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Sandia National Laboratories

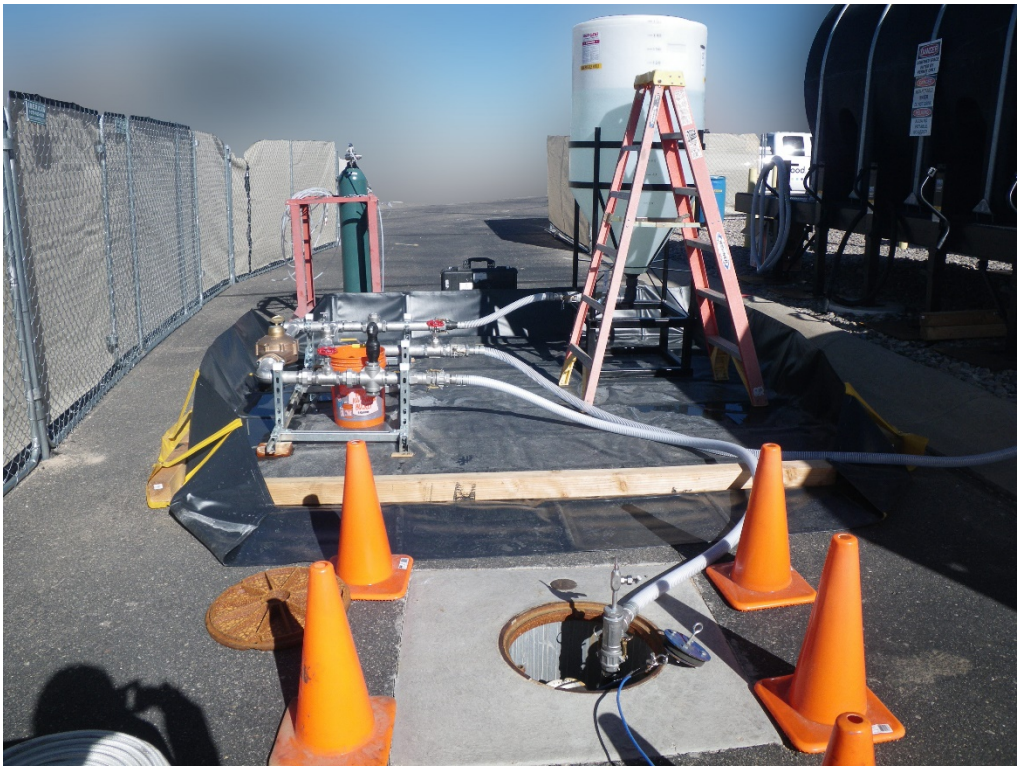
Sandia National Laboratories, New Mexico

Environmental Restoration Operations

A U.S. Department of Energy Environmental Cleanup Program

Consolidated Quarterly Report

April – June 2019



October 2019

U.S. DEPARTMENT OF ENERGY

United States Department of Energy
Sandia Field Office

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CONSOLIDATED QUARTERLY REPORT

October 2019

SANDIA NATIONAL LABORATORIES, NEW MEXICO

ENVIRONMENTAL RESTORATION OPERATIONS

U.S. DEPARTMENT OF ENERGY:	SANDIA FIELD OFFICE
CONTRACTOR:	NATIONAL TECHNOLOGY AND ENGINEERING SOLUTIONS OF SANDIA
PROJECT MANAGER:	Christi D. Leigh

NUMBER OF POTENTIAL RELEASE SITES SUBJECT TO CORRECTIVE ACTION: 6

SUSPECT WASTE: Radionuclides, metals, organic compounds, and explosives

REPORTING PERIOD: April – June 2019

OVERVIEW

This Sandia National Laboratories, New Mexico Environmental Restoration Operations (ER) Consolidated Quarterly Report (ER Quarterly Report) fulfills all quarterly reporting requirements set forth in the Compliance Order on Consent. Table I-1 lists the six sites remaining in the corrective action process. This ER Quarterly Report presents activities and data as follows:

SECTION I: Environmental Restoration Operations Consolidated Quarterly Report, April – June 2019

SECTION II: Perchlorate Screening Quarterly Groundwater Monitoring Report, April – June 2019

SECTION III: Technical Area-V In-Situ Bioremediation Treatability Study Full-Scale Operation, April – June 2019

ABBREVIATIONS AND ACRONYMS

µg/L	microgram(s) per liter
ABCWUA	Albuquerque Bernalillo County Water Utility Authority
AGMR	Annual Groundwater Monitoring Report
AOC	Area of Concern
BSG	Burn Site Groundwater
CME	Corrective Measures Evaluation
COC	constituent of concern
Consent Order	Compliance Order on Consent
CY	Calendar Year
CYN	Canyons (acronym used for well identification numbers in tables only at Burn Site Groundwater Area of Concern)
Dhc	*Dehalococcoides*
DO	dissolved oxygen
DOE	U.S. Department of Energy
DP	Discharge Permit
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration Operations
ER Quarterly Report	Environmental Restoration Operations Consolidated Quarterly Report
FOP	Field Operating Procedure
GEL	GEL Laboratories LLC
GWQB	Ground Water Quality Bureau
HWB	Hazardous Waste Bureau
INJ	injection (acronym used for well identification only)
ISB	in-situ bioremediation
LWDS	liquid waste disposal system (acronym used for well identification only)
MCL	maximum contaminant level
MDL	method detection limit
mg/L	milligrams per liter
MW	monitoring well (acronym used for well identification only)
ND	nondectect
NMED	New Mexico Environment Department
NNSA	National Nuclear Security Administration
NPN	nitrate plus nitrite
ORP	oxidation reduction potential
pH	potential of hydrogen (negative logarithm of the hydrogen ion concentration)
SC	specific conductivity
SNL/NM	Sandia National Laboratories, New Mexico
SWMU	Solid Waste Management Unit

TA1-W	Technical Area-I (Well) (acronym used for well identification only)
TA2-W	Technical Area-II (Well) (acronym used for well identification only)
TA2-SW	Technical Area-II (Southwest) (acronym used for well identification only)
TAG	Tijeras Arroyo Groundwater
TAV	Technical Area-V (acronym used for well identification numbers in tables only)
TA-V	Technical Area-V
TAVG	Technical Area-V Groundwater
TCE	trichloroethene
TJA	Tijeras Arroyo (acronym used for well identification numbers in tables only)
TOC	total organic carbon
TSWP	Treatability Study Work Plan
VOC	volatile organic compound

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SECTION I
ENVIRONMENTAL RESTORATION OPERATIONS CONSOLIDATED QUARTERLY REPORT, April – June 2019

1.0 Introduction

This Environmental Restoration Operations (ER) Consolidated Quarterly Report (ER Quarterly Report) provides the status of ongoing corrective action activities being implemented at Sandia National Laboratories, New Mexico (SNL/NM) during the April - June 2019 reporting period.

Table I-1 lists the Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) identified for corrective action at SNL/NM. This section of the ER Quarterly Report summarizes the work completed during this quarterly reporting period at sites undergoing corrective action. Corrective action activities were conducted during this reporting period at the three groundwater AOCs (Burn Site Groundwater [BSG] AOC, Technical Area-V [TA-V] Groundwater [TAVG] AOC, and Tijeras Arroyo Groundwater [TAG] AOC).

Corrective action activities are deferred at the Long Sled Track (SWMU 83), the Gun Facilities (SWMU 84), and the Short Sled Track (SWMU 240) because these three sites are active mission facilities. These three active mission sites are located in Technical Area-III.

There were no SWMUs or AOCs in the corrective action complete regulatory process during this quarterly reporting period.

2.0 Environmental Restoration Operations Work Completed

The following subsections identify the constituents of concern (COCs), summarize the corrective action milestones, and describe the ER work completed during the April - June 2019 reporting period at the three groundwater AOCs.

2.1 Sites Undergoing Corrective Action

In a letter dated April 14, 2016, the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) defined the scope and milestones for corrective action at three groundwater AOCs (BSG AOC, TAVG AOC, and TAG AOC) (NMED April 2016). Sections I.2.1.1 through I.2.1.3 discuss the specific milestones from this letter.

2.1.1 Burn Site Groundwater Area of Concern

Nitrate has been identified as a COC in groundwater at the BSG AOC based on detections above the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) in samples collected from monitoring wells. The EPA MCL and State of New Mexico drinking water standard for nitrate (as nitrogen) is 10 milligrams per liter (mg/L).

The U.S. Department of Energy/National Nuclear Security Administration (DOE/NNSA) and SNL/NM personnel met with the NMED HWB on July 20, 2015 to discuss the status of sites currently undergoing corrective action. For the BSG AOC, all parties agreed to a weight-of-evidence characterization program: (1) to conduct additional isotopic analyses/nitrate fingerprinting and age-dating of the groundwater; (2) to conduct a transducer study using existing wells to determine whether the groundwater is unconfined, semi-confined, or confined; and (3) to conduct an aquifer pumping test to help determine the origin of the elevated nitrates in the groundwater.

The groundwater sampling and analysis program for the BSG AOC currently includes perchlorate analyses of water from one groundwater monitoring well (CYN-MW15).

The following activities occurred at BSG AOC during the April - June 2019 reporting period:

- Groundwater sampling was conducted in April 2019. Table I-2 presents the identification and the sampling frequency for BSG AOC monitoring wells. The analytical results for CY 2019 groundwater monitoring will be presented in the SNL/NM CY 2019 Annual Groundwater Monitoring Report (AGMR), which is anticipated to be submitted to the NMED in the summer of 2020.

- Perchlorate analysis of groundwater samples from the BSG AOC is discussed in Section II of this ER Quarterly Report.

2.1.2 Technical Area-V Groundwater Area of Concern

Trichloroethene (TCE) and nitrate have been identified as COCs in groundwater at the TAVG AOC based on detections above the EPA MCLs in samples collected from monitoring wells. The EPA MCLs and the State of New Mexico drinking water standards for TCE and nitrate (as nitrogen) are 5 micrograms per liter (µg/L) and 10 mg/L, respectively.

Personnel from the DOE/NNSA, DOE Headquarters Office of Environmental Management, SNL/NM, and NMED HWB worked together to address the groundwater contamination at the TAVG AOC. A meeting was held with the NMED HWB on July 20, 2015, and all parties agreed on a phased Treatability Study of in-situ bioremediation to evaluate the effectiveness of in-situ bioremediation as a potential technology to treat the groundwater contamination at the TAVG AOC.

To implement the Treatability Study, SNL/NM personnel plan to install up to three injection wells (TAV-INJ1, TAV-INJ2, and TAV-INJ3) at TA-V near the highest contaminant concentrations in groundwater detected in monitoring wells TAV-MW6, TAV-MW10, and LWDS-MW1, respectively. The substrate solution containing essential food and nutrients for biostimulation will be prepared in aboveground tanks. This substrate solution, along with the biodegradation bacteria, will be gravity-injected to groundwater via injection wells.

The NMED HWB approved the Revised Treatability Study Work Plan (TSWP) (SNL/NM March 2016) on May 10, 2016 (NMED May 2016). In accordance with the Revised TSWP, the Treatability Study will be conducted in two phases. Phase I includes a pilot test followed by full-scale operation at the first injection well (TAV-INJ1). SNL/NM personnel have completed the pilot test at injection well TAV-INJ1. The operation and results of the pilot test were presented in Section III of the October 2018 ER Quarterly Report (SNL/NM October 2018). Based on the results of the pilot test, DOE/NNSA and SNL/NM personnel proposed eight modifications for the full-scale operation at TAV-INJ1 (DOE July 2018). The NMED HWB subsequently approved the modifications on August 13, 2018 (NMED August 2018). Therefore, the forthcoming implementation of the Treatability Study is governed by the Revised TSWP and where applicable, the approved modifications for full-scale operation.

Phase II of the Treatability Study includes well installation and full-scale operation at the second and third injection wells (TAV-INJ2 and TAV-INJ3). A decision to install the Phase II wells is dependent upon the findings of the Phase I full-scale operation.

The NMED Ground Water Quality Bureau (GWQB) requires a groundwater Discharge Permit (DP) for operation of the injection wells. NMED GWQB issued DP-1845 to DOE/NNSA for the SNL/NM TA-V Treatability Study injection wells on May 26, 2017 (NMED May 2017a). The DP-1845 term starts on May 30, 2017 and ends on May 30, 2022. As required by DP-1845, DOE/NNSA and SNL/NM personnel submit separate quarterly reports to the NMED GWQB.

The following activities occurred at TAVG AOC during the April - June 2019 reporting period:

- Full-scale operation of Phase I of the Treatability Study began in October 2018. The injection period was completed on April 25, 2019. The injection period spanned approximately six months, as planned in the Revised TSWP (SNL/NM March 2016). One hundred and ten (110) injections totaling 531,516 gallons of treatment solution were discharged to groundwater over the six-month period via injection well TAV-INJ1. The average volume of treatment solution per injection was approximately 4,832 gallons. Along with the treatment solution, a total of 122.8 liters of the biodegradation bacteria were injected to groundwater over the six-month period. No significant problems were encountered during these full-scale injections. Section III of this ER Quarterly Report provides more details on the full-scale operation for this reporting period.

- The injection period of the full-scale operation of Phase I is followed by two years' monitoring for the performance of the in-situ bioremediation, at a monthly frequency for three months and then quarterly for the remainder of the two-year period, as planned in the Revised TSWP (SNL/NM March 2016). Groundwater monitoring was conducted at the treatment zone (i.e., in the proximity of injection well TAV-INJ1) as well as outside the treatment zone during this reporting period. Section III presents the groundwater monitoring results for the Treatability Study for this quarter. Analytical results for DP-specific requirements are presented in DP quarterly reports that are submitted separately to the NMED GWQB.

- The TA-V groundwater monitoring network currently comprises 18 active monitoring wells. Of these 18 wells, well TAV-MW6 is designated as a Treatability Study performance monitoring well and follows the sampling frequency and analytes specified for the Treatability Study (see Section III). Because of its proximity to the injection well TAV-INJ1, well TAV-MW7 continues to serve as a monitoring well for the Treatability Study, although programmatically it belongs to the TA-V groundwater monitoring network (SNL/NM January 2019). Groundwater monitoring results at wells TAV-MW6 and TAV-MW7 will continue to be reported in Section III of the ER quarterly reports for the duration of the Treatability Study.

- Table I-2 presents the sampling frequency for the monitoring wells at TAVG AOC for the 17 wells in the TA-V groundwater monitoring network (18 wells, minus well TAV-MW6). Groundwater sampling was conducted in May and June 2019. The SNL/NM CY 2019 AGMR will present the analytical results for CY 2019 groundwater monitoring, which is scheduled for submittal to the NMED HWB in the summer of 2020.

- Two first-time exceedances of EPA MCLs occurred in this reporting period at the TA-V groundwater monitoring network:
    - Concentrations of nitrate plus nitrite in May in well LWDS-MW2 were 12.3 mg/L and 10.1 mg/L in the environmental sample and duplicate, exceeding the EPA MCL of 10 mg/L.
    - Concentration of TCE in May in well TAV-MW4 was 5.44 µg/L, exceeding the EPA MCL of 5 µg/L.

  These two wells will be sampled in the third quarter of CY 2019. The sampling results will be evaluated for any increasing trend at these two wells in subsequent ER Quarterly Reports.

2.1.3 Tijeras Arroyo Groundwater Area of Concern

Nitrate has been identified as a COC in groundwater for the TAG AOC based on exceedances of the EPA MCL in samples collected from monitoring wells completed in the Perched Groundwater System and in the merging zone above the Regional Aquifer. TCE has been identified as a COC for the Perched Groundwater System. No TCE concentrations in Regional Aquifer samples have exceeded the EPA MCL. The EPA MCLs and State of New Mexico drinking water standards for TCE and nitrate (as nitrogen) are 5 µg/L and 10 mg/L, respectively.

In May 2017, NMED HWB completed its review of the Current Conceptual Model and Corrective Measures Evaluation Report for the TAG AOC (SNL/NM December 2016), which was submitted to the NMED HWB on November 23, 2016 (DOE November 2016). This November 23, 2016 report was submitted in accordance with NMED's "Agreements and Proposed Milestones" letter of April 14, 2016 (NMED April 2016). The subsequent disapproval letter issued by the NMED HWB (NMED May 2017b) requested the inclusion of additional information in a revised report. The Revised TAG Current Conceptual Model and Corrective Measures Evaluation Report was then submitted to the NMED HWB on February 13, 2018 (SNL/NM February 2018). During a June 20, 2018 meeting, NMED HWB personnel stated that they will complete their review of the revised report in CY 2019.

During June 2019 groundwater samples were collected from the seven monitoring wells (TA2-W-19, TA2-W-26, TA2-W-28, TJA-2, TJA-3, TJA-4, and TJA-7) scheduled for quarterly sampling. Table I-2 presents the CY 2019 sampling frequency for the TAG monitoring wells. The analytical results for the TAG AOC CY 2019 groundwater monitoring will be included in the SNL/NM CY 2019 AGMR, which is scheduled for submittal to the NMED HWB in the summer of 2020.

2.2 Sites in Corrective Action Complete Regulatory Process

There are currently no SWMUs or AOCs in the corrective action complete regulatory process.

3.0 References

DOE, see U.S. Department of Energy.

New Mexico Environment Department (NMED), April 2016. Letter to J.P. Harrell (U.S. Department of Energy, NNSA/Sandia Field Office) and M. W. Hazen (Sandia National Laboratories, New Mexico), "Summary of Agreements and Proposed Milestones Pursuant to the Meeting of July 20, 2015, March 30, 2016, Sandia National Laboratories, EPA ID# NM5890110518, HWB-SNL-16-MISC," NMED, Hazardous Waste Bureau, Santa Fe, New Mexico, April 14, 2016.

New Mexico Environment Department (NMED), May 2016. Letter to J. Harrell (U.S. Department of Energy NNSA/Sandia Field Office) and P. Davies (Sandia National Laboratories, New Mexico), "Approval Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern, Sandia National Laboratories, EPA ID# NM5890110518, HWB-SNL-15-020," NMED, Hazardous Waste Bureau, Santa Fe, New Mexico, May 10, 2016.

New Mexico Environment Department (NMED), May 2017a. Ground Water Discharge Permit, Sandia National Laboratories/New Mexico, Discharge Permit-1845, NMED, Ground Water Quality Bureau, Santa Fe, New Mexico, May 26, 2017.

New Mexico Environment Department (NMED), May 2017b. Letter to J.P. Harrell (U.S. Department of Energy NNSA/Sandia Field Office) and Carol Adkins (Sandia National Laboratories), "Disapproval Tijeras Arroyo Groundwater Current Conceptual Model and Corrective Measures Evaluation Report, December 2016, Sandia National Laboratories [*sic*] New Mexico, EPA ID# NM5890110518, HWB-SNL-16-020," May 18, 2017.

New Mexico Environment Department (NMED), August 2018. Letter to J.P. Harrell (U.S. Department of Energy NNSA/Sandia Field Office) and R.O. Griffith (Sandia National Laboratories), "Approval: Technical Area-V (TA-V) Treatability Study Notification of Full-Scale Operation at Well TAV-INJ1, Sandia National Laboratory, EPA ID# NM5890110518, HWB-SNL-15-020," August 13, 2018.

NMED, see New Mexico Environment Department.

Sandia National Laboratories, New Mexico (SNL/NM), March 2016. *Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern, Sandia National Laboratories, Albuquerque, New Mexico,* Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), December 2016. *Tijeras Arroyo Groundwater Current Conceptual Model and Corrective Measures Evaluation Report*, Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), February 2018. *Revised Tijeras Arroyo Groundwater Current Conceptual Model and Corrective Measures Evaluation Report*, Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), October 2018. *Environmental Restoration Operations Consolidated Quarterly Report April – June 2018*, Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), January 2019. *Environmental Restoration Operations Consolidated Quarterly Report July – September 2018, Sandia National Laboratories, Albuquerque, New Mexico,* Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

SNL/NM, see Sandia National Laboratories, New Mexico.

U.S. Department of Energy (DOE), November 2016. Letter to J.E. Kieling (New Mexico Environment Department), "Tijeras Arroyo Groundwater Current Conceptual Model and Corrective Measures Evaluation Report, December 2016," November 23, 2016.

U.S. Department of Energy (DOE), July 2018. Letter to J. E. Kieling (New Mexico Environment Department), "Technical Area-V (TA-V) Treatability Study Notification of Full-Scale Operation at Well TAV-INJ1", July 20, 2018.

Tables

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Table I-1
Solid Waste Management Units and Areas of Concern
Where Corrective Action is Not Complete

Solid Waste Management Units and Areas of Concern	
Site Number	**Site Description**
83	Long Sled Track
84	Gun Facilities
240	Short Sled Track
NA	Tijeras Arroyo Groundwater Investigation (TAG AOC)
NA	TA-V Groundwater Investigation (TAVG AOC)
NA	Burn Site Groundwater Investigation (BSG AOC)

Notes:

AOC = Area of Concern.
BSG = Burn Site Groundwater.
NA = Not applicable. A site number was not assigned.
TAG = Tijeras Arroyo Groundwater.
TA-V = Technical Area-V.
TAVG = Technical Area-V Groundwater.

Table I-2
Groundwater Sampling and Analysis

Investigation Site	Sampling Frequency in CY 2019	Quarter of Sampling in CY 2019	Location of Analytical Results	Location of Perchlorate Analytical Results	Monitoring Wells in Network
TAVG AOC [a]	Quarterly	1,2,3,4	AGMR	NA	LWDS-MW1, TAV-MW2, TAV-MW4, TAV-MW7 TAV-MW8, TAV-MW10, TAV-MW11, TAV-MW12, TAV-MW14, TAV-MW15, TAV-MW16
	Annually	2	AGMR	NA	AVN-1, LWDS-MW2, TAV-MW3, TAV-MW5, TAV-MW9, TAV-MW13
BSG AOC	Semiannually	2,4	AGMR	Section II of ER Consolidated Quarterly Report	CYN-MW4, CYN-MW7, CYN-MW8, CYN-MW9, CYN-MW10, CYN-MW11, CYN-MW12, CYN-MW13, CYN-MW14A, CYN-MW15
TAG AOC [b]	Quarterly	1,2,3,4	AGMR	NA	TA2-W-19, TA2-W-26, TA2-W-28, TJA-2, TJA-3, TJA-4, TJA-7
	Semiannually	1,3	AGMR	NA	TA1-W-06, TA2-W-01, TA2-W-27, TJA-6
	Annually	3	AGMR	NA	PGS-2, TA1-W-01, TA1-W-02, TA1-W-03, TA1-W-04, TA1-W-05, TA1-W-08, TA2-NW1-595, WYO-3

Notes:

[a]TAVG AOC monitoring network comprises 18 active wells: 17 wells are listed here; well TAV-MW6 currently is part of the Treatability Study and follows a separate monitoring plan (see Section 2.1.2).
[b] Monitoring well WYO-4 was deleted from the sampling schedule in response to the August 2017 meeting with NMED HWB personnel.

AGMR = Annual Groundwater Monitoring Report.
AOC = Area of Concern.
AVN = Area-V (North) (acronym used for well identification only).
BSG = Burn Site Groundwater (Area of Concern).
CY = Calendar Year.
CYN = Canyons (Burn Site Groundwater Area of Concern; acronym used for well identification only).
ER = Environmental Restoration Operations.
HWB = Hazardous Waste Bureau.
LWDS = Liquid waste disposal system (acronym used for well identification only).
MW = Monitoring well (acronym used for well identification only).
NA = Not applicable. No wells in the site network are currently being sampled and analyzed for perchlorate, or were not sampled during this quarterly reporting period.
NMED = New Mexico Environment Department.
PGS = Parade Ground South (acronym used for well identification only).
TA1-W = Technical Area-I (Well) (acronym used for well identification only).
TA2-NW = Technical Area-II (Northwest) (acronym used for well identification only).
TA2-W = Technical Area-II (Well) (acronym used for well identification only).
TAG = Tijeras Arroyo Groundwater (Area of Concern).
TAV = Technical Area-V (acronym used for well identification only).
TAVG = Technical Area-V Groundwater (Area of Concern).
TJA = Tijeras Arroyo (acronym used for well identification only).
WYO = Wyoming (acronym used for well identification only).

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SECTION II
PERCHLORATE SCREENING QUARTERLY GROUNDWATER MONITORING REPORT, April – June 2019

1.0 Introduction

Section IV.B of the Compliance Order on Consent (the Consent Order), between the New Mexico Environment Department (NMED), the U.S. Department of Energy (DOE), and Sandia National Laboratories, New Mexico (SNL/NM), effective on April 29, 2004, stipulates that a select group of groundwater monitoring wells at SNL/NM be sampled for perchlorate (NMED April 2004). This section of the Environmental Restoration Operations (ER) Consolidated Quarterly Report (ER Quarterly Report) summarizes the perchlorate screening groundwater monitoring completed during the April – June 2019 reporting period in response to the requirements of the Consent Order. The outline of this report is based on the required elements of a "Periodic Monitoring Report" described in Section X.D. of the Consent Order (NMED April 2004).

In November 2005, DOE/National Nuclear Security Administration (NNSA) and SNL/NM personnel submitted a letter report on the status of perchlorate screening in groundwater at SNL/NM monitoring wells (SNL/NM November 2005). The letter report summarized previous correspondence and sampling results and outlined proposed future work to comply with NMED Hazardous Waste Bureau (HWB) requirements for perchlorate screening of groundwater. As specified in the letter report, quarterly reports are submitted for wells active in the perchlorate screening monitoring well network.

Based on the NMED HWB response (NMED January 2006), DOE/NNSA and SNL/NM personnel submit each quarterly report within 90 days following the quarter that the data represent. In November 2008, DOE/NNSA and SNL/NM personnel received approval from the NMED HWB to proceed to semiannual reporting (NMED November 2008); however, upon further consideration, the NMED HWB once more required quarterly reporting (NMED April 2009). This did not alter the previously negotiated frequency for monitoring well CYN-MW6, an existing Burn Site Groundwater (BSG) Area of Concern (AOC) monitoring well that has been under the sampling and reporting requirements of the Consent Order since the well was installed, which remains at a semiannual frequency for sampling and reporting. Due to declining water levels, CYN-MW6 has insufficient water to routinely sample and the replacement monitoring well (CYN-MW15) was installed in December 2014; the negotiated semiannual sampling frequency transferred to the replacement well.

In September 2011, DOE/NNSA and SNL/NM personnel requested an extension of the submittal dates by one month for ER Quarterly Reports (SNL/NM September 2011). The NMED HWB approved the request (NMED September 2011), which allows DOE/NNSA and SNL/NM personnel to submit perchlorate quarterly reports within 120 days following the quarter that the data represent.

This report is the forty-eighth perchlorate screening quarterly report submitted since the November 2005 letter report; the previous reports were submitted for fourth quarter of CY 2005 through the fourth quarter of CY 2018 (SNL/NM February 2006 and April 2019).

Groundwater at BSG AOC monitoring well CYN-MW15 was sampled semiannually for the tenth time during the reporting period (Table II-1). The corresponding reporting will continue for as long as a well remains active in the perchlorate screening network, or unless otherwise negotiated with the NMED.

2.0 Scope of Activities

This report provides April – June 2019 perchlorate screening groundwater monitoring analytical results for the well CYN-MW15, the only well currently active in the perchlorate screening program (Figure II-1, Table II-1). In accordance with the requirements of Table XI-1 of the Consent Order, a well with four consecutive quarters of non-detects (NDs) for perchlorate at the screening level/method detection limit (MDL) of 4 micrograms per liter (µg/L) is removed from the requirement of continued monitoring for perchlorate. Data for numerous wells identified in the Consent Order have satisfied this requirement; therefore, these wells have been removed from the perchlorate screening program. Previous reports provided perchlorate results for these wells and are not discussed in this current report. Table II-2 lists the wells discussed in previous perchlorate screening reports.

SNL/NM personnel performed groundwater sampling for perchlorate at monitoring well CYN-MW15 in April 2019 (Table II-1). Groundwater sampling activities were conducted in accordance with procedures outlined in the *Burn Site Groundwater Monitoring, Mini-SAP for Third Quarter, Fiscal Year 2019* (SNL/NM March 2019).

As described in the Mini-Sampling and Analysis Plan (SAP), groundwater sampling was performed in accordance with current SNL/NM Long-Term Stewardship Project Field Operating Procedures (FOPs). A portable Bennett™ groundwater sampling system was used to collect the groundwater samples. The sampling pump and tubing bundle were decontaminated prior to placement into the monitoring well in accordance with procedures described in FOP 05-03, "Groundwater Monitoring Equipment Decontamination" (SNL/NM

January 2018a). The well was purged a minimum of one saturated screen volume before sampling in accordance with FOP 05-01, "Groundwater Monitoring Well Sampling and Field Analytical Measurements" (SNL/NM January 2018b). Field water quality measurements for turbidity, potential of hydrogen (pH), temperature, specific conductivity (SC), oxidation-reduction potential (ORP), and dissolved oxygen (DO) were obtained from the well prior to collecting the groundwater sample. Groundwater temperature, SC, ORP, DO, and pH were measured with an In-Situ Incorporated Aqua TROLL® 600 Multiparameter water quality meter. Turbidity was measured with a HACH™ Model 2100Q turbidity meter. Purging continued until four stable measurements for turbidity, pH, temperature, and SC were obtained. Groundwater stability is considered acceptable when the following parameters are achieved:

- Turbidity measurements are less than 5 nephelometric turbidity units, or within 10 percent for turbidity values greater than 5 nephelometric turbidity units.
- pH is within 0.1 units.
- Temperature is within 1.0 degree Celsius.
- SC is within 5 percent.

Field measurement logs documenting details of well purging and water quality measurements have been submitted to the SNL/NM Customer Funded Record Center.

Groundwater samples were submitted to GEL Laboratories, LLC (GEL) for chemical analysis of perchlorate using U.S. Environmental Protection Agency (EPA) Method 314.0 (EPA November 1999). Table II-3 provides the sample identification, Analysis Request/Chain-of-Custody form number, and the associated groundwater investigation. The analytical report from GEL, including certificates of analysis (COA) (Appendix A), analytical methods, MDLs, practical quantitation limits, dates of analyses, results of quality control analyses, and data validation findings (Appendix B), have been submitted to the SNL/NM Customer Funded Record Center.

3.0 Regulatory Criteria

For a given monitoring well, four consecutive ND results using the screening level/MDL of 4 µg/L are considered by the NMED HWB as evidence of the absence of perchlorate, such that additional monitoring for perchlorate in that well is not required. If perchlorate is detected using the screening level/MDL of 4 µg/L in a specific well, then monitoring will

continue at that well at a frequency negotiated with the NMED. The Consent Order (NMED April 2004) also requires that detections equal to or greater than 4 µg/L be evaluated by DOE/NNSA and SNL/NM personnel to determine the nature and extent of perchlorate contamination and incorporate the results of this evaluation into a Corrective Measures Evaluation (CME), based on a screening level/MDL of 4 µg/L. The Consent Order, Section VII.C, clarifies that the CME process will be initiated where there is a documented release to the environment, and where corrective measures are necessary to protect human health and the environment.

3.1 Burn Site Groundwater Area of Concern

In March 2007, NMED HWB sent a letter of approval, which required DOE/NNSA and SNL/NM personnel to "determine the nature and extent of the contamination and complete a CME for the perchlorate-impacted groundwater in the vicinity of CYN-MW6" (NMED March 2007). As this was based solely on four quarters of monitoring results, DOE and SNL/NM personnel submitted a letter to the NMED HWB in April 2007 (SNL/NM April 2007) recommending further characterization through continued quarterly monitoring of monitoring well CYN-MW6 for an additional four quarters, ending in December 2007, to ensure appropriate characterization of this well. In January 2008, DOE/NNSA and SNL/NM personnel requested a meeting with the NMED HWB to discuss the need for continued monitoring or additional characterization work and, potentially, a CME.

In preparation for discussing the perchlorate-impacted groundwater in the vicinity of monitoring well CYN-MW6, and to show that the requirement "to determine the nature and extent of contamination" (NMED March 2007) had been met, DOE/NNSA and SNL/NM personnel provided supporting information to the NMED HWB (SNL/NM March 2008). Perchlorate in surface soil has been characterized at several Solid Waste Management Units (SWMUs) in the study area (SNL/NM June 2006 and March 2008–Appendix C). Based on these data, DOE/NNSA and SNL/NM personnel consider the nature and extent of perchlorate in groundwater at the BSG AOC to be sufficiently characterized. Since 2004, groundwater samples from four other monitoring wells in the vicinity of the BSG AOC have been analyzed for perchlorate, including monitoring wells CYN-MW1D, CYN-MW5, CYN-MW7, and CYN-MW8. All wells were sampled for four quarters and all results were ND for perchlorate (SNL/NM March 2008–Appendix D).

In accordance with the requirements of Section VI.K.1.b of the Consent Order (NMED April 2004), a human health risk assessment has been performed to evaluate the potential for adverse health effects from the concentrations of perchlorate detected in monitoring well CYN-MW6 groundwater samples. The maximum perchlorate concentration to date of 8.93 µg/L was used in the risk assessment. The calculated hazard

quotient of 0.35 is less than the NMED HWB target level of a hazard index (the sum of all hazard quotients) of 1.0 (NMED June 2006, SNL/NM March 2008–Appendix E). For another point of comparison, NMED HWB risk assessment guidance lists a tap water standard of 13.8 µg/L for perchlorate (NMED February 2019); therefore, the historical maximum concentration detected is 35 percent less than the NMED HWB tap water standard.

Because perchlorate concentrations in samples from monitoring well CYN-MW6 have exceeded the screening level, DOE/NNSA and SNL/NM personnel initiated a negotiation process with the NMED HWB (SNL/NM March 2007) to determine the frequency of continued monitoring. In November 2008, DOE/NNSA and SNL/NM personnel received approval from the NMED HWB to proceed with semiannual monitoring of perchlorate in monitoring well CYN-MW6 and proceed with semiannual reporting of all perchlorate results (NMED November 2008). Upon further consideration, the NMED HWB once more required that DOE/NNSA and SNL/NM personnel resume quarterly reporting of perchlorate results with the exception of monitoring well CYN-MW6 (NMED April 2009). Due to declining water levels, CYN-MW6 has insufficient water to routinely sample and was replaced; the last sample collected at CYN-MW6 was on October 15, 2012. The replacement monitoring well (CYN-MW15) was installed in December 2014 and assumed the negotiated semiannual monitoring frequency. Monitoring well CYN-MW14A was also installed in December 2014; this well was considered a new monitoring well that requires quarterly sampling due to its deep screen interval.

In April 2009, NMED HWB sent a letter that required DOE/NNSA and SNL/NM personnel to characterize the nature and extent of the perchlorate contamination in soil and groundwater in the BSG AOC (NMED April 2009). A characterization work plan was prepared and submitted to the NMED HWB (SNL/NM November 2009), approved by the NMED HWB (NMED February 2010), and implemented in July 2010.

3.2 Tijeras Arroyo Groundwater and Technical Area-V Groundwater Areas of Concern

The April 2009 letter from the NMED HWB to DOE/NNSA and SNL/NM personnel was not limited to the BSG AOC (NMED April 2009). The NMED HWB had also requested that DOE/NNSA and SNL/NM personnel monitor perchlorate concentrations for a minimum of four quarters at five monitoring wells in the Tijeras Arroyo Groundwater (TAG) AOC and at four monitoring wells in the Technical Area-V Groundwater AOC . All nine wells from these two AOCs have been sampled for four consecutive monitoring events with no perchlorate detections being reported; therefore, these nine wells have been removed from the perchlorate monitoring network. A TAG monitoring well (TA2-SW1-320) was damaged and was replaced by well, TA2-W-28 in December 2014. The replacement well

was installed for monitoring the same depth interval as damaged well TA2-SW1-320. Because well TA2-SW1-320 was not one of the four TAG wells selected for perchlorate sampling, replacement well TA2-W-28 does not require perchlorate sampling.

4.0 Monitoring Results

Table II-3 summarizes the details of samples collected from monitoring well CYN-MW15 in the April - June 2019 reporting period . Table II-4 summarizes the current and historical perchlorate results for this well. Appendix A provides the analytical laboratory COAs for the April – June 2019 perchlorate data. For the fifth time in ten sampling events (since December 2014), perchlorate was ND at the screening level/MDL of 4.0 µg/L in the April 2019 CYN-MW15 environmental groundwater sample (Figure II-2). The hydrograph for monitoring well CYN-MW15 (Figure II-2) shows that the water table elevation has been slightly decreasing over the past several years.

Table II-5 summarizes the stabilized water quality values measured immediately before the groundwater samples were collected. The field water quality measurements include turbidity, pH, temperature, SC, ORP, and DO.

The analytical data were reviewed and validated in accordance with Administrative Operating Procedure 00-03, "Data Validation Procedure for Chemical and Radiochemical Data," (SNL/NM June 2017). No problems were identified with the analytical data that resulted in qualification of the data as unusable. The data are acceptable, and reported quality control measures are adequate. Appendix B provides the data validation sample findings summary sheets for the perchlorate data.

No variances or nonconformances in perchlorate sampling field activities, or field conditions from requirements in the groundwater monitoring Mini-SAP (SNL/NM April 2019), were identified during the April - June 2019 sampling activities.

5.0 Summary and Conclusions

Based on analytical data presented in Table II-4 and in previous reports, the following statements can be made:

- The perchlorate concentration for the groundwater sample from monitoring well CYN-MW15 for the April - June 2019 sampling event was ND. This is the fifth sampling event

(non-consecutive) that perchlorate was ND at this well since December 2014 (Figure II-2).

- Since June 2004 (the start of sampling as required by the Consent Order), perchlorate was detected above the screening level/MDL (4 µg/L) in groundwater samples from only one well (CYN-MW6) and its replacement well (CYN-MW15) in the perchlorate monitoring network.

- DOE/NNSA and SNL/NM personnel will continue semiannual monitoring of perchlorate at monitoring well CYN-MW15.

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Figures

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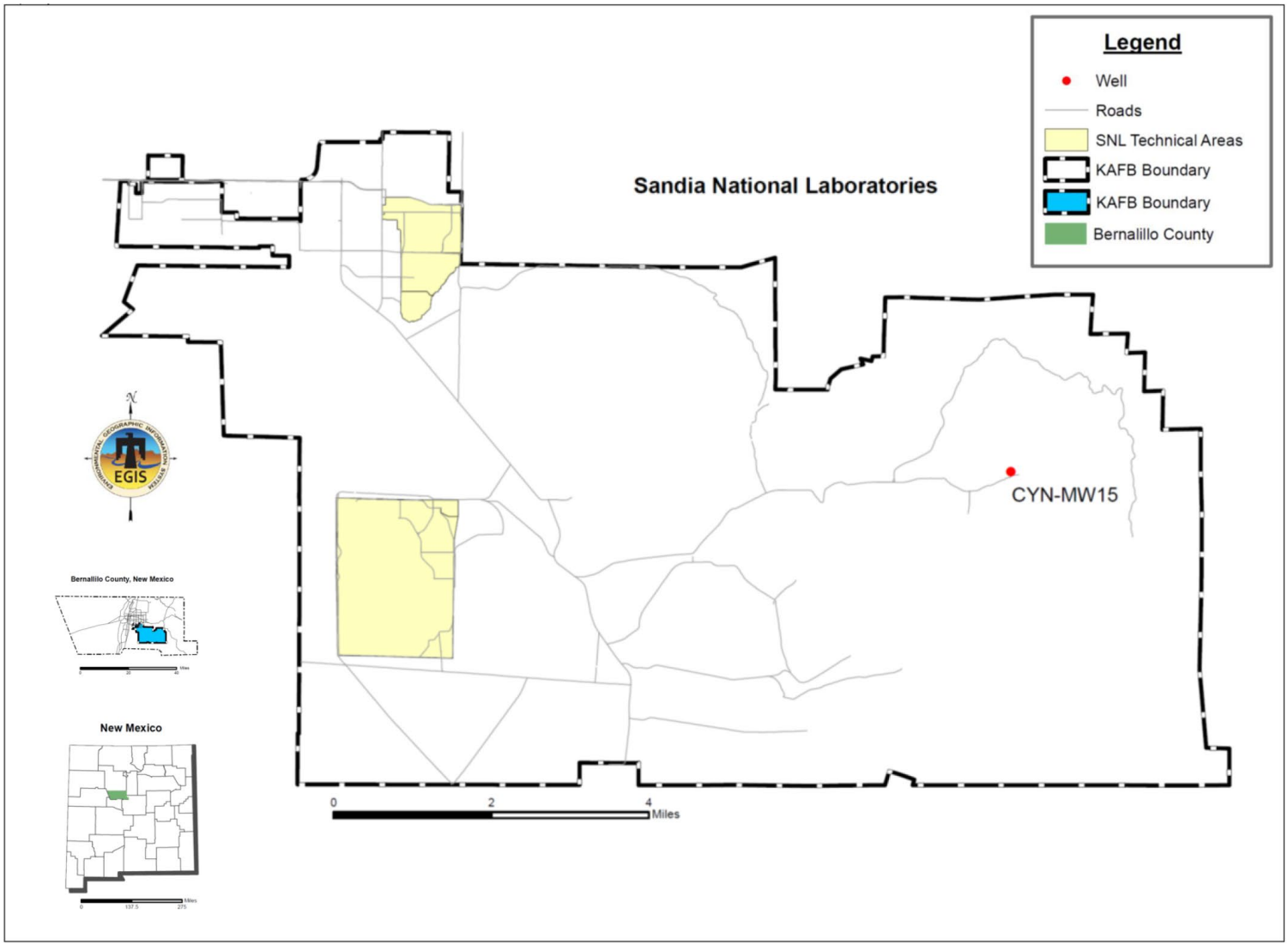

Sandia National Laboratories, New Mexico
Environmenatl Geographic Information System

New Mexico State Plane Central Zones, 1983
1988 North American Vertical Datum

Figure II-1
Sandia National Laboratories, New Mexico
Current Perchlorate Screening Monitoring Well Network, April – June 2019

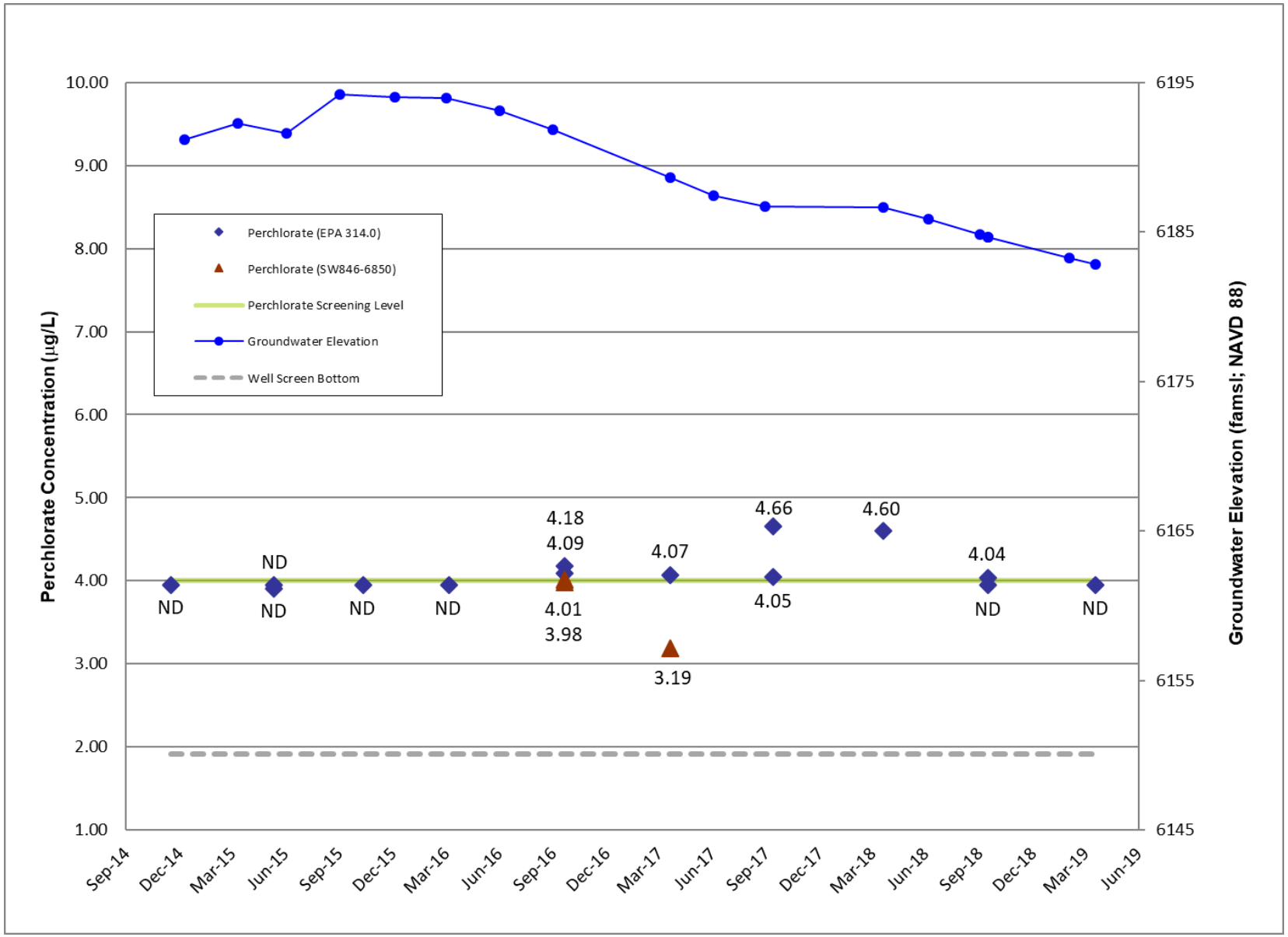

Figure II-2

Groundwater Elevations and Perchlorate Concentrations Over Time in CYN-MW15

Tables

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Table II-1
Current Perchlorate Screening Monitoring Well Network
April - June 2019

Well	Date Sampled	Number of Consecutive Sampling Events[a]	Remaining Number of Sampling Events	Sampling Equipment
CYN-MW15	17-Apr-19	10	TBD[b]	Bennett™ Pump

Notes

[a]Includes this sampling event.
[b]This well was installed as a replacement well for CYN-MW6. Because perchlorate concentrations in CYN-MW6 have exceeded the screening level/MDL, DOE/NNSA, SNL/NM, and the NMED HWB have agreed to further characterization through continued monitoring in the BSG AOC (NMED February 2010).

AOC = Area of Concern.
BSG = Burn Site Groundwater.
CY = Calendar Year.
CYN = Canyons (Burn Site Groundwater Area of Concern).
DOE = U.S. Department of Energy.
HWB = Hazardous Waste Bureau.
MDL = Method detection limit.
MW = Monitoring well.
NMED = New Mexico Environment Department.
NNSA = National Nuclear Security Administration.
SNL/NM = Sandia National Laboratories, New Mexico.
TBD = To be determined.

Table II-2
Monitoring Wells Discussed in Previous Perchlorate Screening Reports

Well	
CCBA-MW1	MWL-MW1
CCBA-MW2	MWL-MW7
CTF-MW1	MWL-MW8
CTF-MW2	MWL-MW9
CTF-MW3	NWTA3-MW2
CYN-MW1D	OBS-MW1
CYN-MW5	OBS-MW2
CYN-MW6	OBS-MW3
CYN-MW7	SWTA3-MW4
CYN-MW8	TA1-W-03
CYN-MW9	TA1-W-06
CYN-MW10	TA1-W-08
CYN-MW11	TA2-W-01
CYN-MW12	TA2-W-27
CYN-MW14A	TAV-MW11
LWDS-MW1	TAV-MW12
MRN-2	TAV-MW13
MRN-3D	TAV-MW14
MWL-BW1	TAV-MW15
MWL-BW2	TAV-MW16

Notes

BW = Background well.
CCBA = Coyote Canyon Blast Area.
CTF = Coyote Test Field.
CYN = Canyons (Burn Site Groundwater Area of Concern).
LWDS = Liquid waste disposal system.
MRN = Magazine Road North.
MW = Monitoring well.
MWL = Mixed Waste Landfill.
NWTA = Northwest Technical Area (-III).
OBS = Old Burn Site.
SWTA = Southwest Technical Area (-III).
TA1-W = Technical Area-I (Well).
TA2-W = Technical Area-II (Well).
TAV = Technical Area-V.

Table II-3
Sample Details for April - June 2019 Perchlorate Sampling

Well	Sample Identification	AR/COC Number	Associated Groundwater Investigation
CYN-MW15	108030-008	619631	BSG AOC

Notes

AOC = Area of Concern.
AR/COC = Analysis Request/Chain-of-Custody.
BSG = Burn Site Groundwater.
CY = Calendar Year.
CYN = Canyons (Burn Site Groundwater Area of Concern).
MW = Monitoring well.

Table II-4
Summary of Perchlorate Screening Analytical Results for the Current Monitoring Well Network as of April - June 2019

Well	Sample Date	AR/COC Number	Sample Number	Result (µg/L)	MDL (µg/L)	PQL (µg/L)	MCL (µg/L)	Laboratory Qualifier[a]	Validation Qualifier[b]	Analytical Method[c]	Comments
Burn Site Groundwater Area of Concern											
CYN-MW15	17-Dec-14	615941	096979-020	ND	4.0	12	NE	U		EPA 314.0	
	11-Jun-15	616178	097842-020	ND	4.0	12	NE	U		EPA 314.0	
			097843-020	ND	4.0	12	NE	U		EPA 314.0	Duplicate sample
	10-Nov-15	616396	098486-020	ND	4.0	12	NE	U		EPA 314.0	
	05-Apr-16	616862	099139-008	ND	4.0	12	NE	U		EPA 314.0	
	21-Oct-16	617385	100705-004	4.09	4.0	12	NE	J		EPA 314.0	
			100705-R04	3.98	0.25	1	NE			SW846 6850	
			100706-004	4.18	4.0	12	NE	J		EPA 314.0	Duplicate sample
			100706-R04	4.01	0.25	1	NE			SW846 6850	Duplicate sample
	19-Apr-17	617823	102400-013	4.07	4.0	12	NE	J		EPA 314.0	
			102400-R13	3.19	0.1	0.4	NE	Hh	J-	SW846 6850	
	13-Oct-17	618205	103748-004	4.05	4.0	12	NE	J		EPA 314.0	
			103749-004	4.66	4.0	12	NE	J		EPA 314.0	Duplicate sample
	19-Apr-18	618667	105068-008	4.60	4.0	12	NE	J		EPA 314.0	
	16-Oct-18	619203	106473-004	ND	4.0	12	NE	U		EPA 314.0	
			106474-004	4.04	4.0	12	NE	J		EPA 314.0	Duplicate sample
	17-Apr-18	619631	108030-008	ND	4.0	12	NE	U		EPA 314.0	

Notes

[a]Laboratory Qualifier
If cell is blank, then all quality control samples meet acceptance criteria with respect to submitted samples.
H = Analytical holding time was exceeded.
h = Prep holding time exceeded.
J = Estimated value, the analyte concentration fell above the effective MDL and below the effective PQL.
U = Analyte is absent or below the MDL.

[b]Validation Qualifier
If cell is blank, then all quality control samples meet acceptance criteria with respect to submitted samples.
J- = The associated numerical value is an estimated quantity with a suspected negative bias.

Table II-4 (concluded)
Summary of Perchlorate Screening Analytical Results for the Current Monitoring Well Network as of April - June 2019

Notes (continued)

[c]Analytical Method
EPA 314.0: EPA, November 1999, "Perchlorate in Drinking Water Using Ion Chromatography," EPA 815/R-00-014 .
SW846 6850: EPA, 1986 (and updates), "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd ed., EPA, Washington, D.C.

% = Percent.
µg/L = Micrograms per liter.
AR/COC = Analysis Request/Chain-of-Custody.
CFR = Code of Federal Regulations.
CY = Calendar Year.
CYN = Canyons (Burn Site Groundwater Area of Concern).
EPA = U.S. Environmental Protection Agency.
MCL = Maximum contaminant level. Established by the EPA Primary Water Regulations (40 CFR 141.11, Subpart B) and subsequent amendments or Title 20, Chapter 7, Part 1 of the New Mexico Administrative Code, incorporating 40 CFR 141.
MDL = Method detection limit. The minimum concentration that can be measured and reported with 99% confidence that the analyte is greater than zero; analyte is matrix-specific.
MW = Monitoring well.
ND = Non-detect (at MDL).
NE = Not established.
PQL = Practical quantitation limit. The lowest concentration of analytes in a sample that can be reliably determined within specified limits of precision and accuracy by the indicated method under routine laboratory operating conditions.

Table II-5
Perchlorate Screening Groundwater Monitoring
Field Water Quality Measurements[a], April - June 2019

Well	Sample Date	Temperature (°C)	Specific Conductivity (µmhos/cm)	Oxidation-Reduction Potential (mV)	pH	Turbidity (NTU)	Dissolved Oxygen (% Sat)	Dissolved Oxygen (mg/L)
Burn Site Groundwater Area of Concern								
CYN-MW15	17-Apr-19	14.28	1132.1	221.1	7.10	0.37	13.11	1.15

Notes

[a]Field measurements obtained immediately before the groundwater sample was collected.

°C = Degrees Celsius.
% Sat = Percent saturation.
µmhos/cm = Micromhos per centimeter.
CY = Calendar Year.
CYN = Canyons (Burn Site Groundwater Area of Concern).
mg/L = Milligrams per liter.
mV = Millivolt(s).
MW = Monitoring well.
NTU = Nephelometric turbidity unit.
pH = Potential of hydrogen (negative logarithm of the hydrogen ion concentration).

Appendix A
Analytical Laboratory Certificates of Analysis for the Perchlorate Data

SMO 2012-ARCOC (4-2012)

CONTRACT LABORATORY
ANALYSIS REQUEST AND CHAIN OF CUSTODY

AOP 95-16

Internal Lab

Batch No. N/A

AR/COC 619631

		SMO Use		
Project Name:	BSG AOC	Date Samples Shipped:	4/17/19	SMO Authorization:
Project/Task Manager:	Michael Skelly	Carrier/Waybill No:	296769	SMO Contact Phone: Wendy Palencia/505-844-3132
Project/Task Number:	195122.12.11.01	Lab Contact:	Edie Kent/843-769-7385	Send Report to SMO: Stephanie Montaño/505-284-2553
Service Order:	CF058-19	Lab Destination:	GEL	
Tech Area:		Contract No:	1983530	
Building:	Room:	Operational Site:		

☐ Waste Characterization
☐ RMA
☐ Released by COC No.
☑ 4° Celsius

Bill to: Sandia National Laboratories (Accounts Payable), P.O. Box 5800, MS-0154, Albuquerque, NM 87185-0154 476753

Sample No.	Fraction	Sample Location Detail	Depth (ft)	Date/Time Collected	Sample Matrix	Container Type	Container Volume	Preservative	Collection Method	Sample Type	Parameter & Method Requested	Lab Sample ID
108029	001	BSG-FB 5	NA	4/17/19 10:16	DIW	G	3x40 ml	HCl	G	FB	VOC, TCL (SW846-8260B)	001
108030	001	CYN-MW15	182	4/17/19 10:16	GW	G	3x40 ml	HCl	G	SA	VOC, TCL (SW846-8260B)	002
108030	002	CYN-MW15	182	4/17/19 10:20	GW	AG	4x1 L	None	G	SA	HE (SW846-8330B LC/MS/MS)	003
108030	003	CYN-MW15	182	4/17/19 10:22	GW	AG	4x1 L	NONE	G	SA	TPH-DRO (SW846-8015)	004
108030	004	CYN-MW15	182	4/17/19 10:18	GW	AG	3x40 ml	NONE	G	SA	TPH-GRO (SW846-8015)	005
108030	005	CYN-MW15	182	4/17/19 10:24	GW	P	125 ml	H2SO4	G	SA	NPN (EPA 353.2)	006
108030	006	CYN-MW15	182	4/17/19 10:25	GW	P	125 ml	None	G	SA	ANIONS-Br,Cl,F,SO4 (SW846-9056)	007
108030	007	CYN-MW15	182	4/17/19 10:26	GW	P	500 ml	None	G	SA	Alk TOT as CaCo3, HCO3-, and CO3-2 (SM2320B)	008
108030	008	CYN-MW15	182	4/17/19 10:27	GW	P	250 ml	None	G	SA	PERCHLORATE (EPA 314.0)	009
108030	009	CYN-MW15	182	4/17/19 10:28	GW	P	500 ml	HNO3	G	SA	METALS,TAL (SW846-6020/7470)	010

Last Chain: ☐ Yes
Validation Req'd: ☑ Yes
Background: ☐ Yes
Confirmatory: ☐ Yes

Sample Tracking — SMO Use
Date Entered:
Entered by:
QC inits.:

Special Instructions/QC Requirements:
EDD ☑ Yes
Turnaround Time ☐ 7-Day* ☐ 15-Day* ☑ 30-Day
Negotiated TAT ☐
Sample Disposal ☐ Return to Client ☑ Disposal by Lab
Return Samples By:
Comments: Received trip blanks from lab with head space. Must perform organic analysis within hold time requirements.

Conditions on Receipt

Sample Team Members	Name	Signature	Init.	Company/Organization/Phone/Cell
	Robert Lynch		RL	SNL/08888/505-844-4013/505-250-7090
	William Gibson		WG	SNL/08888/505-284-3307/505-239-7367

Relinquished by		Org. 8888	Date 4/17/19	Time 1124	Relinquished by	Org.	Date Time
Received by	SMO	Org. 20641	Date 4/17/19	Time 1124	Received by	Org.	Date Time
Relinquished by	SMO	Org. 20641	Date 4/17/19	Time 1215	Relinquished by	Org.	Date Time
Received by		Org. GEL	Date 4/18/19	Time 745	Received by	Org.	Date Time

Lab Use

*Prior confirmation with SMO required for 7 and 15 day TAT

SMO 2012-ARCOC (4-2012)

CONTRACT LABORATORY
ANALYSIS REQUEST AND CHAIN OF CUSTODY (Continuation)

AOP 95-16

AR/COC 619631

Project Name:	BSG AOC	Project/Task Manager:	Michael Skelly	Project/Task No.:	195122.12.11.01
Tech Area:					
Building:	Room:				

Sample No.	Fraction	Sample Location Detail	Depth (ft)	Date/Time Collected	Sample Matrix	Container Type	Container Volume	Preservative	Collection Method	Sample Type	Parameter & Method Requested	Lab use Lab Sample ID
108030	010	CYN-MW15	182	4/17/19 10:29	GW	P	1 L	HNO3	G	SA	GAMMA SPEC, SHORT LIST (EPA 901)	011
108030	011	CYN-MW15	182	4/17/19 10:30	GW	P	1 L	HNO3	G	SA	GROSS-ALPHA/BETA (EPA 900)	012
108030	012	CYN-MW15	182	4/17/19 10:31	GW	P	1 L	HNO3	G	SA	ISO U (HASL-300)	013
108030	013	CYN-MW15	182	4/17/19 10:32	GW	AG	250 ml	NONE	G	SA	TRITIUM (EPA 906)	014
108031	001	BSG-TB 23	NA	4/17/19 10:16	DIW	G	3x40 ml	HCl	G	TB	VOC, TCL (SW846-8260B)	015
108060	004	BSG-TB 24	NA	4/17/19 10:18	DIW	AG	3x40 ml	NONE	G	TB	TPH-GRO (SW846-8015)	016
108061	004	BSG-FB 6	NA	4/17/19 10:18	DIW	AG	3x40 ml	NONE	G	FB	TPH-GRO (SW846-8015)	017

Recipient Initials_____

GEL LABORATORIES LLC
2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Certificate of Analysis

Report Date: June 4, 2019

Company :	Sandia National Laboratories
Address :	1515 Eubank SE,ORG 4142 BLDG. 1090/120, MS 1103 Albuquerque, New Mexico 87123
Contact:	Ms. Wendy Palencia
Project:	Groundwater, Level C Package

Client Sample ID:	108030-008	Project:	SNLSGWtr
Sample ID:	476753009	Client ID:	SNLS005
Matrix:	AQUEOUS		
Collect Date:	17-APR-19 10:27		
Receive Date:	18-APR-19	Client Desc.:	CYN-MW15
Collector:	Client	Vol. Recv.:	

Parameter	Qualifier	Result	DL	RL	Units	PF	DF	Analyst	Date	Time	Batch	Method
Ion Chromatography												
EPA 314.0 Perchlorate by IC "As Received"												
Perchlorate	U	ND	0.004	0.012	mg/L		1	LXA2	05/10/19	2004	1871195	1

The following Analytical Methods were performed:

Method	Description	Analyst Comments
1	EPA 314.0 DOE-AL	

Notes:

Column headers are defined as follows:

DF: Dilution Factor	Lc/LC: Critical Level
DL: Detection Limit	PF: Prep Factor
MDA: Minimum Detectable Activity	RL: Reporting Limit
MDC: Minimum Detectable Concentration	SQL: Sample Quantitation Limit

Appendix B
Data Validation Sample Findings
Summary Sheets for the Perchlorate Data

ANALYTICAL QUALITY ASSOCIATES, INC

PO Box 21987
Albuquerque, NM 87154
1-888-678-5447
www.aqainc.net

Memorandum

Date: June 17, 2019

To: File

From: Linda Thal

Subject: Inorganic Data Review and Validation – SNL
Site: BSG AOC
ARCOC: 619631
SDG: 476753
Laboratory: GEL
Project/Task: 195122.12.11.01
Analysis: General Chemistry

See the attached Data Validation Worksheets for supporting documentation on the data review and validation. This validation was performed according to SNL/NM SMO Procedure AOP 00-03 Rev 5.

Summary

One sample was prepared and analyzed with accepted procedures using methods EPA 9056A (anions by IC), SM 2320B (total alkalinity), EPA 314.0 (perchlorate) and EPA 353.2 (nitrate/nitrite). Data were reported for all required analytes. Problems were identified with the data package that resulted in the qualification of data.

Anions:

1. The MS and replicate were performed on sample 475535006, an EB from another SNL SDG. The associated sample results were detects and will be **qualified J,MS1,RP1** due to lack of matrix-specific accuracy and precision data.

Data are acceptable and reported QC measures appear to be adequate. The following sections discuss the data review and validation.

Holding Times and Preservation

The sample was prepared and analyzed within the prescribed holding times and was properly preserved.

Calibration

All initial and continuing calibrations met QC acceptance criteria except as follows. The initial calibration intercept was negative with an absolute value > the MDL but ≤3X the MDL for fluoride. The associated sample result was a detect >3X the absolute value of the intercept and will not be qualified.

Blanks

No target analytes were detected in any of the blanks.

Laboratory Control Sample (LCS)

All LCS acceptance criteria were met.

Matrix Spike and Matrix Spike Duplicate (MS/MSD)

The MS/PS met QC acceptance criteria except as noted above in the Summary section. It should be noted that the MS/PS analyses for alkalinity and nitrate/nitrite were performed on SNL samples of similar matrix from other SDGs. No data will be qualified.

Laboratory Replicate

The replicate analysis met all QC acceptance criteria except as noted above in the Summary section. It should be noted that the replicate analyses for alkalinity and nitrate/nitrite were performed on SNL samples of similar matrix from other SDGs. No data will be qualified.

Detection Limits/Dilutions

All detection limits were properly reported and correctly adjusted for dilutions performed due to elevated target analyte concentrations and/or matrix interference.

Anions:
The sample was diluted 20X for chloride and sulfate.

Nitrate/Nitrite:
The sample was diluted 25X.

Other QC

No other specific issues that affect data quality were identified.

Reviewed by: Jeanne Peterson **Level:** I **Date:** 06/17/2019

Sample Findings Summary

AR/COC: 619631

Analytical Method	Sample ID	Analyte Name (CAS#)	Qualifier, RC
DOE EML HASL-300, U-02-RC			
	108030-012/CYN-MW15	Uranium-235/236 (15117-96-1/13982-70-)	J, FR7
EPA 900.0/SW846 9310			
	108030-011/CYN-MW15	BETA (12587-47-2)	R, FR4
EPA 901.1			
	108030-010/CYN-MW15	Americium-241 (14596-10-2)	BD, FR3
	108030-010/CYN-MW15	Cesium-137 (10045-97-3)	BD, FR3
	108030-010/CYN-MW15	Cobalt-60 (10198-40-0)	BD, FR3
	108030-010/CYN-MW15	Potassium-40 (13966-00-2)	BD, FR3
EPA 906.0 Modified			
	108030-013/CYN-MW15	Tritium (10028-17-8)	BD, FR3
SW846 3005A/6020B			
	108030-009/CYN-MW15	Manganese (7439-96-5)	R, CK3
SW846 3535A/8015D			
	108030-003/CYN-MW15	Diesel Range Organics (68334-30-5)	UJ, MS5
SW846 3535A/8330B			
	108030-002/CYN-MW15	m-Nitrotoluene (99-08-1)	UJ, I4
	108030-002/CYN-MW15	Nitrobenzene (98-95-3)	UJ, I4
	108030-002/CYN-MW15	o-Nitrotoluene (88-72-2)	UJ, DL3
	108030-002/CYN-MW15	p-Nitrotoluene (99-99-0)	UJ, I4
SW846 8015A/B VOC			
	108030-004/CYN-MW15	Gasoline Range Organics (8006-61-9)	UJ, MS3,MS5
	108060-004/BSG-TB 24	Gasoline Range Organics (8006-61-9)	UJ, MS3,MS5
	108061-004/BSG-FB 6	Gasoline Range Organics (8006-61-9)	UJ, MS3,MS5
SW846 8260B DOE-AL			

Analytical Method	Sample ID	Analyte Name (CAS#)	Qualifier, RC
	108029-001/BSG-FB 5	1,1,2,2-Tetrachloroethane (79-34-5)	UJ, MS5
	108029-001/BSG-FB 5	1,2,3-Trichlorobenzene (87-61-6)	UJ, MS5
	108029-001/BSG-FB 5	1,2,4-Trichlorobenzene (120-82-1)	UJ, MS5
	108029-001/BSG-FB 5	1,2-Dibromo-3-chloropropane (96-12-8)	UJ, MS5
	108029-001/BSG-FB 5	1,2-Dichlorobenzene (95-50-1)	UJ, MS5
	108029-001/BSG-FB 5	1,3-Dichlorobenzene (541-73-1)	UJ, MS5
	108029-001/BSG-FB 5	1,4-Dichlorobenzene (106-46-7)	UJ, MS5
	108029-001/BSG-FB 5	2-Hexanone (591-78-6)	UJ, MS5
	108029-001/BSG-FB 5	4-Methyl-2-pentanone (108-10-1)	UJ, MS5
	108029-001/BSG-FB 5	Acetone (67-64-1)	10U, B
	108029-001/BSG-FB 5	Bromoform (75-25-2)	UJ, MS5
	108029-001/BSG-FB 5	Isopropylbenzene (98-82-8)	UJ, MS5
	108029-001/BSG-FB 5	Tetrachloroethylene (127-18-4)	UJ, MS5
	108030-001/CYN-MW15	1,1,2,2-Tetrachloroethane (79-34-5)	UJ, MS5
	108030-001/CYN-MW15	1,2,3-Trichlorobenzene (87-61-6)	UJ, MS5
	108030-001/CYN-MW15	1,2,4-Trichlorobenzene (120-82-1)	UJ, MS5
	108030-001/CYN-MW15	1,2-Dibromo-3-chloropropane (96-12-8)	UJ, MS5
	108030-001/CYN-MW15	1,2-Dichlorobenzene (95-50-1)	UJ, MS5
	108030-001/CYN-MW15	1,3-Dichlorobenzene (541-73-1)	UJ, MS5
	108030-001/CYN-MW15	1,4-Dichlorobenzene (106-46-7)	UJ, MS5
	108030-001/CYN-MW15	2-Hexanone (591-78-6)	UJ, MS5
	108030-001/CYN-MW15	4-Methyl-2-pentanone (108-10-1)	UJ, MS5
	108030-001/CYN-MW15	Acetone (67-64-1)	10U, B
	108030-001/CYN-MW15	Bromoform (75-25-2)	UJ, MS5
	108030-001/CYN-MW15	Isopropylbenzene (98-82-8)	UJ, MS5
	108030-001/CYN-MW15	Tetrachloroethylene (127-18-4)	UJ, MS5
	108031-001/BSG-TB 23	1,1,2,2-Tetrachloroethane (79-34-5)	UJ, MS5

Analytical Method	Sample ID	Analyte Name (CAS#)	Qualifier, RC
	108031-001/BSG-TB 23	1,2,3-Trichlorobenzene (87-61-6)	UJ, MS5
	108031-001/BSG-TB 23	1,2,4-Trichlorobenzene (120-82-1)	UJ, MS5
	108031-001/BSG-TB 23	1,2-Dibromo-3-chloropropane (96-12-8)	UJ, MS5
	108031-001/BSG-TB 23	1,2-Dichlorobenzene (95-50-1)	UJ, MS5
	108031-001/BSG-TB 23	1,3-Dichlorobenzene (541-73-1)	UJ, MS5
	108031-001/BSG-TB 23	1,4-Dichlorobenzene (106-46-7)	UJ, MS5
	108031-001/BSG-TB 23	2-Hexanone (591-78-6)	UJ, MS5
	108031-001/BSG-TB 23	4-Methyl-2-pentanone (108-10-1)	UJ, MS5
	108031-001/BSG-TB 23	Acetone (67-64-1)	10UJ, B,C3
	108031-001/BSG-TB 23	Bromoform (75-25-2)	UJ, MS5
	108031-001/BSG-TB 23	Isopropylbenzene (98-82-8)	UJ, MS5
	108031-001/BSG-TB 23	Tetrachloroethylene (127-18-4)	UJ, MS5
SW846 9056A			
	108030-006/CYN-MW15	Bromide (24959-67-9)	J, MS1,RP1
	108030-006/CYN-MW15	Chloride (16887-00-6)	J, MS1,RP1
	108030-006/CYN-MW15	Fluoride (16984-48-8)	J, MS1,RP1
	108030-006/CYN-MW15	Sulfate (14808-79-8)	J, MS1,RP1

All other analyses met QC acceptance criteria; no further data should be qualified.

SECTION III
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APPENDICES

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SECTION III
TECHNICAL AREA-V IN-SITU BIOREMEDIATION TREATABILITY STUDY FULL-SCALE OPERATION, April – June 2019

1.0 Background

Sandia National Laboratories, New Mexico (SNL/NM) personnel are conducting a Treatability Study of in-situ bioremediation (ISB) at Technical Area-V (TA-V). SNL/NM personnel plan to conduct the Treatability Study in two phases. Phase I includes a pilot test followed by full-scale operation at the first injection well (TAV-INJ1); Phase II includes full-scale operations at two additional injection wells (TAV-INJ2 and TAV-INJ3) contingent on the success of Phase I. The three injection wells, TAV-INJ1, TAV-INJ2, and TAV-INJ3, are located near monitoring wells TAV-MW6, TAV-MW10, and LWDS-MW1, respectively, where the highest contaminant concentrations in TA-V groundwater have been detected.

SNL/NM personnel have installed the first injection well TAV-INJ1 and completed the Phase I pilot test at this well. The operation and results of the pilot test were presented in Section III of the October 2018 Environmental Restoration Operations (ER) Consolidated Quarterly Report (ER Quarterly Report) (SNL/NM October 2018). The Phase I full-scale operation at well TAV-INJ1 began in October 2018 with the first injection occurring on November 1, 2018. The injection period lasted approximately six months with the final injection on April 25, 2019. The injection period is followed by two years of groundwater monitoring for the performance of the ISB, at a monthly frequency starting May 2019 for three months and then quarterly ending May 2021.

The implementation of the Treatability Study is governed by the Revised Treatability Study Work Plan (TSWP) (SNL/NM March 2016) and where applicable, the approved modifications for the full-scale operation at TAV-INJ1 (U.S. Department of Energy [DOE] July 2018; New Mexico Environment Department [NMED] August 2018). Appendix A includes a copy of the NMED Hazardous Waste Bureau approval letter and DOE's submittal of the proposed modifications.

This Section III of the ER Quarterly Report provides a summary of the six-month injection period of the Phase I full-scale operation from November 2018 to April 2019. This section also presents the monitoring results for the April – June 2019 reporting period. A technical memorandum for the Phase I Treatability Study, including both the pilot test and the full-

scale operation, will be produced after the Phase I performance monitoring period has concluded in May 2021, in accordance with the Revised TSWP (SNL/NM March 2016).

2.0 Full-Scale Operation Activities at Well TAV-INJ1

The ISB Treatability Study is designed to evaluate the efficacy of injecting a substrate solution and bioaugmentation culture to induce the denitrification of nitrate and complete dechlorination of trichloroethene (TCE) in the Regional Aquifer. The substrate solution, along with KB-1 dechlorinating bacteria (a product purchased from SiREM), is gravity-injected into the groundwater via injection wells. As planned in the Revised TSWP, the goal of the full-scale injections at well TAV-INJ1 is to deliver a total of 530,000 gallons of substrate solution mixed with 120 liters of KB-1 dechlorinating bacteria over a six-month period (SNL/NM March 2016).

The As-Built Engineering Drawings for the full-scale injection assembly are included in Appendix B. The drawings include the final site layout plan, injection manifold and well head assembly diagram, and injection system diagram. As shown in Sheet 4, the site layout plan for full-scale test at well TAV-INJ1, two aboveground tanks were used for full-scale operation, reduced from the four originally proposed in the Revised TSWP (SNL/NM March 2016) (see Modification #2 in Appendix A).

2.1 Volume of Injection

For the full-scale injections at well TAV-INJ1, the substrate solution was mixed in two aboveground 5,000-gallon polyethylene tanks (Deoxygenation Tanks A and B). The 1st batch was injected on November 1, 2018 and the 110th and final batch was injected on April 25, 2019. Table III-1 presents the volume, the average flow rate, and the maximum injection head (water column height inside the well casing) above static groundwater level for each injection batch. A total of 531,516 gallons of substrate solution was discharged to groundwater, averaging 4,832 gallons per batch (i.e., per injection or per tank).

During the first three months of the injection period, each tank was emptied within one workday (i.e., standard injection). Starting in mid-February 2019, the project team implemented a longer (extended) period of injections at lower flow rates when the substrate solution was controlled to flow at a lower pressure head. Extended injections normally took overnight to complete. Hydrogeologically, extended injections at lower flow rates were beneficial for optimizing the distribution and transport of nutrients and bacteria to the

surrounding region because the flow was more evenly distributed along the well screen. Lowering the pressure head would reduce the mounding near the injection well. Extended injections also helped open up flow channels near the well. Thereafter, the intermittent standard injections experienced less pressure head buildup than previous injections.

2.2 Substrate Solution and Bioaugmentation Culture

Table III-2a presents the functionality of each component of the substrate solution and their weight proposed before starting the full-scale operation. The weight of each component per 1,000 gallons of water is converted to weight per 5,000 gallons of water in the last column of Table III-2a for easy comparison to the actual usage presented in Table III-2b.

Table III-2b presents the actual usage of each component and KB-1 dechlorinating bacteria for each of the 110 injections. The quantities of diammonium phosphate, sodium bromide, and KB-1 dechlorinating bacteria were the same as proposed during the six-month injection. The quantities of potassium bicarbonate and sodium sulfite changed from time to time throughout the injection period. The quantities of ethyl lactate and Accelerite® remained the same as proposed until the last six injections, when the quantity of ethyl lactate was reduced and Accelerite® was eliminated in order to stabilize the final in-well groundwater chemistry in anticipation of the end of the injection period.

Potassium bicarbonate and sodium sulfite were the key ingredients for achieving conditions necessary for the survival of the KB-1 dechlorinating bacteria by lowering dissolved oxygen (DO) to less than 1 milligram per liter (mg/L) and oxidation reduction potential (ORP) to below negative 75 millivolts in the substrate solution. For each injection, these two chemicals were mixed in potable water first to deoxygenate and reduce the water to desired conditions. The water quality in the tanks was evaluated using electronic sondes and meters. The quantities of these two chemicals were increased from the quantities originally planned in Table III-2a in order to achieve the necessary DO and ORP levels. Adjustments to the quantities of these two components were frequently made during the six-month period, as shown in Table III-2b, to induce optimal conditions not only in the tanks but also in the well for the dechlorinating bacteria to establish.

Once the DO and ORP in the tanks reached acceptable levels, the rest of the chemicals (i.e., the nutrients and the tracer) were added to the tanks and recirculated for optimal mixing. A batch was ready to inject when the key parameters were met: potential of hydrogen (pH) between 7 and 9, DO less than 1 mg/L, and ORP below negative 75 millivolts.

The Revised TSWP required that each daily injection be followed by approximately 100 gallons of chase water to push the substrate solution away from the well screen to mitigate biofouling (SNL/NM March 2016). After potassium bicarbonate and sodium sulfite were mixed in the 5,000-gallon tank but before the nutrients and tracer were added, approximately 100 gallons were drawn and stored in a standalone 150-gallon chase water tank. Chase water was used when one injection was completed and the next injection was scheduled for the following workday. Chase water was not necessary when the next injection followed on the same workday (Table III-1).

Table III-2b also presents the total quantities of the chemicals used in the full-scale operation. The mixing ratio for the substrate solution consisted of approximately 99.88 percent potable water and 0.12 percent amendments including the inert tracer. The mixing ratio of the KB-1 dechlorinating bacteria was approximately 1.1 liter per 5,000 gallons of substrate solution. A total of 122.8 liters of the KB-1 dechlorinating bacteria were injected to groundwater during full-scale operation.

2.3 Cleaning of the Aboveground Injection System

After completing the injections, the aboveground injection system was cleaned, partially dismantled, and stored. The project site was secured pending the decision on whether to proceed with Phase II of the Treatability Study. The two 5,000-gallon aboveground tanks and the associated equipment and piping were cleaned using household bleach in May 2019. The wastewater was discharged to a nearby sanitary sewer manhole at TA-V. The discharge was approved by the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) under Permit Number 2069K (ABCWUA September 2018), and was conducted in accordance with the conditions set forth in the approval.

3.0 Groundwater Monitoring for Full-Scale Operation at Well TAV-INJ1

The first treatment zone of the Treatability Study encompasses the injection well TAV-INJ1 and two nearby monitoring wells (TAV-MW6 and TAV-MW7). In-Situ Incorporated Aqua TROLL® 600 Multiparameter sondes were installed in these three wells. The parameters measured by the sonde include pressure, DO, ORP, pH, specific conductivity, temperature, and turbidity, in accordance with the Revised TSWP (SNL/NM March 2016). Pressure readings were converted to groundwater elevation above mean sea level for reporting.

Groundwater levels for the three wells before, during, and after the six-month injection period are discussed in Section 3.1. Details for the other parameters will be presented in the technical memorandum for the Phase I Treatability Study. Section 3.2 presents the groundwater elevation contour map for the entire area of TA-V.

Groundwater samples were collected from the three wells in the treatment zone as well as eight wells outside the treatment zone as planned in the Revised TSWP (SNL/NM March 2016). Table III-3 lists the sampling dates for the April – June 2019 reporting period for all the wells pertinent to the Treatability Study. Sections 3.3 and 3.4 present more details on the sampling frequency and analytical parameters for each well. Analytical results are presented in Tables III-4 through III-7. Table III-8 summarizes the stabilized water quality parameters measured immediately before sample collection at each well sampled during this reporting period.

3.1 Groundwater Levels in the Treatment Zone

Figures III-1 through 3 show the groundwater elevations in wells TAV-INJ1, TAV-MW6, and TAV-MW7, respectively. Note that the vertical scale (treatment solution or groundwater elevation) is different for each figure. The pre-injection static groundwater elevations are also shown as a point of reference throughout the injection period.

Figure III-1 shows the treatment solution/groundwater elevations measured at TAV-INJ1, starting on October 25, 2018 and ending on June 30, 2019. All 110 peak injection heads are included in this figure. The injection head ranged from approximately 120 feet above static to approximately 370 feet above static. Between December 21, 2018 and the first injection in 2019 on January 8, the groundwater elevation returned to approximate static level. After the final injection on April 25, 2019, the water level returned to and remained at static level since May 13, 2019.

Figure III-2 shows the groundwater elevations measured at monitoring well TAV-MW6 during the same period from October 25, 2018 to June 30, 2019. Well TAV-MW6 is located approximately 50 feet east-southeast of the injection well, and is screened across the water table as is the injection well. Ninety-three (93) of the 110 injections were recorded in well TAV-MW6, because the sonde was pulled out of the well the day before the well was sampled and re-installed the day after, while injections were ongoing in well TAV-INJ1. For the 93 injections, the groundwater elevation at well TAV-MW6 rose and fell in response to injections at TAV-INJ1, with a much lower magnitude than observed in the injection well: the peak groundwater elevation above static ranged between 0.21 and 3.77 feet in well

TAV-MW6. The groundwater elevation in well TAV-MW6 has returned to static level by the end of June 2019.

Figure III-3 shows the groundwater elevations measured at monitoring well TAV-MW7 from December 19, 2018 to June 30, 2019. Well TAV-MW7 is located approximately 27 feet east-southeast of the injection well, and is screened approximately 90 feet below the water table. The gaps in Figure III-3 indicate no sonde was in the well either when the well was sampled or because of equipment failure. No sonde was installed in well TAV-MW7 before December 19, 2018 due to equipment failure. The groundwater elevations in well TAV-MW7 did not respond to injections at TAV-INJ1. The groundwater elevation in well TAV-MW7 has returned to static level by the end of June 2019.

3.2 Groundwater Levels at Technical Area-V

Figure III-4 shows the April 2019 groundwater elevation contour map (potentiometric surface figure) for the Regional Aquifer at TA-V. The groundwater elevation contours are similar to the pre-operation October 2018 contours (SNL/NM April 2019). Groundwater flows generally to the west and southwest in the vicinity of the ISB treatment zone. The full-scale injections did not create a long-term impact on the potentiometric surface at TA-V.

3.3 Groundwater Monitoring in the Treatment Zone

Performance monitoring for the ISB Treatability Study full-scale operation at well TAV-INJ1 involves groundwater sampling at the injection well and two nearby monitoring wells TAV-MW6 and TAV-MW7. Even though well TAV-MW7 does not serve for monitoring the performance of ISB, this well is included in the monitoring of the ISB at well TAV-INJ1 to define the vertical impact of the injected solution. Pre-operation sampling was conducted in September 2018 with results presented in the April 2019 ER Quarterly Report (SNL/NM April 2019).

During the six-month injection period from November 2018 to April 2019, injection well TAV-INJ1 was not sampled, well TAV-MW6 was sampled monthly, and well TAV-MW7 was sampled quarterly, in accordance with the Revised TWSP (SNL/NM March 2016) and where applicable, the approved modifications for the full-scale operation at TAV-INJ1 (DOE July 2018; NMED August 2018).

The injection period is followed by two years of groundwater monitoring for the performance of the ISB. Wells TAV-INJ1 and TAV-MW6 will be sampled monthly for May, June, and July 2019, and then quarterly ending May 2021, in accordance with the Revised TSWP (SNL/NM March 2016). Sampling frequency at well TAV-MW7 is quarterly in accordance with Modification #7 in Appendix A.

During this reporting period, injection well TAV-INJ1 was sampled twice after the injections were concluded at the end of April; monitoring well TAV-MW6 was sampled three times; and monitoring well TAV-MW7 was sampled once (Table III-3).

3.3.1 Groundwater Monitoring at Well TAV-INJ1

During the full-scale operation, the project team discovered significant sediment accumulation in the injection well. This is probably due to the repeated disturbance of the geological formation by the 110 injections over the six-month period. As a result, the sampling pump was placed higher than the pre-operation sampling when the well was free of suspended sediment. The purge volume before sample collection at well TAV-INJ1 during the pilot test and pre-operation sampling in September 2018, was 59 gallons. However, after six-month injections, the well was dry after pumping approximately 11.5 gallons of well water. The usual practice is to let the well recover overnight and collect samples the next day. However, the microbial sample was required to be collected immediately after purging on the first day. In the two sampling events at well TAV-INJ1, the microbial samples were collected on June 3 and June 25, and the rest of the samples were collected on June 4 and June 26, 2019 (Table III-3).

The analytical parameters for groundwater samples from well TAV-INJ1 include the following in accordance with Modification #8 in Appendix A:

- Alkalinity (total, bicarbonate, and carbonate)
- Ammonia (as nitrogen)
- Anions (bromide and sulfate)
- *Dehalococcoides* (Dhc) and, if Dhc is present, vinyl chloride reductase
- Dissolved metals (arsenic, iron, and manganese)
- Methane/ethane/ethene
- Nitrate plus nitrite (NPN)
- Total organic carbon (TOC)
- Volatile organic compounds (VOCs)

Table III-4 provides the analytical results for the April – June 2019 sampling at well TAV-INJ1. The results show that:

- The two constituents of concern in the groundwater at TA-V, nitrate (as NPN) and TCE, were not detected in the two sampling events at well TAV-INJ1.
- Alkalinity and ammonia concentrations did not change much during the three-week timeframe of the two sampling events in June 2019.
- Results of bromide and sulfate in the June 4, 2019 sample appear to be anomalous because both results were significantly lower than those in the June 26, 2019 sample. The bromide concentration in aboveground tanks was approximately 19 mg/L. The bromide concentration in the June 26, 2019 was more reasonable. Continued sampling in the third quarter of CY 2019 will clarify these results.
- The Dhc are in the same order of magnitude at 10E6 gene copies per liter from the two sampling events. This is the starting population of the introduced dechlorinating bacteria in the groundwater.
- During the ISB, the substrate solution produces strongly redox conditions in the aquifer that solubilize and mobilize naturally occurring metals and metalloids. As expected, concentrations of arsenic, iron, and manganese increased during the three-week timeframe of the two sampling events in June 2019. Concentrations of arsenic exceeded the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 0.01 mg/L. The solubilization of these metals is a transient phenomenon and is limited to the treatment zone. Solubilized metals and metalloids will precipitate into solid form once they leave the anaerobic treatment zone.
- High levels of methane were detected in the groundwater at the injection well, while ethene was not detected.
- TOC concentration decreased more than half.

3.3.2 Groundwater Monitoring at Well TAV-MW6

The analytical parameters for groundwater samples from well TAV-MW6 are the same as those for well TAV-INJ1 in accordance with Modification #8 in Appendix A.

Table III-5 provides the analytical results for the April –June 2019 sampling at well TAV-MW6. The results show that:

- NPN concentrations were 16.6/16.7, 7.9, and 7.29 mg/L in samples collected in April (including a duplicate), May, and June 2019, respectively. NPN concentrations were above the EPA MCL of 10 mg/L in April and were the highest since the well was installed in 2002. NPN concentrations decreased to baseline levels and were below the EPA MCL in May and June.

- TCE concentrations were 6.91/7.56, 6.78, and 6.74 micrograms per liter in samples collected in April (including a duplicate), May, and June 2019, respectively, exceeding the EPA MCL of 5 micrograms per liter. These concentrations are consistent with the baseline sampling results.
- Bromide is the inert tracer that was added to the substrate solution. Bromide concentration is expected to increase in well TAV-MW6 as the substrate solution moves away from the injection well. Bromide concentrations increased gradually from the baseline result of 0.815 mg/L in September 2018 to 4.12 mg/L in June 2019.
- The results for the rest of the analytes are consistent with the baseline sampling results.
- Groundwater field parameters before sample collection in April, May, and June do not show significant change, except for DO (Table III-8). DO has decreased from 5.27 mg/L to 3.63 mg/L from April to June, 2019.

3.3.3 Groundwater Monitoring at Well TAV-MW7

The analytical parameters for groundwater samples from well TAV-MW7 include the following in accordance with Modification #7 in Appendix A:

- Bromide
- Dissolved metals (arsenic, iron, and manganese)
- Ethene
- NPN
- VOCs

Table III-6 provides the analytical results for the April – June 2019 sampling at well TAV-MW7, which is screened 90 feet below the water table. The results show that:

- For the two constituents of concern, NPN concentration was 5.47 mg/L which is below the EPA MCL of 10 mg/L and TCE was not detected. These results are consistent with the baseline sampling results.
- The results for the rest of the analytes are also consistent with the baseline sampling results, including bromide.

3.4 Groundwater Monitoring Outside the Treatment Zone

In accordance with Section 5.5 of the Revised TSWP (SNL/NM March 2016), eight wells are sampled quarterly for dissolved metals (iron, manganese, and arsenic) to evaluate potential impact of substrate solution on groundwater outside the Phase I Treatability Study

treatment zone. The eight wells are: LWDS-MW1, TAV-MW2, TAV-MW4, TAV-MW8, TAV-MW10, TAV-MW11, TAV-MW12, and TAV-MW14. The analytical parameters for groundwater samples from these wells include the following:

- Dissolved metals (arsenic, iron, and manganese)
- NPN
- VOCs

These parameters are the same as those for the other wells in the TA-V groundwater monitoring network (SNL/NM June 2019). Table III-3 lists the sampled dates for these wells in this reporting period. Table III-7 provides the analytical results for the April – June 2019 sampling at the eight wells. Duplicate samples were collected from well TAV-MW12, per the monitoring scheme of the SNL/NM Long-Term Stewardship program for the TA-V groundwater monitoring network.

All analytical results and field parameters are consistent with the historical values at these eight wells presented in Chapter 5 of the CY 2018 Annual Groundwater Monitoring Report (SNL/NM June 2019).

3.5 Summary of Groundwater Monitoring Results for the Treatability Study

Approximately one month after injections were completed, the groundwater elevations returned to static level in the injection well (Figure III-1). The groundwater elevations in wells TAV-MW6 and TAV-MW7 also returned to static levels by the end of this reporting period (Figures III-2 and III-3).

Unlike the groundwater level response observed in well TV-MW6, groundwater level response in well TAV-MW7 shows no direct hydraulic connection with the injections. Figure III-3 confirms the rationale for excluding well TAV-MW7 as an ISB performance monitoring well and reverting it back to the TA-V groundwater monitoring network, which is administered by the SNL/NM Long-Term Stewardship program (see Modification #7 in Appendix A).

With the influx of substrate solution, the water in and surrounding the injection well has turned anaerobic and reduced, the conditions necessary for the dechlorinating bacteria to establish population. Based on the groundwater analytical results at the injection well:

- Both NPN and TCE were not detected. Nitrate would have been biodegraded by native bacteria as being the most favorable electron accepter after DO was depleted (see Section 3.0 of the Revised TSWP [SNL/NM March 2016]). It is also possible

that the native groundwater was pushed away from the well by the injections and has not flowed back or completely mixed with the injected solution.

- There was sufficient initial population of the Dhc (on the order of 10E6 gene copies per liter) in the groundwater at the injection well. Additional monitoring is necessary to detect any dechlorination activity.
- Concentrations of dissolved metals have increased as expected.
- High levels of methane and TOC being consumed indicate active microbial activity in the groundwater near the injection well along with carbon consumption. However, ethene is the parameter indicating complete dechlorination from TCE, and dechlorination has not occurred or not to a detectable extent.

Well TAV-MW6 serves as monitoring well for the performance of ISB in the treatment zone. The groundwater analytical results at this well indicate that:

- Bromide, the inert tracer, has migrated to well TAV-MW6.
- The Dhc have not reached well TAV-MW6.
- The groundwater DO levels have decreased at TAV-MW6, an early sign that the groundwater is turning anaerobic at this well.

Groundwater results from well TAV-MW7 indicate that the substrate solution injected at TAV-INJ1 has not impacted the deeper groundwater monitored by this well.

For the eight wells located outside the treatment zone, there is no impact on the groundwater chemistry at these wells from the substrate solution injected at well TAV-INJ1.

4.0 Deviations

No deviations were encountered with regards to the Revised TWSP (SNL/NM March 2016) and where applicable, the approved modifications for the full-scale operation at TAV-INJ1 (DOE July 2018; NMED August 2018).

In Modification #7 in Appendix A, SNL/NM personnel proposed installing an in-situ water quality sonde (i.e., In-Situ Incorporated Aqua TROLL® 600 Multiparameter sonde) in well TAV-MW7 during full-scale operation. The groundwater elevation during and after the six-month injection period (Figure III-3) and the analytical results at well TAV-MW7 (Table III-6) indicate that the injection of approximately 530,000 gallons substrate solution at well TAV-INJ1 did not impact the deep hydrostratigraphic zone where well TAV-MW7 is screened. Therefore, SNL/NM proposes to remove the sonde from this well because

continuously collecting water quality data is not necessary. Groundwater field parameters are measured each time before the well is sampled (as in Table III-8). This provides sufficient information on water quality at well TAV-MW7.

5.0 References

ABCWUA, see Albuquerque Bernalillo County Water Utility Authority.

Albuquerque Bernalillo County Water Utility Authority (ABCWUA), September 2018. Letter to J.W. Todd (U.S. Department of Energy, NNSA/Sandia Field Office), "Request to Discharge Two Waste Streams to the Sanitary Sewer at Technical Area-V under ABCWUA Industrial Wastewater Permit Number 2069K," ABCWUA, Albuquerque, New Mexico, September 18, 2018.

DOE, see U.S. Department of Energy.

New Mexico Environment Department (NMED), August 2018. Letter to J.P. Harrell (U.S. Department of Energy NNSA/Sandia Field Office) and R.O. Griffith (Sandia National Laboratories), "Approval: Technical Area-V (TA-V) Treatability Study Notification of Full-Scale Operation at Well TAV-INJ1, Sandia National Laboratory, EPA ID#NM5890110518, HWB-SNL-15-020," August 13, 2018.

NMED, see New Mexico Environment Department.

Sandia National Laboratories, New Mexico (SNL/NM), March 2016. *Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern,* Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), October 2018. *Environmental Restoration Operations Consolidated Quarterly Report April – June 2018*, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), April 2019. *Environmental Restoration Operations Consolidated Quarterly Report October – December 2018*, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories, New Mexico (SNL/NM), June 2019. *Annual Groundwater Monitoring Report, Calendar Year 2018*, Long-Term Stewardship Consolidated Groundwater Monitoring Program, Long-Term Stewardship and Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

SNL/NM, see Sandia National Laboratories, New Mexico.

U.S. Department of Energy (DOE), July 2018. Letter to J. E. Kieling (New Mexico Environment Department), "Technical Area-V (TA-V) Treatability Study Notification of Full-Scale Operation at Well TAV-INJ1", July 20, 2018.

Figures

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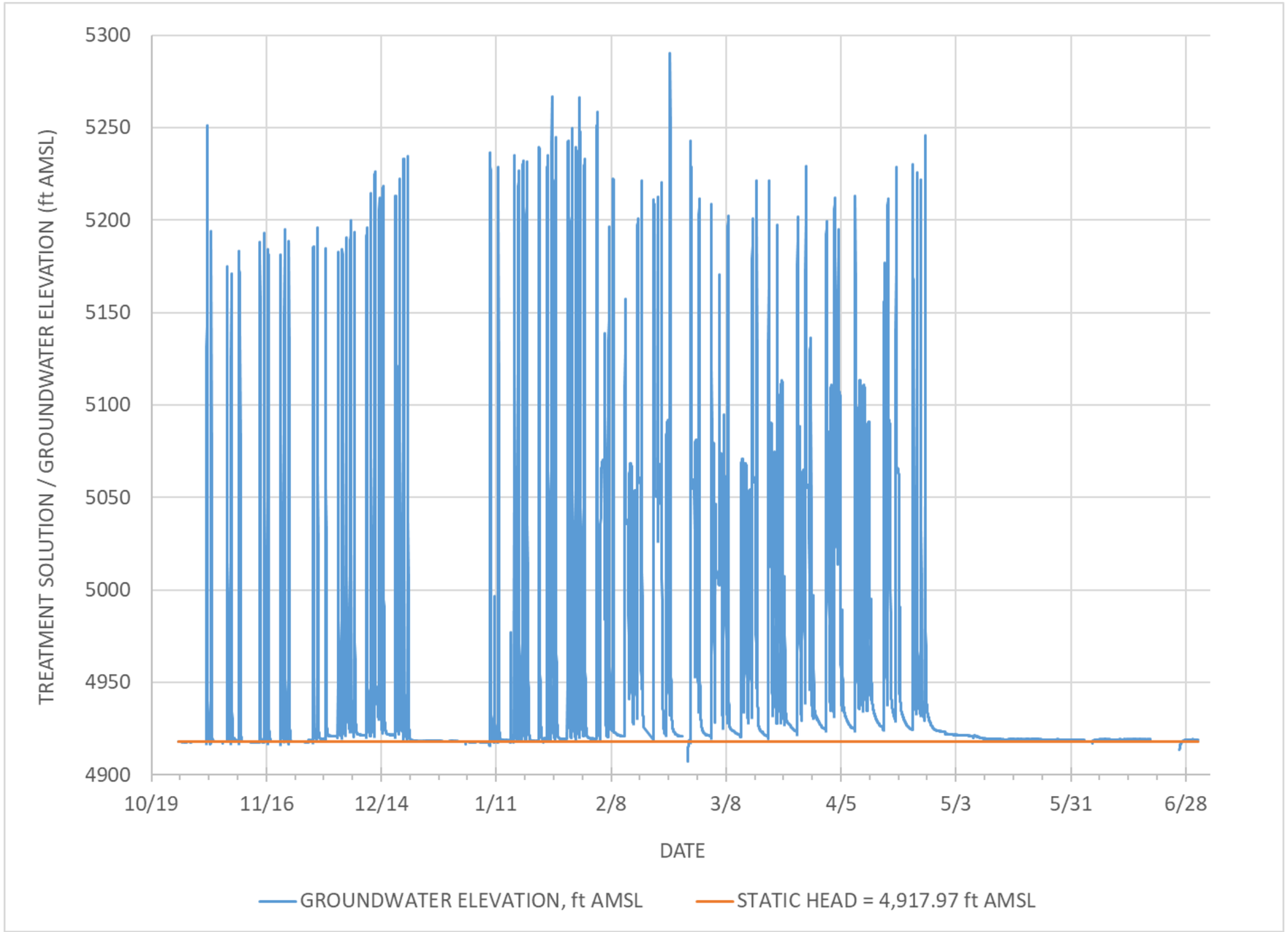

Figure III-1
Treatment Solution/Groundwater Elevations in Well TAV-INJ1, October 25, 2018 – June 30, 2019

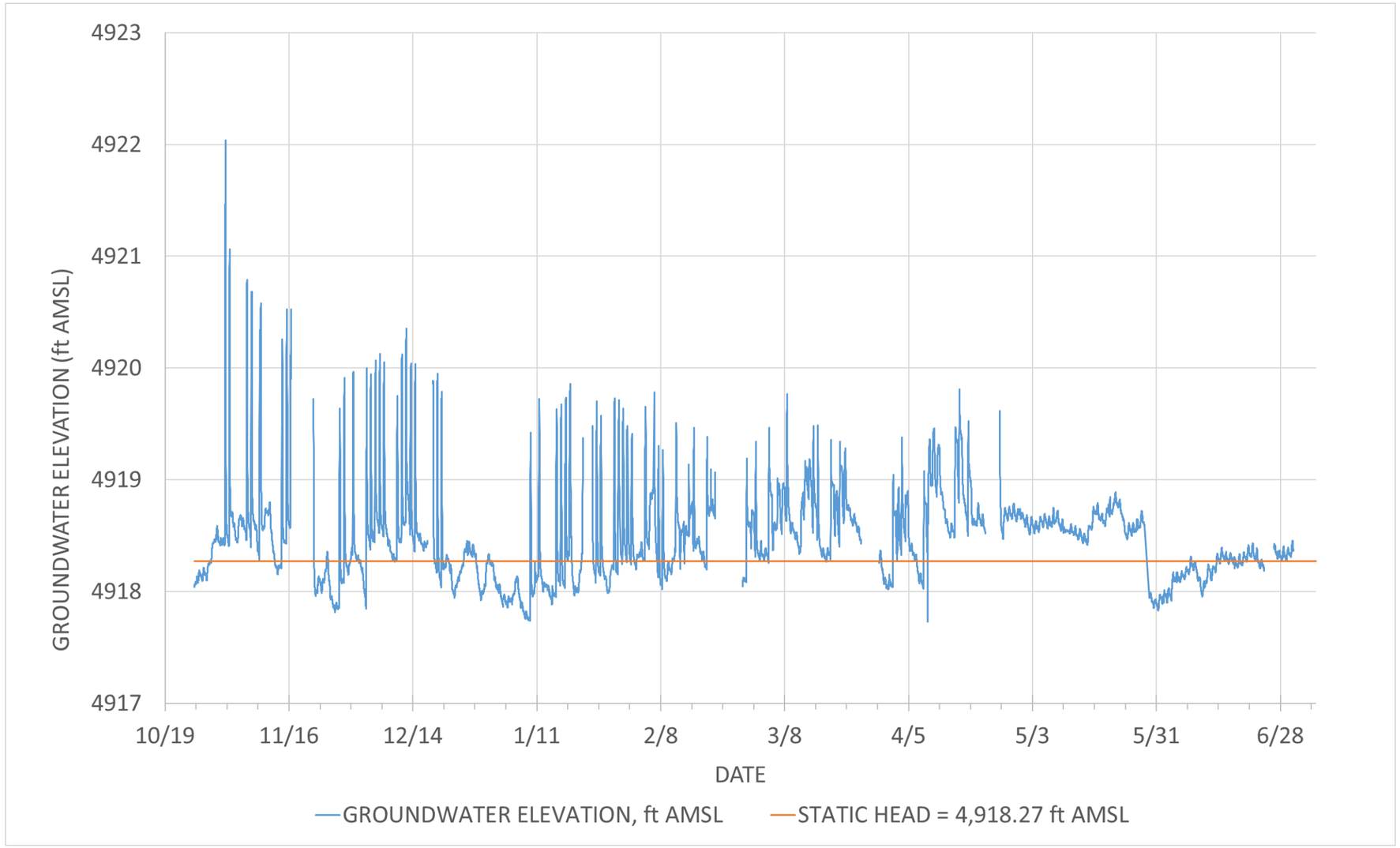

Figure III-2
Groundwater Elevations in Well TAV-MW6, October 25, 2018 – June 30, 2019

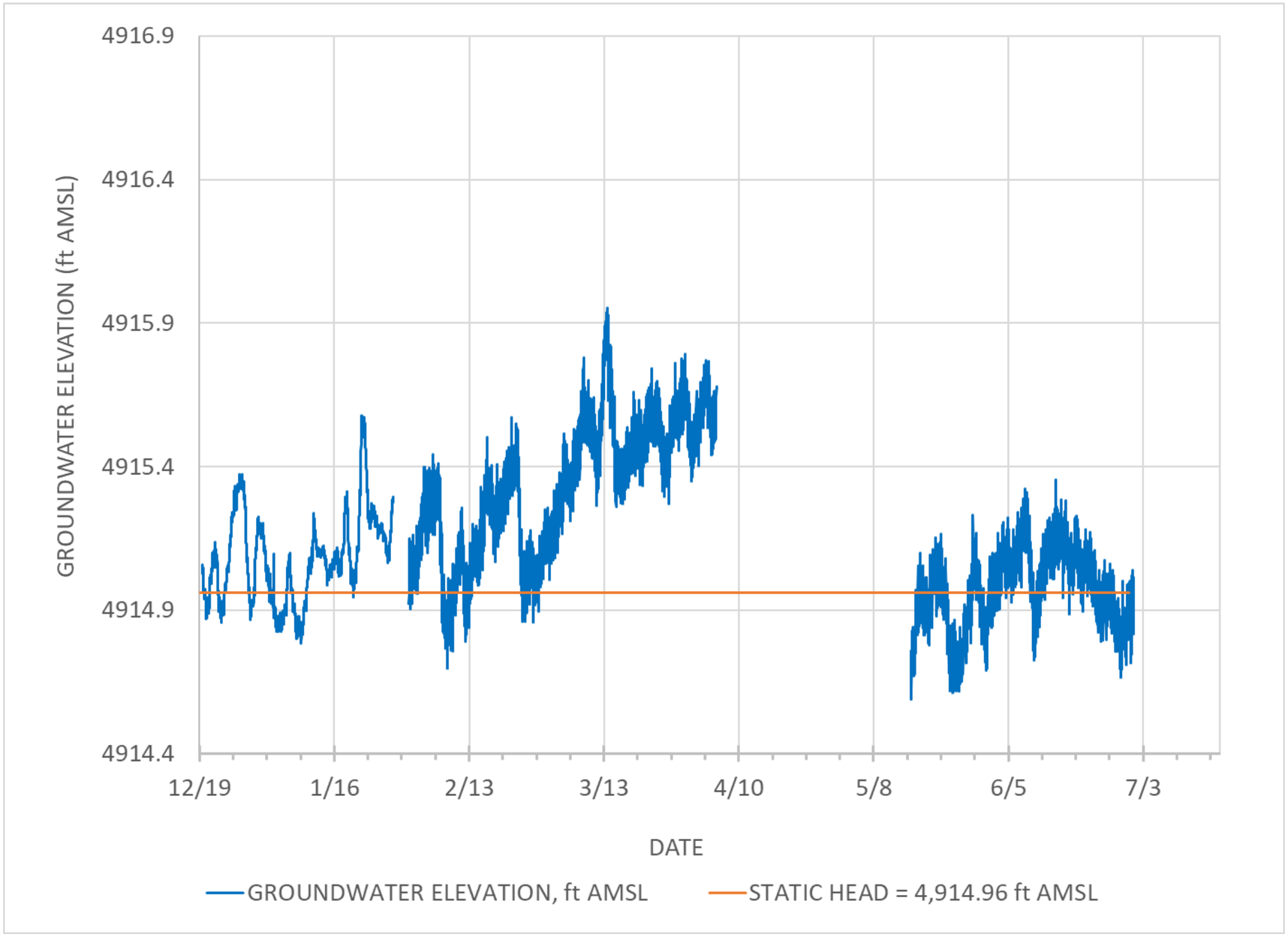

Figure III-3
Groundwater Elevations in Well TAV-MW7, December 19, 2018 – June 30, 2019

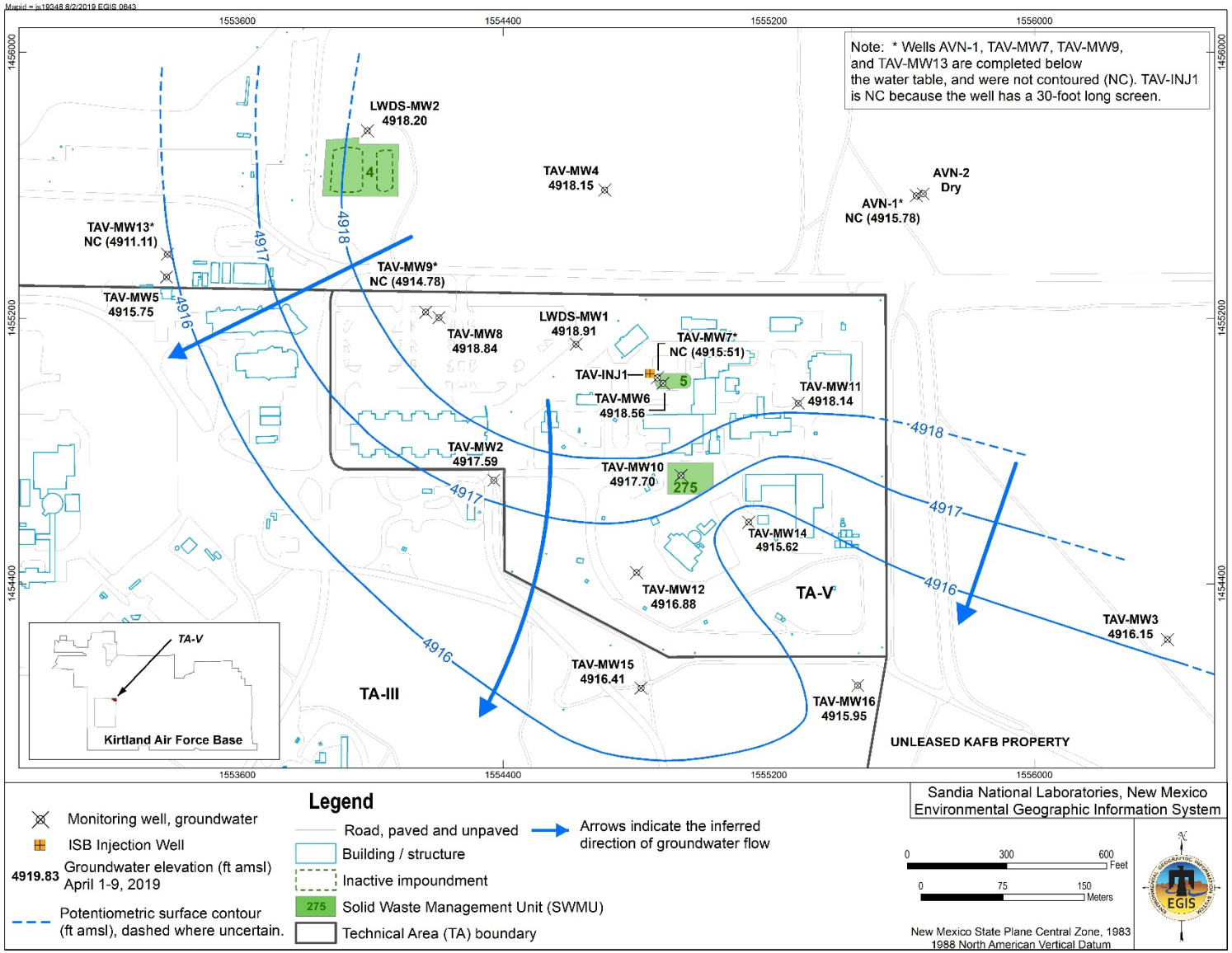

Figure III-4
Well Locations and Potentiometric Surface Contours for April 2019

Tables

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Table III-1 Summary of Injections at Well TAV-INJ1

Injection #	Date(s) of Injection	Injection Type [a]	Deoxygenation Tank Designation	Totalizer Flow Meter Start (gallons)	Totalizer Flow Meter End (gallons)	Chase Water [b] (gallons)	Volume Injected [c] (gallons)	Average Injection Flow Rate [d] (gallons per minute)	Injection Head [e] (feet)
1	11/1/2018	STANDARD	B	13980	18626	100	4746	16.3	296.78
2	11/2/2018	STANDARD	A	18626	23340	100	4814	19.9	268.98
3	11/6/2018	STANDARD	A	23471	27969	100	4598	18.1	245.90
4	11/7/2018	STANDARD	B	28070	32746	100	4776	13.5	223.77
5	11/9/2018	STANDARD	A	32750	37318	0 [a]	4568	19.1	235.41
6	11/9/2018	STANDARD	B	28070	32746	100	4776	13.5	223.77
7	11/14/2018	STANDARD	A	42038	46708	100	4770	21.8	265.37
8	11/15/2018	STANDARD	B	46708	51392	100	4784	21.4	266.61
9	11/16/2018	STANDARD	A	51413	56058	100	4745	18.7	264.74
10	11/19/2018	STANDARD	B	56182	60650	124	4592	19.1	256.86
11	11/20/2018	STANDARD	A	60774	65240	100	4566	21.1	272.87
12	11/21/2018	STANDARD	B	65362	70037	100	4775	19.7	261.23
13	11/27/2018	STANDARD	A	70162	74889	110	4837	21.9	268.05
14	11/28/2018	STANDARD	B	75025	79750	100	4825	18.1	270.53
15	11/30/2018	STANDARD	A	79871	84538	110	4777	18.7	265.86
16	12/3/2018	STANDARD	B	84669	89345	100	4776	21.9	259.73
17	12/4/2018	STANDARD	A	89471	94214	100	4843	19.1	263.49
18	12/5/2018	STANDARD	B	94339	99090	100	4851	18.2	255.53
19	12/6/2018	STANDARD	A	99214	103865	100	4751	21.4	268.30
20	12/7/2018	STANDARD	B	104090	108713	100	4723	19.7	273.18
21	12/10/2018	STANDARD	A	108813	113412	100	4699	17.8	269.74
22	12/11/2018	STANDARD	B	113535	118223	100	4788	19.6	250.38
23	12/12/2018	STANDARD	A	118348	123010	100	4762	19.1	299.77
24	12/13/2018	STANDARD	B	123133	127754	100	4721	16.7	251.35
25	12/14/2018	STANDARD	A	127878	132457	100	4679	15.3	290.82
26	12/17/2018	STANDARD	B	132689	137279	100	4690	15.3	265.27
27	12/18/2018	STANDARD	A	137408	142254	100	4946	16.3	297.13
28	12/19/2018	STANDARD	B	142379	147004	100	4725	19.2	313.61
29	12/20/2018	STANDARD	A	147134	151760	100	4726	13.7	312.68
30	1/9/2019	STANDARD	A	151887	156694	100	4907	20.1	290.33
31	1/11/2019	STANDARD	B	156728	160959	100	4331	17.1	286.66
32	1/15/2019	STANDARD	A	161196	165777	100	4681	12.8	303.93
33	1/16/2019	STANDARD	B	165914	170696	100	4882	14.1	296.44
34	1/17/2019	STANDARD	A	170717	175414	100	4797	12.4	260.27
35	1/18/2019	STANDARD	B	175438	180307	100	4969	12.6	300.81

Table III-1 Summary of Injections at Well TAV-INJ1 (continued)

Injection #	Date(s) of Injection	Injection Type [a]	Deoxygenation Tank Designation	Totalizer Flow Meter Start (gallons)	Totalizer Flow Meter End (gallons)	Chase Water [b] (gallons)	Volume Injected [c] (gallons)	Average Injection Flow Rate [d] (gallons per minute)	Injection Head [e] (feet)
36	1/21/2019	STANDARD	A	180428	185169	100	4841	13.8	304.37
37	1/23/2019	STANDARD	B	185346	189859	100	4613	13.5	315.98
38	1/24/2019	STANDARD	A	189979	194581	100	4702	13.2	299.42
39	1/25/2019	STANDARD	B	194698	199278	100	4680	13.8	308.36
40	1/28/2019	STANDARD	A	199399	204019	100	4720	12.4	293.10
41	1/29/2019	STANDARD	B	204138	208763	100	4725	11.9	283.26
42	1/30/2019	STANDARD	A	0 [f]	4700	105	4805	14.2	318.20
43	1/31/2019	STANDARD	B	0 [f]	4914	100	5014	13.1	313.39
44	2/1/2019	STANDARD	A	0 [f]	4865	100	4965	18.4	294.37
45	2/4/2019	STANDARD	B	211307	215870	100	4663	16.1	289.23
46	2/5/2019 - 2/6/2019	EXTENDED	A	215994	220702	0	4708	3.4	126.56
47	2/6/2019	STANDARD	B	220702	225434	100	4832	21.0	218.38
48	2/7/2019	STANDARD	A	225558	230409	100	4951	19.4	303.60
49	2/8/2019	STANDARD	B	230535	235315	100	4880	19.5	302.11
50	2/11/2019	STANDARD	A	235443	240345	0	4902	22.2	306.15
51	2/11/2019 - 2/12/2019	EXTENDED	B	240345	245236	0	4891	4.5	171.70
52	2/12/2019 - 2/13/2019	EXTENDED	A	245236	250129	0	4893	4.2	167.00
53	2/13/2019 - 2/14/2019	EXTENDED	B	250129	255097	0	4968	3.4	120.00
54	2/14/2019 - 2/15/2019	EXTENDED	A	255097	259661	0	4564	4.5	161.00
55	2/15/2019	STANDARD	B	259662	264125	100	4563	21.2	267.39
56	2/18/2019	STANDARD	A	264257	269155	0	4898	23.3	287.40
57	2/18/2019 - 2/19/2019	EXTENDED	B	269160	274188	0	5028	4.8	140.50
58	2/19/2019 - 2/20/2019	EXTENDED	A	274188	279137	0	4949	3.6	142.66
59	2/21/2019 - 2/22/2019	EXTENDED	A	279142	284270	0	5128	5.7	171.00
60	2/22/2019	STANDARD	B	284270	289188	100	5018	29.5	308.00
61	2/27/2019	STANDARD	A	289314	294101	0	4787	26.1	309.99
62	2/27/2019 - 2/28/2019	EXTENDED	B	294103	298961	0	4858	3.9	156.00
63	2/28/2019 - 3/1/2019	EXTENDED	A	298962	303730	0	4768	4.9	160.40
64	3/1/2019	STANDARD	B	303730	308544	100	4914	20.4	190.94
65	3/4/2019	STANDARD	A	308788	313599	0	4811	22.9	287.79
66	3/4/2019 - 3/5/2019	EXTENDED	B	313599	318422	0	4823	5.5	157.40
67	3/5/2019 - 3/6/2019	EXTENDED	A	318422	323267	0	4845	3.4	198.00
68	3/6/2019 - 3/7/2019	EXTENDED	B	323267	328104	0	4837	5.7	151.00
69	3/7/2019 - 3/8/2019	EXTENDED	A	328104	333060	0	4956	5.5	141.00
70	3/8/2019	STANDARD	B	333060	337698	100	4738	20.8	285.00

Table III-1 Summary of Injections at Well TAV-INJ1 (continued)

Injection #	Date(s) of Injection	Injection Type [a]	Deoxygenation Tank Designation	Totalizer Flow Meter Start (gallons)	Totalizer Flow Meter End (gallons)	Chase Water [b] (gallons)	Volume Injected [c] (gallons)	Average Injection Flow Rate [d] (gallons per minute)	Injection Head [e] (feet)
71	3/11/2019 - 3/12/2019	EXTENDED	A	337831	342741	0	4910	6.3	150.80
72	3/12/2019 - 3/13/2019	EXTENDED	B	342741	347614	0	4873	5.2	146.00
73	3/13/2019 - 3/14/2019	EXTENDED	A	347614	352534	0	4920	4.9	133.00
74	3/14/2019	STANDARD	B	352534	357312	0	4778	23.3	276.00
75	3/14/2019 - 3/15/2019	EXTENDED	A	357314	362278	0	4964	4.8	139.00
76	3/15/2019	STANDARD	B	362278	366982	100	4804	22.3	331.00
77	3/18/2019	STANDARD	A	367112	371909	0	4797	26.7	301.50
78	3/18/2019 - 3/19/2019	EXTENDED	B	371909	376742	0	4833	6.2	169.90
79	3/19/2019 - 3/20/2019	EXTENDED	A	376742	381570	0	4828	6.7	153.00
80	3/20/2019	STANDARD	B	381570	386385	0	4815	22.4	276.00
81	3/20/2019 - 3/21/2019	EXTENDED	A	386385	391266	0	4881	7.6	182.00
82	3/21/2019 - 3/22/2019	EXTENDED	B	391266	396219	100	5053	8.4	192.00
83	3/25/2019	STANDARD	A	396362	401056	0	4694	23.4	277.20
84	3/25/2019 - 3/26/2019	EXTENDED	B	401056	406023	0	4967	6.9	166.00
85	3/26/2019 - 3/27/2019	EXTENDED	A	406023	410923	0	4900	4.5	142.00
86	3/27/2019	STANDARD	B	410923	415748	0	4825	28.3	305.00
87	3/27/2019 - 3/28/2019	EXTENDED	A	415748	420606	0	4858	4.4	135.00
88	3/28/2019	STANDARD	B	420606	425590	100	5084	12.4	214.00
89	4/1/2019	STANDARD	A	425635	430375	0	4740	22.6	251.00
90	4/1/2019 - 4/2/2019	EXTENDED	B	430375	435269	0	4894	6.3	160.50
91	4/2/2019 - 4/3/2019	EXTENDED	A	435269	440075	0	4806	8.8	187.00
92	4/3/2019	STANDARD	B	440075	445068	0	4993	23.8	288.50
93	4/3/2019 - 4/4/2019	EXTENDED	A	445068	449962	0	4894	4.1	111.40
94	4/4/2019 - 4/5/2019	EXTENDED	B	449962	454944	100	5082	7.0	182.00
95	4/8/2019	STANDARD	A	455070	459838	0	4768	23.8	289.82
96	4/8/2019	STANDARD	B	459838	464809	0	4971	7.3	176.00
97	4/9/2019	STANDARD	A	464809	469740	0	4931	7.8	189.00
98	4/10/2019	STANDARD	B	469740	474698	0	4958	7.9	187.00
99	4/11/2019	STANDARD	A	474698	479649	100	5051	6.1	167.00
100	4/15/2019	STANDARD	B	479749	484565	0	4816	15.1	238.00
101	4/15/2019 - 4/16/2019	EXTENDED	A	484565	489547	0	4982	7.7	183.00
102	4/16/2019	STANDARD	B	489547	494598	0	5051	21.9	280.00
103	4/16/2019 - 4/17/2019	EXTENDED	A	494598	499548	0	4950	6.7	160.00
104	4/18/2019	STANDARD	B	499548	504435	0	4887	25.7	270.00
105	4/18/2019 - 4/19/2019	EXTENDED	A	504435	509406	100	5071	5.7	136.00

Table III-1 Summary of Injections at Well TAV-INJ1 (concluded)

Injection #	Date(s) of Injection	Injection Type [a]	Deoxygenation Tank Designation	Totalizer Flow Meter Start (gallons)	Totalizer Flow Meter End (gallons)	Chase Water [b] (gallons)	Volume Injected [c] (gallons)	Average Injection Flow Rate [d] (gallons per minute)	Injection Head [e] (feet)
106	4/22/2019	STANDARD	B	509506	514412	0	4906	27.2	279.00
107	4/22/2019	STANDARD	A	514412	519319	0	4907	17.0	239.00
108	4/23/2019	STANDARD	A	519319	524148	100	4929	24.6	297.00
109	4/24/2019	STANDARD	A	524281	529039	100	4858	25.0	289.00
110	4/25/2019	STANDARD	A	529166	533975	100	4909	25.2	303.00

Notes:
[a] STANDARD = Injection conducted at moderate to high flow rate and completed within the workday.
EXTENDED = Injection conducted at low to moderate flow rate and completed overnight.
[b] Chase water = 0 when it was not needed because the next injection started on the same workday.
[c] Volume Injected calculated as the difference between the end and the start of Totalizer Readings plus the Chase Water volume.
[d] Average Injection Flow Rate is a field estimate based on total volume and duration of an injection.
[e] Injection Head is a field estimate from the instantaneous readings on the sonde during an injection. Injection head above static levels were furthered calculated and shown in Figure III-1.
[f] Totalizer flow meter broke and temporarily replaced by another flow meter.
# = Number.
INJ = Injection well (acronym used for well identification only).
TAV = Technical Area-V (acronym used for well identification only).

Table III-2a
Proposed Substrate Solution Components for Full-Scale Operation at Well TAV-INJ1 [a]

Substrate Solution Component	Function	Mixing Ratio (by weight)	Weight per 1,000 gal of Water	Convert to Weight per Injection (~5,000 gal of Water)
Primary Components				
Ethyl lactate	Electron donor (substrate)	80.4%	5.64 lbs	28.2 lbs
Diammonium phosphate	Nutrient and pH buffer	9.0%	0.63 lbs	3.15 lbs
Accelerite® [b]	Nutrient	6.4%	0.45 lbs	2.25 lbs
Potassium Bicarbonate	pH buffer and acid reducer	1.7%	0.11 lbs	0.55 lbs
Sodium Sulfite	Deoxygenation and reduction agent	2.5%	0.17 lbs	0.85 lbs
Primary Components per 1,000 or 5,000 gal of Potable Water		**100%**	**7 lbs**	**35 lbs**
Additional Component Mixed with Substrate Solution				
Sodium bromide	Inert tracer (as bromide)	Not applicable; adjusted per field condition	0.2 lbs	1 lbs

Notes:

[a] Proposed amount as presented in Appendix A, Modification #3 before the start of full-scale operation. Converted to weight per injection of 5,000 gallons of water for easy comparison with Table III-2b.

[b] Accelerite® Bioremediation Nutrient is a product of JRW Bioremediation, LLC.

% = Percent.
gal = Gallon(s).
INJ = Injection (acronym used for well identification only).
lbs = Pounds.
pH = Potential of hydrogen (negative logarithm of the hydrogen ion concentration).
TAV = Technical Area-V (acronym used for well identification only).

Table III-2b
Summary of Bioremediation Solution Components for Full-Scale Operation at Well TAV-INJ1 by Injections

Injection#	Date(s) of Injection	Ethyl Lactate (lbs)	Diammonium Phosphate (lbs)	Accelerite® (lbs)	Potassium Bicarbonate (lbs)	Sodium Sulfite (lbs)	Total Substrate Component per Injection (lbs)	Sodium Bromide (lbs)	KB-1 Dechlorinator (L)
1	11/1/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.20
2	11/2/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
3	11/6/2018	30.40	3.17	1.94	15.03	10.03	60.56	0.99	1.20
4	11/7/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
5	11/9/2018	30.40	3.17	1.94	15.03	10.03	60.56	0.99	2.20
6	11/9/2018	30.40	3.17	1.94	15.03	10.03	60.56	0.99	0.00
7	11/14/2018	30.40	3.17	1.94	15.04	10.03	60.57	0.99	1.10
8	11/15/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.40
9	11/16/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
10	11/19/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.40
11	11/20/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.30
12	11/21/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
13	11/27/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
14	11/28/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
15	11/30/2018	30.40	3.17	1.94	12.52	8.36	56.39	0.99	1.10
16	12/3/2018	30.40	3.17	1.94	4.39	2.93	42.83	0.99	1.10
17	12/4/2018	30.40	3.17	1.94	4.39	2.93	42.83	0.99	0.80
18	12/5/2018	30.40	3.17	1.94	6.89	4.60	47.01	0.99	1.10
19	12/6/2018	30.40	3.17	1.94	10.02	6.69	52.22	0.99	1.10
20	12/7/2018	30.40	3.17	1.94	8.77	5.86	50.14	0.99	1.10
21	12/10/2018	30.40	3.17	1.94	8.77	5.86	50.14	0.99	1.20
22	12/11/2018	30.40	3.17	1.94	8.77	5.86	50.14	0.99	1.10
23	12/12/2018	30.40	3.17	1.94	6.26	4.17	45.94	0.99	1.10
24	12/13/2018	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
25	12/14/2018	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
26	12/17/2018	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
27	12/18/2018	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
28	12/19/2018	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
29	12/20/2018	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
30	1/9/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20

Table III-2b
Summary of Bioremediation Solution Components for Full-Scale Operation at Well TAV-INJ1 by Injections (continued)

Injection #	Date(s) of Injection	Ethyl Lactate (lbs)	Diammonium Phosphate (lbs)	Accelerite® (lbs)	Potassium Bicarbonate (lbs)	Sodium Sulfite (lbs)	Total Substrate Component per Injection (lbs)	Sodium Bromide (lbs)	KB-1 Dechlorinator (L)
31	1/11/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.00
32	1/15/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	2.20
33	1/16/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
34	1/17/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
35	1/18/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
36	1/21/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
37	1/23/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
38	1/24/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
39	1/25/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
40	1/28/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
41	1/29/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
42	1/30/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
43	1/31/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
44	2/1/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
45	2/4/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
46	2/5/2019 - 2/6/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
47	2/6/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
48	2/7/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
49	2/8/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
50	2/11/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	2.20
51	2/11/2019 - 2/12/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.00
52	2/12/2019 - 2/13/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
53	2/13/2019 - 2/14/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
54	2/14/2019 - 2/15/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
55	2/15/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
56	2/18/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.20
57	2/18/2019 - 2/19/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.00
58	2/19/2019 - 2/20/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
59	2/21/2019 - 2/22/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
60	2/22/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
61	2/27/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	2.10
62	2/27/2019 - 2/28/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.00

Table III-2b
Summary of Bioremediation Solution Components for Full-Scale Operation at Well TAV-INJ1 by Injections (continued)

Injection #	Date(s) of Injection	Ethyl Lactate (lbs)	Diammonium Phosphate (lbs)	Accelerite® (lbs)	Potassium Bicarbonate (lbs)	Sodium Sulfite (lbs)	Total Substrate Component per Injection (lbs)	Sodium Bromide (lbs)	KB-1 Dechlorinator (L)
63	2/28/2019 - 3/1/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.90
64	3/1/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
65	3/4/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	2.00
66	3/4/2019 - 3/5/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.00
67	3/5/2019 - 3/6/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
68	3/6/2019 - 3/7/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
69	3/7/2019 - 3/8/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.10
70	3/8/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	0.90
71	3/11/2019 - 3/12/2019	30.40	3.17	1.94	3.75	2.51	41.77	0.99	1.00
72	3/12/2019 - 3/13/2019	30.40	3.17	1.94	6.28	2.51	44.31	0.99	1.00
73	3/13/2019 - 3/14/2019	30.40	3.17	1.94	6.28	2.51	44.31	0.99	1.10
74	3/14/2019	30.40	3.17	1.94	6.28	2.51	44.31	0.99	0.00
75	3/14/2019 - 3/15/2019	30.40	3.17	1.94	6.28	2.51	44.31	0.99	0.00
76	3/15/2019	30.40	3.17	1.94	6.28	2.51	44.31	0.99	0.00
77	3/18/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
78	3/18/2019 - 3/19/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
79	3/19/2019 - 3/20/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
80	3/20/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	1.90
81	3/20/2019 - 3/21/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
82	3/21/2019 - 3/22/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	1.10
83	3/25/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	2.50
84	3/25/2019 - 3/26/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
85	3/26/2019 - 3/27/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	1.20
86	3/27/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	2.50
87	3/27/2019 - 3/28/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
88	3/28/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	1.20
89	4/1/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
90	4/1/2019 - 4/2/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	2.50
91	4/2/2019 - 4/3/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	1.40
92	4/3/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	2.30
93	4/3/2019 - 4/4/2019	30.40	3.17	1.94	7.50	2.51	45.52	0.99	0.00
94	4/4/2019 - 4/5/2019	30.40	3.17	1.94	9.37	2.51	47.39	0.99	1.30

Table III-2b
Summary of Bioremediation Solution Components for Full-Scale Operation at Well TAV-INJ1 by Injections (continued)

Injection #	Date(s) of Injection	Ethyl Lactate (lbs)	Diammonium Phosphate (lbs)	Accelerite® (lbs)	Potassium Bicarbonate (lbs)	Sodium Sulfite (lbs)	Total Substrate Component per Injection (lbs)	Sodium Bromide (lbs)	KB-1 Dechlorinator (L)
95	4/8/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	2.50
96	4/8/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	0.00
97	4/9/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	1.20
98	4/10/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	0.90
99	4/11/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	1.70
100	4/15/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	2.50
101	4/15/2019 - 4/16/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	0.00
102	4/16/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	2.50
103	4/16/2019 - 4/17/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	0.00
104	4/18/2019	44.09	3.17	1.94	9.37	2.51	61.08	0.99	0.00
105	4/18/2019 - 4/19/2019	30.40	3.17	0.00	9.37	2.51	45.46	0.99	2.50
106	4/22/2019	30.40	3.17	0.00	12.52	2.51	48.61	0.99	3.80
107	4/22/2019	30.40	3.17	0.00	12.52	2.51	48.61	0.99	0.00
108	4/23/2019	30.40	3.17	0.00	12.52	2.51	48.61	0.99	1.90
109	4/24/2019	30.40	3.17	0.00	12.52	2.51	48.61	0.99	2.90
110	4/25/2019	30.40	3.17	0.00	12.52	2.51	48.61	0.99	2.90
Total for this Full-Scale Operation		3481 lbs	349 lbs	201 lbs	770 lbs	390 lbs	**5191 lbs**	109 lbs	122.8 L

Notes:
# = Number.
lbs = Pounds.
L = Liter.

Table III-3
Groundwater Sampling Conducted for Treatability Study, April – June 2019

Monitoring Well	Sampling Date
Wells in the Treatment Zone	
TAV-INJ1	3-4 Jun 2019, 25-26 Jun 2019
TAV-MW6	23 Apr 2019, 28 May 2019, 24 Jun 2019
TAV-MW7	13 May 2019
Wells Outside the Treatment Zone	
LWDS-MW1	10 Jun 2019
TAV-MW2	17 May 2019
TAV-MW4	22 May 2019
TAV-MW8	23 May 2019
TAV-MW10	5 Jun 2019
TAV-MW11	20 May 2019
TAV-MW12	30 May 2019
TAV-MW14	31 May 2019

Notes:

[a]Microbial samples were collected on June 3 and June 25, and the rest of the samples were collected on June 4 and June 26, 2019 after the water level had recovered.

INJ = Injection well
LWDS = Liquid waste disposal system
MW = Monitoring well
TAV = Technical Area-V

Table III-4
Analytical Results of Groundwater Sampling at Well TAV-INJ1, April-June 2019

Sample Date	Analyses	Analyte	Result[a]	MDL[b]	PQL[c]	MCL[d]	Units	Lab Qual[e]	Val Qual[f]	Sample No.	Analtyical Method[g]	Lab[h]
4-Jun-19	GENERAL CHEMISTRY	Alkalinity as $CaCO_3$	1260	1.45	4	NE	mg/L		J	108467-006	SM 2320B	GEL
4-Jun-19	GENERAL CHEMISTRY	Alkalinity, bicarb as $CaCO_3$	1260	1.45	4	NE	mg/L			108467-006	SM 2320B	GEL
4-Jun-19	GENERAL CHEMISTRY	Alkalinity, carb as $CaCO_3$	ND	1.45	4	NE	mg/L	U		108467-006	SM 2320B	GEL
4-Jun-19	AMMONIA	Ammonia	89.8	4.25	12.5	NE	mg/L	B	J	108467-002	EPA 350.1	GEL
4-Jun-19	ANIONS	Bromide	2.09	0.067	0.2	NE	mg/L	N	J-	108467-004	SW846 9056A	GEL
4-Jun-19	ANIONS	Sulfate	2.48	0.133	0.4	NE	mg/L			108467-004	SW846 9056A	GEL
3-Jun-19	MICROBIAL	Dehalococcoides	2000000	3000	3000	NE	Enumeration/L			108474-001	Gene-Trac Dhc	SiREM
4-Jun-19	METALS	Arsenic	**0.0286**	0.002	0.005	0.01	mg/L			108467-007	SW846 3005A/6020B	GEL
4-Jun-19	METALS	Iron	0.724	0.033	0.1	NE	mg/L			108467-007	SW846 3005A/6020B	GEL
4-Jun-19	METALS	Manganese	0.35	0.001	0.005	NE	mg/L			108467-007	SW846 3005A/6020B	GEL
4-Jun-19	MEE	Methane	11000	0.094	0.5	NE	µg/L		J	108471-001	AM20GAX	PACE
4-Jun-19	MEE	Ethane	0.13	0.011	0.1	NE	µg/L		J	108471-001	AM20GAX	PACE
4-Jun-19	MEE	Ethene	ND	0.008	0.1	NE	µg/L	U	UJ	108471-001	AM20GAX	PACE
4-Jun-19	NPN	Nitrate plus nitrite as N	ND	0.017	0.05	10	mg/L	U	UJ	108467-005	EPA 353.2	GEL
4-Jun-19	TOC	Total Organic Carbon Average	277	33	100	NE	mg/L			108467-003	SW846 9060A	GEL
4-Jun-19	VOC	Dichloroethene, cis-1,2-	ND	0.3	1	70	µg/L	U		108467-001	SW846 8260B	GEL
4-Jun-19	VOC	Trichloroethene	ND	0.3	1	5	µg/L	U		108467-001	SW846 8260B	GEL
26-Jun-19	Alkalinity	Alkalinity as $CaCO_3$	1470	1.45	4	NE	mg/L		J	108624-006	SM 2320B	GEL
26-Jun-19	Alkalinity	Alkalinity, bicarb as $CaCO_3$	1470	1.45	4	NE	mg/L			108624-006	SM 2320B	GEL
26-Jun-19	Alkalinity	Alkalinity, carb as $CaCO_3$	ND	1.45	4	NE	mg/L	U		108624-006	SM 2320B	GEL
26-Jun-19	Ammonia	Ammonia	112	4.25	12.5	NE	mg/L	*B	J	108624-002	EPA 350.1	GEL
26-Jun-19	Anions	Bromide	16.5	0.67	2	NE	mg/L			108624-004	SW846 9056A	GEL
26-Jun-19	Anions	Sulfate	158	1.33	4	NE	mg/L			108624-004	SW846 9056A	GEL
25-Jun-19	Microbial	Dehalococcoides	1000000	2600	2600	NE	Enumeration/L			108629-001	Gene-Trac Dhc	SiREM
26-Jun-19	Dissolved Metals	Arsenic	**0.0316**	0.002	0.005	0.01	mg/L			108624-007	SW846 3005A/6020B	GEL
26-Jun-19	Dissolved Metals	Iron	1.8	0.033	0.1	NE	mg/L			108624-007	SW846 3005A/6020B	GEL
26-Jun-19	Dissolved Metals	Manganese	0.529	0.001	0.005	NE	mg/L		J	108624-007	SW846 3005A/6020B	GEL
26-Jun-19	MEE	Methane	16000	0.046	0.5	NE	µg/L		J	108627-001	AM20GAX	PACE
26-Jun-19	MEE	Ethane	0.14	0.005	0.1	NE	µg/L		J	108627-001	AM20GAX	PACE
26-Jun-19	MEE	Ethene	ND	0.004	0.1	NE	µg/L	U	UJ	108627-001	AM20GAX	PACE
26-Jun-19	NPN	Nitrate plus nitrite as N	ND	0.085	0.25	10	mg/L	U		108624-005	EPA 353.2	GEL
26-Jun-19	TOC	Total Organic Carbon Average	104	16.5	50	NE	mg/L		J	108624-003	SW846 9060A	GEL
26-Jun-19	VOC	Dichloroethene, cis-1,2-	ND	0.3	1	70	µg/L	U		108624-001	SW846 8260B	GEL
26-Jun-19	VOC	Trichloroethene	ND	0.3	1	5	µg/L	U		108624-001	SW846 8260B	GEL

Note: Header nomenclature is explained following Table III-8 in the “Footnotes for Technical Area-V Analytical Results Tables” summary.

Table III-5
Analytical Results of Groundwater Sampling at Well TAV-MW6, April-June 2019

Sample Date	Analyses	Analyte	Result[a]	MDL[b]	PQL[c]	MCL[d]	Units	Lab Qual[e]	Val Qual[f]	Sample No.	Analtyical Method[g]	Lab[h]
23-Apr-19	Alkalinity	Alkalinity as $CaCO_3$	190	1.45	4	NE	mg/L			108171-003	SM 2320B	GEL
23-Apr-19	Alkalinity	Alkalinity, bicarb as $CaCO_3$	190	1.45	4	NE	mg/L			108171-003	SM 2320B	GEL
23-Apr-19	Alkalinity	Alkalinity, carb as $CaCO_3$	ND	1.45	4	NE	mg/L	U		108171-003	SM 2320B	GEL
23-Apr-19	Ammonia	Ammonia	0.121	0.017	0.05	NE	mg/L		J+	108171-001	EPA 350.1	GEL
23-Apr-19	Anions	Bromide	2.15	0.067	0.2	NE	mg/L			108169-003	SW846 9056A	GEL
23-Apr-19	Anions	Sulfate	45.9	0.665	2	NE	mg/L			108169-003	SW846 9056A	GEL
23-Apr-19	Microbial	Dehalococcoides	<3000	3000	3000	NE	Enumeration/L			108154-001	Gene-Trac Dhc	SiREM
23-Apr-19	Dissolved Metals	Arsenic	0.00258	0.002	0.005	0.01	mg/L	J		108171-004	SW846 3005A/6020B	GEL
23-Apr-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108171-004	SW846 3005A/6020B	GEL
23-Apr-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108171-004	SW846 3005A/6020B	GEL
23-Apr-19	MEE	Methane	4.6	0.046	0.5	NE	µg/L		J	108158-001	AM20GAX	PACE
23-Apr-19	MEE	Ethane	ND	0.005	0.1	NE	µg/L	U	UJ	108158-001	AM20GAX	PACE
23-Apr-19	MEE	Ethene	ND	0.004	0.1	NE	µg/L	U	UJ	108158-001	AM20GAX	PACE
23-Apr-19	NPN	Nitrate plus nitrite as N	**16.6**	0.425	1.25	10	mg/L		J+	108171-002	EPA 353.2	GEL
23-Apr-19	TOC	Total Organic Carbon Average	0.67	0.33	1	NE	mg/L	J	1.0U	108169-002	SW846 9060A	GEL
23-Apr-19	VOC	Dichloroethene, cis-1,2-	0.97	0.3	1	70	µg/L	J		108169-001	SW846 8260B	GEL
23-Apr-19	VOC	Trichloroethene	**6.91**	0.3	1	5	µg/L			108169-001	SW846 8260B	GEL
23-Apr-19 (DUP)	Alkalinity	Alkalinity as $CaCO_3$	191	1.45	4	NE	mg/L			108254-003	SM 2320B	GEL
23-Apr-19 (DUP)	Alkalinity	Alkalinity, bicarb as $CaCO_3$	191	1.45	4	NE	mg/L			108254-003	SM 2320B	GEL
23-Apr-19 (DUP)	Alkalinity	Alkalinity, carb as $CaCO_3$	ND	1.45	4	NE	mg/L	U		108254-003	SM 2320B	GEL
23-Apr-19 (DUP)	Ammonia	Ammonia	0.132	0.017	0.05	NE	mg/L		J+	108254-001	EPA 350.1	GEL
23-Apr-19 (DUP)	Anions	Bromide	2.12	0.067	0.2	NE	mg/L			108253-003	SW846 9056A	GEL
23-Apr-19 (DUP)	Anions	Sulfate	45.9	0.665	2	NE	mg/L			108253-003	SW846 9056A	GEL
23-Apr-19 (DUP)	Microbial	Dehalococcoides	<3000	3000	3000	NE	Enumeration/L			108155-001	Gene-Trac Dhc	SiREM
23-Apr-19 (DUP)	Dissolved Metals	Arsenic	0.00252	0.002	0.005	0.01	mg/L	J		108254-004	SW846 3005A/6020B	GEL
23-Apr-19 (DUP)	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108254-004	SW846 3005A/6020B	GEL
23-Apr-19 (DUP)	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108254-004	SW846 3005A/6020B	GEL
23-Apr-19 (DUP)	MEE	Methane	4.6	0.046	0.5	NE	µg/L		J	108159-001	AM20GAX	PACE
23-Apr-19 (DUP)	MEE	Ethane	ND	0.005	0.1	NE	µg/L	U	UJ	108159-001	AM20GAX	PACE
23-Apr-19 (DUP)	MEE	Ethene	ND	0.004	0.1	NE	µg/L	U	UJ	108159-001	AM20GAX	PACE
23-Apr-19 (DUP)	NPN	Nitrate plus nitrite as N	**16.7**	0.425	1.25	10	mg/L		J+	108254-002	EPA 353.2	GEL
23-Apr-19 (DUP)	TOC	Total Organic Carbon Average	0.637	0.33	1	NE	mg/L	J	1.0U	108253-002	SW846 9060A	GEL
23-Apr-19 (DUP)	VOC	Dichloroethene, cis-1,2-	0.98	0.3	1	70	µg/L	J		108253-001	SW846 8260B	GEL
23-Apr-19 (DUP)	VOC	Trichloroethene	**7.56**	0.3	1	5	µg/L			108253-001	SW846 8260B	GEL
28-May-19	Alkalinity	Alkalinity as $CaCO_3$	198	1.45	4	NE	mg/L			108465-006	SM 2320B	GEL
28-May-19	Alkalinity	Alkalinity, bicarb as $CaCO_3$	198	1.45	4	NE	mg/L			108465-006	SM 2320B	GEL
28-May-19	Alkalinity	Alkalinity, carb as $CaCO_3$	ND	1.45	4	NE	mg/L	U		108465-006	SM 2320B	GEL
28-May-19	Ammonia	Ammonia	0.146	0.017	0.05	NE	mg/L			108465-002	EPA 350.1	GEL
28-May-19	Anions	Bromide	3.14	0.335	1	NE	mg/L			108465-004	SW846 9056A	GEL
28-May-19	Anions	Sulfate	39.3	0.665	2	NE	mg/L			108465-004	SW846 9056A	GEL

Table III-5 (concluded)
Analytical Results of Groundwater Sampling at Well TAV-MW6, April-June 2019

Sample Date	Analyses	Analyte	Result[a]	MDL[b]	PQL[c]	MCL[d]	Units	Lab Qual[e]	Val Qual[f]	Sample No.	Analtyical Method[g]	Lab[h]
28-May-19	Microbial	Dehalococcoides	<5000	5000	5000	NE	Enumeration/L			108473-001	Gene-Trac Dhc	SiREM
28-May-19	Dissolved Metals	Arsenic	ND	0.002	0.005	0.01	mg/L	U		108465-007	SW846 3005A/6020B	GEL
28-May-19	Dissolved Metals	Iron	0.0807	0.033	0.1	NE	mg/L	J		108465-007	SW846 3005A/6020B	GEL
28-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108465-007	SW846 3005A/6020B	GEL
28-May-19	MEE	Methane	100	0.046	0.5	NE	µg/L		J	108469-001	AM20GAX	PACE
28-May-19	MEE	Ethane	ND	0.005	0.1	NE	µg/L	U	UJ	108469-001	AM20GAX	PACE
28-May-19	MEE	Ethene	ND	0.004	0.1	NE	µg/L	U	UJ	108469-001	AM20GAX	PACE
28-May-19	NPN	Nitrate plus nitrite as N	7.9	0.17	0.5	10	mg/L			108465-005	EPA 353.2	GEL
28-May-19	TOC	Total Organic Carbon Average	0.671	0.33	1	NE	mg/L	J		108465-003	SW846 9060A	GEL
28-May-19	VOC	Dichloroethene, cis-1,2-	0.95	0.3	1	70	µg/L	J		108465-001	SW846 8260B	GEL
28-May-19	VOC	Trichloroethene	**6.78**	0.3	1	5	µg/L			108465-001	SW846 8260B	GEL
24-Jun-19	Alkalinity	Alkalinity as $CaCO_3$	205	1.45	4	NE	mg/L			108622-006	SM 2320B	GEL
24-Jun-19	Alkalinity	Alkalinity, bicarb as $CaCO_3$	205	1.45	4	NE	mg/L			108622-006	SM 2320B	GEL
24-Jun-19	Alkalinity	Alkalinity, carb as $CaCO_3$	ND	1.45	4	NE	mg/L	U		108622-006	SM 2320B	GEL
24-Jun-19	Ammonia	Ammonia	0.0999	0.017	0.05	NE	mg/L	*B	J+	108622-002	EPA 350.1	GEL
24-Jun-19	Anions	Bromide	4.12	0.335	1	NE	mg/L			108622-004	SW846 9056A	GEL
24-Jun-19	Anions	Sulfate	38.8	0.665	2	NE	mg/L			108622-004	SW846 9056A	GEL
24-Jun-19	Microbial	Dehalococcoides	<3000	3000	3000	NE	Enumeration/L			108628-001	Gene-Trac Dhc	SiREM
24-Jun-19	Dissolved Metals	Arsenic	0.00281	0.002	0.005	0.01	mg/L	J		108622-007	SW846 3005A/6020B	GEL
24-Jun-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108622-007	SW846 3005A/6020B	GEL
24-Jun-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108622-007	SW846 3005A/6020B	GEL
24-Jun-19	MEE	Methane	170	0.046	0.5	NE	µg/L		J	108626-001	AM20GAX	PACE
24-Jun-19	MEE	Ethane	ND	0.005	0.1	NE	µg/L	U	UJ	108626-001	AM20GAX	PACE
24-Jun-19	MEE	Ethene	ND	0.004	0.1	NE	µg/L	U	UJ	108626-001	AM20GAX	PACE
24-Jun-19	NPN	Nitrate plus nitrite as N	7.29	0.17	0.5	10	mg/L			108622-005	EPA 353.2	GEL
24-Jun-19	TOC	Total Organic Carbon Average	0.66	0.33	1	NE	mg/L	J		108622-003	SW846 9060A	GEL
24-Jun-19	VOC	Dichloroethene, cis-1,2-	0.93	0.3	1	70	µg/L	J		108622-001	SW846 8260B	GEL
24-Jun-19	VOC	Trichloroethene	**6.74**	0.3	1	5	µg/L			108622-001	SW846 8260B	GEL

Note: Header nomenclature is explained following Table III-8 in the “Footnotes for Technical Area-V Analytical Results Tables” summary.

Table III-6
Analytical Results of Groundwater Sampling at Well TAV-MW7, April-June 2019

Sample Date	Analyses	Analyte	Result[a]	MDL[b]	PQL[c]	MCL[d]	Units	Lab Qual[e]	Val Qual[f]	Sample No.	Analtyical Method[g]	Lab[h]
13-May-19	Anions	Bromide	0.26	0.067	0.2	NE	mg/L			108416-005	SW846 9056A	GEL
13-May-19	Dissolved Metals	Arsenic	0.00297	0.002	0.005	0.01	mg/L	J		108416-003	SW846 3005A/6020B	GEL
13-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108416-003	SW846 3005A/6020B	GEL
13-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108416-003	SW846 3005A/6020B	GEL
13-May-19	MEE	Ethene	ND	0.004	0.1	NE	µg/L	U	UJ	108460-001	AM20GAX	PACE
13-May-19	NPN	Nitrate plus nitrite as N	5.47	0.17	0.5	10	mg/L			108416-002	EPA 353.2	GEL
13-May-19	VOC	Dichloroethene, cis-1,2-	ND	0.3	1	70	µg/L	U		108416-001	SW846 8260B	GEL
13-May-19	VOC	Trichloroethene	ND	0.3	1	5	µg/L	U		108416-001	SW846 8260B	GEL

Note: Header nomenclature is explained following Table III-8 in the “Footnotes for Technical Area-V Analytical Results Tables” summary.

Table III-7
Analytical Results of Groundwater Sampling at Wells
LWDS-MW1, TAV-MW2, TAV-MW4, TAV-MW8, TAV-MW10, TAV-MW11, TAV-MW12, and TAV MW14, April-June 2019

Sample Date	Analyses	Analyte	Result[a]	MDL[b]	PQL[c]	MCL[d]	Units	Lab Qual[e]	Val Qual[f]	Sample No.	Analtyical Method[g]	Lab[h]
LWDS-MW1												
10-Jun-19	Dissolved Metals	Arsenic	0.00458	0.002	0.005	0.01	mg/L	J		108455-003	SW846 3005A/6020B	GEL
10-Jun-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108455-003	SW846 3005A/6020B	GEL
10-Jun-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108455-003	SW846 3005A/6020B	GEL
10-Jun-19	NPN	Nitrate plus nitrite as N	**13.8**	0.17	0.5	10	mg/L			108455-002	EPA 353.2	GEL
10-Jun-19	VOC	Dichloroethene, cis-1,2-	3.59	0.3	1	70	µg/L			108455-001	SW846 8260B	GEL
10-Jun-19	VOC	Trichloroethene	**17.5**	0.3	1	5	µg/L			108455-001	SW846 8260B	GEL
TAV-MW2												
17-May-19	Dissolved Metals	Arsenic	0.00367	0.002	0.005	0.01	mg/L	J		108430-003	SW846 3005A/6020B	GEL
17-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108430-003	SW846 3005A/6020B	GEL
17-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108430-003	SW846 3005A/6020B	GEL
17-May-19	NPN	Nitrate plus nitrite as N	6.36	0.17	0.5	10	mg/L			108430-002	EPA 353.2	GEL
17-May-19	VOC	Dichloroethene, cis-1,2-	ND	0.3	1	70	µg/L	U		108430-001	SW846 8260B	GEL
17-May-19	VOC	Trichloroethene	3.28	0.3	1	5	µg/L			108430-001	SW846 8260B	GEL
TAV-MW4												
22-May-19	Dissolved Metals	Arsenic	0.00369	0.002	0.005	0.01	mg/L	J		108437-003	SW846 3005A/6020B	GEL
22-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108437-003	SW846 3005A/6020B	GEL
22-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108437-003	SW846 3005A/6020B	GEL
22-May-19	NPN	Nitrate plus nitrite as N	6.25	0.17	0.5	10	mg/L			108437-002	EPA 353.2	GEL
22-May-19	VOC	Dichloroethene, cis-1,2-	0.54	0.3	1	70	µg/L	J		108437-001	SW846 8260B	GEL
22-May-19	VOC	Trichloroethene	**5.44**	0.3	1	5	µg/L			108437-001	SW846 8260B	GEL
TAV-MW8												
23-May-19	Dissolved Metals	Arsenic	0.00236	0.002	0.005	0.01	mg/L	J		108441-003	SW846 3005A/6020B	GEL
23-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108441-003	SW846 3005A/6020B	GEL
23-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108441-003	SW846 3005A/6020B	GEL
23-May-19	NPN	Nitrate plus nitrite as N	7.97	0.17	0.5	10	mg/L			108441-002	EPA 353.2	GEL
23-May-19	VOC	Dichloroethene, cis-1,2-	0.5	0.3	1	70	µg/L	J		108441-001	SW846 8260B	GEL
23-May-19	VOC	Trichloroethene	4.4	0.3	1	5	µg/L			108441-001	SW846 8260B	GEL
TAV-MW10												
5-Jun-19	Dissolved Metals	Arsenic	0.00236	0.002	0.005	0.01	mg/L	J		108453-003	SW846 3005A/6020B	GEL
5-Jun-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108453-003	SW846 3005A/6020B	GEL
5-Jun-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108453-003	SW846 3005A/6020B	GEL
5-Jun-19	NPN	Nitrate plus nitrite as N	**15.3**	0.85	2.5	10	mg/L			108453-002	EPA 353.2	GEL
5-Jun-19	VOC	Dichloroethene, cis-1,2-	1.92	0.3	1	70	µg/L			108453-001	SW846 8260B	GEL
5-Jun-19	VOC	Trichloroethene	**13**	0.3	1	5	µg/L			108453-001	SW846 8260B	GEL
TAV-MW11												
20-May-19	Dissolved Metals	Arsenic	0.00389	0.002	0.005	0.01	mg/L	J		108432-003	SW846 3005A/6020B	GEL
20-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108432-003	SW846 3005A/6020B	GEL
20-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108432-003	SW846 3005A/6020B	GEL

Table III-7
Analytical Results of Groundwater Sampling at Wells
LWDS-MW1, TAV-MW2, TAV-MW4, TAV-MW8, TAV-MW10, TAV-MW11, TAV-MW12, and TAV MW14, April-June 2019 (concluded)

Sample Date	Analyses	Analyte	Result[a]	MDL[b]	PQL[c]	MCL[d]	Units	Lab Qual[e]	Val Qual[f]	Sample No.	Analtyical Method[g]	Lab[h]
TAV-MW11												
20-May-19	NPN	Nitrate plus nitrite as N	8.13	0.17	0.5	10	mg/L			108432-002	EPA 353.2	GEL
20-May-19	VOC	Dichloroethene, cis-1,2-	0.53	0.3	1	70	µg/L	J		108432-001	SW846 8260B	GEL
20-May-19	VOC	Trichloroethene	4.33	0.3	1	5	µg/L			108432-001	SW846 8260B	GEL
TAV-MW12												
30-May-19	Dissolved Metals	Arsenic	ND	0.002	0.005	0.01	mg/L	U		108445-003	SW846 3005A/6020B	GEL
30-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108445-003	SW846 3005A/6020B	GEL
30-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108445-003	SW846 3005A/6020B	GEL
30-May-19	NPN	Nitrate plus nitrite as N	7.03	0.425	1.25	10	mg/L		J+	108445-002	EPA 353.2	GEL
30-May-19	VOC	Dichloroethene, cis-1,2-	ND	0.3	1	70	µg/L	U		108445-001	SW846 8260B	GEL
30-May-19	VOC	Trichloroethene	3.01	0.3	1	5	µg/L			108445-001	SW846 8260B	GEL
30-May-19 (DUP)	Dissolved Metals	Arsenic	ND	0.002	0.005	0.01	mg/L	U		108446-003	SW846 3005A/6020B	GEL
30-May-19 (DUP)	Dissolved Metals	Iron	0.0785	0.033	0.1	NE	mg/L	J		108446-003	SW846 3005A/6020B	GEL
30-May-19 (DUP)	Dissolved Metals	Manganese	0.00287	0.001	0.005	NE	mg/L	J		108446-003	SW846 3005A/6020B	GEL
30-May-19 (DUP)	NPN	Nitrate plus nitrite as N	7.1	0.425	1.25	10	mg/L		J+	108446-002	EPA 353.2	GEL
30-May-19 (DUP)	VOC	Dichloroethene, cis-1,2-	ND	0.3	1	70	µg/L	U		108446-001	SW846 8260B	GEL
30-May-19 (DUP)	VOC	Trichloroethene	2.94	0.3	1	5	µg/L			108446-001	SW846 8260B	GEL
TAV-MW14												
31-May-19	Dissolved Metals	Arsenic	0.0021	0.002	0.005	0.01	mg/L	J		108449-003	SW846 3005A/6020B	GEL
31-May-19	Dissolved Metals	Iron	ND	0.033	0.1	NE	mg/L	U		108449-003	SW846 3005A/6020B	GEL
31-May-19	Dissolved Metals	Manganese	ND	0.001	0.005	NE	mg/L	U		108449-003	SW846 3005A/6020B	GEL
31-May-19	NPN	Nitrate plus nitrite as N	9.95	0.85	2.5	10	mg/L			108449-002	EPA 353.2	GEL
31-May-19	VOC	Dichloroethene, cis-1,2-	0.46	0.3	1	70	µg/L	J		108449-001	SW846 8260B	GEL
31-May-19	VOC	Trichloroethene	4.94	0.3	1	5	µg/L			108449-001	SW846 8260B	GEL

Note: Header nomenclature is explained following Table III-8 in the “Footnotes for Technical Area-V Analytical Results Tables” summary.

Table III-8
Field Water Quality Measurements[i] before Groundwater Sampling at Each Well, April-June 2019

Well ID	Sample Date	Temperature (°C)	Specific Conductivity (µmhos/cm)	Oxidation Reduction Potential (mV)	pH	Turbidity (NTU)	Dissolved Oxygen (% Sat)	Dissolved Oxygen (mg/L)
TAV-INJ1	03-Jun-19	20.30	2020.11	-278.38	6.64	79.2	1.20	0.09
TAV-INJ1	04-Jun-19	21.44	2373.18	-228.65	6.74	16.5	3.53	0.27
TAV-INJ1	25-Jun-19	20.04	2901.98	-311.43	6.84	58.0	0.26	0.02
TAV-INJ1	26-Jun-19	21.29	2911.21	-301.32	6.93	63.2	0.22	0.02
TAV-MW6	23-Apr-19	19.97	677.00	109.5	7.47	1.98	69.70	5.27
TAV-MW6	28-May-19	22.03	708.00	136.35	7.34	1.75	57.40	4.18
TAV-MW6	24-Jun-19	22.95	705.12	97.98	7.34	6.26	50.45	3.63
TAV-MW7	13-May-19	20.43	542.60	77.6	7.39	2.64	2.50	0.19
LWDS-MW1	10-Jun-19	18.75	742.88	162.5	7.38	1.37	95.12	7.49
TAV-MW2	17-May-19	20.96	758.41	199.4	7.27	1.85	69.13	5.40
TAV-MW4	22-May-19	20.54	550.62	198.9	7.53	2.53	75.92	5.98
TAV-MW8	23-May-19	21.46	629.15	198.2	7.44	1.18	76.44	5.91
TAV-MW10	05-Jun-19	21.41	676.68	34.9	7.51	0.63	81.07	6.21
TAV-MW11	20-May-19	20.00	607.00	203.2	7.51	0.46	77.00	6.06
TAV-MW12	30-May-19	20.10	649.00	168.8	7.46	0.98	68.20	5.37
TAV-MW14	31-May-19	21.59	702.73	37.8	7.46	1.71	82.07	6.27

Note: Header nomenclature is explained following Table III-8 in the “Footnotes for Technical Area-V Analytical Results Tables” summary.

Footnotes for Technical Area-V Analytical Results Tables

% = Percent.
$CaCO_3$ = Calcium carbonate.
Dhc = *Dehalococcoides*.
Enumeration/L = gene copies per liter.
EPA = U.S. Environmental Protection Agency.
ID = Identifier.
INJ = Injection well (acronym used for well identification only).
LWDS = Liquid waste disposal system (acronym used for well identification only).
µg/L = Micrograms per liter.
mg/L = Milligrams per liter.
MEE = Methane, ethane, ethene.
MW = Monitoring well (acronym used for well identification only).
No. = Number.
NPN = Nitrate plus nitrite, as nitrogen.
TAV = Technical Area-V (acronym used for well identification only).
TOC = Total organic carbon.
VOC = Volatile organic compound.

[a]Result
Detected VOCs are presented in the tables.
Bold = Value exceed the established MCL.
ND = Not detected (at method detection limit).

[b]MDL
MDL = Method detection limit. The minimum concentration or activity that can be measured and reported with 99% confidence that the analyte is greater than zero, analyte is matrix specific.

[c]PQL
PQL = Practical quantitation limit. The lowest concentration of analytes in a sample that can be reliably determined within specified limits of precision and accuracy by that indicated method under routine laboratory operating conditions.

[d]MCL
MCL = Maximum contaminant level. 2018 Edition of the Drinking Water Standards and Health Advisories Tables, EPA 822-F-18-001, Office of Water, U.S. Environmental Protection Agency, Washington, DC, November 2018.

NE = Not established.

[e]Lab Qualifier
If cell is blank, then all quality control samples met acceptance criteria with respect to submitted samples.
* = Recovery of relative percent difference (RPD) not within acceptance limits and/or spike amount not compatible with the sample or the duplicate RPD's are not applicable where the concentration falls below the effective PQL.
B = The analyte was found in the blank above the effective MDL.
J = Estimated value, the analyte concentration fell above the effective MDL and below the effective PQL.
N = Results associated with a spike analysis that was outside control limits.
U = Analyte is absent or below the method detection limit.

Footnotes for Technical Area-V Analytical Results Tables (Continued)

[f]Validation Qualifier

If cell is blank, then all quality control samples met acceptance criteria with respect to submitted samples.

J = The associated value is an estimated quantity.
J+ = Estimated value with a suspected positive bias.
J- = Estimated value with a suspected negative bias.
UJ = The analyte was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

[g]Analytical Method

AM20GAX = Proprietary method of Pace Analytical Services, LLC.
Gene-Trac Dhc = Proprietary method of SiREM.

Clesceri, Rice, Baird, and Eaton, 2012, *Standard Methods for the Examination of Water and Wastewater*, 22nd ed., Method 2320B, published jointly by American Public Health Association, American Water Works Association, and Water Environment Federation. Washington, D.C.

EPA, 1986, (and updates), "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd ed. , U.S. Environmental Protection Agency, Cincinnati, Ohio

EPA, 1984, "Methods for Chemical Analysis of Water and Wastes." EPA 600-4-79-020, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA, 1993, "Method 350.1, Determination of Ammonia Nitrogen by Semi-Automated Colorimetry." Revision 2.0.

EPA, 1993, "Method 353.2, Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry." Revision 2.0.

[h]Lab

GEL = GEL Laboratories LLC, 2040 Savage Rd, Charleston, SC 29407.
PACE = Pace Analytical Services LLC, Energy Services Lab, 220 William Pitt Way, Pittsburgh, PA 15238.
SiREM = SiREM, 130 Stone Rd. W, Guelph, Ontario, N1G 3Z2, Canada.

[i]Field Water Quality Measurements

Field measurements collected prior to sampling.

°C = Degrees Celsius.
% Sat = Percent saturation.
μmhos/cm = Micromhos per centimeter.
mg/L = Milligrams per liter.
mV = Millivolts.
NTU = Nephelometric turbidity units.
pH = Potential of hydrogen (negative logarithm of the hydrogen ion concentration).

Appendix A

NMED's Approval Letter and DOE's Submittal with the Enclosure Describing Full-Scale Operation Modifications

State of New Mexico
ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6313
Phone (505) 476-6000 Fax (505) 476-6030
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SUSANA MARTINEZ
Governor
JOHN A. SANCHEZ
Lieutenant Governor

BUTCH TONGATE
Cabinet Secretary
J. C. BORREGO
Deputy Secretary

CERTIFIED MAIL – RETURN RECEIPT REQUESTED

August 13, 2018

Jeffrey P. Harrell
Manager
U.S. Department of Energy
NNSA/Sandia Field Office
P.O. Box 5400, MS 0184
Albuquerque, NM 87185-5400

Richard O. Griffith
Senior Manager
Sandia National Laboratories
P.O. Box 5800, MS 0726
Albuquerque, NM 87185-5400

RE: APPROVAL
TECHNICAL AREA-V (TA-V) TREATABILITY STUDY NOTIFICATION OF FULL-SCALE OPERATION AT WELL TAV-INJ1
SANDIA NATIONAL LABORATORY
EPA ID#NM5890110518
HWB-SNL-15-020

Dear Mr. Harrell and Mr. Griffith:

The New Mexico Environment Department (NMED) received the letter titled *Technical Area-V (TA-V) Treatability Study Notification of Full-Scale Operation at Well TAV-INJ1,* dated July 20, 2018, submitted by the U.S. Department of Energy on behalf of itself and NTESS (collectively, the Permittees), on July 26, 2018. NMED has reviewed the letter and hereby issues this Approval of the proposed modifications to the Work Plan and concurs with the decision to proceed with full-scale operation at well TAV-INJ1 of the Treatability Study/Interim Measure at TA-V.

If you have any questions regarding this matter, please contact Naomi Davidson of my staff at (505) 222-9504.

Sincerely,

John E. Kieling
Chief
Hazardous Waste Bureau

cc: D. Cobrain, NMED HWB
B. Wear, NMED HWB
N. Davidson, NMED HWB
L. King, EPA Region 6 (6PD-N)
J. Todd, DOE/NNSA/SFO, MS-0184
D. Rast, DOE/NNSA/SFO, MS-0184
J. Cochran, SNL/NM, MS-0719
E. Boatman, SNL/NM, MS-0718

File: SNL 2018 and Reading, SNL-15-020

Department of Energy
National Nuclear Security Administration
Sandia Field Office
P.O. Box 5400
Albuquerque, NM 87185

JUL 20 2018

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

Subject: Technical Area-V (TA-V) Treatability Study Notification of Full-Scale Operation at Well TAV-INJ1

Dear Mr. Kieling:

The Department of Energy/National Nuclear Security Administration/Sandia Field Office (DOE/NNSA/SFO) and its management and operating contractor, National Technology and Engineering Solutions of Sandia, LLC (NTESS) intend to proceed with full-scale operation at well TAV-INJ1 as part of the Treatability Study of in-situ bioremediation at TA-V Groundwater Area of Concern, Sandia National Laboratories/New Mexico (SNL/NM). Full-scale operation will not commence until at least 60 days after this notification is received at New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB), in accordance with the 2016 Revised Treatability Study Work Plan.

Associated modifications to the full-scale operation based on the experience and monitoring results of the pilot test at well TAV-INJ1 were discussed among personnel from DOE/NNSA/SFO, SNL/NM, and NMED HWB in a meeting held on June 20, 2018. The modifications and the rationale for the modifications to conduct full-scale operation at well TAV-INJ1 are provided in the enclosure.

If you have questions contact David Rast of our staff at (505) 845-5349.

Sincerely,

Jeffrey P. Harrell
Manager

Enclosure

cc: See Page 2

cc w/enclosure:
Naomi Davidson
NMED-HWB
121 Tijeras Avenue, NE,
Albuquerque, New Mexico 87102-3400

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NMED-HWB
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Susan Lucas-Kamat
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Zimmerman Library, UNM
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cc w/o enclosure:
Amy Blumberg, SNL/NM
Paul Shoemaker, SNL/NM
Christi Leigh, SNL/NM
John Cochran, SNL/NM
Jun Li, SNL/NM
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Howard Huie, DOE/EM-31
Douglas Tonkay, DOE/EM-31
Thomas Longo, NNSA/NA-533
Jessica Arcidiacono, NNSA/NA-533
Cynthia Wimberly, SFO/OOM
James Todd, SFO/ENG
Susan Lacy, SFO/ENG
Steven Black, SFO/ENG
David Rast, SFO/ENG
NNSA-2018-001960

Technical Area-V (TA-V) Treatability Study
Notification of Full-Scale Operation at Well TAV-INJ1

CERTIFICATION STATEMENT

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment for knowing violations.

Paul E. Shoemaker
Signature

July 10, 2018
Date

Paul E. Shoemaker
Defense Waste Management Programs
Sandia National Laboratories/New Mexico
Albuquerque, New Mexico 87185
Operator

and

Signature

7/23/2018
Date

Jeffrey P. Harrell, Manager
U.S. Department of Energy
National Nuclear Security Administration
Sandia Field Office
Owner

ENCLOSURE

The Department of Energy/National Nuclear Security Administration, Sandia Field Office and Sandia National Laboratories, New Mexico (SNL/NM) personnel (i.e., the project team) plan to implement the following modifications for the full-scale operation of the in-situ bioremediation (ISB) Treatability Study at the Technical Area-V (TA-V) Groundwater Area of Concern. The modifications were based on the experience and monitoring results of the pilot test conducted at well TAV-INJ1. The original proposal in the Revised Treatability Study Work Plan (TSWP) (SNL/NM March 2016; NMED May 2016) is repeated verbatim, followed by the rationale for modification and a summary statement of the modification to be implemented in full-scale operation at well TAV-INJ1.

#1: Method for Deoxygenation in Aboveground Tanks

In Section 4.2.2, Page 4-9, the Revised TSWP states, "*One tank will be inoculated with a small amount of soil core/cuttings from the injection well screened interval and have KB-1® Primer added. The purposes of adding soil core/cuttings to the substrate solution are to (1) inoculate the solution with native microorganisms, (2) create a diverse microbial community that will more likely work synergistically with the bioaugmentation culture, and (3) reduce the lag time for initiating biostimulation associated with utilization of the substrate in the subsurface.*"

Rationale for Modification: Two injections of the substrate solution were conducted during the pilot test. The soil core/cuttings were not added to the substrate solution during the first injection, but were added during the second injection. The pilot test results showed that KB-1® Primer itself could produce favorable conditions – low dissolved oxygen (DO) and negative oxidation-reduction potential (ORP) – for safely injecting KB-1® Dechlorinator. KB-1® Dechlorinator are the dechlorinating bacteria that require anaerobic environment to survive.

Based on the experience gained during the pilot test, it is not necessary to rely on growing the microbial community in the aboveground tanks to produce low DO and negative ORP inside the tanks. In fact, the KB-1® Primer alone can sufficiently produce these conditions. Not relying on microbial growth in the aboveground tanks eliminates the biofouling concern for the water stored in the tanks.

During full-scale injection, we will bioaugment the aquifer with KB-1® Dechlorinator throughout the six-month injection; therefore, the three purposes stated above become unnecessary because of the long-term bioaugmentation in the aquifer.

Full-Scale Operation Modification #1: Use substrate components (i.e., chemicals) only to deoxygenate potable water in aboveground tanks.

#2: Number of Aboveground Deoxygenation Tanks for Full-Scale Operation

In Section 4.2.2, Pages 4-9 and 4-10, the Revised TSWP states "*A similar process will be applied to the full-scale injections. Two pairs of tanks will be used for full-scale injection (see section 4.3.2). Both pairs of tanks will be filled halfway with potable water, inoculated, and have KB-1® Primer added. After turning anaerobic, the tanks will be filled with potable water and*

mixed with proportional amounts of the substrate solution components. As with the push/pull test, deoxygenation of the entire tank volume is expected within one to two days. Once anaerobic conditions are restored, half of the tank contents (from each pair) will be injected. This pair of tanks will then be refilled with potable water and mixed with proportional amounts of the substrate solution components. Provided that approximately half a tank of the deoxygenated solution remains in each tank, this accelerated deoxygenation schedule is expected to continue without further use of KB-1® Primer during the remainder of the injection period. By alternating two pair of tanks, injection would not be interrupted while waiting for the substrate solution to turn anaerobic."

Rationale for Modification: Using substrate components (i.e., chemicals) to achieve low DO and negative ORP of the substrate solution for safely injecting KB-1® Dechlorinator, the injection operation can be simplified by alternating two deoxygenation tanks. Based on the experience from the pilot test, the chemicals can lower the DO and ORP to desired levels within a couple of hours. It takes about five and a half hours to inject approximately 5,000 gallons of substrate solution. Therefore, theoretically we can prepare a tank of substrate solution and empty it within a single day. In practice, we will prepare one tank and empty its content the next day. We will alternate using the two existing tanks used in the pilot test. With this modification, we do not need to install two more tanks as proposed in the Revised TSWP.

Full-Scale Operation Modification #2: Use two existing 5,000-gallon aboveground tanks for full-scale injection.

#3: Substitute for KB-1® Primer

In Section 4.2.2, Page 4-8, the Revised TSWP states "*KB-1® Primer is a proprietary mixture of amino acids, potassium bicarbonate, and sodium sulfite that is used to accelerate deoxygenation of water inorganically (sodium sulfite) while still providing an electron donor (amino acids) and buffer (potassium bicarbonate). It can therefore be used as a substitute for ethyl lactate, diammonium phosphate, and yeast extract, although it is significantly more costly and therefore, not suitable for the large volumes planned under full scale injection.*"

Rationale for Modification: With the goal of using chemical method for deoxygenation, the project team conducted bench-scale, 5-gallon bucket tests to evaluate the functionality of the key components of KB-1® Primer. The results of the bucket tests showed that by using the two key ingredients, potassium bicarbonate and sodium sulfite, combined with ethyl lactate and diammonium phosphate, we could achieve the same desired conditions as using the KB-1® Primer alone. The functionality of ethyl lactate as the electron donor and diammonium phosphate as the nutrient can effectively substitute for the amino acids in the KB-1® Primer.

Attachment A includes the Safety Data Sheets (SDS) for potassium bicarbonate and sodium sulfite.

Full-Scale Operation Modification #3: Eliminate KB-1® Primer. Use potassium bicarbonate and sodium sulfite. A Revised Table 4-1 is provided below for the substrate solution components in full-scale operation.

Minor adjustments to the quantities of the substrate components could be necessary during full-scale operation depending on the in-situ water quality measurements of the aboveground tanks content and the groundwater in well TAV-INJ1.

Revised Table 4-1
Substrate Solution Components

Substrate Solution Component	Function	Mixing Ratio (by weight)	Weight per 1,000 gal Water
Primary Components			
Ethyl lactate	Electron donor (substrate)	80.4%	5.64 lbs
Diammonium phosphate	Nutrient and pH buffer	9.0%	0.63 lbs
Accelerite® [a]	Nutrient	6.4%	0.45 lbs
Potassium Bicarbonate	Buffer and acid reducer	1.7%	0.11 lbs
Sodium Sulfite	Deoxygenation and reduction agent	2.5%	0.17 lbs
Primary Components per 1,000 gal Potable Water		**100%**	**7 lbs**
Additional Component Mixed with Substrate Solution			
Sodium bromide	Inert tracer (as bromide)	Not applicable; adjusted per field condition	0.2 lbs

[a] Accelerite® Bioremediation Nutrient is a product of JRW Bioremediation, LLC.
% = Percent.
gal = Gallon(s).
lbs = Pounds.

#4: Substitute for Yeast Extract

In Section 4.2.1, Page 4-7, the Revised TSWP states "*Diammonium phosphate and yeast extract will be added as nutrients to support microbial growth.*"

Rationale for Modification: Accelerite® Bioremediation Nutrient is a product of JRW Bioremediation, LLC (JRW). The composition of Accelerite® is a proprietary nutrient blend of yeast metabolites including B-vitamins and other soluble nutrients. Accelerite® was tested in the bench-scale bucket tests and proved to function the same as the yeast extract obtained from Sigma-Aldrich. There are two advantages of using Accelerite®. First, it is significantly more concentrated, requiring less material to achieve the desired effect. The overall cost for Accelerite® is less than the yeast extract because less material is required. Secondly, Accelerite® is received in liquid form and is much easier to handle in the field than the powder-form yeast extract. Therefore, Accelerite® Bioremediation Nutrient from JRW is chosen to substitute for yeast extract in the full-scale operation.

Attachment A includes the SDS for Accelerite® is Bioremediation Nutrient.

Full-Scale Operation Modification #4: Use Accelerite® Bioremediation Nutrient in place of yeast extract. The Revised Table 4-1 provides the quantity needed for Accelerite® in full-scale operation.

#5: Sampling for Laboratory Analysis of Tank Content

In Section 5.4.2, Pages 5-17 and 5-18 of the Revised TSWP do not state that samples of the injected substrate solution during full-scale injections will be collected for laboratory analysis. However, sampling is implied as we did during the pilot test injections, in accordance with Section 5.4.1, Page 5-15, which states, "*A sample of the injected substrate solution will be collected as it is being injected and analyzed for parameters listed in Table 5-4 and measured for field parameters specified in section 5.3.*"

Rationale for Modification: Samples of the substrate solution in aboveground tanks were collected for laboratory analysis during the pilot test injections. The objective of sampling the tank content was to confirm the ingredients of the substrate solution. However, significant matrix interferences were reported by the analytical laboratory, which resulted in high dilutions for most samples. While preparing the substrate solution, the daily dose, masses or volumes of the substrate components as well as the KB-1® Dechlorinator could be accurately measured before mixing. The volume of the potable water could be accurately measured by the flow meter connected to the fire hydrant. These records provided sufficient information on what was being injected. The laboratory analysis of the tank content did not add any value because the process knowledge of the injectate was sufficient. Therefore, laboratory analysis of the substrate solution is not necessary. In addition, an in-situ water quality sonde is used to monitor the turbidity, specific conductance, pH, ORP, DO, temperature, and pressure in each tank.

Full-Scale Operation Modification #5: No sampling of the aboveground tank content.

#6: Groundwater Sampling at Well TAV-INJ1 during Injection

In Section 5.2.2, Page 5-18, the Revised TSWP states, "*During injection, DO, ORP, and pH will be monitored in well TAV-INJ1 using downhole electronic probes and a data logger. Water levels will also be frequently monitored immediately prior and throughout each workday during injections. Additionally, wells TAV-INJ1, TAV-MW6, and TAV-MW7 will be monitored monthly during injection for the analyses (Table 5-4) and the field parameters listed in section 5.3.*"

Rationale for Modification: During the performance monitoring of the pilot test, it was apparent that we were dominantly sampling the substrate solution that was injected at well TAV-INJ1 instead of the native groundwater. Strong matrix interferences were reported by the analytical laboratory due to the various substrate ingredients. Because we know exactly how we prepare the substrate solution in aboveground tanks, it is not necessary to collect groundwater samples from the injection well during the six-month injection period.

However, we will collect groundwater samples from well TAV-MW6 during injection as planned in the Revised TSWP. In addition, in-situ water quality sondes will be installed in wells TAV-INJ1 and TAV-MW6 during injection. Turbidity, specific conductance, pH, ORP, DO, temperature, and pressure (correlates to water level) will be logged continuously at a frequency set by the project team.

Full-Scale Operation Modification #6: No groundwater sampling at injection well TAV-INJ1 during the six-month injection. Groundwater sampling at well TAV-INJ1 will start one month after the completion of full-scale injections, as proposed for the post-injection monitoring in the Revised TSWP.

#7: ISB Performance Monitoring at Well TAV-MW7

In Section 5.2.2, Page 5-17 (top of page), the Revised TSWP states "*Did results from deeper well TAV-MW7 support the conclusion that further injections will not adversely affect deeper groundwater?"*

Increases in nitrate or bromide concentrations and detections of TCE or associated daughter products in well TAV-MW7 would indicate further injection could drive contamination deeper."

Rationale for Modification: During the pilot test injections, an in-situ water quality sonde was installed in each of the three wells (TAV-INJ1, TAV-MW6, and TAV-MW7). The sonde has sensors for turbidity, specific conductance, pH, ORP, DO, temperature, and pressure. The pressure reading correlates to the height of the water column above the sonde. These seven parameters were logged continuously at a pre-specified interval (e.g., every minute). When injections occurred in well TAV-INJ1 (Figure 1a), we observed instantaneous response in well TAV-MW6 (Figure 1b). However, no response was observed in well TAV-MW7 (Figure 1c). These results indicate that wells TAV-INJ1 and TAV-MW6, both screened across the groundwater table, are **not** hydrogeologically connected with well TAV-MW7, which is screened 90 feet deeper.

The results from the four-month performance monitoring after the pilot test injections also show no indication of any injected ingredient in well TAV-MW7, even though well TAV-MW7 is laterally closer to well TAV-INJ1 than well TAV-MW6. The monitoring results of well TAV-MW7 have been similar to its baseline sampling results in the October – December 2017 Discharge Permit DP-1845 Quarterly Report submitted to the NMED GWQB. A copy of this report was also provided to the NMED HWB.

Well TAV-MW7 would not be useful for monitoring the ISB treatment zone surrounding wells TAV-INJ1 and TAV-MW6. Therefore, we propose to revert it back to the TA-V groundwater monitoring network, which is administered by the SNL Long-Term Stewardship (LTS) group. Under the LTS monitoring plan, well TAV-MW7 is sampled semiannually for nitrate plus nitrite (NPN), volatile organic compounds, and dissolved metals (arsenic, iron, and manganese).

Full-Scale Operation Modification #7: Revert well TAV-MW7 back to the LTS sampling plan with the following additions:

- Increase the sampling frequency from semiannually to quarterly.
- Include bromide in the current analysis suite.
- Include ethene in the current analysis suite, per requirement of the Discharge Permit DP-1845.
- Install an in-situ water quality sonde in well TAV-MW7 in full-scale operation.

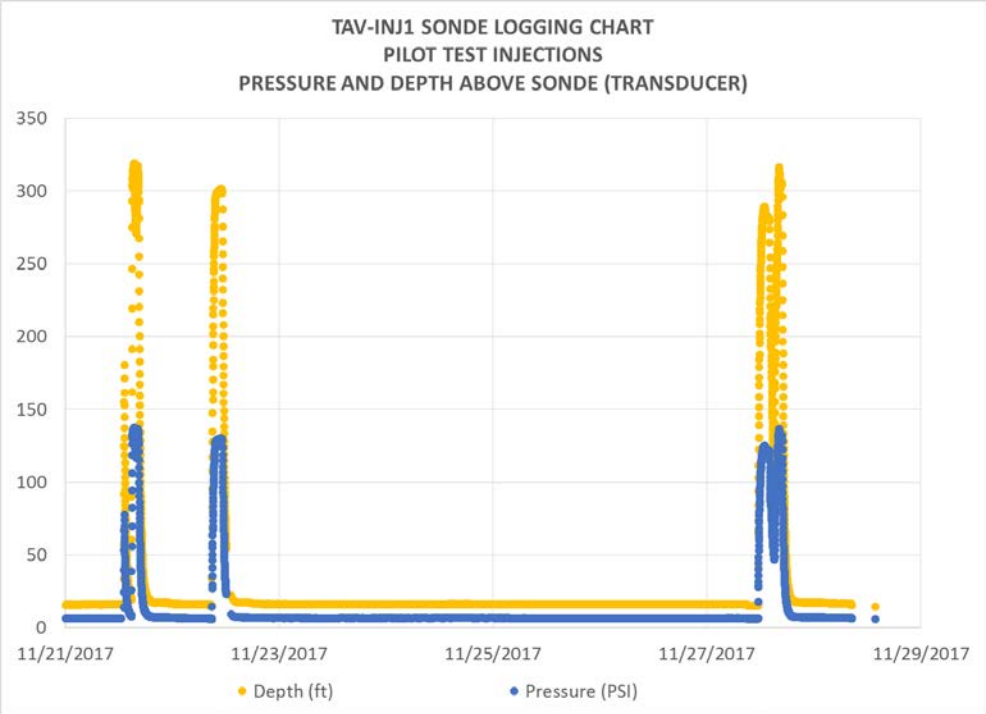

Figure 1a
Pressure and Water Column Height in well TAV-INJ1 during Injections

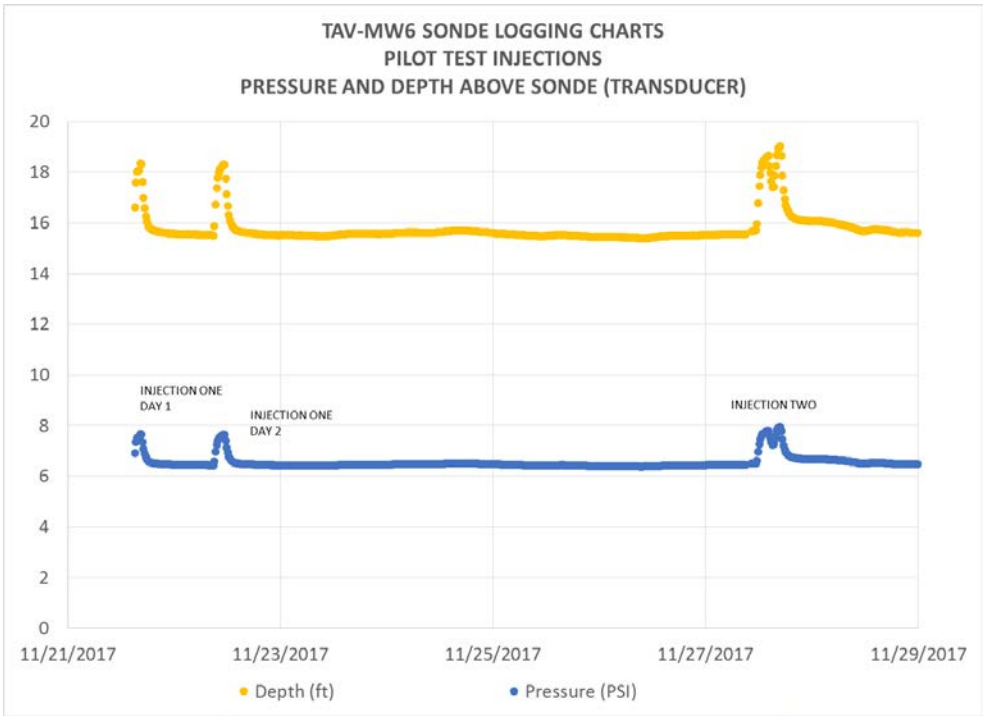

Figure 1b
Pressure and Water Column Height in well TAV-MW6 in
Response to Injections at well TAV-INJ1

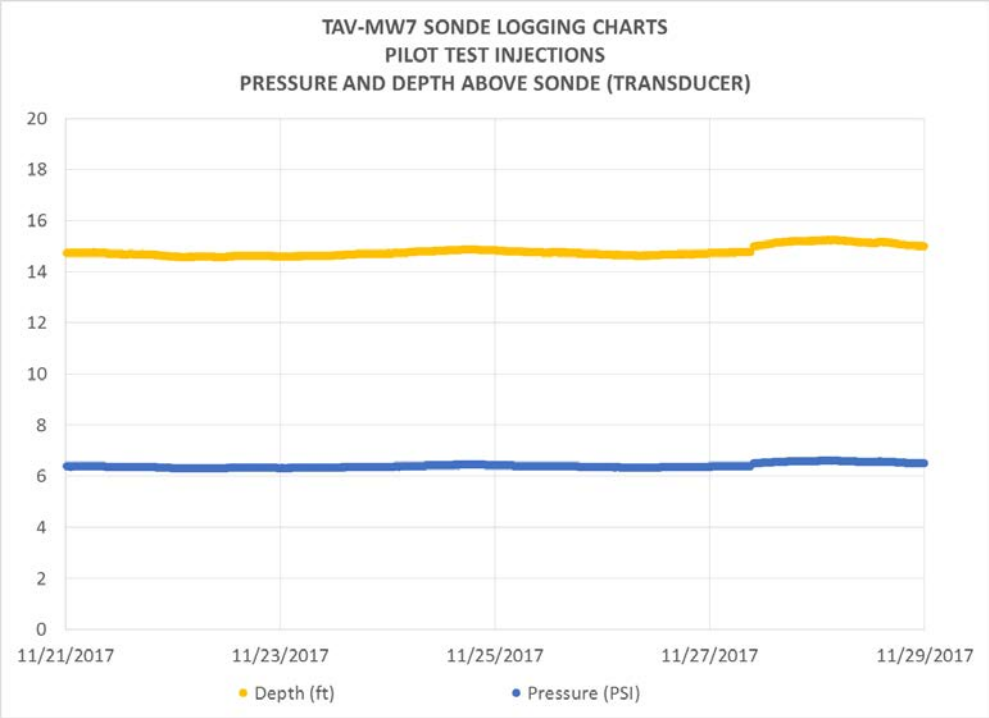

Figure 1c
Pressure and Water Column Height in well TAV-MW7 in
Response to Injections at well TAV-INJ1

In the unlikely event that the sonde readings or the analytical results from well TAV-MW7 show any variation from the baseline, it will be reinstated into the ISB performance monitoring campaign as soon as possible.

#8: Analytical Parameters for Groundwater Samples

In Section 5.3, Page 5-11, Table 5-4, the Revised TSWP provides the analytical parameters for groundwater samples to be collected during the Treatability Study.

Rationale for Modification: Table 5-4 is a comprehensive list that includes all potentially useful parameters identified in the **planning** stage. Based on the results from the pilot test performance monitoring, nine analytes will be eliminated for full-scale operation as explained below.

- Chloride and fluoride – These analytes are not indicative of the performance of the ISB; therefore, are not useful to monitor.

- Nitrite – Baseline samples were collected from injection well TAV-INJ1 and the two nearby monitoring wells TAV-MW6 and TAV-MW7 before the pilot test. Nitrite was either detected near the Practical Quantification Limit or was not detected in the baseline samples (see Table B-2 of the October – December 2017 DP-1845 Quarterly Report). During pilot test performance monitoring, nitrite was not

detected in any of the groundwater samples from wells TAV-INJ1, TAV-MW6, and TAV-MW7 (see Tables B-1 and B-4 of the October – December 2017 DP-1845 Quarterly Report).

Nitrite is highly reactive and is an intermediate compound formed during nitrification and denitrification. It can be oxidized to nitrate or reduced to ammonium in an aquifer. Results of the baseline sampling and the performance monitoring after pilot test injections (which generated reducing conditions in the aquifer) indicate that nitrite apparently does not exist at detectable concentrations during ISB at TA-V. Based on this understanding, nitrite will be eliminated from the analyte list in full-scale operation. Analyses for ammonia and NPN will remain.

- Calcium, magnesium, potassium, and sodium – These analytes are not indicative of the performance of the ISB; therefore, are not useful to monitor.

- Orthophosphate as P – Diammonium phosphate (DAP) is an ingredient of the substrate solution. It acts as a pH buffer and provides phosphorous to support microbial cell generation. Figure 2 presents the orthophosphate concentrations in well TAV-INJ1 during the pilot test performance monitoring. It shows that phosphorous was rapidly utilized by microbes. Figure 2 also presents the concentrations of Total Organic Carbon (TOC), which is the main source for microbial growth. Figure 2 shows the more gradual consumption of TOC compared to the exponential utilization of orthophosphate. It is expected that phosphorous will be completely consumed prior to the depletion of TOC. Therefore, TOC is a more robust and reliable indicator for microbial respiration and growth in the treatment zone. Based on this understanding, orthophosphate will be eliminated from the analyte list in full-scale operation. Analysis for TOC will remain.

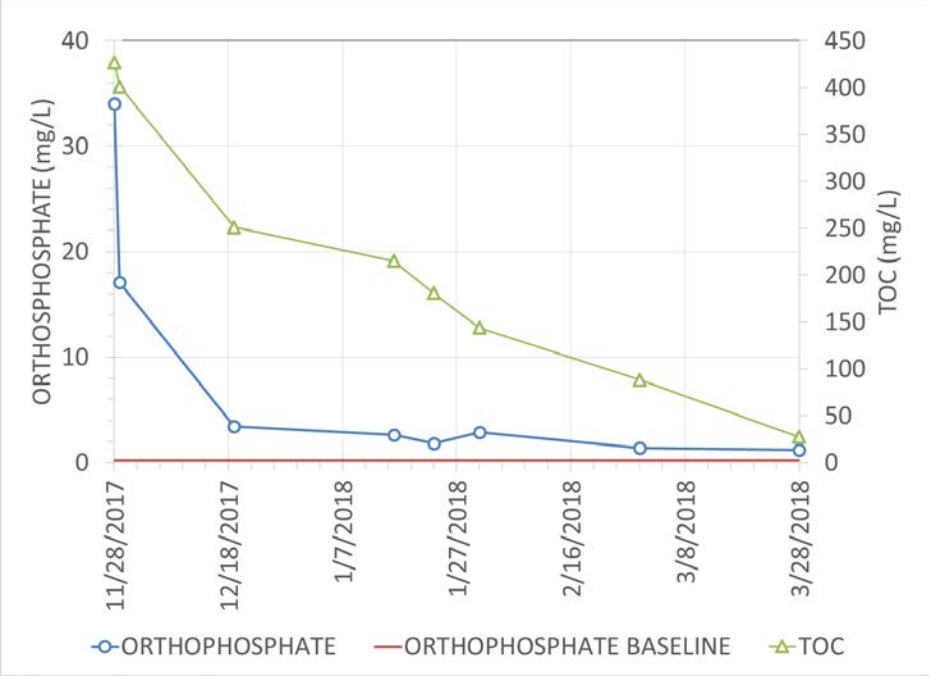

Figure 2
Orthophosphate and TOC Concentrations at TAV-INJ1 following Pilot Test Injections

- Sulfide – Similar to nitrite, sulfides generated during ISB are intermediate compounds and are not expected to persist in a dissolved state. Reactive sulfide was not detected in any of the groundwater samples from wells TAV-INJ1, TAV-MW6, and TAV-MW7 during the pilot test performance monitoring. Therefore, sampling for sulfides in the groundwater from the treatment zone is not warranted for the full-scale operation.

  However, due to the potential for hydrogen sulfide gas to accumulate in the well casing of the injection well, a handheld hydrogen sulfide gas meter will be used to monitor the hydrogen sulfide gas levels during the full-scale injections. The data may be useful to evaluate ISB performance and to address any worker safety concerns for conducting groundwater sampling.

Full-Scale Operation Modification #8: Eliminate unnecessary analytical parameters when wells TAV-INJ1 and TAV-MW6 are sampled. The Revised Table 5-4 is provided below for the analytical parameters for full-scale operation.

Revised Table 5-4
Analytical Parameters for Groundwater Samples

Analytical Group/Analyte in Table 5-4 of the Revised TSWP	Analyte in Table 5-4 of the Revised TSWP	Revised Analyte List for Full-Scale Operation
Alkalinity (total, bicarbonate, and carbonate)	Alkalinity	Yes
Ammonia (as Nitrogen)	Ammonia	Yes
Anions	Bromide	Yes
Anions	Chloride	No
Anions	Fluoride	No
Anions	Nitrite	No
Anions	Sulfate	Yes
Dehalococcoides (Dhc) and, if Dhc is present, vinyl chloride reductase (vcrA).	Dhc and vcrA	Yes
Dissolved Metals	Arsenic	Yes
Dissolved Metals	Calcium	No
Dissolved Metals	Iron	Yes
Dissolved Metals	Magnesium	No
Dissolved Metals	Manganese	Yes
Dissolved Metals	Potassium	No
Dissolved Metals	Sodium	No
Methane/Ethane/Ethene (MEE)	MEE	Yes
Nitrate plus Nitrite (NPN)	NPN	Yes
Orthophosphate (as P)	Orthophosphate (as P)	No
Total Organic Carbon (TOC)	TOC	Yes
Sulfide	Sulfide	No
Volatile Organic Compounds (VOCs)	VOCs	Yes

References

New Mexico Environment Department (NMED), May 2016. Letter to J. Harrell (U.S. Department of Energy NNSA/Sandia Field Office) and P. Davies (Sandia National Laboratories, New Mexico), “Approval Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern, Sandia National Laboratories, EPA ID# NM5890110518, HWB-SNL-15-020,” NMED, Hazardous Waste Bureau, Santa Fe, New Mexico, May 10, 2016.

Sandia National Laboratories, New Mexico (SNL/NM), March 2016. *Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern, Sandia National Laboratories, Albuquerque, New Mexico*.

Appendix B

Bioremediation Treatability Study
Aboveground Injection System at TAV-INJ1
As-Built Engineering Drawings