results

- In the October 2014 technical memorandum,[2] it was recommended that metals analysis would not be performed on the shallow standpipe wells when there was insufficient water for purging. During the third quarter 2019 sampling event, there was sufficient water for metals analysis in all the on-facility source area wells sampled.
- During the third quarter 2019, Cr(VI)[3] was detected below the state MCL (10.0 µg/L) in MW-7 (1.6 µg/L), MW-13 (3.1 µg/L), MW-16 (1.1 µg/L) and MW-24 (Screens 1, 2 and 4 [0.7 µg/L, 1.6 µg/L and 0.1J µg/L]). Cr(VI) results were non-detect in MW-24 (Screen 3) with a reporting limit of 0.4 µg/L.
- During the third quarter 2019, total chromium was detected below the state MCL (50.0 µg/L) in MW-7 (25.0 µg/L), MW-13 (8.5 µg/L), MW-16 (40.0 µg/L) and MW-24 (Screens 1 and 2 [1.7J µg/L and 1.3J µg/L, respectively]). Total chromium results were non-detect in MW-24 (Screens 3 and 4) with a reporting limit of 3.0 µg/L.

Other On-facility Wells

This well group consists of monitoring wells MW-6, MW-8, MW-11, MW-22 and MW-23. These wells are located on the JPL facility but outside the source area.

Perchlorate Analytical Results

- During the third quarter 2019, perchlorate was detected at or above the state MCL (6.0 µg/L) in MW-22 (Screen 1 [160.0 µg/L]).
- During the third quarter 2019, perchlorate was detected below the state MCL (6.0 µg/L) in MW-6 (3.7J µg/L), MW-11 (Screen 1 [1.2J µg/L]), MW-22 (Screens 2 and 3 [2.9J µg/L and 2.5J µg/L, respectively]), and MW-23 (Screens 1 through 3 [1.7J µg/L, 4.0 µg/L and 3.1J µg/L, respectively]).

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[2] NASA. 2014. *Technical Memorandum Third Quarter 2014 Groundwater Monitoring Summary, National Aeronautics and Space Administration Jet Propulsion Laboratory, Pasadena, California*. October.

[3] On July 1, 2014, the State Water Resources Control Board (SWRCB) adopted an MCL for Cr(VI) of 10.0 µg/L. See http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chromium6.shtml.

- During the third quarter 2019, perchlorate was not detected in MW-8 and MW-11 (Screens 2 through 4) with a reporting limit of 4.0 µg/L.
- Perchlorate concentrations increased from their respective last sampling event to the third quarter 2019 in MW-22 (Screens 1 and 2 [65.0 µg/L to 160.0 µg/L and 2.7J µg/L to 2.9J µg/L, respectively]) and MW-23 (Screens 2 and 3 [3.4J µg/L to 4.0 µg/L and 2.6J µg/L to 3.1J µg/L, respectively]).
- Perchlorate concentrations decreased from their respective last sampling event to the third quarter 2019 in MW-6 (6.0 µg/L to 3.7J µg/L), MW-11 (Screen 1 [1.3J µg/L to 1.2J µg/L]), MW-22 (Screen 3 [2.6J µg/L to 2.5J µg/L]) and MW-23 (Screen 1 [1.9J µg/L to 1.7J µg/L]).

VOC ANALYTICAL RESULTS

- During the third quarter 2019, carbon tetrachloride was not detected in the other on-facility wells with a reporting limit of 0.5 µg/L.
- During the third quarter 2019, TCE was detected below the state and federal MCL (5.0 µg/L) in MW-6 (3.2 µg/L), MW-11 (Screens 3 and 4 [0.2J µg/L and 0.3J µg/L, respectively]), MW-22 (Screens 1 and 2 [0.2J µg/L, each]) and MW-23 (Screens 1 and 2 [0.2J µg/L and 3.0 µg/L, respectively]). No other TCE detections occurred in the remaining other on-facility wells.
- During the third quarter 2019, PCE was detected below the state and federal MCL (5.0 µg/L) in MW-6 (0.8 µg/L) and MW-23 (Screen 2 [0.5J µg/L]). No other PCE detections occurred in the remaining other on-facility wells during the third quarter 2019.

OTHER NOTABLE ANALYTICAL RESULTS

- During the third quarter 2019, Cr(VI) was detected below the state MCL (10.0 µg/L) in MW-6 (1.5 µg/L), MW- 8 (0.2J µg/L), MW-11 (Screen 1 [0.1J µg/L]), MW-22 (Screens 1 through 3 [0.6 µg/L, 0.5 µg/L and 1.2 µg/L, respectively]) and MW-23 (Screens 1 through 4 [0.2J µg/L, 0.9 µg/L, 2.7 µg/L, and 2.9 µg/L, respectively]).
- Cr(VI) was not detected in MW-11 (Screens 2 and 3) during the third quarter 2019.
- During the third quarter 2019, total chromium was detected below the state MCL (50.0 µg/L) in MW-6 (9.9 µg/L), MW-8 (3.4 µg/L), MW-11 (Screen 3 [4.0 µg/L]) and MW-23 (Screens 1 through 4 [0.7J µg/L, 1.1J µg/L, 3.1 µg/L and 3.2 µg/L, respectively]).
- Total chromium was not detected in MW-11 (Screens 1 and 2) and MW-22 (Screens 1 through 3) during the third quarter 2019.
- Total chromium in well MW-6 has been detected below the state MCL of 50.0 µg/L six times since the second quarter 2014 (26.0 µg/L [third quarter 2014], 27.0 µg/L [first quarter 2017], 24.0 µg/L [second quarter 2018], 13.0 µg/L [first quarter 2019], 48.0 [second quarter 2019] and 9.9 µg/L [third quarter 2019), while all other sampling events since the second quarter 2014 have been above the state MCL of 50.0 µg/L. Total chromium results in the other on-facility wells will continue to be closely evaluated during subsequent sampling events.

PERIMETER OFF-FACILITY WELLS

The perimeter off-facility wells are located near the JPL fence line along the perimeter of the property. This group of wells consists of MW-1, MW-3, MW-4, MW-5, MW-9, MW-10, MW-12, MW-14 and MW-15 (MW-1 and MW-9 were not sampled during the third quarter 2019).

PERCHLORATE ANALYTICAL RESULTS

- During the third quarter 2019, perchlorate was detected above the state MCL (6.0 µg/L) in well MW-4 (Screen 2 [34.0 µg/L]).
- Perchlorate was detected below the state MCL (6.0 µg/L) in MW-3 (Screens 3 and 4 [1.4J µg/L and 1.1J µg/L, respectively]), MW-12 (Screens 3 through 5 [4.9 µg/L, 2.6J µg/L, and 2.2J µg/L, respectively]) and MW-14 (Screens 1 through 4 [2.5J µg/L, 4.2 µg/L, 3.9J µg/L, and 4.6 µg/L, respectively]).
- During the third quarter 2019, perchlorate was non-detect in MW-3 (Screen 2), MW-4 (Screens 1 and 3), MW-5, MW-10, MW-12 (Screens 1 and 2) and MW-14 (Screen 5).
- Perchlorate concentrations increased from their respective last sampling event to the third quarter 2019 in MW-3 (Screen 3 and [1.0J µg/L to 1.4J µg/L]), MW-4 (Screen 2 [31.0 µg/L to 34.0 µg/L]), MW-12 (Screens 4 and 5 [2.5J µg/L to 2.6J µg/L and 1.4J µg/L to 2.2J µg/L, respectively]) and MW-14 (Screens 1, 2 and 4 [2.4J µg/L to 2.5J µg/L, 3.9J µg/L to 4.2 µg/L and 3.5J µg/L to 4.6 µg/L, respectively]).
- Perchlorate concentrations decreased from their respective last sampling event to the third quarter 2019 in MW-3 (Screen 4 [1.2J µg/L to 1.1J µg/L]), MW-4 (Screen 3 [3.9J µg/L to non-detect]), MW-12 (Screens 1 and 2 [1.0J µg/L to non-detect, each]) and MW-14 (Screen 3 [4.8 µg/L to 3.9J µg/L]).
- Perchlorate concentrations in MW-3 (Screen 2) have been non-detect or detected below the state MCL (6.0 µg/L) since the second quarter 2018. However, during the period from second quarter 2014 to first quarter 2018, perchlorate was detected in MW-3 (Screen 2) thirteen times at concentrations above the state MCL (6.0 µg/L) ranging from 9.3 µg/L to 68.0 µg/L. Perchlorate concentrations will continue to be closely monitored since MW-3 is within the capture zone of the MHTS.
- The perchlorate concentration of 34.0 µg/L in MW-4 (Screen 2) continues to be down from the high detection of 250.0 µg/L (third quarter 2013). Since the first quarter 2011, concentrations have exceeded the state MCL (6.0 µg/L [ranging from 6.5 µg/L to 250.0 µg/L]) with thirteen exceptions: first, third, and fourth quarters of 2015, all quarters of 2016, all quarters of 2017, and first and third quarters of 2018. MW-4 is within the capture zone of the MHTS.
- Perchlorate concentrations in MW-12 (Screen 2) were detected below the state MCL (6.0 µg/L) from the first quarter 2008 through the third quarter 2010. Since the fourth quarter 2010, the detections have been above the state MCL (6.0 µg/L) during eight of the last thirty-five sampling events. It should be noted that perchlorate concentrations in MW-12 (Screen 2) have been below the state MCL (6.0 µg/L) since fourth quarter 2013 ranging from non-detect (twelve of the twenty-four quarters) to 5.6 µg/L (fourth quarter 2013). MW-12 is within the capture zone of the MHTS.

VOC Analytical Results

- During the third quarter 2019, carbon tetrachloride was detected above the state MCL (0.5 µg/L) in MW-12 (Screen 3 [2.2 µg/L]) and below the state MCL (0.5 µg/L) in MW-12 (Screens 4 and 5 [0.4J µg/L and 0.3J µg/L, respectively]). No other carbon tetrachloride detections occurred in the perimeter off-facility wells during the third quarter 2019.
- During the third quarter 2019, TCE was detected below the state and federal MCL (5.0 µg/L) in MW-4 (Screens 2 and 3 [1.2 µg/L, each]), MW-12 (Screen 3 [0.3J µg/L]) and MW-14 (Screens 1 through 4 [0.6 µg/L, 1.4 µg/L, 0.7 µg/L and 0.3J µg/L, respectively]). No other TCE detections occurred in the perimeter off-facility wells during the third quarter 2019.
- During the third quarter 2019, PCE was detected below the state and federal MCL (5.0 µg/L) in wells MW-4 (Screens 2 and 3 [0.5J µg/L, each]) and MW-14 (Screens 2 and 3 [0.3J µg/L and 0.4J µg/L, respectively]). No other PCE detections occurred in the perimeter off-facility wells during the third quarter 2019.

Other Notable Analytical Results

- During the third quarter 2019, Cr(VI) was detected below the state MCL (10.0 µg/L) in MW-3 (Screens 3 and 4 [1.4 µg/L and 0.1J µg/L, respectively]), MW-4 (Screens 1 and 2 [0.1J µg/L and 1.1 µg/L, respectively]), MW-5 (0.2J µg/L), MW-10 (1.0 µg/L), MW-12 (Screens 1 and 3 [0.5 µg/L and 0.3 µg/L, respectively]), MW-14 (Screens 2 and 3 [0.6 µg/L and 0.4 µg/L, respectively]) and MW-15 (0.5 µg/L). No other Cr(VI) detections occurred in the perimeter off-facility wells during the third quarter 2019.
- During the third quarter 2019, total chromium was detected above the state MCL (50.0 µg/L) in MW-4 (Screen 3 [53.0 µg/L]) and below the state MCL (50.0 µg/L) in MW-3 (Screens 3 and 4 [1.2J µg/L and 47.0J µg/L, respectively]), MW-5 (0.8J µg/L), MW-10 (7.8 µg/L), MW-14 (Screens 1 and 2 [1.2J µg/L and 1.0J µg/L, respectively]) and MW-15 (2.6J µg/L). No other total chromium detections occurred in the perimeter off-facility wells during the third quarter 2019.
- Total chromium has been detected in MW-4 (Screen 3) twice at concentrations at or above the federal MCL (100.0 µg/L) since the third quarter 1996. The first occurred during the third quarter 2015 (120.0J µg/L) and the second occurred during the second quarter 2019 (100.0 µg/L). Total chromium has been detected at concentrations above the state MCL (50.0 µg/L) in MW-4 (Screen 3) six times (53.0 µg/L [third quarter 2019], 100.0 µg/L [second quarter 2019], 87.0J µg/L [fourth quarter 2017], 55.0 µg/L [second quarter 2017], 93.0 µg/L [second quarter 2016] and 120.0J µg/L [third quarter 2015] since the third quarter 1996.

Off-facility Wells

The off-facility wells consist of monitoring wells MW-17, MW-18, MW-19, MW-20, MW-21, MW-25 and MW-26. These wells are located near and down gradient of the two off-facility treatment plants: MHTS and Lincoln Avenue Water Company (LAWC) treatment system. Daily operation of the MHTS began in February 2011. Operation of the LAWC system began in July 2004.

PERCHLORATE ANALYTICAL RESULTS

- During the third quarter 2019 sampling event, concentrations of perchlorate above the state MCL (6.0 µg/L) were reported in samples collected from wells MW-18 (Screen 4 [16.0 µg/L]), MW-21 (Screen 1 [7.5 µg/L]) and MW-25 (Screens 1 through 4 [6.7 µg/L, 13.0 µg/L, 10.0 µg/L, and 8.4 µg/L, respectively]).
- Perchlorate was detected below the state MCL (6.0 µg/L) in MW-17 (Screens 3 and 4 [5.5 µg/L and 4.4 µg/L, respectively]), MW-18 (Screen 3 [3.0J µg/L]), MW-19 (Screens 1 through 5 [1.7J µg/L, 3.8J µg/L, 3.8J µg/L, 3.7J µg/L and 2.3J µg/L, respectively]), MW-20 (Screen 2 [2.0J µg/L]), MW-21 (Screens 2 through 5 [2.9J µg/L, 3.9J µg/L, 3.5J µg/L, and 2.8J µg/L, respectively]) and MW-26 (Screens 1 and 2 [3.1J µg/L and 2.9J µg/L, respectively]).
- During the third quarter 2019, concentrations of perchlorate were not detected in MW-17 (Screen 2), MW-18 (Screens 2 and 5), MW-20 (Screens 1, 3 through 5), and MW-25 (Screen 5) with a reporting limit of 4.0 µg/L.
- Perchlorate concentrations increased from their respective last sampling event to the third quarter 2019 in MW-17 (Screen 4 [3.7J µg/L to 4.4 µg/L]), MW-18 (Screen 3 [2.6J µg/L to 3.0J µg/L]), MW-19 (Screens 1 through 5 [non-detect to 1.7J µg/L, 2.6J µg/L to 3.8J µg/L, 2.3J µg/L to 3.8J µg/L, 2.7J µg/L to 3.7J µg/L and 1.9J µg/L to 2.3J µg/L, respectively]), MW-20 (Screen 2 [0.9J µg/L to 2.0J µg/L]), MW-21 (Screens 1 through 5 [7.0 µg/L to 7.5 µg/L, 1.8J µg/L to 2.9J µg/L, 2.3J µg/L to 3.9J µg/L, 2.4J µg/L to 3.5J µg/L and 1.6J µg/L to 2.8J µg/L, respectively]), MW-25 (Screen 3 [8.6 µg/L to 10.0 µg/L]) and MW-26 (Screens 1 and 2 [1.8J µg/L to 3.1J µg/L and 2.0J µg/L to 2.9J µg/L, respectively]).
- Perchlorate concentrations decreased from their respective last sampling event to the third quarter 2019 in MW-17 (Screens 3 [6.5 µg/L to 5.5 µg/L]), MW-18 (Screen 4 [17.0 µg/L to 16.0 µg/L]) and MW-25 (Screens 1, 2 and 4 [7.1 µg/L to 6.7 µg/L, 14.0 µg/L to 13.0 µg/L and 8.8 µg/L to 8.4 µg/L, respectively]).
- Perchlorate concentrations in MW-17 (Screen 3) have remained relatively stable since 2011 with concentrations ranging from non-detect to 8.5 µg/L. MW-17 is located within the capture zone of the LAWC treatment system.
- The perchlorate concentration of 4.4 µg/L in MW-17 (Screen 4) during the third quarter 2019 is the nineteenth detection below the state MCL (6.0 µg/L) since the first quarter 2015. From the third quarter 2002 to the fourth quarter 2012, the perchlorate concentrations in MW-17 (Screen 4) had been either non-detect or below the state MCL (6.0 µg/L) with only one detection that exceeded the state MCL (second quarter 2003 [6.5 µg/L]). From the first quarter 2013 through the fourth quarter 2014, the perchlorate concentrations in MW-17 (Screen 4) exceeded the state MCL in seven of the eight quarters with exceedances ranging from 6.8 µg/L to 18.0 µg/L. From the first quarter 2015 to the third quarter 2019 sampling events, perchlorate in MW-17 (Screen 4) remained below the state MCL (6.0 µg/L) with concentrations ranging from non-detect (first quarter 2017) to 4.9 µg/L (first quarter 2018). The changes in perchlorate concentrations at MW-17 (Screen 4) are believed to be associated with operation of NASA's mid-plume treatment system, which began operation in 2011.
- The perchlorate detection of 3.0J µg/L in MW-18 (Screen 3) is the ninth consecutive detection below the state MCL (6.0 µg/L). From the fourth quarter 2005 to second quarter 2017 perchlorate concentrations in MW-18 (Screen 3) have been above the state MCL (6.0

µg/L) ranging from 6.2 µg/L (second quarter 2017) to 144.0 µg/L (third quarter 2011) with one exception (non-detect [second quarter 2007]).

- During the period from the third quarter 2008 through first quarter 2012, perchlorate was detected in MW-20 (Screen 4) at concentrations exceeding the state MCL (6.0 µg/L) during seven of fifteen sampling events. Concentrations exceeding the state MCL ranged from 15.1 µg/L to 123.0J µg/L. Perchlorate was not detected during the remaining eight sampling events between third quarter 2008 and first quarter 2012. During the period from second quarter 2012 to third quarter 2019 (i.e., thirty quarterly sampling events), perchlorate has not been detected in MW-20 (Screen 4).
- During the period from third quarter 2008 through first quarter 2012, perchlorate was detected in MW-20 (Screen 5) at concentrations exceeding the state MCL (6.0 µg/L) during six of fifteen sampling events. During this time period, perchlorate concentrations exceeding the state MCL ranged from 11.5 µg/L to 56.5 µg/L. Perchlorate was not detected during the remaining nine sampling events during this period with one exception (4.2 µg/L [second quarter 2011]). From the second quarter 2012 to third quarter 2019 perchlorate concentrations have remained non-detect in MW-20 (Screen 5).

VOC ANALYTICAL RESULTS

- During the third quarter 2019, carbon tetrachloride was detected above the state MCL (0.5 µg/L) in MW-18 (Screen 4 [1.0 µg/L]) and below the state MCL (0.5 µg/L) in MW-18 (Screen 3 [0.3J µg/L]). No other carbon tetrachloride detections occurred in the remaining off-facility wells during the third quarter 2019.
- Prior to the last five sampling events, the carbon tetrachloride concentrations in MW-18 (Screen 3) have exceeded the state MCL (0.5 µg/L) since the first quarter 2005 with concentrations ranging from 0.5 µg/L to 43.0 µg/L. During the last five sampling events, carbon tetrachloride in MW-18 (Screen 3) was 0.3J µg/L (third and fourth quarters 2018 and first and third quarters 2019) and 0.2J µg/L (second quarter 2019). Carbon tetrachloride detections in MW-18 (Screen 4) have exceeded the state MCL since the third quarter 1996 with one exception (non-detect [fourth quarter 2010]).
- During the third quarter 2019, TCE was detected in MW-17 (Screens 3 and 4 [1.9 µg/L and 0.6 µg/L, respectively]), MW-18 (Screen 4 [0.6 µg/L]), MW-19 (Screens 2 and 3 [0.9 µg/L and 0.3J µg/L, respectively]), MW-20 (Screen 2 [0.4J µg/L]), MW-21 (Screens 1 through 4 [0.6 µg/L, 0.3Jµg/L, 1.9 µg/L and 0.7 µg/L, respectively]), MW-25 (Screen 1 [1.5 µg/L]) and MW-26 (Screens 1 and 2 [0.3J µg/L, each]); however, no detections exceeded the state and federal MCL (5.0 µg/L). No other TCE detections occurred in the remaining off-facility wells during the third quarter 2019.
- During the third quarter 2019, PCE was detected in MW-17 (Screens 3 and 4 [0.3J µg/L and 0.2J µg/L, respectively]), MW-18 (Screen 4 [0.5J µg/L]), MW-19 (Screens 2 through 5 [2.4 µg/L, 0.8 µg/L, 0.5J µg/L and 0.4J µg/L, respectively]), MW-20 (Screen 3 [0.6 µg/L]), MW-21 (Screens 1 through 5 [0.4J µg/L, 1.6 µg/L, 1.8 µg/L, 2.0 µg/L, and 0.7 µg/L, respectively]), MW-25 (Screen 3 [0.4J µg/L]), and MW-26 (Screens 1 and 2 [0.9 µg/L and 2.2 µg/L, respectively]); however, no detections exceeded the state and federal MCL (5.0 µg/L). PCE was not detected in the remaining off-facility wells during the third quarter 2019.

OTHER NOTABLE ANALYTICAL RESULTS

- During the third quarter 2019, Cr(VI) was detected below the state MCL (10.0 µg/L) in MW-17 (Screens 2 and 4 [0.1J µg/L and 1.4 µg/L, respectively]), MW-18 (Screens 2, 3 and 4 [0.05J µg/L, 1.5 µg/L and 2.1 µg/L, respectively]), MW-20 (Screens 1, 4 and 5 [0.2J µg/L, 0.1J µg/L and 0.1J µg/L, respectively]), MW-21 (Screens 1 through 4 [1.3 µg/L, 0.2 µg/L, 0.1J µg/L and 1.3 µg/L, respectively]), MW-25 (Screens 1 through 5 [0.3 µg/L, 1.0 µg/L, 1.9 µg/L, 0.5 µg/L and 0.1J µg/L, respectively]), and MW-26 (Screens 1 and 2 [0.5 µg/L and 0.9 µg/L, respectively]).
- Cr(VI) was not detected in MW-17 (Screen 3), MW-20 (Screens 2 and 3) and MW-21 (Screen 5).
- During the third quarter 2019, total chromium was detected below the state MCL (50.0 µg/L) in MW-17 (Screen4 [0.8J µg/L]), MW-18 (Screens 3 and 4 [1.6J µg/L and 3.2 µg/L, respectively]), MW-20 (Screens 1 and 2 [0.6J µg/L, each]), MW-21 (Screens 1 through 5 [2.3J µg/L, 1.4J µg/L, 1.6J µg/L, 11.0J µg/L and 1.8J µg/L, respectively]), MW-25 (Screens 1 through 5 [2.0J µg/L, 3.1 µg/L, 2.4J µg/L, 1.8J µg/L and 0.5J µg/L, respectively]) and MW-26 (Screen 2 [2.6J µg/L]).
- Total chromium was not detected in MW-17 (Screen 2 and 3), MW-18 (Screen 2), MW-20 (Screens 3 through 5) and MW-26 (Screen 1).

ALL WELL CATEGORIES (OTHER RESULTS)

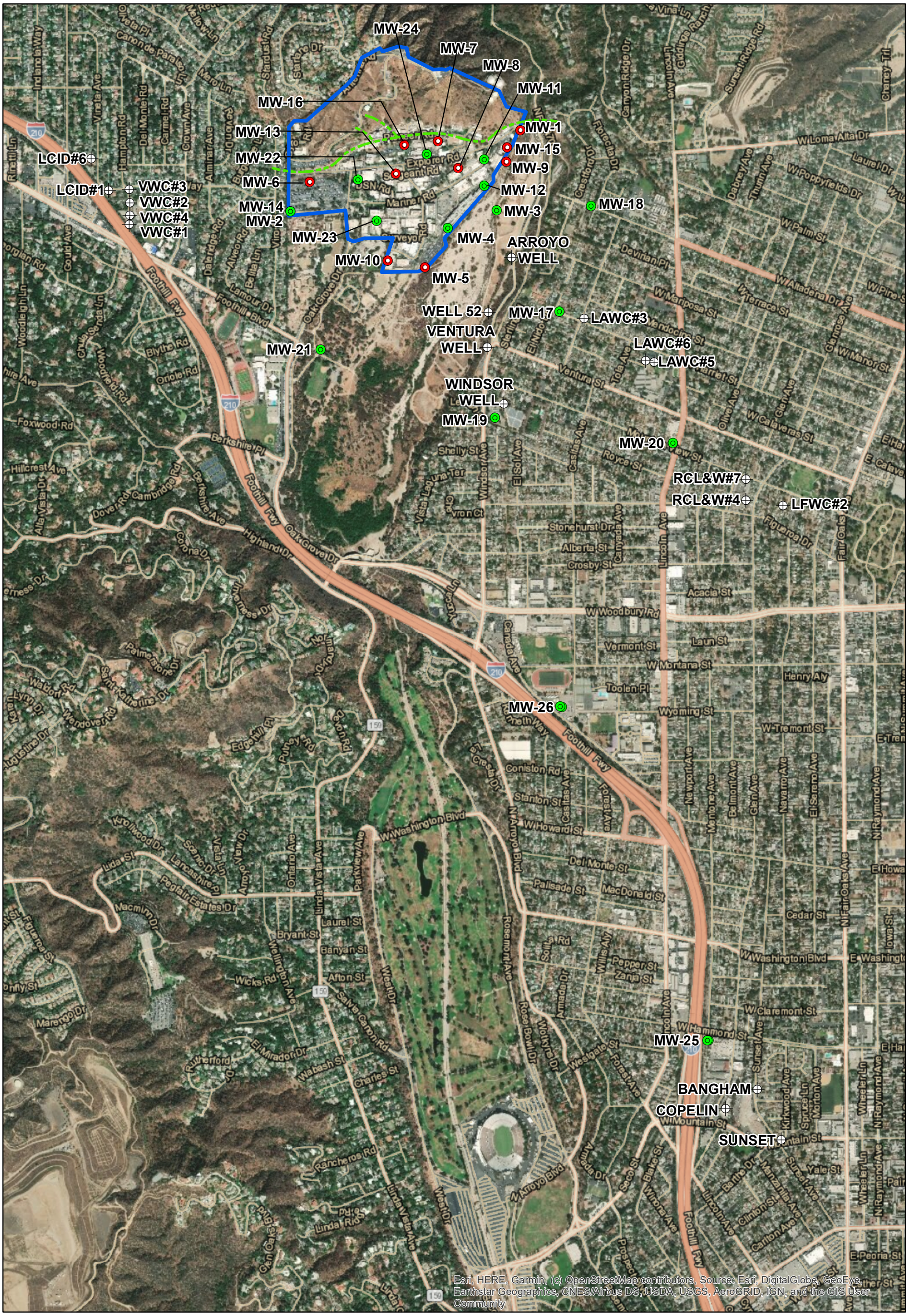
- Comparing the second quarter 2019 to the third quarter 2019, groundwater elevations decreased by an average of 14.14 feet.
- It was reported in the May 2019 technical memorandum that there was a bend in MW-16 at a depth of 255 feet below the top of casing preventing the installation of a submersible pump to purge and sample the well. A video survey was conducted by Pacific Surveys on August 2, 2019 which determined that no bend or irregularity existed in the well. The well was sampled successfully during the third quarter monitoring event.
- Groundwater elevations recorded in the JPL monitoring wells showed a steady decline from the first and second quarters of 2011 through the fourth quarter of 2014 at which time the levels approached and/or exceeded historic lows last recorded in 1996 and 1997. Groundwater elevations fluctuated between fourth quarter 2014 and first quarter 2017 but increased by an average of approximately 25 feet between first and second quarters of 2017. Groundwater elevations dropped by an average of 36 feet between second quarter 2017 and fourth quarter 2018 and increased by an average of 23 feet between fourth quarter 2018 and third quarter 2019. As of third quarter 2019, groundwater levels remain approximately 54 feet below the second quarter 2011 elevations. Groundwater elevations will continue to be closely monitored.
- Groundwater level measurements collected during the third quarter 2019 indicate that groundwater gradients and flow directions are generally consistent with previous observations (see Figure 8).

ATTACHMENTS

Attachments to this technical memorandum include the following:

- Attachment 1: Quality Assurance/Quality Control Summary
- Attachment 2: Data Validation Reports
- Attachment 3: Laboratory Analytical Reports
- Attachment 4: Field Logs
- Attachment 5: Water Level Measurements
- Attachment 6: Time-Series Concentration Plots
- Attachment 7: Tables 1A, 2A and 3A (Historical Perchlorate, VOCs and Metals from 1996 to present)
- Attachment 8: Summary of Construction Details for All JPL Groundwater Wells

FIGURES



Legend

- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well
- Approximate Location of Thrust Fault
- JPL Facility Boundary

N W E S

0 500 1,000 1,500 Feet

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Locations of JPL Groundwater Monitoring Wells and Nearby Municipal Production Wells

DESIGNED BY: JHG DRAWN BY: JHG CHECKED BY: DC	JPL - Pasadena, CA Contract No: W912PL-13-D-0018 TO 001	Figure 1 Oct 2019

MW-22
1) 0.5 U
2) 0.5 U / 0.5 U
3) 0.5 U
4) NA
5) NA

MW-24
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) NA
5) NA

MW-16
1) 0.5 U

MW-7
1) 0.5 U

MW-8
1) 0.5 U

MW-11
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) NA

MW-1
1) NA

MW-15
1) NA

MW-9
1) NA

MW-12
1) 0.5 U
2) 0.5 U
3) 2.2
4) 0.4 J
5) 0.3 J

MW-6
1) 0.5 U

MW-3
1) NA
2) 0.5 U
3) 0.5 U /0.5 U
4) 0.5 U
5) NA

LCID#6
NA

LCID#1
NA

VWC#3
NA

VWC#2
NA

VWC#4
NA

VWC#1
NA

MW-18
1) NA
2) 0.5 U / 0.5 U
3) 0.3 J
4) 1.0
5) 0.5 U

MW-14
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) 0.5 U

ARROYO
0.8

LAWC#3
NA

LAWC#5
NA

LFWC#2
NA

MW-13
1) 0.5 U

RCL&W#7
NA

RCL&W#4
NA

MW-23
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) NA
5) NA

MW-20
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) 0.5 U

MW-21
1) 0.5 U
2) 0.5 U / 0.5 U
3) 0.5 U / 0.5 U
4) 0.5 U
5) 0.5 U

LAWC#6
2.1

MW-10
1) 0.5 U

MW-17
1) NA
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) NA

MW-4
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) NA
5) NA

WINDSOR
NA

MW-5
1) 0.5 U

MW-25
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U / 0.5 U
5) 0.5 U

WELL 52
0.5 U

VENTURA
NA

MW-26
1) 0.5 U
2) 0.5 U

MW-19
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) 0.5 U

Legend

- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well (Data Not Available)
- Municipal Production Well (Data From July/August 2019)
- Cross-Section Transect A-A'
- Estimated Isoconcentration Line (0.5 µg/L)
- JPL Facility Boundary
- Approximate Location of Thrust Fault
- Groundwater Flow Direction

N W E S

0 600 1,200 1,800 Feet

MW-8
1) 0.5 U

Well ID
Concentration in micrograms per liter
Screen number

J = Detected estimated value
U = Not detected estimated value
NA = Not Analyzed

Bold font indicates detected concentration below the State maximum contaminant level (MCL) of 0.5 micrograms per liter; red font indicates concentration exceeds MCL.

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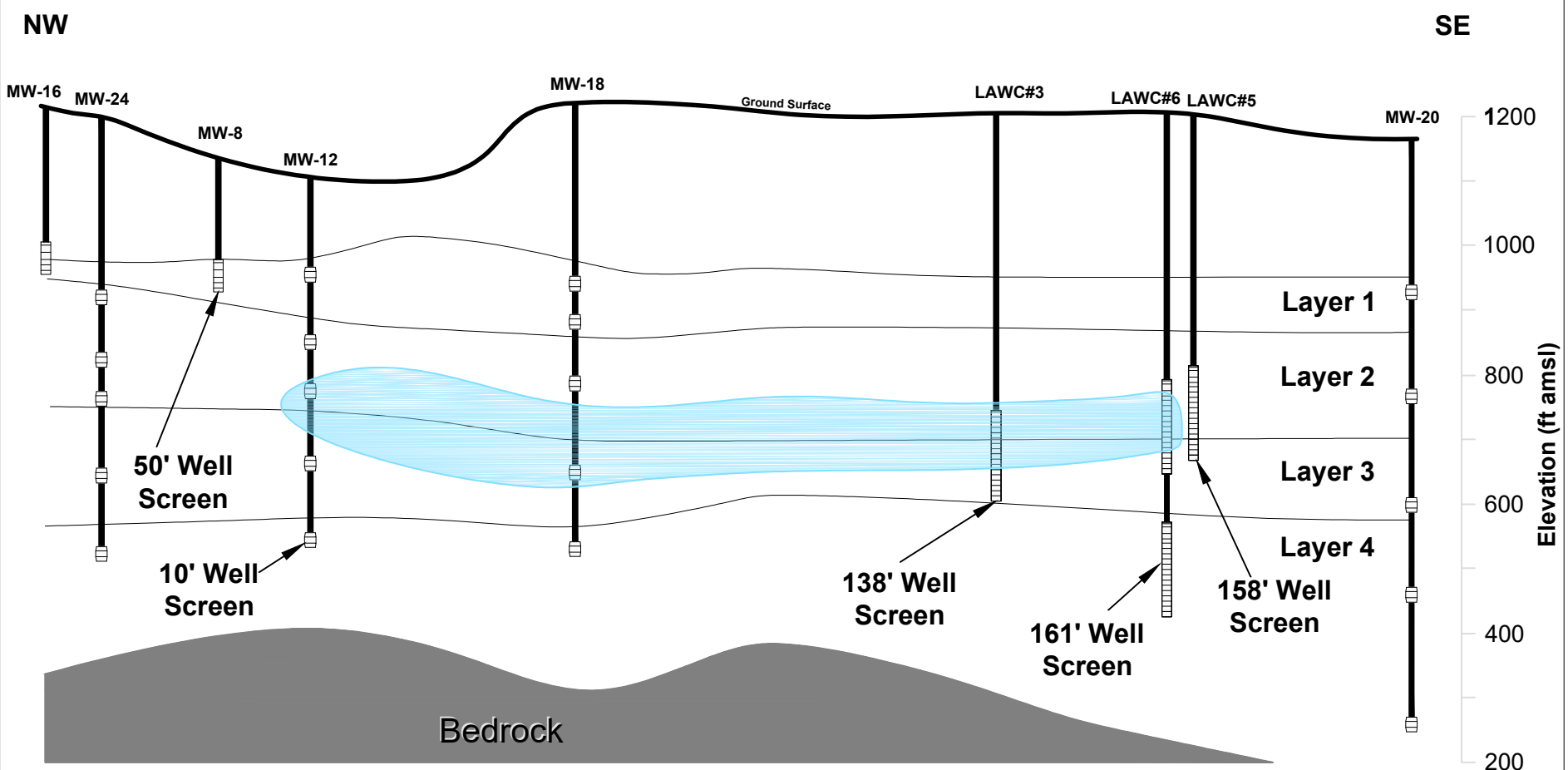
Carbon Tetrachloride in Groundwater July/August 2019

DESIGNED BY: JHG	JPL - Pasadena, CA	Figure 2
DRAWN BY: JHG	Contract No: FA8903-16-D-0049	Oct 2019
CHECKED BY: DC		



Note: Concentrations are Reported in µg/L

50.0
20.0
10.0
5.0
0.5

Z exag: 3.0

0 500 1000

HORIZONTAL SCALE IN FEET (Approximate)

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Horizontal and Vertical Extent of Carbon Tetrachloride in Groundwater July/August 2019

DESIGNED BY JHG DRAWN BY JHG CHECKED BY DC	JPL - Pasadena, CA Contract No: FA8903-16-D-0049	Figure 3 Oct 2019

MW-22
1) 160
2) 2.9 J / 2.9 J
3) 2.5 J
4) NA
5) NA

MW-24
1) 17.0
2) 4.5
3) 4.0 U
4) NA
5) NA

MW-16
1) 2.9 J

MW-7
1) 4.3

MW-8
1) 4.0 U

MW-11
1) 1.2 J
2) 4.0 U
3) 4.0 U
4) 4.0 U
5) NA

MW-1
1) NA

MW-15
1) NA

MW-9
1) NA

MW-12
1) 4.0 U
2) 4.0 U
3) 4.9
4) 2.6 J
5) 2.2 J

MW-6
1) 3.7 J

LCID#6
NA

LCID#1
NA

VWC#3
NA

VWC#2
NA

VWC#4
NA

VWC#1
NA

MW-3
1) NA
2) 4.0 U
3) 1.4 J / 1.3 J
4) 1.1 J
5) NA

MW-18
1) NA
2) 4.0 U / 4.0 U
3) 3.0 J
4) 16.0
5) 4.0 U

MW-14
1) 2.5 J
2) 4.2
3) 3.9J
4) 4.6
5) 4.0 U

ARROYO
8.4

LAWC#3
NA

LAWC#5
NA

LFWC#2
4.6

RCL&W#7
4.0 U

RCL&W#4
4.0 U

MW-20
1) 4.0 U
2) 2.0 J
3) 4.0 U
4) 4.0 U
5) 4.0 U

LAWC#6
11.0

MW-17
1) NA
2) 4.0 U
3) 5.5
4) 4.4
5) NA

WINDSOR
NA

MW-25
1) 6.7
2) 13.0
3) 10.0
4) 6.2 / 8.4
5) 4.0 U

MW-26
1) 3.1 J
2) 2.9 J

MW-13
1) 29.0

MW-23
1) 1.7 J
2) 4.0
3) 3.1 J
4) NA
5) NA

MW-21
1) 7.5
2) 2.9 J / 2.2 J
3) 3.9 J / 3.3 J
4) 3.5 J
5) 2.8 J

MW-10
1) 4.0 U

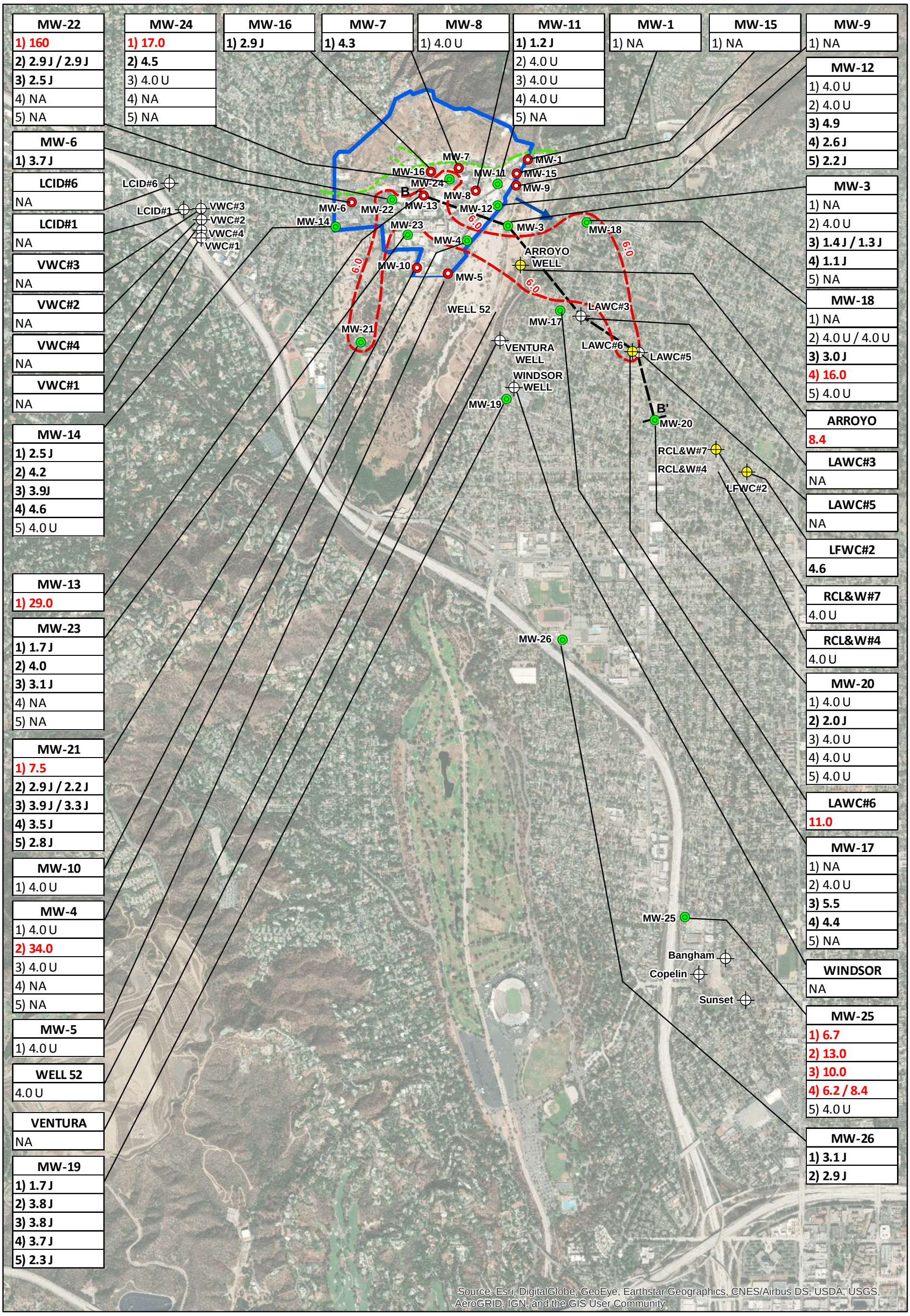
MW-4
1) 4.0 U
2) 34.0
3) 4.0 U
4) NA
5) NA

MW-5
1) 4.0 U

WELL 52
4.0 U

VENTURA
NA

MW-19
1) 1.7 J
2) 3.8 J
3) 3.8 J
4) 3.7 J
5) 2.3 J



Legend

- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well (Data Not Available)
- Municipal Production Well (Data From July/August 2019)
- Cross-Section Transect B-B'
- Estimated Isoconcentration Line (6 µg/L)
- Approximate Location of Thrust Fault
- JPL Facility Boundary
- Groundwater Flow Direction

N, W, E, S

0 600 1,200 1,800 Feet

MW-8 / 1) 0.5 U — Well ID; Screen number; Concentration in micrograms per liter

J = Detected estimated value
U = Not detected estimated value
NA = Not Analyzed

Bold font indicates detected concentration below the State maximum contaminant level (MCL) of 6 micrograms per liter; red font indicates concentration exceeds MCL.

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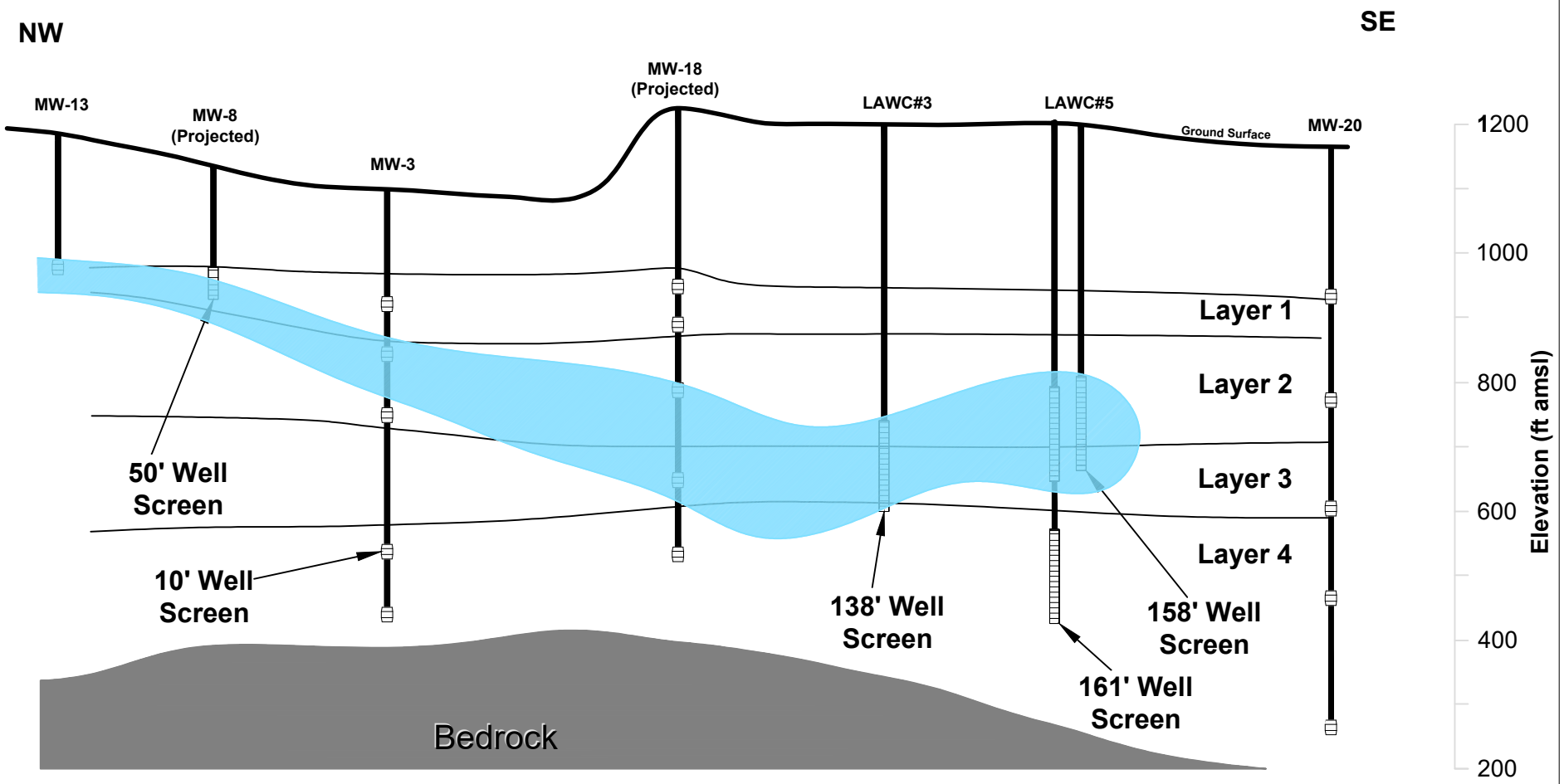
Perchlorate in Groundwater
July/August 2019

DESIGNED BY	JPL - Pasadena, CA	Figure 4
JHG		
DRAWN BY		
JHG	Contract No: FA8903-16-D-0049	Oct 2019
CHECKED BY		
DC		



Note: Concentrations are Reported in µg/L

1000.0
500.0
200.0
100.0
6.0

Z exag: 3.0

0 500 1000

HORIZONTAL SCALE
IN FEET
(Approximate)

TIDEWATER INC
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Horizontal and Vertical Extent
of Perchlorate in Groundwater
July/August 2019

DESIGNED BY JHG DRAWN BY JHG CHECKED BY DC	JPL - Pasadena, CA Contract No: FA8903-16-D-0049	Figure 5 Oct 2019

MW-22
1) 0.5 U
2) 0.5 U / 0.5 U
3) 0.5 U
4) NA
5) NA

MW-24
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) NA
5) NA

MW-16
1) 0.5 U

MW-7
1) 0.5 U

MW-8
1) 0.5 U

MW-11
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) NA

MW-1
1) NA

MW-15
1) NA

MW-9
1) NA

MW-12
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) 0.5 U
5) 0.5 U

MW-6
1) 0.8

MW-3
1) NA
2) 0.5 U
3) 0.5 U / 0.5 U
4) 0.5 U
5) NA

LCID#6
NA

LCID#1
NA

MW-18
1) NA
2) 0.5 U / 0.5 U
3) 0.5 U
4) 0.5 J
5) 0.5 U

VWC#3
NA

VWC#2
NA

VWC#4
NA

VWC#1
NA

ARROYO
0.5 U

MW-14
1) 0.5 U
2) 0.3 J
3) 0.4 J
4) 0.5 U
5) 0.5 U

LAWC#3
NA

LAWC#5
NA

LFWC#2
1.8

MW-13
1) 0.5 U

RCL&W#7
NA

RCL&W#4
NA

MW-23
1) 0.5 U
2) 0.5 J
3) 0.5 U
4) NA
5) NA

MW-20
1) 0.5 U
2) 0.5 U
3) 0.6
4) 0.5 U
5) 0.5 U

MW-21
1) 0.4 J
2) 0.9 / 1.6
3) 1.0 /1.8
4) 2.0
5) 0.7

LAWC#6
0.7

MW-10
1) 0.5 U

MW-17
1) NA
2) 0.5 U
3) 0.3 J
4) 0.2 J
5) NA

MW-4
1) 0.5 U
2) 0.5 J
3) 0.5 J
4) NA
5) NA

WINDSOR
NA

MW-5
1) 0.5 U

MW-25
1) 0.5 U
2) 0.5 U
3) 0.4 J
4) 0.5 U / 0.5 U
5) 0.5 U

WELL 52
0.7

MW-26
1) 0.9
2) 2.2

VENTURA
NA

MW-19
1) 0.5 U
2) 2.4
3) 0.8
4) 0.5 J
5) 0.4 J

MW-6 MW-22 MW-14 MW-13 MW-23 MW-7 MW-16 MW-24 MW-8 MW-11 MW-1 MW-15 MW-9 MW-12 MW-3 MW-18 MW-4 MW-10 MW-5 MW-21 WELL 52 MW-17 MW-19 MW-20 MW-26 MW-25 LCID#6 LCID#1 VWC#3 VWC#2 VWC#4 VWC#1 ARROYO WELL VENTURA WELL WINDSOR WELL LAWC#3 LAWC#6 LAWC#5 RCL&W#7 RCL&W#4 LFWC#2 Bangham Copelin Sunset

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well (Data Not Available)
- Municipal Production Well (Data From July/August 2019)
- Estimated Isoconcentration Line (5 µg/L)
- JPL Facility Boundary
- Approximate Location of Thrust Fault
- Groundwater Flow Direction

N W E S

0 600 1,200 1,800 Feet

MW-8
1) 0.5 U

Well ID
Concentration in micrograms per liter
Screen number

J = Detected estimated value
U = Not detected estimated value
NA = Not Analyzed

Bold font indicates detected concentration below the State maximum contaminant level (MCL) of 5 micrograms per liter; red font indicates concentration exceeds MCL.

TIDEWATER INC
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Tetrachloroethene in Groundwater July/August 2019

DESIGNED BY: JHG DRAWN BY: JHG CHECKED BY: DC	JPL - Pasadena, CA Contract No: FA8903-16-D-0049	Figure 6 Oct 2019

MW-22
1) 0.2 J
2) 0.2 J / 0.2 J
3) 0.5 U
4) NA
5) NA

MW-24
1) 0.5 U
2) 0.5 U
3) 0.5 U
4) NA
5) NA

MW-16
1) 0.5 U

MW-7
1) 0.5 U

MW-8
1) 0.5 U

MW-11
1) 0.5 U
2) 0.5 U
3) **0.2 J**
4) 0.3 J
5) NA

MW-1
1) NA

MW-15
1) NA

MW-9
1) NA

MW-12
1) 0.5 U
2) 0.5 U
3) 0.3 J
4) 0.5 U
5) 0.5 U

MW-6
1) 3.2

LCID#6
NA

LCID#1
NA

VWC#3
NA

VWC#2
NA

VWC#4
NA

VWC#1
NA

MW-14
1) 0.6
2) 1.4
3) 0.7
4) 0.3 J
5) 0.5 U

MW-13
1) 0.5 U

MW-23
1) 0.2 J
2) 3.0
3) 0.5 U
4) NA
5) NA

MW-21
1) 0.6
2) 0.5 U / **0.3 J**
3) 1.3 / 1.9
4) 0.7
5) 0.5 U

MW-10
1) 0.5 U

MW-4
1) 0.5 U
2) 1.2
3) 1.2
4) NA
5) NA

MW-5
1) 0.5 U

WELL 52
3.2

VENTURA
NA

MW-19
1) 0.5 U
2) 0.9
3) 0.3 J
4) 0.5 U
5) 0.5 U

MW-3
1) NA
2) 0.5 U
3) 0.5 U / 0.5 U
4) 0.5 U
5) NA

MW-18
1) NA
2) 0.5 U / 0.5 U
3) 0.5 U
4) 0.6
5) 0.5 U

ARROYO
1.6

LAWC#3
NA

LAWC#5
NA

LFWC#2
NA

RCL&W#7
NA

RCL&W#4
NA

MW-20
1) 0.5 U
2) 0.4 J
3) 0.5 U
4) 0.5 U
5) 0.5 U

LAWC#6
1.7

MW-17
1) NA
2) 0.5 U
3) 1.9
4) 0.6
5) NA

WINDSOR
NA

MW-25
1) 1.5
2) 0.5 U
3) 0.5 U
4) 0.5 U / 0.5 U
5) 0.5 U

MW-26
1) 0.3 J
2) 0.3 J

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Deep Multi-Port Monitoring Well Location
- Shallow Monitoring Well Location
- Municipal Production Well (Data Not Available)
- Municipal Production Well (Data From July/August 2019)
- Estimated Isoconcentration Line (5 µg/L)
- JPL Facility Boundary
- Approximate Location of Thrust Fault
- Groundwater Flow Direction

N W E S

0 600 1,200 1,800 Feet

MW-8
1) 0.5 U

Well ID
Concentration in micrograms per liter
Screen number

J = Detected estimated value
U = Not detected estimated value
NA = Not Analyzed

Bold font indicates detected concentration below the State maximum contaminant level (MCL) of 5 micrograms per liter; red font indicates concentration exceeds MCL.

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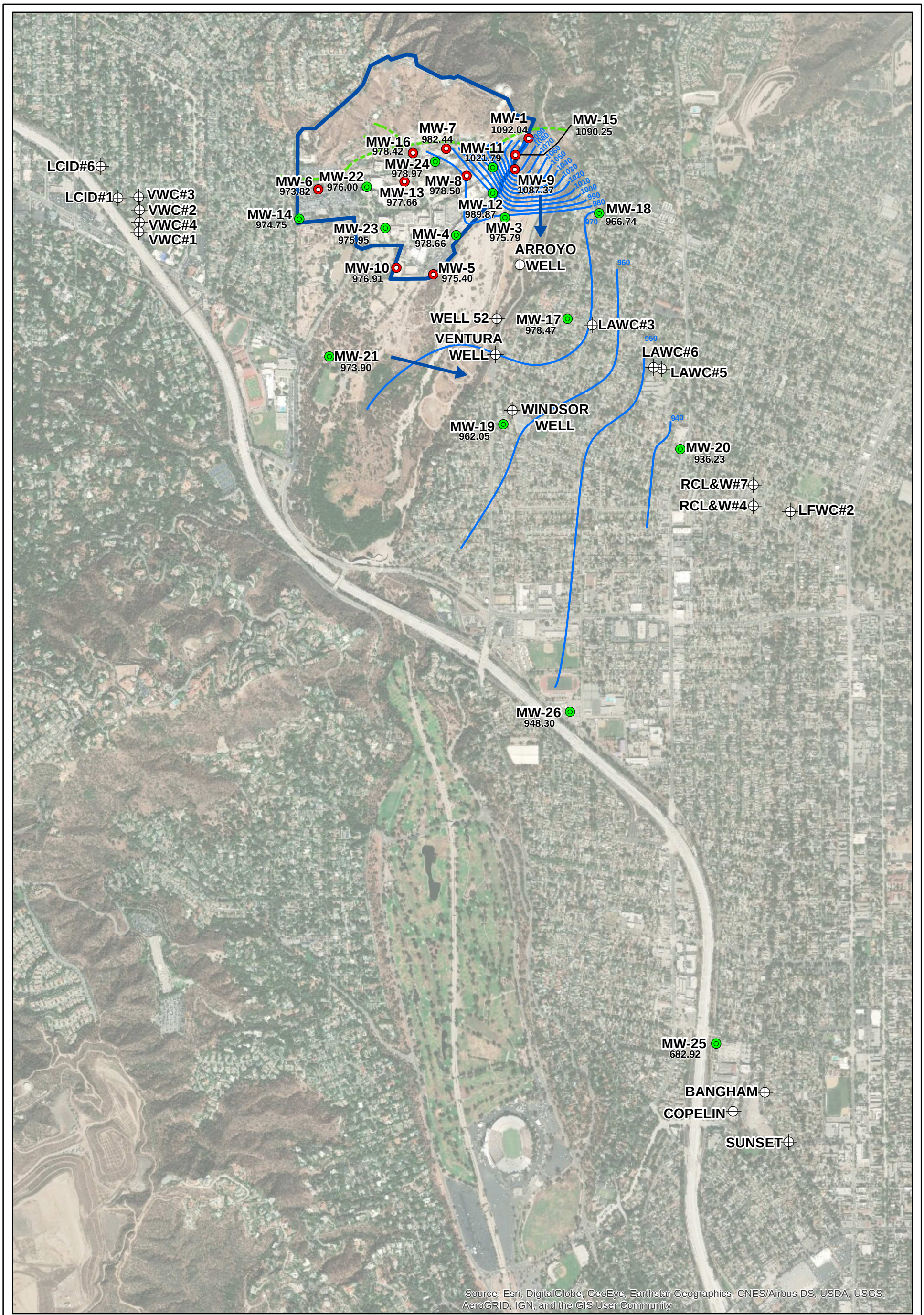
Trichloroethene in Groundwater July/August 2019

DESIGNED BY JHG	JPL - Pasadena, CA	Figure 7
DRAWN BY JHG	Contract No: FA8903-16-D-0049	Oct 2019
CHECKED BY DC		



Legend

- Shallow Monitoring Well Location
- Deep Multi-Port Monitoring Well Location
- Municipal Production Well
- Groundwater Elevation Contour (ft amsl)
- JPL Facility Boundary
- Approximate Location of Thrust Fault
- Groundwater Flow Direction

N
W E
S

0 500 1,000 1,500 Feet

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Groundwater Elevation Contours July/August 2019

DESIGNED BY JHG DRAWN BY JHG CHECKED BY DC	JPL - Pasadena, CA Contract No: W912PL-13-D-0018 TO 001	Figure 8 Oct 2019