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Sandia National Laboratories, New Mexico Environmental Restoration Operations

Installation of Injection Well TAV-INJ1 at the Technical Area-V Groundwater Area of Concern

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United States Department of Energy
Sandia Field Office

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ACRONYMS AND ABBREVIATIONS

%	percentage
°C	degree(s) Celsius
µmhos	micromhos
µS/cm	microSiemens per centimeter
amsl	above mean sea level
AOP	Administrative Operating Procedure
ARCH	Air-rotary casing hammer
ARDH	Air-rotary downhole hammer
bgs	below ground surface
cm	centimeter
CSS	Colorado Silica Sand
ER	Environmental Restoration
FOP	Field Operating Procedure
ft	feet or foot
ft^3	cubic foot or cubic feet
gal.	gallon(s)
Hr	hour
HWB	Hazardous Waste Bureau
ID	inside diameter
INJ	injection (well designation only)
L	liter
Max.	Maximum value
Min.	Minimum value
mm	millimeter
mV	millivolts
MW	monitoring well
na	not applicable
NM	New Mexico
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NTU	nephelometric turbidity unit(s)
OD	outside diameter
pH	potential of hydrogen
POD	point of diversion
PVC	polyvinyl chloride
Rathole	Extra hole drilled at the bottom of the borehole to allow for slough
SNL/NM	Sandia National Laboratories, New Mexico
TA-V	Technical Area-V
TAV	Technical Area-V (well designation only)
TCE	Trichloroethylene
TD	total depth
Temp.	temperature
Work Plan	*Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern*

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1.0 INTRODUCTION

This report documents the installation of injection well TAV-INJ1 at the Technical Area-V (TA-V) Groundwater Area of Concern at Sandia National Laboratories, New Mexico (SNL/NM). The U.S. Department of Energy (DOE) and the management and operating contractor for Sandia National Laboratories beginning on May 1, 2017, National Technology & Engineering Solutions of Sandia, LLC (NTESS), hereinafter collectively referred to as DOE/NTESS, prepared this well installation report.

Well installation activities were conducted in accordance with the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB)-approved work plan *Revised Treatability Study Work Plan for In-Situ Bioremediation at the Technical Area-V Groundwater Area of Concern* (Work Plan) (SNL/NM March 2016). The Work Plan was approved by NMED HWB prior to the start of field work (NMED May 2016).

Drilling activities were performed from September 2017 through November 2017 by SNL/NM Environmental Restoration (ER) Operations personnel, and the drilling contractor Cascade Drilling LP. Drilling activities began with borehole drilling and sampling on September 12, 2017. Well construction was completed on October 11, 2017 and well development was concluded on November 1, 2017. A land survey to establish the location coordinates and elevations of the well was conducted on May 16, 2018, and transmitted to ER personnel on May 24, 2018.

1.1 Project Objectives

The objectives of the field program were to install and develop injection well TAV-INJ1. The Work Plan (SNL/NM March 2016) specified that the well be installed in the TA-V courtyard near the main entrance (Figure 1-1). The purpose of the well is to inject a nutrient-amended solution and microbial bioaugmentation culture to implement a treatability study for potential remediation of groundwater contamination at the TA-V Groundwater Area of Concern. The groundwater contaminants of concern are nitrate and trichloroethylene (TCE). The purpose of the injected solution is to reduce nitrate concentrations by denitrification, and TCE concentrations by reductive dichlorination.

Drilling and installation of injection well TAV-INJ1 started on September 12, 2017, and ended October 11, 2017. (Table 1-1). Well development started on October 24, and ended on November 1, 2017.

Table 1-1
Summary of Primary Field Activities Conducted during September 2017 to November 2017

Well	Type of Well	Casing TD (ft bgs)	Primary Field Activity
TAV-INJ1	Injection, PVC	544.54	Drilling, Well Installation, and Well Development

bgs = Below ground surface.
ft = Feet.
PVC = Polyvinyl chloride.
TAV = Technical Area-V.
TD = Total Depth.

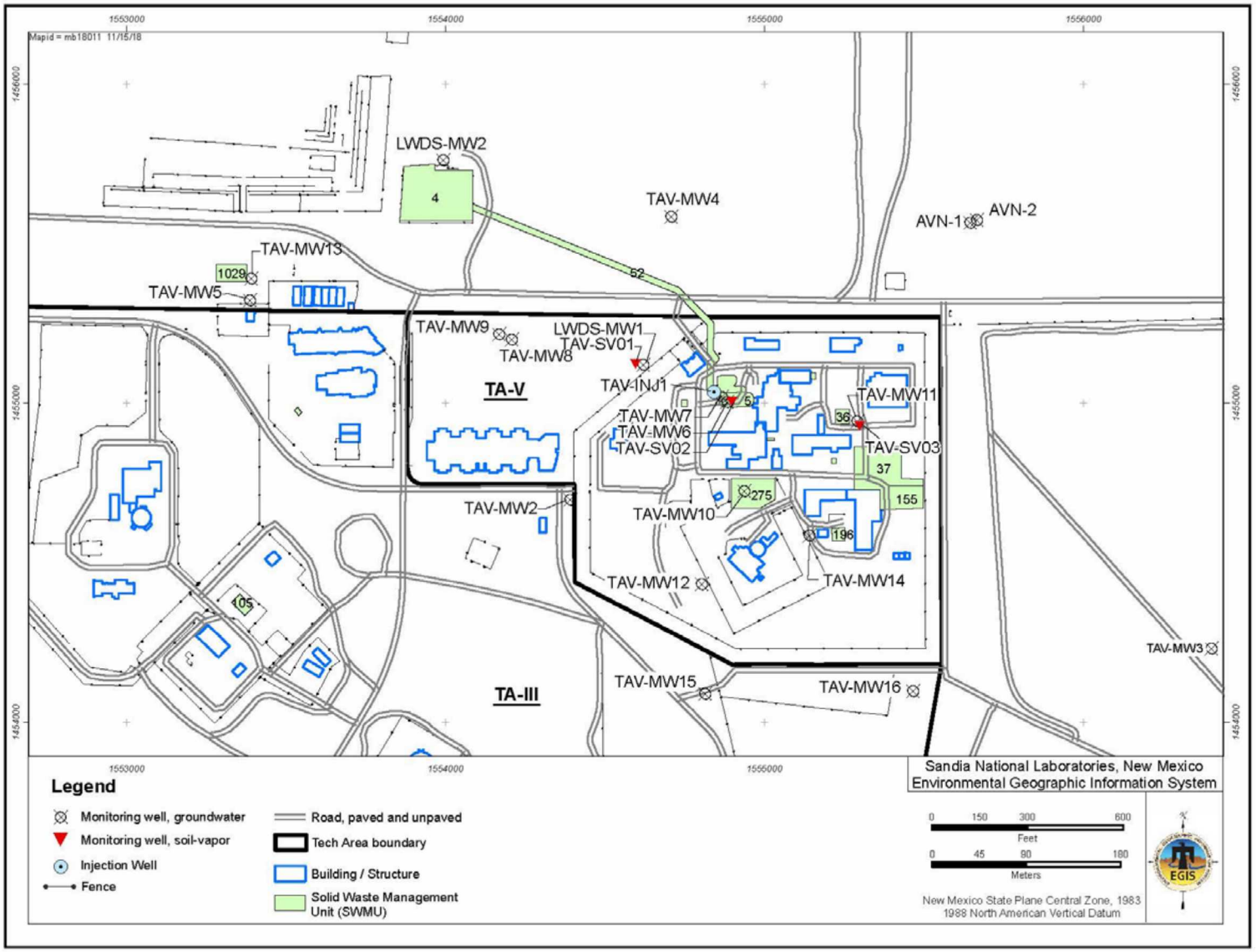

Figure 1-1
The Location of Injection Well TAV-INJ1 in Technical Area-V

1.2 Report Organization

This report is organized by field activity:

- Chapter 2.0 describes the drilling activities including drilling, well installation, and well development.
- Chapter 3.0 describes the construction and installation of the well vault.
- Chapter 4.0 describes the land surveying of well coordinates and elevations.
- Chapter 5.0 lists the variances from the Work Plan.
- Chapter 6.0 lists the references cited in this report.

The following appendices provide supplemental information:

- Appendix A provides the lithologic logs.
- Appendix B provides photographs of the lithologic cuttings.
- Appendix C provides the photographs of the core samples.
- Appendix D presents the well construction data sheets.
- Appendix E contains the well construction diagrams.
- Appendix F provides the well development forms.

This report satisfies the reporting requirements for both the NMED HWB and the New Mexico Office of the State Engineer (NMOSE) as described in the Work Plan (SNL/NM March 2016). The Compliance Order on Consent (NMED April 2004) also specifies 27 reporting elements for the installation of a monitoring well. The NMOSE requirements and guidance are provided in "Rules and Regulations Governing Well Driller Licensing; Construction, Repair, and Plugging of Wells" (NMOSE August 2005). The injection well is permitted by NMOSE as Point of Diversion (POD) 126 - TAV-INJ1 of Permit File RG-900065 (NMOSE July 2016a, NMOSE July 2016b).

Additional field documentation consisting of pages from the field logbook and safety records are on file at the SNL Records Center.

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2.0 INJECTION WELL DRILLING, INSTALLATION, AND DEVELOPMENT

Cascade Drilling LP performed all drilling and well installation operations and SNL/NM ER Operations personnel supervised the operations. The injection well TAV-INJ1 was drilled using the air-rotary casing hammer (ARCH) method with a Speedstar 50K drilling rig and associated equipment. Figure 2-1 shows the drill rig and drilling location. Continuous coring samples were collected using an air-rotary downhole hammer (ARDH) from approximately 20 feet (ft) above the static water table to 40 ft below the static water table.

Figure 2-1
The Pipe Truck, Drill Rig, and Forklift on Location for Injection Well TAV-INJ1 in the Technical Area-V Main Courtyard (view to the east, September 12, 2017)

Table 2-1 lists applicable Field Operating Procedures (FOPs) and the Administrative Operating Procedure (AOP). The most current versions of the procedures were used.

Table 2-1
Applicable Sandia National Laboratories, New Mexico Procedures

Procedure Number	Procedure Title
FOP 05-04	Groundwater Monitoring Waste Management
FOP 12-11	Drilling Methods, Designing, and Installing Groundwater Monitoring Wells
FOP 94-01	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-05	Borehole Lithologic Logging
FOP 94-25	Documentation of Field Activities
FOP 94-41	Well Development
FOP 94-57	Decontaminating Drilling and Associated Field Equipment
FOP 94-71	Land Surveying
AOP 08-05	Monitoring Well Installation, Decommissioning, and Planning

AOP = Administrative Operating Procedure.
FOP = Field Operating Procedure.

The following sections describe the borehole drilling and well construction activities.

2.1 Drilling and Installation of Injection Well TAV-INJ1

The drilling equipment (i.e., rig, bits, collars, pipe, and drive casing) was decontaminated with a high-pressure water sprayer (steam cleaner) prior to the start of drilling operations. Decontamination was conducted at the Environmental Resources Field Operations decontamination pad in Technical Area-III.

The borehole for injection well TAV-INJ1 was spudded in alluvium through an opening cut in the asphalt in the courtyard just south of the TA-V main entrance. Drilling initially advanced through 20 ft of clean fill (medium sized gravel) that had been installed after utilities potholing. Drilling then progressed through damp uniform fine grained sand, with intermittent layers of gravels and cobbles. Appendices A and B provide the lithologic log and photographs, respectively. The gravels and cobbles were primarily composed of sub-angular to sub-rounded limestone with occasional quartzite and igneous rock fragments.

The first 200 ft of the borehole was advanced with a tricone bit, and 11.75-inch outside diameter (OD) drive casing that kept the alluvium from sloughing into the borehole. From 200 ft below ground surface (bgs) to total depth (TD) the bit and casing were changed to an 8.5 inch tricone bit, and 9.625-inch OD drive casing.

Continuous core samples 10-ft long were collected from approximately 20 ft above to 40 ft below the static water table (from 495 to 547 ft bgs). The anticipated water level at TAV-INJ1 was interpolated from the Annual Groundwater Monitoring Report, Plate 1 SNL/NM Monitoring Well Locations and Base Wide Potentiometric Surface Map of the Regional Aquifer for the Kirtland Air Force Base Vicinity July 2015 (SNL/NM June 2016). The cores were obtained with an ARDH drill that advanced a 5-ft long, 4-inch diameter acetate lined core barrel. Collecting a 10-ft core interval required two core runs, as shown in Table 2-2.

After each 10-ft interval was cored ARCH drilling resumed to advance the borehole. All core samples were photographed (Appendix C) before segments were removed for laboratory analysis. The remaining core was sealed and stored at the Environmental Resources Field

Office. The core will be stored for at least six months as specified in the Work Plan (SNL/NM March 2016).

During coring, excess core was consistently recovered. Coring penetration was normally limited to 2 ft, and typically 4 to 5 ft of core was recovered (Table 2-2). There were two exceptions: (1) Core Interval #2 started at 505 ft bgs, and an attempt was made to recover 5 ft of core. The core barrel penetrated 3.5 ft of core from 505 to 508.5 ft bgs, and reached refusal. Five feet of very densely packed core was recovered, and the acetate sleeve was severely distorted and was stuck in the core barrel. (2) Core Interval #6 was the final core sample collected and coring starting at 547 ft bgs. The core barrel immediately would not penetrate (met refusal) the formation. However, approximately three feet of core material was recovered.

Throughout coring, the driller felt the core barrel contact the formation at the starting depth, and penetrate to the final depth. The driller did not believe that the excess material was due to slough or caving accumulating in the borehole.

Table 2-2
Depth of Continuous Core Samples Collected from TAV-INJ1

Core Interval	Anticipated Depth to Water (ft bgs)	Planned Cored Interval (ft bgs)	Core Run	Actual Core Penetration (ft bgs)	Actual Core Recovery (ft/%)
1		495 – 505	1	495 - 497.5	5 / 200
			2	497.5 - 499	5 / 330
2	513	505 – 515	1	505 – 508.5	5 / 140
			2	508.5 – 510.5	5 / 250
3		515 – 525	1	515 - 517	5 / 250
			2	517 - 519	5 / 250
4		525 – 535	1	525 - 527	5 / 250
			2	527 - 529	5 / 250
5		535 – 545	1	535 - 537	3 / 150
			2	537 - 539	5 / 250
6		545 – 555	1	545 - 547	4 / 200
			2	547 – 547 (refusal)	3 / *nc

bgs = Below ground surface.
ft = Feet.
*nc = Not calculated (3 ft/0 ft).

On October 2, 2017, the borehole was at a TD of 560 ft bgs with the 9-5/8 drive casing set at a depth of 555 ft bgs (leaving 5 ft of open hole). The construction and installation of the dual casing injection well (5-inch monitoring and 1.5-inch injection polyvinyl chloride [PVC] casing) was being prepared. All well materials were installed through the temporary steel drive casing. To isolate the lower portion of the borehole, two bags of bentonite chips were added. As the bentonite chips were added, the drive casing was pulled up to prevent hydrating the bentonite inside the drive casing and causing it to plug the pipe. When the drive casing was pulled up a few feet the formation began to heave into the open wellbore and then rapidly rose into the drive casing.

To stabilize the borehole and stop the heaving formation, the 9-5/8 drive casing was driven back down to 555 ft bgs and the formation was tagged at 543 ft bgs inside the drive casing. The formation had rapidly risen (within approximately 10 minutes) 12 ft inside the drive casing.

To complete the well, the heaving formation needed to be stabilized. Two options were considered: (1) Add potable water from the pipe truck tank to the 9-5/8 drive casing. The hydraulic pressure of the water column in the drive casing would prevent the formation heaving into the borehole. (2) Vacuum out the heaving formation by continuously adding potable water from a 4-inch hose connected to the fire hydrant to the drive casing, and inserting a 1-inch air hose to the bottom of the wellbore to evacuate the formation and water. Compressed air would be fed into the 1-inch hose, and the air released down hole would elevate and vacuum out the formation material until it stopped heaving.

Option one was selected to stabilize the borehole, and approximately 800 gallons of potable water was added to the drive casing. Option two, to vacuum out the formation, was not selected because it was deemed to be difficult to determine how much water had been added to the borehole. The amount of water added to borehole would have to be estimated by comparing the amount of water recovered in the hopper (which would include formation material, potable water, and groundwater), and evaluate how much water had been added into the drive casing from the 4-inch hose. Also, vacuuming would have continued until the borehole had "stabilized;" there was no set or predetermined water volume or time limit. It was determined that vacuuming would have had a much greater potential impact to the surrounding formation, and therefore Option two was not implemented.

Approximately 800 gallons of potable water from the pipe truck tank was added to the 9-5/8 drive casing. The potable water was obtained from the fire hydrant located in the southwest portion of the TA-V courtyard. Next, twelve 5-gallon buckets of Pel Plug ½-inch TR60 Time Release Bentonite Pellets were added to the borehole. The column of water held back the formation until the coated bentonite pellets hydrated, swelled, and sealed off the heaving formation. Time-release bentonite pellets were used because their coating allowed the pellets to settle through the water column without forming a plug in the drive casing. This allowed the drive casing to be jacked up after the installation of the bentonite time release pellets.

The well was constructed with two separate 5-inch and 1.5- inch diameter casings as shown in Figure 2-2. The top of the 30-ft long, 5-inch monitoring well screen was set in alluvial sediments at 509 ft bgs, approximately 5 ft above the static water level (Figure 2-2 and Appendix D). The monitoring casing consists of a nominal 5-inch (inside diameter [ID] of 4.767 inches and an OD of 5.563 inches), Schedule 80 PVC, flush-threaded, blank casing and a 30-ft 0.020-inch slot, Schedule 80 PVC screen. The sump consisted of a 5-ft length of Schedule 80 PVC, flush threaded, blank casing with a threaded bottom cap.

The top of the 20 ft long, 1.5-inch injection well screen was located approximately 5 ft below the static water level at 519 ft bgs (Figure 2-2 and Appendix D). The injection casing consists of a nominal 1.5-inch (ID of 1.610 and an OD of 1.900 inches) Schedule 80 PVC, flush-threaded, blank casing, and a 20-ft 0.040-inch slot, Schedule 80 PVC screen. The sump consists of a 5-ft length of Schedule 80 PVC, flush threaded, blank casing with a threaded bottom cap.

Both threaded bottom caps contain solid 5-inch long PVC plugs placed in the bottom of the sump to reduce the possibility of dislodging the end cap during future well development, sampling, or injection activities. Below the water table, the two casings were bound together with plastic zip ties. Above the water table, in the grouted portion of the borehole stainless steel worm drive, hose clamps were used to secure the two casings together. PVC centralizers were

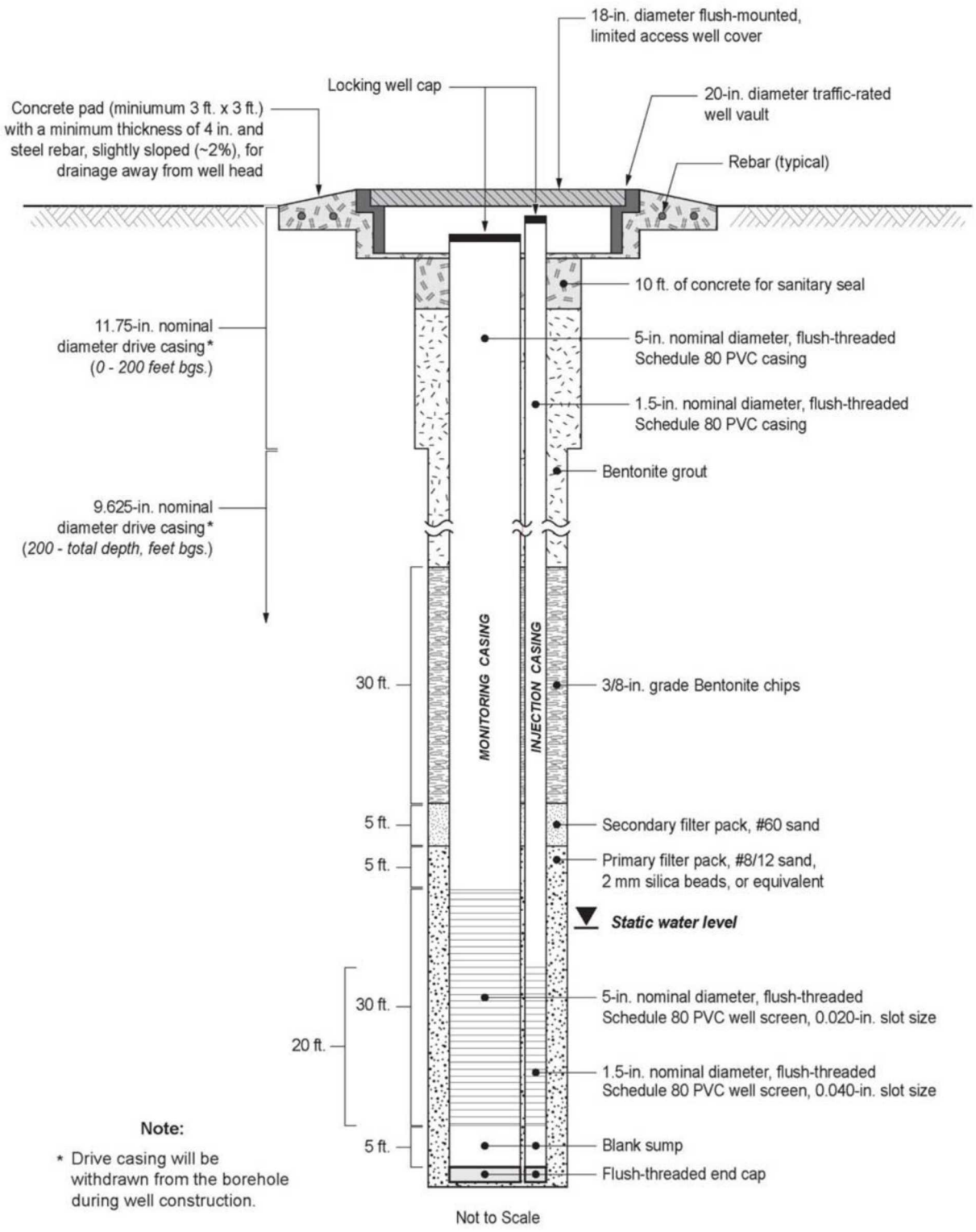


Figure 2-2
Injection Well TAV-INJ1 Well Design as Proposed in the Work Plan

placed above and below the 5-inch PVC casing screened section, and at 100-ft intervals on the blank casing. Appendix D, Well Construction Diagrams provide a summary of the well construction, and Appendix E includes the well construction data sheets.

Half-inch Bentonite TR60 Time Release Pellets were installed from the bottom of the open wellbore at 560 ft bgs to 547 ft bgs. SiLibeads ®, 2 millimeter (mm) silica beads were installed as the primary sand pack in the annulus around the screen from 547 ft bgs to 5 ft above the 5-inch casing monitoring well screen (504 ft bgs). Above the SiLibeads, a 5-ft thick layer of relatively coarse #10-20 Colorado Silica Sand (CSS) was placed from 504 to 499 ft bgs. The layer of coarse CSS was installed to prevent the overlying fine sand from settling into the SiLibeads. A layer of fine sand (CSS #60) was installed from 499 to 494 ft bgs. A 34-ft thick bentonite chip seal of 3/8-inch Baroid Holeplug™ was placed from 460 to 494 ft bgs. The chips were hydrated with approximately 50 gallons of water, and allowed to set up (hydrate) for one hour before the first lift of bentonite grout was pumped into the well annulus with a hose.

Bentonite grout (consisting of Baroid Quik-Grout™ granulated bentonite and water) was used to fill the well annulus. The first lift of approximately 100 ft of grout (consisting of ten 50-pound bags of Quik-Grout™ plus 280 gallons of water) was pumped into the well annulus with a hose and allowed to set for 24 hours. The subsequent lifts of grout were then pumped into the annulus with a hose in approximate 100-ft lifts until the annulus was filled to the surface. A one-hour hold time was observed between the installation of each additional 100-ft layer of bentonite grout. The well annulus was filled with bentonite grout from 35 to 460 ft bgs.

From 14 to 35 ft bgs the annulus was filled with 3/8-inch bentonite chips. The chips were hydrated with approximately 30 gallons of water, and allowed to set up for one hour. The Work Plan called final annulus layer be a 10-ft layer of concrete with a 1-inch weep pipe installed to divert any infiltrating water (Figure 2-2). Instead, the final 14 ft of the annulus was first filled with 10 ft of Quickcrete ® and then the annulus was filled with 3.5 ft of #10-20 coarse sand. The Quickcrete is the sanitary seal for the wellbore to prevent infiltration of surface water down the wellbore. The 3.5 ft of coarse sand will drain away any water that enters the well vault and prevent it from entering the PVC monitoring and injection casings. Section 3.0 provides a detailed explanation of the reasons for these changes.

While drilling and installing the well materials, environmentally sensitive protocols were used to ensure the injection well would not affect or contaminate the aquifer. For example, two vegetable-based compounds, manufactured by Matex Chemical Control, were used. “ES Thread Compound” was used on the drive-casing and drill-pipe threads. The casing hammer and the downhole hammer used “RDO 302 ES Hammer Oil.” Drilling waste, including vadose zone and saturated zone cuttings, was disposed of according to applicable state and federal regulations, as specified in the project-specific waste management plan (SNL/NM October 2016).

2.2 TAV-INJ1 Well Development

The well development plan, steps, and objectives for TAV-INJ1 are provided by the procedure Well Development FOP 94-41, Revision 2, (SNL/NM July 2016) and the Work Plan (SNL/NM March 2016). The minimum volume of water required to be removed from a new well when the borehole was drilled without the use of drilling mud is five wellbore volumes. The FOP defines the adequacy of well development at the point where the minimum wellbore volume has been removed, and representative groundwater is obtained.

Representative groundwater is indicated when potential of hydrogen (pH), temperature, and specific conductivity measurements are within 10 percent for 3 consecutive wellbore volumes, and the water is visibly clear of suspended solids with a turbidity of less than 5 nephelometric turbidity units (NTU). Calculation of the wellbore volume takes into consideration the groundwater contained in the well screen and the groundwater present in the adjacent saturated sand pack. The sand pack is assumed to have a porosity of 30 percent. The calculated wellbore volume for injection well TAV-INJ1 was 49 gallons at the time of development.

The impact of the 800 gallons of potable water added during well installation to stabilize the heaving formation affected the duration of the well development. During well development the minimum volume of water to be removed was set at 800 gallons. In addition, to assist in determining if representative groundwater was produced, the characteristics of TAV-MW6, the nearest groundwater monitoring well, were compiled as shown in Table 2-3. The groundwater chemical properties from TAV-MW6 were used as indicators of the presence of representative groundwater during the development of TAV-INJ1.

A sample of potable water was analyzed to help assess the impact of 800 gallons of potable water being added to the Regional Aquifer. The potable water sample was obtained from the spigot on the east side of the TA-V courtyard next to Building 6580 and Table 2-3 shows the results. During well development it was noted that the early pH values were unusually high (Figure 2-4 and Appendix F). The potable water sample has a pH value of 8.27, which is significantly higher than the range of values observed from TAV-MW6 (7.26 to 7.74).

Injection well TAV-INJ1 was developed from October 24, 2017 to November 1, 2017 utilizing the 5-inch monitoring well casing. The development followed the standard practice to remove sediment and fine-sized particles from the well sump and screen slots. Work was conducted using a development (pump hoist) rig operated by Cascade Drilling LP. Water produced during well development was containerized and disposed of according to applicable state and federal regulations, as specified in the project-specific waste management plan (SNL/NM October 2016).

Well development began with 30 minutes of well swabbing to circulate and clean out sediment in the screen and sand pack. Next, a 4-inch diameter, 2.5-gallon bailer was installed on the winch line, and recovered turbid brownish water with a high concentration of clay and fine-grained sediment. Approximately 30 gallons of sediment and muddy water was bailed. The bailer passed freely inside the casing indicating that the casing and screen were not significantly bent or crooked. A 3-inch diameter electrical submersible pump was then installed with 21-ft lengths of 1-inch diameter galvanized pipe. The bottom of the pump was set near the bottom of the well screen at 544 ft bgs. Pumping was attempted several times, but each time the pump shut off due to electrical overload. The pump was raised 10 ft to 534 ft bgs, and then to 524 ft bgs, but continued to shut off. The pump was retrieved and an additional 15 gallons was bailed from the wellbore.

Table 2-3
Summary of Monitoring Well TAV-MW6 and Potable Water Field Measurement Data

Date	Depth to Water (ft bgs)	Time (24 Hr)	Volume (gal.)	Temperature (°C)	Specific Conductance (µS/cm)	Oxidation-Reduction Potential (mV)	pH	Turbidity (NTU)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)
TAV-MW6										
12/9/2015	512.08	9:39	34	18.89	661.5	225.0	7.32	4.15	77.5	7.16
2/25/2016	512.17	10:14	31	19.89	660.3	282.5	7.56	3.08	75.6	6.88
5/25/2016	512.23	9:44	30	22.21	702.9	345.8	7.29	3.45	78.4	6.81
8/9/2016	512.24	9:59	30	21.66	649.9	213.5	7.74	2.34	78.4	6.89
11/28/2016	511.90	9:55	30	17.76	659.9	274.2	7.62	0.70	74.1	7.03
2/27/2017	512.69	10:34	32	19.00	669.1	224.9	7.51	4.48	75.3	6.96
6/7/2017	512.92	9:55	32	21.42	698.2	160.4	7.54	5.71	78.1	6.89
8/10/2017	513.01	9:54	29	22.03	707.5	294.7	7.26	1.83	80.8	7.03
			Min.	17.76	649.90	160.40	7.26	0.70	74.10	6.81
			Max.	22.21	707.50	345.80	7.74	5.71	80.80	7.16
			Mean	20.36	676.16	252.63	7.48	3.22	77.28	6.96
Potable Water										
10/30/2017	na	na	na	16.083	276.9	659.0	8.27	1.62	65.3	6.43

bgs = Below ground surface.
°C = Degree(s) Celsius.
ft = Feet.
gal. = Gallons.
Hr = Hour.
L = Liter.
Max. = Maximum value.
µS/cm = microSiemens per centimeter.
mg = Milligram.
Min. = Minimum value.
MW = Monitoring well.
mV = Millivolts.
na = Not applicable.
NTU = Nephelometric turbidity unit(s).
% = Percentage.
pH = Potential of hydrogen.
TAV = Technical Area-V.

A new higher capacity 4-inch diameter pump was purchased and installed in the well at the bottom of the well screen. Pumping then resumed and was successful. Some of the early pumped water was placed in an Imhoff Settling Cone and after settling the cone contained 50 percent clays and fine-grained sediment (by height). The high sediment content likely prevented the 3-inch diameter pump from lifting the water to the surface because of the friction and load it added to the smaller pump.

Typically, at the start of well development the well is pumped at a relatively high rate (3 to 4 gallons/ minute) until the water becomes visually cleaner. The pumping rate is then decreased to approximately 1 gallon/minute. Eventually turbidity drops below 5 NTUs, and the well is pumped until three consecutive wellbore volumes with less than 10 percent parameter (pH, temperature, and specific conductivity) variations are observed. At this point the groundwater is considered representative and well development is complete.

Because of the surrounding formations' low permeability it was not possible to conduct a typical well development at TAV-INJ1. During well development as water was pumped from the well the water level dropped. The pump would be shut off to allow the water level in the borehole to recover as shown in Figure 2-3 and Appendix F. This pumping cycle caused turbidity values to increase as shown in Figure 2-3. The figure shows that when pumping starts the turbidity values are low because sediment in the 1-inch galvanized pipe settled to the lower portions of the pipe. As pumping proceeds, turbidity increases as water from the lower portion of the pipe where the sediment has settled is pumped out. Also, as water in the wellbore near the pump reaches the surface turbidity increases because the pump startup has agitated the water and increased the turbidity. Eventually turbidity values decrease as clean formation water reaches the surface. Towards the end of pumping, turbidity values increase likely due to turbulence caused by water falling into the wellbore or the water level dropping within the wellbore.

Initially during well development, approximately 100 gallons was pumped out during each pumping period, as shown in Figure 2-3 and Appendix F. During the later stages of well development (from 1,005 to 1,340 gallons), the amount of water extracted during each pumping period was reduced to approximately 50 gallons. The smaller volume of water increased the number of pumping cycles that could be done over time, and this helped in removing the fine sediments from the wellbore and surrounding formation.

Groundwater with turbidity near 5 NTUs (5.09 NTUs) was first measured after 1,045 gallons had been extracted. However, as is shown in Figure 2-3 and Appendix F collecting three well bore volumes (150 gallons) with stabilized readings (less than 10 percent variability) and a turbidity of less than 5 NTUs was not possible because of the cyclic turbidity variations. Therefore, to ensure that future groundwater sampling would collect a representative sample, an additional 315 gallons (1,340 gallons total) was pumped from TAV-INJ during well development.

During well development, pH values were also examined to determine if representative groundwater had been obtained. The pH values remained predominantly above 8.0 until approximately 800 gallons had been extracted, as shown by the moving average in Figure 2-4. Above 800 gallons, the pH values moving average dropped below 8.0. This change in pH values during well development is most likely due to the effective removal of 800 gallons of potable water added during the well installation. Table 2-3 shows potable water from TA-V has a pH of 8.27. This is significantly higher than the pH of the formation water collected from TAV-MW6, which has an average pH value of 7.48.

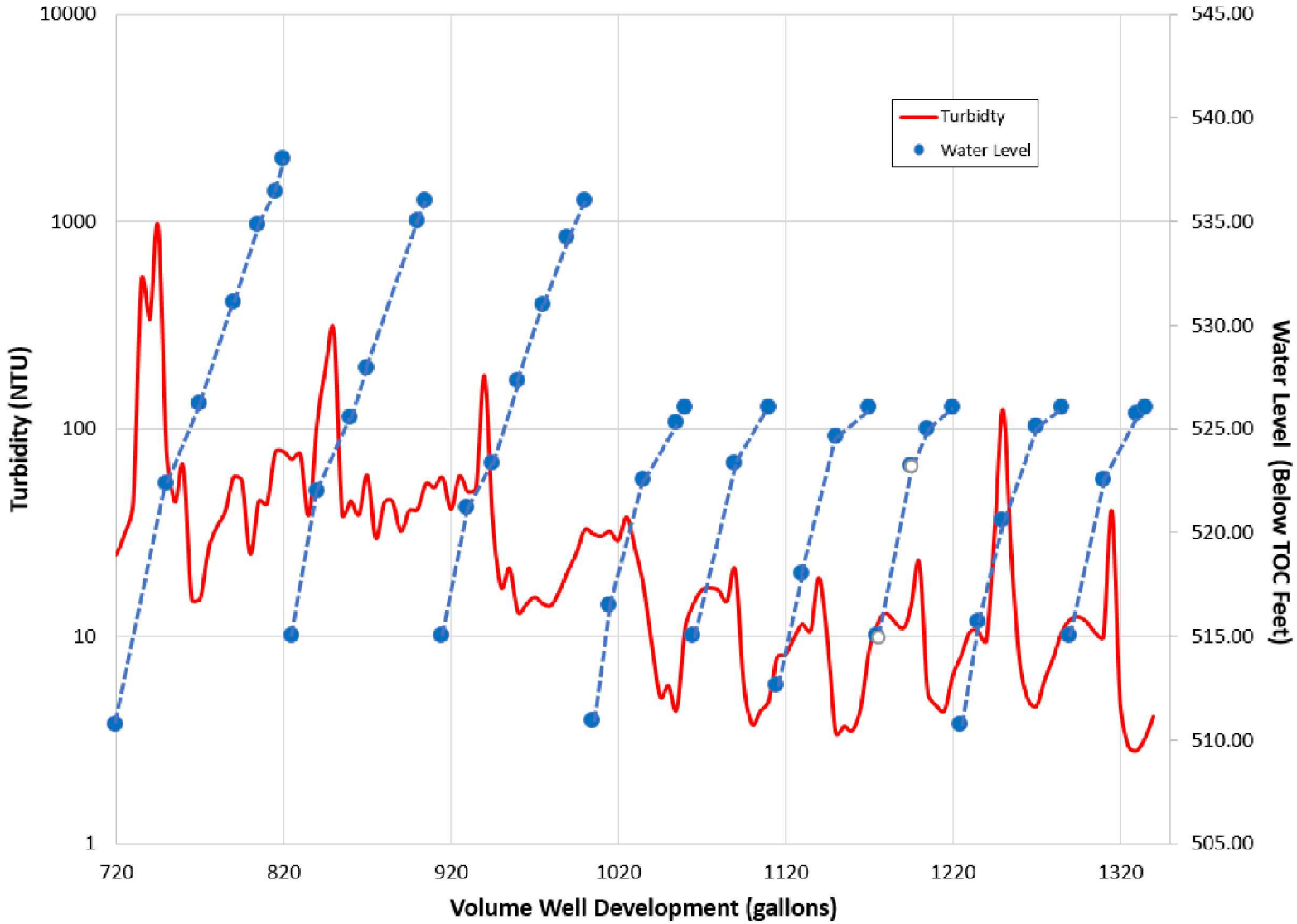


Figure 2-3
Injection Well TAV-INJ1 Well Development Water Volume Versus Turbidity and Water Level

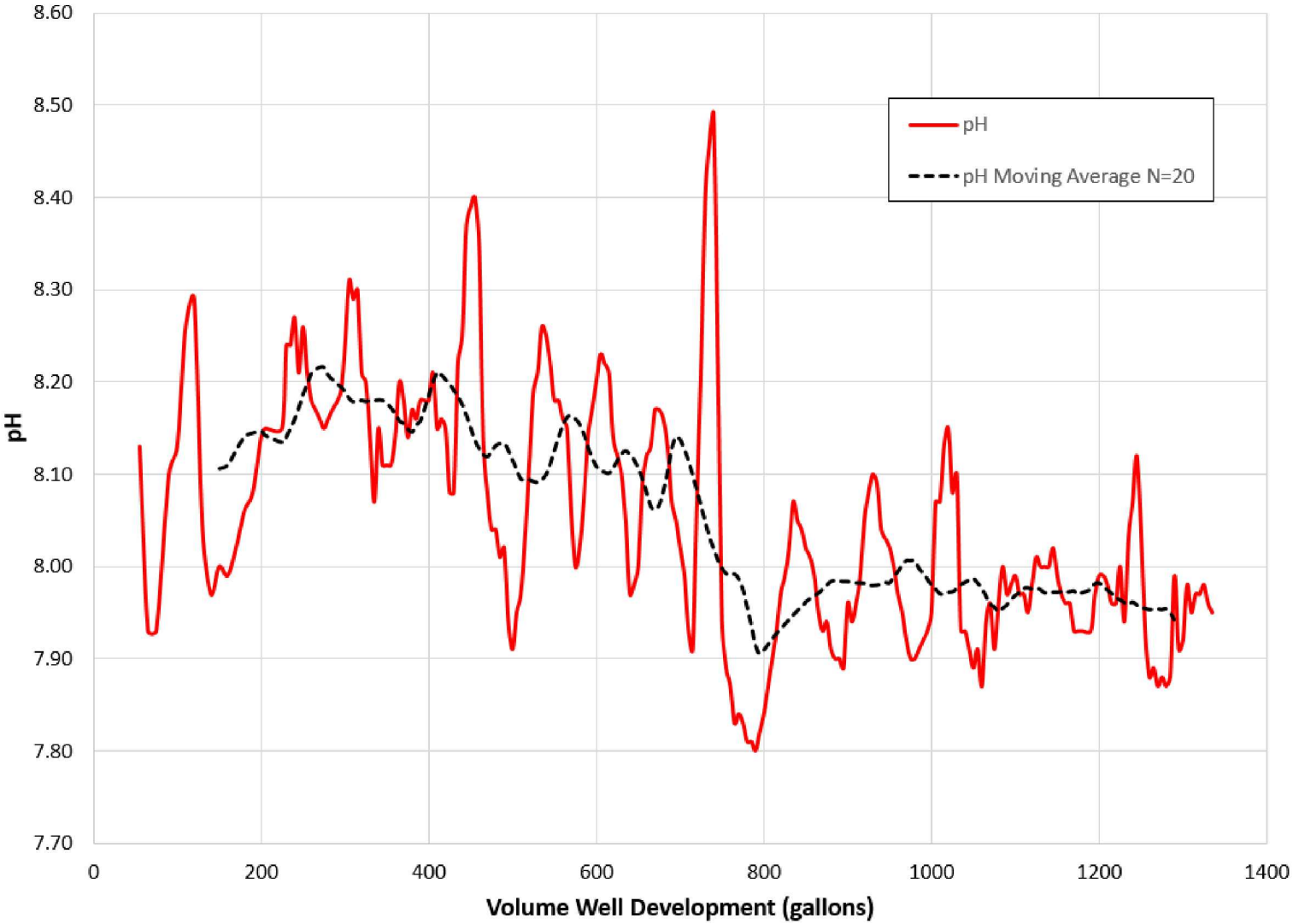


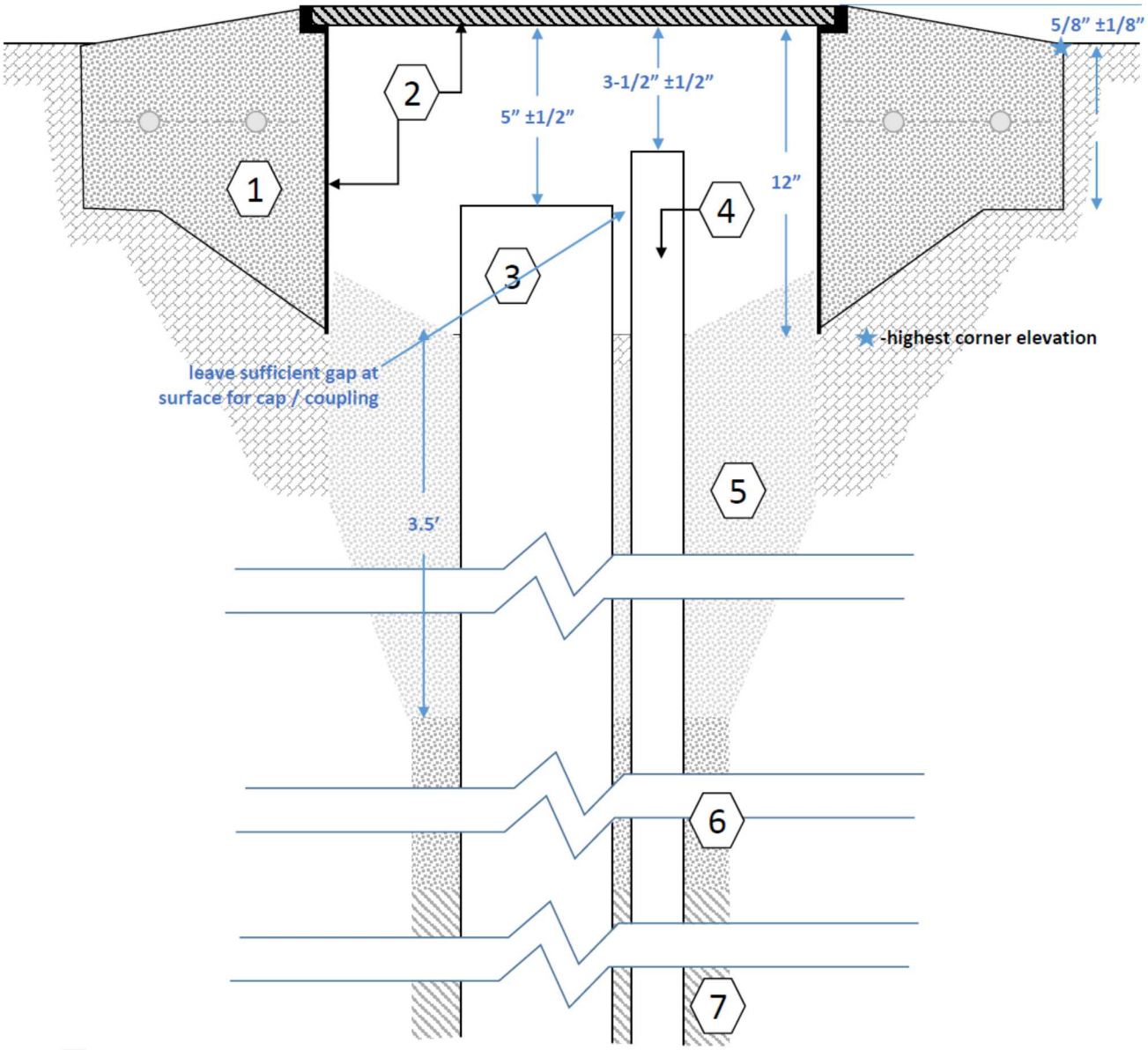
Figure 2-4
Injection Well TAV-INJ1 Well Development Water Volume Versus pH

Representative groundwater samples are expected to be collected from the injection well in future sampling events. The final turbidity measurement was 4.10 NTU and the groundwater was visibly clear.

3.0 TAV-INJ1 WELL VAULT INSTALLATION

An 20-inch diameter, round well vault was installed at injection well TAV-INJ1 to protect the well. The 5-inch and 1.5-inch diameter PVC well casings were cut off below grade, and fitted with water tight caps and locks. The vault was set in rebar reinforced concrete, and the concrete was sloped to directs water away from the vault. The Work Plan (SNL/NM March 2016) specified that the well vault be set in concrete (Figure 2-2), and Statement of Work to the drilling contractor (SNL/NM May 2016) required that a 1-inch diameter weep pipe be installed to allow for possible rain water to drain from the vault.

The well vault was not completed as designed because the weep pipe could become plugged, and the low permeability of the surrounding formation may have prevented water from draining away. Instead a 3.5-ft thick layer of coarse sand was installed in the vault annulus (Figure 3-1) to drain away water. Below the coarse sand a 10-ft thick layer of concrete was installed as a sanitary seal that prevents water from entering the well annulus. A brass marker stamped with the well identification number was inserted into the surface of the vault concrete.



1. 36-inch square, 6-inch thick steel reinforced pad [wire mesh (4"X4" W2 – W3 Remesh) and No. 3 rebar reinforced], 12-inch thick at manhole tapered over 6 inches). Pad surface will slope from manhole to edges for positive drainage from wellhead.
2. 18-inch Round, Traffic-grade (H-20 load rating), Water Resistant Manhole with 12-inch Galvanized Skirt
3. 5-inch Dia., SCH80 PVC Casing, Cut Level, set. ~ 6" below bottom of manhole lid, include compression "J-plug" (not shown)
4. 1.5-inch Dia., SCH80 PVC Casing, Cut Level, set. ~4" below bottom of manhole lid. and 1" above top of 5-inch dia. well casing, include compression "J-plug" (not shown)
5. Clean sand filled annulus approximately 3.5 feet thick on top of sanitary well seal.
6. 10' of concrete for sanitary seal
7. Bentonite (expansive) grout

Figure 3-1
As-Built Well Vault Installation

4.0 LAND SURVEYING

Land surveying was conducted on May 16, 2018 to determine northing and easting coordinates and precision elevations (vertical accuracy of 0.01 ft) for TAV-INJ1. Stephen Toler a New Mexico-registered surveyor, from Organization 4852, SNL/NM performed the work. The coordinates and elevations are listed on Table 4-1 and on the well construction diagrams (Appendix E). The northing and easting coordinates are provided in New Mexico Central Zone State Plane coordinates based upon the North American Datum of 1983. The elevations are based upon the North American Vertical Datum of 1988. The top of the 5-inch PVC casing elevation is the measuring point that will be used for subsequent water level measurements.

Table 4-1
Survey Coordinates and Elevations for Injection Well TAV-INJ1

Well	Easting, X	Northing, Y	Ground Surface Elevation* (ft amsl)	Top of 5-inch Diameter Casing Elevation (ft amsl)
TAV-INJ1	1,554,842.81	1,455,032.063	5,430.1	5,429.7

* = Elevation “A” North Edge Concrete Pad
amsl = Above mean sea level.
ft = Feet.
MW = Monitoring Well.
PVC = Polyvinyl chloride.
TAV = Technical Area-V.

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5.0 VARIANCES FROM THE WORK PLAN

There were four variances from the requirements as specified in the Work Plan (SNL/NM March 2016). These four variances are documented and discussed below.

1) As described in Section 2.1, during well installation heaving formation was encountered. To hold back the heaving formation, approximately 800 gallons of potable water was added until the Pel Plug ½-inch TR60 Time Release Bentonite Pellets could be installed, swell, and stabilize the formation.

2) The Work Plan (SNL/NM March 2016) called for the coarse sand or 2-mm silica beads (SiLibeads ®) below the screened casing (Figure 2-2). During well installation, twelve 5-gallon buckets of time-release bentonite pellets were installed below the well casing from 557.0 ft bgs to 547.0 ft bgs as described in Section 2.1. The bentonite pellets were used to stabilize and hold back the heaving formation to allow well installation to proceed.

3) The proposed well vault installation in the Work Plan (SNL/NM March 2016) and Statement of Work (SNL/NM May 2016) was modified. The plans called for the well vault to be filled with concrete, and a 1-inch weep pipe (Figure 2-2). Instead, the final 4 feet of the well vault were filled with coarse sand to drain away water. Below the coarse sand layer, a 10-ft layer of concrete formed the wellbore sanitary seal (Figure 3-1).

4) As discussed in Section 2.2, TAV-INJ1 was not developed in the typical manner because of the low permeability of the formation. During pumping, the water level dropped in the wellbore, and this led cyclical increase in turbidity values as shown in Figure 2-3. To ensure representative groundwater, 1,340 gallons of water were pumped during well development.

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6.0 REFERENCES

New Mexico Environment Department (NMED), April 2004. "Compliance Order on Consent Pursuant to the New Mexico Hazardous Waste Act § 74-4-10: Sandia National Laboratories Consent Order," New Mexico Environment Department, Santa Fe, New Mexico, April 29, 2004.

New Mexico Environment Department (NMED), May 2016. Letter to J.P. 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, March 2016, Sandia National Laboratories, EPA Identification # NM5890110518, HWB-SNL-15-020," Hazardous Waste Bureau, New Mexico Environment Department, Santa Fe, New Mexico, June 4, 2014.

New Mexico Office of the State Engineer (NMOSE), August 2005. "Rules and Regulations Governing Well Driller Licensing; Construction, Repair, and Plugging of Wells," 19.27.4 New Mexico Administrative Code, New Mexico Office of the State Engineer, Santa Fe, New Mexico. 31 August 2005.

New Mexico Office of the State Engineer (NMOSE), July 2016a. "Permit to Explore/Remediate, RG-90065 POD 126 (TAV-MW15)", New Mexico Office of the State Engineer, Albuquerque, New Mexico. 27 July 2016.

New Mexico Office of the State Engineer (NMOSE), July 2016b. "Permit to Explore/Remediate, RG-90065 POD 127 (TAV-MW16)", New Mexico Office of the State Engineer, Albuquerque, New Mexico. 27 July 2016.

NMED, see New Mexico Environment Department.

NMOSE, see New Mexico Office of the State Engineer.

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," Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), May 2016. "Statement of Work – Request for Drilling, Well Completion, and Well Development Services," Environmental Restoration Operations, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), June 2016. "Annual Groundwater Monitoring Report, Calendar Year 2015, SAND2016-5158 R." Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), July 2016. "Well Development," FOP 94-41, Revision 2, Sandia National Laboratories, Albuquerque, New Mexico.

Sandia National Laboratories/New Mexico (SNL/NM), October 2016. ER Site Specific Waste Management Plan For Technical Area-V Area of Concern, Sandia National Laboratories, Albuquerque, New Mexico. 25 October 2016.

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

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APPENDIX A
Lithologic Logs for Injection Well TAV-INJ1

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VISUAL CLASSIFICATION OF SOILS

TA/OU: TA - V	SITE NUMBER: TAV-INJ1	
BORING NUMBER:	COORDINATES:	DATE: 9-12/9-13 2017
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-2017
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17
DRILLING METHOD ~~Arctic~~.		PAGE: 1 OF 9

DEPTH (ft)	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
0-20	A4		→	0-20 ft clean fill. mixed with native fine grained sand. w/ some clay, sample will clump but not hold as a ball. Color is Moderate yellowish brown 10YR 5/4.			9-12-17
				Note all samples wet, unless otherwise noted due to water misting for dust control.			
40'			→	25-28' limestone cobble layer.			
			→	40' Fine grained uniform sand damp, no water added or needed for dust suppression. Small amount of clay will form, but not hold shape. Color between Dark Yellowish orange 10YR 6/6 and Moderate yellowish brown 10YR 5/4 5-10% subrounded-subangular limestone pebbles ¼ - ½" in diameter.			9-13-17 ↓
60			→	50' limestone cobble layer ~ 4-5' subrounded-subangular, ¼ - ½"			
			→	60' Fine grained uniform sand, damp, no water added dust suppression. None needed. Some silt 4%. Color Dark Yellowish Orange 10YR 6/6			
			→	65-75' hit thin 2-3 ft limestone cobble layers, subrounded-subangular ¼ - ½" size.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-INJ 1	
BORING NUMBER: —	COORDINATES:	DATE: 9-13-2017
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-2017
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17
DRILLING METHOD ARL H-		PAGE: 2 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
80'			→	80' Uniform fine grained sand, damp maybe due to intermittent used of water for dust suppression color Moderate yellowish brown 10YR 5/4. Contains 30-40% subrounded to subangular limestone cobbles 1/4 to 1"- 1.5" in size. Some clays will hold form but crumbles.			
100'			→	80'-95' encountered thin 1-2 cobble layers w/ 1/4-1/2 sized limestone cobbles. @ 95' encountered large cobbles 1/4-1.5" subrounded to subangular.			
			→	100' Back into uniform fine grained sand damp, no-little added water needed. Color is moderate yellowish brown. 10YR 5/4			
			→	105-110' Hit limestone cobble layer sub-round to subang 1/4"- 1" in size			
120'			→	120' Uniform fine grained sand, damp no added water. color is Dark Yellowish-orange 10YR 6/6. Drill head has no chatter all sand, but residual cobbles still present, same characters as 105-110' cobbles.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-INJ 1	
BORING NUMBER:	COORDINATES:	DATE: 9-13-2017
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17
DRILLING METHOD ARCH		PAGE: 3 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
140'			→	140' same as 120'			
160'			→	160 same as 120'			
			→	160 -> to 175 drill string is chattering but only small ground up pieces of limestone in f.g. sand, w/o cobbles.			
			→	175' Large cobbles ~ 1-2" encountered subrounded to subangular x 1-2 feet thick layer. Limestone.			
180				180' Back into fine grained uniform sand. Damp w/ small % of clays. it will form into shape, but crumbles. Color is Moderate yellowish brown 10YR 5/4. No water used while drilling. minimal dust.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-INJ1		
BORING NUMBER:	COORDINATES:	DATE: 9-13-2017	
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17	
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17	
DRILLING METHOD ARCH		PAGE: 4 OF 9	

DEPTH (ft)	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
200			→	200' Fine grained uniform sand damp, No added water during drilling, no dust. Color of sand is Moderate yellowish brown 10YR 5/4. Contains 5% coarse sand 0.5-1mm grains subangular looks like quartz feldspar, some limestone & igneous rocks (granite?).			9-13-2017
			→	205-208 coarse cobble layer ½-1½" subrounded-subangular limestone			200'+ 9-14-2017
220			→	220' Fine grained uniform sand, damp no added water while drilling, min. dust. Moderate yellowish brown 10YR 5/4.			
			→	225'-227' limestone cobble layer ½-2" subangular-subrounded. Drive casing dropped. Cavity or cobbles moving.			
240'			→	240' Fine grained uniform sand damp, no added water on sample collected, but water occasionally used during drilling. Moderate yellowish brown 10YR 5/4 At 240 hit 1-2' cobble layer, limestone, subangular ½-1½"			
				245-250' Large cobble layer 1-3" subangular limestone, drive casing dropped intermittent large cobbles until 255' then rapid adv until 260'			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-INJ 1	
BORING NUMBER:	COORDINATES:	DATE: 9-14-2017
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17
ENGINEER/GEOLOGIST: LWM	Depth Date/Time	DATE COMPLETED: 9-26-17
DRILLING METHOD ARCH		PAGE: 5 OF 9

DEPTH (Ft)	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
260'				260' Back into uniform fine grained sand, damp, water used for dust suppr. but not on sample collected. Moderate yellowish brown 10YR 5/4			
				Drill rapidly advanced from 265→ 280'			
280'				280' same as 260 with few limestone cobbles subangular 1/4-1/2"			9-14-17
				290' Limestone cobble layer, ground up by bit b/c working on clearing cyclone hose clogged.			
300'				300 same as 280' fine grained uniform sand damp, moderate yellowish brown 10YR 5/4 in color.			9-15-17
				300+- approx 305' large cobbles 1/2'-1.5" subangular limestone. Casing dropped 2'ft after hammering.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAN - INJ 1	
BORING NUMBER:	COORDINATES:	DATE: 9-15-17
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17
DRILLING METHOD ARCH		PAGE: 6 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
320'				320' Fine grained uniform sand; damp moderate, yellowish brown 10YR 5/4.			
340				340' Fine grained uniform sand, damp some water used for dust suppression moderate, yellowish brown 10YR 5/4 10% coarse, sand ly subrounded - subang qtz, feldspar, and igneous, 10-15% cobbles subrounded - subangular limestone.			
				350' cobble layer 1/2 - 1.5" subrounded to subangular limestone.			
				355' same as 350 cobble layer			
360'				360' same as 320' back into fine grained uniform sand.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TAV	SITE NUMBER: TAV-INJ1		
BORING NUMBER:	COORDINATES:	DATE: 9-15-17 - 9-18-17	
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17	
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17	
DRILLING METHOD ARCH		PAGE: 7 OF 9	

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
380'				380' same as 360' fine grained uniform sand. No significant cobbles/sand. Used hammer from 360 to 380 constantly. First time. Water injected during initial drilling (360'), end none. Little dust.			
				380 → 400' uniform fine gained sand			
400'				400' same fine grained sand. just at 400' hit varied gravel layer, qtz volcanics, feldspar, limestone. Maybe ARG, but because of water added for dust suppression difficult to see grains character. Lithics are ¼-1" subrounded to subangular.			
420				420' fine grained uniform sand. Wet due to dust suppression water. Color is Dark Yellowish orange 10YR 6/6. Has some clay as it will hold a shape but is ~10% as form crumbles.			9-18-17

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-INJ 1		
BORING NUMBER:	COORDINATES:	DATE: 9-19-17	
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17	
ENGINEER/GEOLOGIST: LWM	Depth Date/Time	DATE COMPLETED: 9-26-17	
DRILLING METHOD ARCH		PAGE: 8 OF 9	

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
440'				440' Fine grained uniform sand. same as ~~440~~ 420'. Less water used for dust suppression. Dark yellowish orange 10YR 6/6. 10% limestone cobbles, ¼-1" subrounded to subangular. Beginning cobble layer? No chatter on drill pipe.			
				450' Large limestone cobble layer 1-2" subrounded to subangular.			
460				460' Fine grained uniform sand, dark yellow orange 10YR 6/6. some clay will form, but crumbles. Sand grains look and feel slightly coarser than before.			
480				480' same as 460', water used for dust suppression. Sample wet. 10% ¼" limestone fragments, subangular. Difficult to identify due to mud coating.			
				495' Limestone ~~cobble~~ boulder layer ¼-½" subangular fragments ground up by bit also. Chewing on boulder. Changed to Stratex bit 9-20-17 and drilled through boulder.			492-495' 490-494 boulder

NOTES:

VISUAL CLASSIFICATION OF SOILS

TA/OU: TA-V	SITE NUMBER: TAV-INJ 1	
BORING NUMBER:	COORDINATES:	DATE: 9/21 – 9/26 2017
ELEVATION	GWL: Depth Date/Time	DATE STARTED: 9-12-17
ENGINEER/GEOLOGIST: LUM	Depth Date/Time	DATE COMPLETED: 9-26-17
DRILLING METHOD ARCH		PAGE: 9 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOW ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
500'			→	500' Fine grained uniform sand, slightly damp. wetted due to dust suppression water. Dark yellowish orange 10YR 6/6. ~5% limestone chips, remnants of limestone boulder 492-495', could be stuck in plugged cyclone.		~ ▼	9.21.17 Water Table expected 513' Water Level 514' 9.22.17
			→	514-515 ½-1" limestone cobbles, subangular- to subrounded.		~	515 water in core sample.
			→	517-519 Cored interval looks like ARG, but difficult to see due to mud. Rounded volcanics ~ granite, no mafics (basalt).			
520			→	520' Fine grained uniform sand, wet, below water table. Dark yellowish orange 10YR 6/6. Returns low in hopper fines in borehole. ~10% subangular grains ⅛-¼ of granite limestone, qtzite. Alluvial channel deposits.			9-25-2017
540			→	540' Fine grained uniform sand, samples wet below water table ~515'. Dark yellowish orange 10YR 6/6. No coarse grained fragments, or cobbles, at all. Returns producing more water than yesterday (9-25-2017).			9-26-2017
			→	545' coring hit gravel layer large limestone cobbles, and black limestone fragments. Produced water at rig. out of drive casing.			

NOTES:

APPENDIX B
Photographs of Lithologic Cuttings from Injection Well TAV-INJ1

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Figure B-1
Photograph of cuttings from injection well TAV-INJ1. From right to left cuttings shown are a sample of the clean fill that was emplaced as backfill after potholing was completed, 20, 40, 60, and 80 feet below ground surface.

Figure B-2
Photograph of cuttings from injection well TAV-INJ1. From right to left 100, 120, 140, and 160 feet below ground surface.

Figure B-3
Photograph of cuttings from injection well TAV-INJ1. From right to left
140, 160, 180, and 200 feet below ground surface.

Figure B-4
Photograph of cuttings from injection well TAV-INJ1. From right to left
220, 240, 260, and 280 feet below ground surface.

Figure B-5
Photograph of cuttings from injection well TAV-INJ1. From right to left 300, 320, 340, and 360 feet below ground surface.

Figure B-6
Photograph of cuttings from injection well TAV-INJ1. From right to left 380 and 400 feet below ground surface.

Figure B-7
Photograph of cuttings from injection well TAV-INJ1. From right to left 420, 440, 460, 480, and 500 feet below ground surface.

APPENDIX C
Photographs of Continuous Core Samples from Injection Well TAV-INJ1

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Figure C-1
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 495 to 497.5 feet below ground surface.

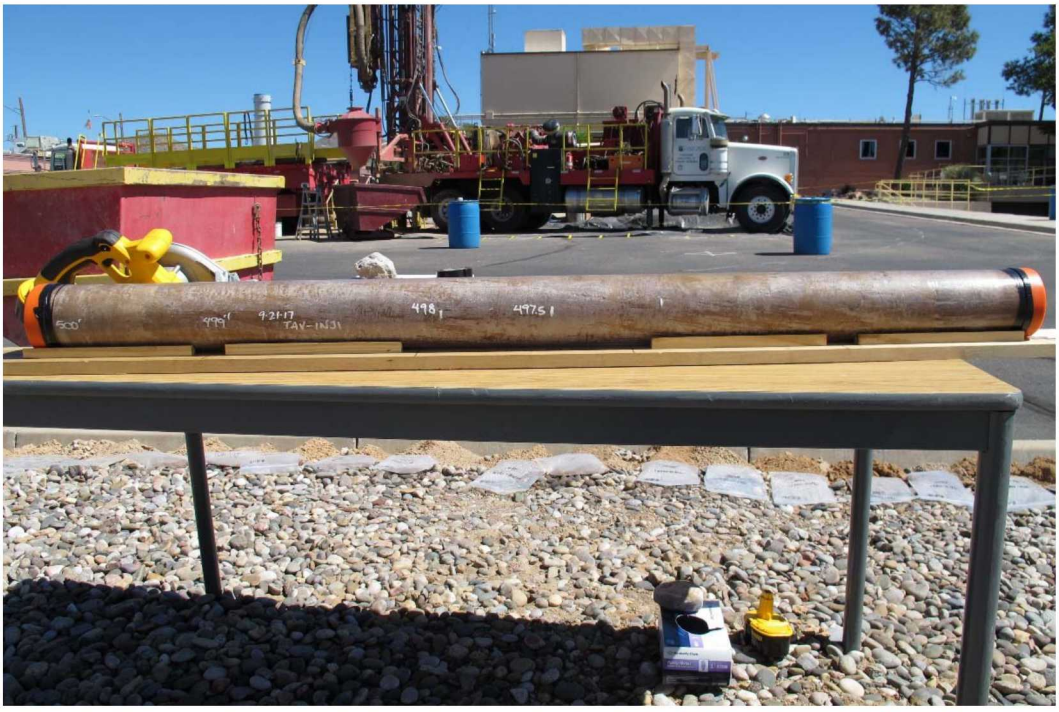

Figure C-2
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 497.5 to 499 feet below ground surface.

Figure C-3
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 505 to 508.5 feet below ground surface.

Figure C-4
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 508.5 to 510 feet below ground surface.

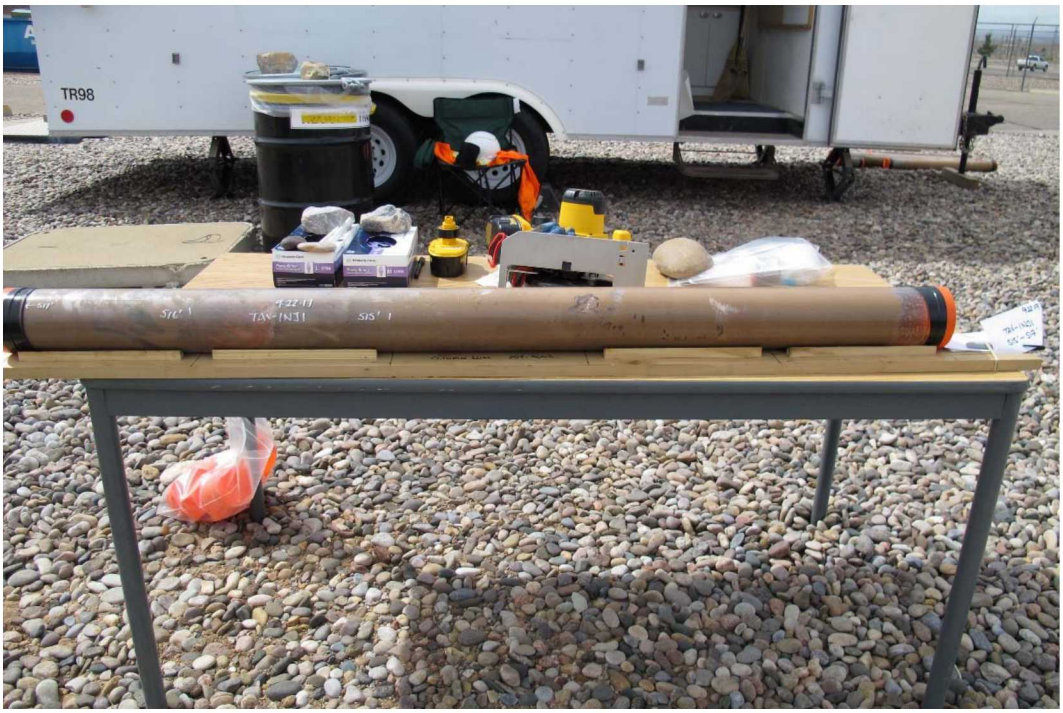

Figure C-5
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 515 to 517 feet below ground surface.

Figure C-6
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 517 to 519 feet below ground surface.

Figure C-7
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 525 to 527 feet below ground surface.

Figure C-8
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 527 to 529 feet below ground surface.

Figure C-9
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 535 to 537 feet below ground surface.

Figure C-10
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 537 to 539 feet below ground surface.

Figure C-11
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 545 to 547 feet below ground surface.

Figure C-12
Photograph of continuous core sample from monitoring well TAV-INJ1. From right to left the sample was from 547+ feet below ground surface. Coring was immediately refused (would not penetrate).

APPENDIX D
Well Construction Data Sheets for Injection Well TAV-INJ1

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Well Construction Data for TAV-INJ1

Technical Area-V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

Items Required by the Order[a] section VIII.D	Comments (acronyms are defined in footnotes)
1. Well name/number	Groundwater injection well TAV-INJ1.
2. Date of well construction	Drilling began on September 12, 2017. Construction completed on October 11, 2017. Development completed on November 1, 2017. Land surveying conducted on May 16, 2018.
3. Drilling method	Air rotary casing hammer to 550 ft bgs.
4. Drilling contractor and name of driller	Cascade Drilling LP, Lee Aylmer, as supervised by Bryan Nydoske (NM License #WD-1210), using a GEFCo Speed Star 50K-CH rig.
5. Borehole diameter and well casing diameter	Borehole: From 0 to 200 ft bgs a tricone bit with 11.75-inch drive casing. From 200 ft bgs to 557 ft bgs, 8.5-inch tricone bit with 9.625-inch diameter drive casing.
	Monitoring casing: 4.75 inches ID, 5.5 inches OD, PVC. Injection casing: 1.48 ID, 1.90 inches OD.
6. Well depth	544.54 ft bgs (544.0 ft minus -0.54 ft stickup).
7. Casing length	543.46 ft (from bottom of sump to top of well casing).
8. Casing materials	Monitoring casing: Schedule 80 PVC. Injection casing: Schedule 80 PVC Centralizers: at the top and bottom of the monitoring casing screened interval 509 and 539 ft bgs, and at 100 ft intervals.
9. Casing and screen joint type	Monitoring and injection casing: flush-threaded, 2 threads per inch, with neoprene o-rings.
10. Screened interval(s)	Monitoring casing: 509.0 to 539.0 ft bgs, with sump from 539.0 to 544.0 ft bgs. Injection casing: 519.0 to 539.0 ft bgs, with sump from 539.0 to 544.0 ft bgs.
11. Screen materials	Monitoring casing Schedule 80 PVC. Injection casing Schedule 80 PVC.
12. Screen slot size and design	Monitoring casing: Twenty-slot (0.020-inch slotted screen with vertical spacing of 0.125-inches). Injection casing: Forty-slot (0.040-inch slotted screen with vertical spacing of 0.1875 inches.)
13. Filter pack material and gradation	Primary: 2 mm SiLibeads.
	Secondary: #10-20 CSS silica sand, and #60 CSS silica sand.
14. Filter pack volume (calculated and actual)[b]	Calculated: 19.6 ft^3, SiLibeads (rathole and screened interval), and #10/20 and #60 sand packs.
	Actual Used: 21.0 ft^3.
15. Filter pack placement method	Gravity feed through drive casing.
16. Filter pack interval(s)	Primary: 504.0 to 547.3 ft bgs of 2 mm SiLibeads.
	Secondary: 499.0 to 504.0 of #10-20 sand, and 494.0 to 499.0 ft bgs of #60 sand.
17. Annular sealant composition	Halliburton Baroid Holeplug® bentonite chips, 3/8-inch grade and Halliburton Baroid Quik-Grout® bentonite grout.

Well Construction Data for TAV-INJ1 *(Continued)*
Technical Area-V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

Items Required by the Order[a] section VIII.D	Comments (acronyms are defined in footnotes)
18. Annular sealant placement method	Chips: gravity feed through drive casing and subsequently hydrated with water gravity feed into drive casing. Grout: gravity feed through drive casing.
19. Annular sealant interval(s)	Bentonite chips: 460.0 – 494.0 ft bgs.
	Bentonite grout: 35.0 – 460.0 ft bgs.
	Bentonite chips: 14.0 – 35.0 ft bgs.
20. Annular sealant volume (calculated and actual)	Calculated: Bentonite chips: 12.3 ft^3. Bentonite grout: 192.9 ft^3 (1443.0 gal.). Bentonite chips: 12.6
	Actual Used: Bentonite chips: 10 ft^3. Bentonite grout: 208.6 ft^3 (1561.0 gal.). Bentonite chips: 12.5 ft^3.
21. Surface sealant composition	Quikrete® concrete.
22. Surface seal placement method	Gravity feed into annulus.
23. Surface sealant interval	4 to 14 ft bgs.
24. Surface sealant volume (calculated and actual)	Calculated: 6.0 ft^3 (44.9 gallons).
	Actual Used: 14.7^3 ft (110 gallons) poured concrete.
25. Surface seal and well apron design and construction	3-ft by 3-ft by 6-inch thick concrete pad, with steel rebar reinforcement.
26. Well development procedure and turbidity measurements	Swab, bailed, attempted to pump, and bailed (see Appendix F for well development history).
27. Well development purge volume(s) and stabilization parameter measurements	Bailed 30 gallons. Attempted to pump 0 gallons. Bailed 15 gallons. Pump 1295 gallons with parameter measurements. Total purge volume was 1340 gallons, corresponding to approximately 27 wellbore volumes. One wellbore volume was calculated to be 49 gallons assuming 30% porosity in saturated sand pack.
28. Type and design and construction of protective casing	Morrison Debuque 18-418XA steel well vault 20-inches in diameter set in a rebar reinforced concrete pad 3-ft by 3-ft.
29. Ground surface elevation*	5,430.1 ft amsl, top of well vault rim.
30. Survey reference point elevation on well casing	5,429.7 ft amsl, for measuring water levels.
31. Name of geologist	Clinton C. Lum.
32. Initial water level	512.64 ft bgs, water level measured just before development, October 24, 2017.
33. Final water level	511.42 ft bgs, after November 13, 2017
34. Date of well development	From October 24, through November 1, 2017.

Well Construction Data for TAV-INJ1 *(Concluded)*
Technical Area-V Groundwater Area of Concern, Sandia National Laboratories/New Mexico

[a]New Mexico Environment Department, April 2004. "Compliance Order on Consent," New Mexico Environment Department, Santa Fe, New Mexico.
[b]Filter pack volume defined as the total volume of filter pack sand placed in well, both adjacent to the well casing, screen, and sump and below the sump (if applicable).

*	= Elevation "A" North Edge Concrete Pad
amsl	= Above mean sea level.
bgs	= Below ground surface.
CSS	= Colorado Silica Sand Inc. (Oglebay Norton Industrial Sands).
ft	= Feet or foot.
ft^3	= Cubic foot (cubic feet).
gal.	= Gallons.
ID	= Inside diameter.
mm	= millimeter.
NM	= New Mexico.
OD	= Outside diameter.
PVC	= Polyvinyl chloride.
Rathole	= Extra hole drilled at the bottom of the borehole to allow for slough.

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APPENDIX E
Well Construction Diagrams for Injection Well TAV-INJ1

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Well Name:	TAV-INJ1	**Drilling Contractor:**	CASCADE DRILLING LP
Project Name:	TAV GROUNDWATER	**Drilling Method:**	AIR ROTARY CASING HAMMER
NMOSE Well File Code:	RG-90065, POINT OF DIVERSION: 128	**Borehole Depth (FBGS):**	544.54
Owner Name:	SNL/NM	**Casing Depth (FBGS):**	543.46
Date Drilling Started:	SEP 12, 2017	**Geo Location:**	INSIDE TA-V
Date Well Dev. Completed:	OCT 11, 2017	**Completion Zone:**	ALLUVIAL-FAN LITHOFACIES
		Completion Formation:	SANTA FE GROUP

Survey Data

Survey Date: MAY 23, 2018
Surveyed By: SNL/NM
State Plane Coordinates: NAD83
(X) Easting: 1554842.81
(Y) Northing: 1455032.63

Surveyed Evaluations (FAMSL)

Protective Casing: 5430.23
Top of Inner Well Casing: 5429.70
Concrete Pad: 5430.19
Ground Surface: 5430.1

Calculated Depths and Elevations

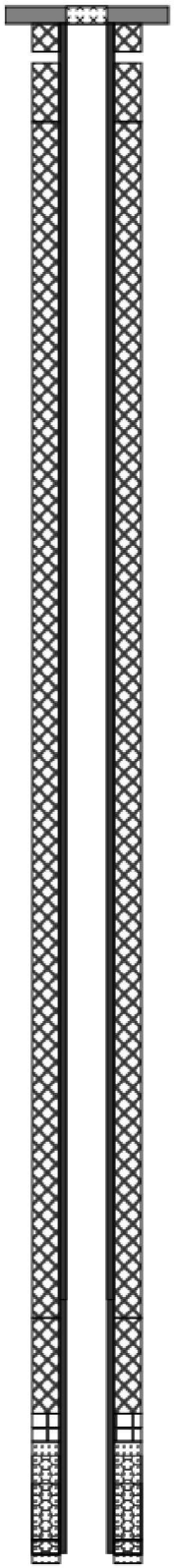
Initial Depth to Water (FBGS) 512.64
Date Initial Depth Measured: OCT 24, 2017
Last Measured Water Elevation (FAMSL):
Date Last Measured:

Miscellaneous Information

Screen Slot Size (in.):
Date Updated: 31-MAY-18
Date Printed from EDMS: JUN 04, 2018

Comments:

TAV-INJ1 IS A DUAL CASING INJECTION WELL WITH A 5 INCH MONITOR CASING WITH A 0.020 SLOT AND A 1.5 INCH INJECTION CASING WITH A 0.040 SLOT. 5" CASING: SCREEN 509.0 TO 539.0 FT, BLANK SUMP 539.0 TO 544.0 FT, CAP 544.0 FT. 1.5" CASING: SCREEN 519.0 TO 539.0 FT, BLANK SUMP 539.0 TO 544.0 FT, CAP 544.0 FT.



Completion Data Measured Depths (FBGS)

Casing Stickup: -0.4

Interval	Material	Start	Stop	Length	ID	OD
BOREHOLE		0.0	544.0	0.0		
CASING	SCHEDULE 80 P...	0.0	543.5	543.5	1.48	1.9
CASING	SCHEDULE 80 P...	0.0	453.5	453.5	4.75	5.5
SEAL	CONCRETE	0.0	10.0	10.0		
SEAL	BENTONITE CH...	14.0	35.0	21.0		
SEAL	BENTONITE GR...	35.0	460.0	425.0		
SEAL	BENTONITE CH...	460.0	494.0	34.0		
SECONDARY PACK	#60 SAND	494.0	499.0	5.0		
SECONDARY PACK	#10-20 SAND	499.0	504.0	5.0		
PRIMARY PACK	2 MM LILIBEADS	504.0	547.3	43.3		
SCREEN (MONITO...	SCHEDULE 80 P...	509.0	539.0	30.0	5	
SCREEN (INJECTIO...	SCHEDULE 80 P...	519.0	539.0	20.0	1.5	
SUMP (MONITORIN...	SCHEDULE 80 P...	539.0	544.0	5.0		
SUMP (INJECTION)	SCHEDULE 80 P...	539.0	544.0	5.0		
CAP		544.0	544.0	0.0		

APPENDIX F
Well Development Forms for Injection Well TAV-INJ1

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Well Development Log

Well Name: TAN-INJ1	Date: 10/24/17
Initial Water Level (fbgs) : 512.75	Personnel: C. Lum / Chris Scott.
Final Water Level:	Well Bore Volume[1] (gals): ~~245~~ 49
Total Depth (fbgs): 544.6' <bottom blank>	5x well bore volume (gals): 245
	10x well bore volume (gals): 2450.

Describe the Well Development Method(s):

Comments:

[1]May use the following gal/ft for each respective diameter well to calculate well bore volume or use the formula

$$[d(ft)/2]^2 \times \pi \times [7.5\ gal/ft^3] = gal/ft$$

For other well diameters (d = diameter).

Well Diameter (in.)	Gals/ft
2.0	0.16
4.0	0.65
4.5	0.83
5.0	1.05
6.0	1.47

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TA-V Treatability Study.	
Well I.D.:	TAV-INJ1	Date: 10-24-to 10-25 2017
Method: Portable pump X	Dedicated pump ____	Pump depth: 540'

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
513'	Start.								
520'	1405	30g	Bailed, very muddy. 10-24-2017.						
10-25-2017.									
511.4	0815	Inserted pump. Tried to pump well. Failed repeatedly. Pull 3" pump.							
		45	Bailed additional 15 gallons.						
		Inserted new 4" pump. Started pumping.							
	1520	50	—	—	—	—	—	—	—
	1526	55	22.362	715.2	15.3	8.13	1972.1	16.6	1.38
	~~1530~~ 1530	65	22.308	719.2	40.6	7.93	53150	53.0	4.60
534.6'	1533	75	22.128	693.0	24.3	7.96	2225.0	38.2	3.30
	~~1537~~	—	—	—	—	—	—	—	—
540'	1540	90	22.118	663.2	-17.2	8.10	1194.0	12.3	1.06
	Bottom of screen.								

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TA-V Groundwater ACX.		
Well I.D.:	TAV-INJ1	Date:	10-26-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

90

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
toc. 510.86									
	744	100	18.970	603.7	-303.9	8.13	961.0	4.3	0.39
	747	110	18.731	605.5	-524.2	8.26	735.0	2.8	0.26
516.3	754	120	18.561	591.0	-474.2	8.29	491.0	2.5	0.23
	807	130	19.154	630.8	-10.6	8.04	1212.0	34.3	3.17
	818	140	20.169	653.1	16.9	7.97	83.5	39.9	3.61
	827	150	21.401	673.2	3.4	8.00	89.5	34.4	3.03
	836	160	22.564	692.2	2.5	7.99	54.08	33.8	2.92
530	844	170	24.821	718.9	6.5	8.02	78.24	36.2	2.99
	851	180	25.169	714.5	-2.6	8.06	84.37	32.4	2.67
	900	190	25.446	718.2	-0.2	8.08	109.92	33.7	2.75
	908	200	25.100	681.6	-25.4	8.14	266.56	26.5	2.18
540	912	205	25.011	675.6	-19.1	8.15	275.3	29.2	2.40
	921	215	Lowered pump to bottom sump pump hard-dry.						
toc. 517.4	1104		well recovered.		Pump 1.5 gallon min.				
	1110	225	22.091	593.5	326.4	8.15	531.4	27.5	2.38
	1114	230	22.193	595.3	52.2	8.24	643.7	24.8	2.16
	1117	235	22.193	608.0	-192.0	8.24	2255.4	11.4	0.99
526.4	1122	240	22.279	596.3	-55.3	8.27	751.4	27.5	2.39
		245	22.491	593.4	-11.4	8.21	965.16	32.5	2.80

Comments: Depth to water measurements taken to toc - top of casing. Casing is 6.5" below ground surface.

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name: TAV AOC.		
Well I.D.: TAV-INJ1	Date: 10-26-2017	
Method: Portable pump _____	Dedicated pump _____	Pump depth: 539

PURGE MEASUREMENTS

	Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
		1131	250	22.264	585.6	100.2	8.26	570.43	50.6	4.39	
TOC	526.20	1136	255	22.235	592.3	85.3	8.21	47.03	46.7	4.06	
TOC	521.70	1142	260	22.317	603.8	72.1	8.18	28.42	51.6	4.47	
		1150	265	22.285	614.5	58.0	8.17	42.02	51.9	4.43	
		1159	270	24.657	646.5	68.3	8.16	47.70	54.8	4.55	
		1201	275	25.450	659.6	58.3	8.15	65.50	56.5	4.63	
	535.8	1204	280	25.774	654.0	50.3	8.16	116.50	55.1	4.47	
surged last	gallon	1209	285	25.999	654.8	70.0	8.17	109.4	55.0	4.41	
	515.6	1408	295	22.425	604.8	15.0	8.19	326.11	37.1	3.21	2 gpm
		1411	300	21.963	581.1	-4.7	8.24	246.4	30.9	2.70	
		1413	305	21.775	548.7	-49.2	8.31	423.01	21.0	1.84	
		1416	310	21.795	539.5	-17.4	8.29	458.01	23.2	2.03	
		1418	315	21.881	540.2	-19.0	8.30	1387.5	20.8	2.70	
		1420	320	21.905	571.0	111.7	8.21	550.57	37.1	3.24	
		1423	325	22.088	570.4	94.1	8.20	466.17	38.2	3.33	
	529.0	1424	330	22.230	567.3	257.4	8.14	62.24	40.2	3.49	
TOC	519.1	1527	325	28.306	594.3	306.6	8.07	117.08	44.2	3.74	2 ppm
		1530	330	22.590	592.8	101.4	8.15	392.04	38.5	3.32	

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:		
Well I.D.: TAV - INJ1	Date: 10-26-2017	
Method: Portable pump X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
	1533	335	22.315	610.2	85.3	8.11	163.2	43.2	3.75	
	1536	340	22.329	633.3	51.5	8.11	63.59	43.7	3.78	
	1538	345	22.387	635.9	63.5	8.11	106.98	49.1	4.26	
	1541	350	22.502	617.1	66.6	8.14	183.99	43.9	3.80	
	1544	355	22.693	574.0	79.2	8.20	330.10	30.3	2.61	
528.70	1547	360	22.847	582.1	85.7	8.18	431.45	34.8	2.99	
520	1649	365	25.923	621.0	-76.6	8.14	371.86	39.0	3.18	2gpm
	1651	370	22.790	588.0	-7.7	8.17	421.29	36.2	3.10	
	1653	375	22.411	587.1	34.3	8.16	235.46	35.7	3.09	
	1655	380	22.461	606.5	23.4	8.18	100.98	35.3	3.06	
	1658	385	22.756	616.7	36.0	818	113.93	42.5	3.65	
	1701	390	22.896	610.8	41.2	8.18	190.71	40.6	3.50	
	1703	395	22.520	556.7	76.7	8.21	450.05	30.8	264	
	1706	400	22.809	554.3	93.3	8.15	329.91	31.9	2.75	
	1709	405	23.282	572.2	92.0	8.16	354.46	32.9	2.80	
	1712	410	23.334	578.8	89.0	8.15	248.87	35.1	2.96	
	1715	415	23.512	591.8	108.2	8.08	53.35	41.4	3.49	
539	1717	420	24.039	627.1	110.5	8.08	110.92	49.6	4.14	

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV GW AOC		
Well I.D.:	TAV-INJ1	Date:	10-27-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
510.85	743	425	16.526	515.0	-131.9	8.22	38.42	25.5	2.52	2 gpm
	746	430	18.885	547.9	-145.5	8.25	28.85	12.2	1.14	
	749	435	18.717	521.0	-257.4	8.37	128.50	3.7	0.35	
	751	440	18.517	493.0	-338.7	8.39	386.94	2.1	0.19	
	754	445	18.635	487.7	-245.1	8.40	597.04	2.4	0.22	←
	756	450	18.860	488.9	-95.7	8.35	1789.6	14.7	1.37	
	759	455	19.164	570.0	-6.6	8.14	1078.5	30.3	2.80	
525.	802	460	19.498	581.9	15.1	8.08	663.82	31.1	2.85	
	805	455	20.277	598.3	28.7	8.04	253.21	34.4	3.11	
	808	460	21.067	615.2	38.1	8.04	672.56	39.8	3.54	
	810	465	18.767	586.4	47.7	8.01	181.49	41.0	3.74	
	813	470	22.150	642.9	47.2	8.02	380.38	41.0	3.57	
532.8	815	475	22356	670.2	54.3	7.94	478.46	45.8	3.97	
	818	480	22.958	685.0	56.6	7.91	192.07	46.6	3.99	
	820	485	23.360	675.4	55.7	7.95	631.85	43.9	3.74	
537	822	490	23.517	663.6	55.3	7.97	521.46	39.6	3.36	
	824	495	23.478	654.8	54.9	8.03	317.39	41.5	3.52.	

Comments:

Specific capacity 0.1 - 0.2 gal-ft draw.

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TA-V GW AOC		
Well I.D.:	TAV-INJ1	Date:	10-27-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 540.

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
515'	1034	500	20.978	587.9	107.2	8.11	430.47	31.3	2.75	2 gpm
	1037	505	20.398	578.8	75.5	8.19	606.70	22.1	1.99	
	1038	510	20.043	554.1	67.4	8.21	579.68	17.6	1.60	
	1040	515	20.597	552.5	56.6	8.26	644.75	24.4	2.19	
	1042	520	20.819	552.9	43.4	8.25	607.53	22.4	2.00	
	1044	525	20.879	547.9	45.4	8.22	1320.0	36.9	3.29	
	1047	530	19.911	525.6	63.4	8.18	166.66	36.2	3.28	
	1050	535	21.549	549.7	67.2	8.18	73.74	35.7	3.15	
	1053	540	22.003	564.6	69.0	8.16	54.40	37.3	3.26	
537.2	1055	545	22.436	582.6	71.9	8.15	62.66	46.4	4.02	
	1058	550	22.926	619.7	76.8	8.06	43.95	45.4	3.89	
	1101	555	23.077	647.0	79.6	8.00	39.80	50.9	4.35	
	1103	560	23.168	652.4	80.5	8.02	28.15	58.3	4.97	
536.'	1106	565	23.202	645.1	79.8	8.07	33.63	58.4	4.98	
539.8	1232	NA								

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV-GW-AOC	
Well I.D.:	TAV-INJ1	Date: 10-27-2017
Method: Portable pump X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
515.4	1312	570	19.993	574.4	103.5	8.14	54.54	41.0	3.70
	1315	575	20.920	574.5	92.2	8.17	7690	35.9	3.20
	1317	580	20.783	553.2	79.1	8.20	86.61	31.0	2.77
	1320	585	20.830	528.3	63.2	8.23	104.7	22.7	2.02
	1322	590	20.970	512.6	50.0	8.22	160.74	19.7	1.75
	1324	595	21.251	519.0	42.2	8.21	313.19	17.1	1.51
	1330	600	21.640	552.7	67.3	8.14	51.73	38.0	3.33
529.8	1333	605	22.200	563.3	72.2	8.12	19.99	38.7	3.37
	1335	610	22.594	578.3	74.8	8.10	23.67	40.5	3.49
	1338	615	21.567	584.8	85.3	8.05	25.23	45.8	4.00
	1340	620	23.474	642.3	87.0	7.99	29.14	49.9	4.24
536.0	1343	625	23.205	638.7	91.9	7.98	30.27	54.3	4.64
	1345	630	23.505	641.0	89.5	8.00	29.07	56.4	4.99

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV-GW AOC.		
Well I.D.:	TAV-INJ1	Date:	10-27-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
515.45	1550	635	21.930	606.1	116.1	8.09	41.23	41.6	3.62	2 gpm
	1552	640	21.510	588.0	108.1	8.12	68.81	36.8	3.24	
	1555	645	21.016	568.4	95.3	8.13	71.81	32.7	2.91	
	1556	650	21.054	546.0	82.7	8.17	76.86	26.9	2.39	
	1558	655	21.233	530.3	74.4	8.17	88.17	24.8	2.19	
	1600	660	21.391	516.5	62.6	8.16	231.50	19.0	1.68	Foam
	1602	665	21.447	542.5	64.4	8.13	612.70	34.1	3.01	
	1605	670	21.780	557.9	77.6	8.07	71.24	37.7	3.31	
528.45	1607	675	22.089	562.4	82.4	8.05	24.23	39.7	3.49	
	1609	680	22.693	580.5	84.8	8.02	28.57	40.8	3.51	
	1612	685	23.010	598.7	87.7	7.99	25.73	42.3	3.62	
	1614	690	23.448	637.0	90.9	7.93	24.43	49.2	4.18	
536.6	1616	695	23.641	657.8	90.6	7.91	25.11	54.8	4.64	

Comments: At 1600 time water became foamy. and continued.

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name: TAV-GW-AOC.		
Well I.D.: TAV-INJ1	Date: 10/30/2017.	
Method: Portable pump X	Dedicated pump	Pump depth: 539'

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
510.75	0819	700	18.228	554.2	12.7	8.07	24.98	31.2	2.91	1.5 gpm.
	0822	705	19.275	543.1	308.1	8.22	31.38	24.4	2.23	
	0825	710	18.817	515.7	-358.0	8.40	43.35	5.9	0.53	
	0828	715	18.941	505.7	-358.6	8.46	520.40	3.5	0.32	
	0831	720	19.080	497.4	-192.8	8.49	339.06	3.2	0.29	
	0836	725	19.062	511.2	256.7	8.22	949.14	16.9	1.55	
522.35	0840	730	19.363	659.2	162.3	7.94	77.24	21.0	1.93	1gpm
	0845	735	19.505	665.5	367.1	7.89	44.42	31.2	2.85	
	0849	740	20.600	694.5	303.0	7.87	65.55	31.8	2.85	
	0853	745	20.785	681.2	352.5	7.83	15.0	25.6	2.28	
526.2	0856	750	21.789	712.3	304.4	7.84	15.1/10.99	25.2	2.21	
	0900	755	22.349	726.8	276.4	7.83	26.2/114.3	28.5	2.47	
	0903	760	22.710	736.1	261.4	7.81	33.6/22.71	29.2	2.52	
	0907	765	23.025	740.1	243.8	7.81	40.9/26.50	32.0	2.74	
531.10	0911	770	23.652	745.3	230.9	7.80	58.6/33.05	28.0	2.37	
	0915	775	24.232	746.0	216.2	7.82	56.2/54.76	24.8	2.08	
	0919	780	24.451	740.2	203.2	7.84	24.97	21.6	1.80	
534.8	0923	785	24.322	729.1	193.7	7.87	44.7/21.44	19.4	1.62	
	0928	790	24.076	716.1	181.9	7.90	43.6/33.54	15.7	1.31	

Comments: Turbidity measurements HACH/YSI Sonde to check results.
YSI turbidity values vary w/ time and when bucket is stirred.

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV-GW-AOC		
Well I.D.:	TAV-INJ1	Date:	10-30-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
536.4	0932	795	24.138	707.3	169.8	7.93	77.2/31.26	14.5	1.22
538.0	0936	800	24.282	696.9	249.3	7.97	77.5/54.85	21.6	1.82
TAP WATER		—	16.083	276.9	659.0	8.27	1.62	65.3	6.43
515.0	1146	805	23.760	681.2	335.0	7.99	71.4/42.92	20.4	1.64
	1150	810	21.786	651.7	330.0	8.02	75.3/31.80	10.6	0.92
	1154	815	21.351	648.3	295.1	8.07	38.31	9.5	0.84
522.0	1157	820	21.163	643.5	331.5	8.05	~~57.3~~ 107/46.10	12.3	1.09
	1201	825	21.447	643.0	329.7	8.04	196/80.02	18.6	1.59
	1206	830	21.641	624.9	331.5	8.02	299/238.15	20.9	1.74
	1211	835	21.748	621.1	298.6	8.01	38.5/32.28	26.6	2.34
525.5	1214	840	22.091	627.7	288.1	7.99	44.9/20.25	32.7	2.86
	1219	845	22.518	636.1	338.1	7.95	38.6/21.31	42.2	3.55
527.9	1224	850	23.215	655.1	329.3	7.93	59.6/18.68	42.3	3.41
	1228	855	23.771	675.9	287.0	7.94	29.7/17.68	38.9	3.28
	1232	860	24.172	696.3	281.5	7.91	43.9/22.13	42.3	3.56
	1236	865	24.029	698.3	319.5	7.90	44.8/23.45	46.0	3.76
	1240	870	23.521	695.3	323.6	7.90	32.1/21.70	46.2	3.86
	1245	875	24.337	696.1	338.3	7.89	40.3/13.34	51.9	4.26

toc.

Comments: Tap water values/sample taken from courtyard spigot <east> 6580.
Turbidity measurements Hatch/Ysi Sonde

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV-GW-AOC		
Well I.D.:	TAV-INJ1	Date:	10-30-2017
Method: Portable pump	Y	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
535.0'	1249	880	24.456	683.9	280.9	7.96	41.0	44.6	3.71
536.0'	1253	885	23.660	650.7	363.6	7.94	54.3	48.9	4.07
	1257	890	23.874	633.7	347.0	7.96	52.1	48.2	4.13
515.0	1507	895	20.579	584.2	386.0	7.99	58.2	36.5	3.26
	1511	900	21.188	589.3	295.3	8.05	40.9	23.5	2.08
	1515	905	20.802	571.7	274.7	8.08	59.2	21.0	1.87
521.20	1520	910	20.854	563.3	252.0	8.10	49.8/42.99	16.1	1.43
	1525	915	21.011	559.7	234.0	8.09	51.74	13.2	1.18
	1529	920	20.991	~~266.4~~	266.4	8.04	181/101.13	28.6	2.56
	—	—	—	554.8	—	—	—	—	—
525.3	1533	925	21.269	570.8	258.6	8.03	35.7/27.91	26.4	2.33
	1538	930	21.541	581.9	256.7	8.02	17.2/22.86	36.0	3.17
	1542	935	22.266	592.7	254.1	8.00	21.2/28.06	36.1	3.15
527.3	1547	940	23.114	614.9	252.5	7.97	13.1/19.50	35.8	3.06
	1551	945	23.620	637.1	251.5	7.95	14.2/11.07	39.4	3.33
	1555	950	23.777	657.6	251.7	7.92	15.4/21.00	41.9	3.52
531.0	1559	955	24.144	669.1	250.0	7.90	14.3/15.88	44.2	3.71
	1604	960	24.574	679.9	247.3	7.90	14.1/16.73	45.2	3.76
	1608	965	24.780	685.1	244.4	7.91	16.6/14.18	46.3	3.83

Comments: Turbidity Hatch/YSI sonde

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAN-GW-AOC		
Well I.D.:	TAN-INJ1	Date:	10-30-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)
534.2	1612	970	24.865	678.9	241.6	7.92	20.7/22.66	46.1	3.81
	1617	975	24.788	663.8	238.0	7.93	25.2/19.09	43.1	3.57
536.0	1621	980	24.550	652.8	236.2	7.95	32.6/31.32	42.9	3.57

Comments: Turbidity Hatch/YSI Sonde

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name: TAV-GW-AOC		
Well I.D.: TAV-INJ1	Date: 10-31-2017	
Method: Portable pump X	Dedicated pump ____	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
510.9	0738	985	16.870	531.6	195.7	8.07	31.1/37.48	32.8	3.02	1 gpm
	0742	990	19.025	549.1	159.5	8.07	30.5/21.45	4.0	0.37	
516.5	0746	995	16.944	513.7	103.2	8.13	32.0/18.01	6.3	0.59	
	0749	1000	18.434	524.6	-356.2	8.15	29.0/21.52	3.3	0.31	
	0754	1005	18.432	510.1	176.0	8.06	37.5/16.37	16.4	1.53	
	0758	1010	18.038	508.7	189.4	8.10	264/71.09	7.1	0.66	
522.5	0802	1015	18.701	575.2	187.1	7.93	17.6/50.4	26.2	2.41	
	0806	1020	19.058	599.8	210.3	7.93	9.14/12.58	41.4	~~03~~ 3.78	
	0811	1025	19.732	609.4	219.0	7.91	5.69/3.62	34.7	3.17	
	815	1030	20.979	629.3	214.6	7.89	5.77	35.1	3.14	
525.3	820	1035	20.155	619.5	221.4	7.91	4.45	45.3	3.97	
526.0	823	1040	22.737	666.8	214.5	7.87	11.9/11.68	38.1	3.28	
515	0952	1045	15.526	577.1	221.8	7.94	14.3/3.80	29.9	2.93	1 gpm
	0957	1050	20.960	657.6	222.8	7.96	16.7/13.31	36.8	3.32	
	1001	1055	21.976	663.6	226.3	7.91	17.1/11.91	37.7	3.30	
	1005	1060	18.859	617.8	227.0	7.96	166/6.20	32.1	2.93	
	1010	1065	20.665	634.1	223.7	8.00	14.7/13.80	34.9	3.15	
523.3	1014	1070	21.373	618.1	224.1	7.97	20.7	32.4	2.81	
	1019	1075	21.869	618.4	206.4	7.98	5.80	25.3	2.21	bubbles

Comments: Turbidity Hatch/YSI Sonde single valve is Hatch.

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAN-GW-AOC		
Well I.D.:	TAN-1NJ1	Date:	10-31-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
	10.23	1080	21.831	618.8	211.5	7.99	3.75	31.9	2.78	
	1027	1085	19.274	588.2	218.2	7.97	4.35	40.6	3.63	
526	1031	1090	21.340	609.4	219.9	7.97	4.89	37.3	3.23	
512.6	1244	1095	19.804	601.0	218.1	7.95	7.92	25.0	2.28	1 gpm
	1249	1100	21.171	633.0	221.6	7.98	8.13	25.4	2.19	
	1254	1105	20.508	632.4	221.8	8.01	9.79	23.9	2.14	
518.	1258	1110	19.198	610.2	211.1	8.00	11.4	24.1	2.16	
	1302	1115	19.039	614.2	217.9	8.00	10.6	31.2	2.81	
	1306	1120	20.497	598.3	222.4	8.00	19.1	33.8	3.04	bubbles
	1311	1125	20.954	571.4	220.8	8.02	9.52	32.2	2.86	
524.6	1315	1130	19.473	567.5	226.4	7.99	3.40	34.6	3.10	
	1320	1135	19.989	586.7	226.5	7.97	3.67	43.5	3.82	
	1324	1140	20.857	595.8	229.9	7.96	3.51	43.2	3.83	
	1328	1145	23.171	626.6	229.5	7.96	4.55	42.2	3.61	
526.0	1333	1150	23.260	635.0	231.1	7.93	8.56	48.7	4.21	
515.0	1508	1155	22.212	645.9	225.6	7.93	11.4	35.4	3.07	
	1512	1160	22.009	640.7	226.6	7.93	12.9	42.0	3.70	
	1520	~~1165~~	21.625	648.0	234.2	7.93	10.9	32.9	2.81	

Comments: 1170

Turbidity - Hatch meter.

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV-GW-AOC	
Well I.D.:	TAV-INJ1	Date: 10-31-2017
Method: Portable pump X	Dedicated pump	Pump depth: 539'

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
523.2	1527	1175	20.496	634.3	231.5	7.97	14.0	35.4	3.15	
	1531	1180	21.554	604.0	229.0	7.99	22.5	35.8	3.09	bubbles.
525	1536	1185	21.041	581.3	226.0	7.99	5.32	28.9	2.52	
	1540	1190	21.257	570.1	227.8	7.98	4.64	40.9	3.44	
	1545	1195	22.371	597.2	229.9	7.96	4.88	35.3	3.06	
526	1549	1200	23.254	597.3	229.6	7.96	6.45	44.9	3.76	

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name:	TAV-GW-AOC		
Well I.D.:	TAV-INJ1	Date:	11-1-2017
Method: Portable pump	X	Dedicated pump	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
510.75	0744	1205	15.183	510.1	399.3	8.00	8.04	37.1	3.61	1 gpm
	0749	1210	16.849	546.5	413.2	7.94	10.4	19.3	1.82	
515.7	0754	1215	16.933	568.0	279.3	8.03	10.6	9.6	0.91	
	0758	1220	17.801	580.8	-359.3	8.07	9.50	6.9	0.64	
	0801	1225	18.557	592.7	67.2	8.12	32.1	9.4	0.88	
520.6	0806	1230	17.054	564.0	271.3	8.04	124	16.8	1.52	
	0810	1235	17.574	~~335.4~~	327.0	7.93	24.5	30.1	2.86	
	—	—	—	527.8	—	—	—	—	—	
	0815	1240	17.960	597.8	371.4	7.88	7.43	33.0	3.11	
	0820	1245	18.995	615.1	312.9	7.89	4.92	31.4	2.90	
525.1	0825	1250	19.024	632.7	380.2	7.87	4.60	33.9	3.08	
	0830	1255	20.482	651.3	360.1	7.88	6.20	33.4	2.97	
	0835	1260	21.467	661.6	364.9	7.87	7.87	36.3	3.17	
526.0	0840	1265	22.461	649.5	362.1	7.88	10.4	46.5	3.96	
515.0'	1014	1270	19.308	615.0	266.8	7.99	12.0	42.0	3.98	
	1019	1275	19.241	643.8	377.1	7.91	12.4	38.0	3.44	
	1023	1280	21.292	671.5	350.5	7.92	11.7	32.8	2.89	
	1028	1285	21.286	663.5	329.9	7.98	10.4	29.2	2.58	
522.5	1033	1290	21.313	658.2	367.3	7.95	9.9	32.1	2.81	

Comments:

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FIELD MEASUREMENT LOG FOR GROUNDWATER SAMPLE COLLECTION

Project Name: TAN-GW-AOC		
Well I.D.: TAN-INJ1	Date: 11-1-2017	
Method: Portable pump X	Dedicated pump ____	Pump depth: 539

PURGE MEASUREMENTS

Depth to Water (ft)	Time 24 hr	Vol. (L/gal)	Temp (°C)	SC (µS/cm)	ORP (mV)	pH	Turbidity (NTU)	DO (%)	DO (mg/L)	
	1038	1295	21.565	647.0	358.3	7.97	40.0	28.3	2.47	
	1043	1300	21.580	610.0	353.2	7.97	4.80	26.5	2.31	bubble.
	1047	1305	21.810	~~696~~9.2	302.1	7.98	2.93	30.0	2.62	
525.7	1052	1310	22.467	628.9	319.5	7.96	2.80	28.1	2.42	
526.0'	1056	1315	22.913	640.0	327.0	7.95	3.24	28.5	2.44	
	1100	1320	24.037	665.6	289.1	7.92	4.10	30.7	2.59	

Comments:

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