GJO-MOA 19.2.3

Aquifer Test Data Analyses (Phase II, Part 1)

MOAB PROJECT

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Calculation Cover Sheet

Calc. No. Moab–10–2002–03–03–00 **Discipline:** Hydrogeology **Number of Sheets:** 10

Project:
Moab Groundwater

Site:
Moab, UT

Feature:
Aquifer Test Data Analyses (Phase II, Part 1)

Sources of Data:
July/August 2002 Field Investigation

Sources of Formulae & References:

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___________, 2002b. *Work Plan for Characterization of Groundwater Brine Zones for Interim Action at the Moab, Utah, UMTRA Project Site, Addendum A*, GJO–MOA 19.1.2-2, prepared for the U.S. Department of Energy Grand Junction Office, Grand Junction, Colorado.

Preliminary Calc. ☐ **Final Calc.** ☒ **Supersedes Calc. No.** ____________

Rev. No.	Revision	Calculation by	Date	Checked by	Date	Approved by	Date
		[illegible signature]	10/17/02	Dave Peterson	10/17/2002	[illegible signature]	10/17/02

Introduction

The U.S. Department of Energy (DOE) is designing an interim action to reduce risk to endangered fish from ammonia discharging from the unconfined alluvial system to backwaters of the Colorado River adjacent to the Moab Project Site. Fresh water in the unconfined alluvial system at the Moab Project Site is underlain by a saltwater brine zone. Pumping from the shallow fresh water system (during pump-and-treat remediation) may cause the salt water to rise to a higher elevation and intrude the freshwater. Saltwater intrusion would result in degradation of the overlying fresh water, which could adversely impact the tamarisk plant communities that are providing beneficial phytoremediation at the site. Besides causing salt water intrusion into the shallow ground water, rising salt water may bring higher ammonia concentrations to the surface and cause added contamination to the river. For these reasons, additional characterization of the aquifer to support the well field design for the interim action is required.

Previous results from field tests conducted in March 2002 are presented in the *Characterization of Groundwater Brine Zones at the Moab Project Site (Phase I),* June 2002 (DOE 2002a). Phase I results suggest that the design of the pumping well used to conduct the tests, which was screened from the upper fresh water (less than 5,000 milligrams per liter total dissolved solids [TDS]) zone to the lower brine unit, prevented the development of a definitive conclusion regarding the relationship between drawdown in a remediation extraction well and upwelling in the underlying brine zone. For this reason, additional testing (Phase II) was conducted with a well screened only in the upper fresh water zone.

Purpose and Scope

This calculation set presents results for two short-term tests (Part 1) conducted as part of the Phase II characterization. All work was performed in accordance with Addendum A of the *Work Plan for the Characterization of Groundwater Brine Zones for Interim Remediation Activities at the Moab, Utah, UMTRA Project Site* (DOE 2002b). Results of long-term tests (Part 2) will be reported at a later date upon completion of on-going tasks determine the maximum pumping rate that can be sustained without any rise in the underlying brine zone.

The primary objectives of the short-term tests (Part 1) presented in this calculation set are to determine the sustainable pumping rate for well PZ1S and to use the results from PZ1S to decide if new pumping and observations wells, and additional testing at a higher flow rate, are required. A secondary objective of the short-term tests is to determine aquifer parameters for use as input to a flow model to support the design of the well field.

Task 1 – Determination of the Sustainable Pumping Rate for Well PZ1S

Well PZ1S, located within the PW01 well cluster, is a 2-inch diameter well screened from 13.8 to 19.1 feet below ground surface (ft bgs). Low-flow sampling from well PZ1S during the February 2002 PW01 aquifer tests resulted in significant drawdown, suggesting this well had a low sustainable pumping rate.

Although this well was developed immediately after installation by SMI (April 2001), additional well development was completed prior to determination of the flow rate. After the latest development, the sustainable flow rate was measured to be between 0.25 to 0.5 gallons per minute (gal/min).

In accordance with DOE (2002b), PZ1S could not be used as the pumping well because its sustainable flow rate was less than 1 gal/min. The choice of an alternative pumping well is described under Task 2.

Task 2 –Pumping Well 449 and Observation Well 450

Well Installation

Using a hollow stem auger drill rig, wells 449 and 450 were installed by GJO contractor personnel in the vicinity of the PW01 well cluster in June 2002. Locations for these wells are shown in Figure 1. Well 449 was designed as a pumping well to maximize the sustainable flow rate. This 6-inch diameter well was constructed with 0.020-inch circumslot PVC well screen from 13.6 to 27.6 ft bgs.

Well 450 was installed as an observation well for tests using 449 as the pumping well. Well 450 construction is similar to that of well 449. Well 450 is a 2-inch diameter well screened over approximately the interval of 13 to 28 ft bgs with 0.020-inch slotted PVC screen. The completion logs for wells 449 and 450 are contained in Appendix A.

Well Development

Both wells 449 and 450 were developed beginning on July 2, 2002. Development techniques included alternating pumping from the well and surging over the screened intervals. Up to 4 ft of formation sand (fine sand) was encountered at the bottom of well 449 prior to development, and up to 2 ft of sand was found at the bottom of well 450. All sand was removed during the development process

Well 450 was developed for approximately 8 hours, while well 449 required development time of approximately 20 hours.

Baseline Sampling

Prior to starting the aquifer test, baseline ground water samples were collected from newly installed wells 449 and 450. These samples were collected within the screen interval of the two wells at depths of 15, 19, 23, and 28 ft below top of casing (btoc). All samples were collected using a peristaltic pump, with the pump intake attached to the end of a line that was lowered down the well to the desired depths. Prior to the collection of each sample, the intake line was purged to ensure the sample collected was representative of the desired depth. To confirm the line was adequately purged, a YSI instrument was set up at the surface to monitor the temperature, pH, and conductivity of the discharge from the peristaltic pump. The sample was not collected until the field parameters measured by the YSI instrument stabilized.

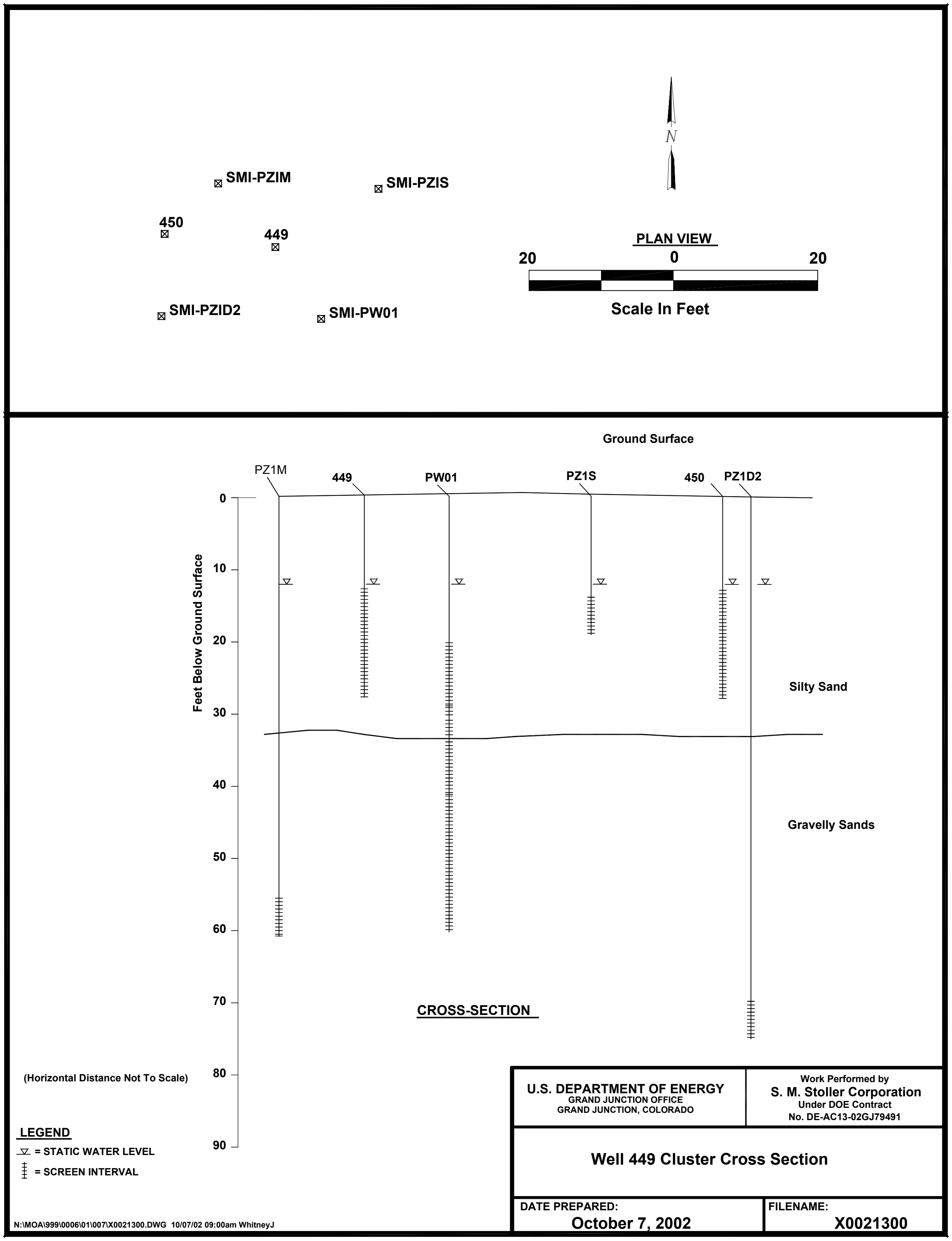
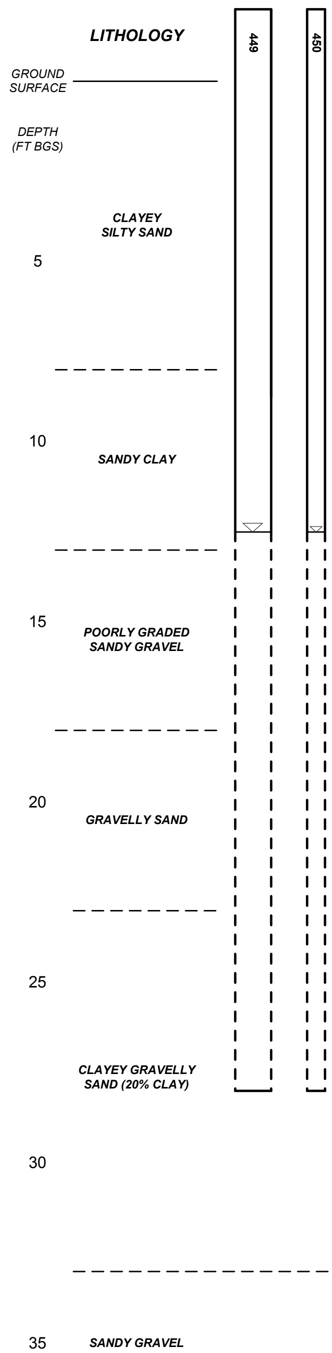


Figure 1. Well 449 Cluster Map and Cross Section

The samples were filtered in the field using a 0.45 micron (μ) filter and collected in a 500-milliliter (mL) HPDE container are preserved. Each sample was analyzed at the Grand Junction Office (GJO) Environmental Sciences Laboratory (ESL) for density, conductivity (which was later converted to specific conductance), ammonia (as N), chloride, sulfate and uranium. A 125-mL split of each sample was made and submitted to the GJO Analytical Chemistry Laboratory for TDS analysis. Figure 2 presents the lithology, well screen interval, and analytical results for the baseline samples collected from wells 449 and 450.



WELL NO.	DEPTH (ft btoc)	SPECIFIC CONDUCTANCE (uS/cm)	DENSITY (g/cm^3)	TDS (mg/L)	NH_3 as N (mg/L)	Cl (mg/L)	SO_4 (mg/L)	U (mg/L)
449	15	17775	1.0073	12240	450	1338	6897	1.215
450	15	15769	1.0072	12233	450	1348	6906	1.244
449	19	16487	1.0064	12430	450	1373	7074	1.260
450	19	16698	1.0052	12140	430	1374	7074	1.299
449	23	16888	1.0068	12370	480	1341	7168	1.390
450	23	16905	1.0068	12290	450	1365	7060	1.190
449	28	16617	1.0072	12560	550	1300	7469	1.578
450	28	17465	1.008	12900	600	1445	7697	1.743

Figure 2. Baseline Sampling Results From Wells 449 and 450.

Step Test

A step test was conducted at pumping well 449 on July 17, 2002, using flow rates of 1, 2, 3, and 4 gal/min. Figure 3 presents the drawdown data collected from the pumping well for each of the four steps. As indicated by this plot, well 449 appears to have a sustainable pumping rate of 3 gal/min. Drawdown leveled off within 10 minutes during the 1 and 2 gal/min steps; in contrast, it took almost 4 hours for the drawdown to remain constant after increasing the flow to 3 gal/min. Pumping at a rate of 4 gal/min would have take the water level below the intake level of a pump set near the bottom of the screen.

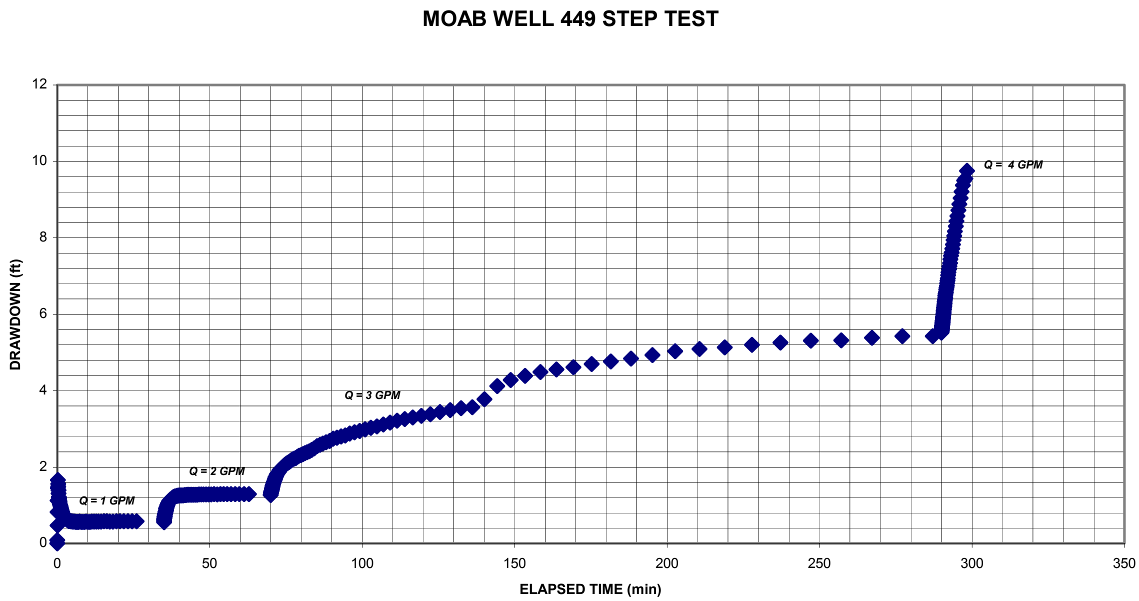


Figure 3. Well 449 Step Test—Drawdown Data

The specific capacity was calculated for each step by dividing the flow rate (gal/min) by the measured drawdown at the end of each step. Based on this step-drawdown test, the specific capacity of well 449 ranges from less than 0.41 to 1.75 gal/min/ft. The specific capacity results for each step are presented in Table 1.

Table 1. Well 449 Step Test Specific Capacity Results

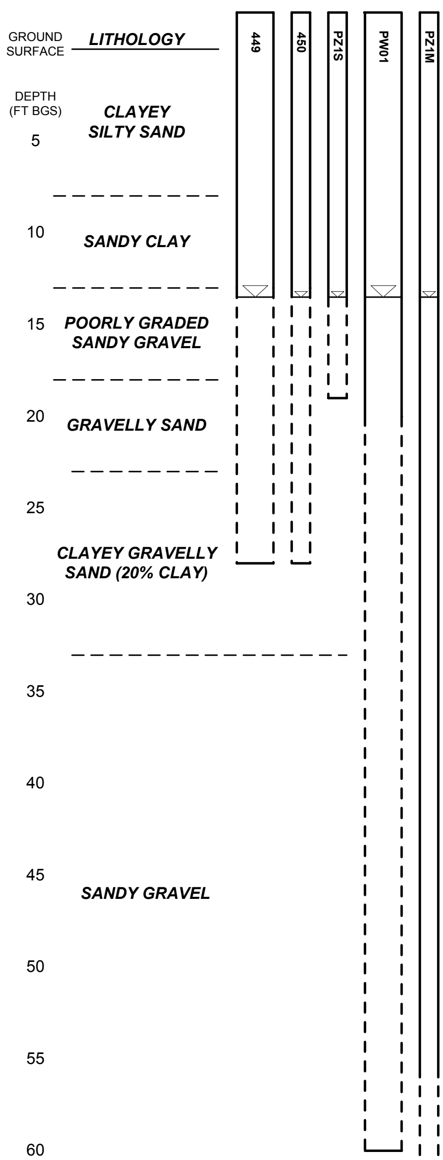
Test Step (gal/min)	Total Drawdown (ft)	Specific Capacity (gal/min/ft)
1	0.57	1.75
2	1.30	1.54
3	5.43	0.55
4	> 9.75	< 0.41

August 13, 2002 Short-Term Aquifer Test

Prior to starting short-term aquifer tests, ground water samples were collected from pumping well 449, and observation wells 450, PZ1S, PW01, and PZ1M to determine baseline conditions within each of the wells. The sample collection procedures and analyses were identical to those followed for the 449 and 450 baseline characterization. Sample depths and results of the baseline sampling at the pumping and observation wells prior to the initiation of the aquifer tests are shown on Figure 4.

An aquifer test was started on August 13, 2002, pumping 3 gal/min from well 449. Samples were collected off the discharge line from well 449 after 10 minutes of pumping, and again after 70 minutes of pumping. After approximately 5 hours into the test, ground water samples were collected from the well 449 discharge line and from each of the four observation wells.

After the test ran for approximately 21 hours, the water level inside the pumping well was near the pump intake. Consequently, one last sample of the 449 discharge was collected and the test was stopped after 21.75 hours. During the recovery phase, samples were collected again from each of the observation wells.



WELL NO.	DEPTH (ft btoc)	SPECIFIC CONDUCTANCE (uS/cm)	DENSITY (g/cm^3)	TDS (mg/L)	NH_3 as N (mg/L)	Cl (mg/L)	SO_4 (mg/L)	U (mg/L)
PZ1S	19	16705	1.0057	12310	475	1354	6998	-
PW01	25	16191	1.0066	12130	425	1336	6830	-
449	27	17228	1.0058	12510	400	1335	7086	1.369
450	27	17578	1.006	12470	450	1394	7287	1.443
PZ1M	60	48358	1.0244	35167	1425	9018	15808	-

Figure 4. Baseline Sampling Results From the 449 Well Cluster

Table 2. Sample Results From the August 13, 2002, Aquifer Test

SAMPLE LOCATION / DEPTH	DATE/TIME COLLECTED	TIME SINCE TEST STARTED (hrs)	DENSITY (g/cm^3)	SPECIFIC CONDUCTANCE (µS/cm)	AMMONIA NH_3-N (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	SO_4/Cl RATIO	URANIUM (mg/L)	TDS (mg/L)
PMP WELL 449 / 27'	8/13, 0950	-0.2[a]	1.0058	17228	400	1335	7086	5.31	1.369	12510
PMP WELL 449 / 27'	8/13, 1010	0.2	1.0057	17091	400	1363	7061	5.18	1.306	12390
PMP WELL 449 / 27'	8/13, 1110	1.2	1.0059	16882	420	1356	7071	5.21	1.268	12360
PMP WELL 449 / 27'	8/13, 1520	5.3	1.0059	16893	420	1381	7245	5.25	1.335	12390
PMP WELL 449 / 27'	8/14, 0730	21.5	1.0072	16352	450	1350	7211	5.34	1.289	12480
OBS WELL 450 / 27'	8/13, 0830	-1.5[a]	1.006	17578	450	1394	7287	5.23	1.443	12470
OBS WELL 450 / 27'	8/13, 1555	5.9	1.0083	17646	525	1475	7889	5.35	1.701	13070
OBS WELL 450 / 27'	8/14, 0820	22.3[b]	1.0071	17664	560	1466	7790	5.31	1.689	12970
OBS WELL PZ1S / 19'	8/13, 0820	-1.7[a]	1.0057	16705	475	1354	6998	5.17	na	12310
OBS WELL PZ1S / 19'	8/13, 1540	5.7	1.0059	17231	520	1409	7220	5.12	na	12290
OBS WELL PZ1S / 19'	8/14, 0835	22.6[b]	1.0067	16257	425	1380	7167	5.19	na	12300
OBS WELL PW01 / 25'	8/13, 0815	-1.8[a]	1.0066	16191	425	1336	6830	5.11	na	12130
OBS WELL PW01 / 25'	8/13, 1550	5.8	1.0071	18354	400	1388	8088	5.83	na	13190
OBS WELL PW01 / 25'	8/14, 0840	22.7[b]	1.007	16017	220	1404	7215	5.14	na	12500
OBS WELL PZ1M / 60'	8/13, 0825	-1.6[a]	1.0244	48358	1425	9018	15808	1.75	na	35167
OBS WELL PZ1M / 60'	8/13, 1525	5.4	1.0261	51823	550	10081	16257	1.61	na	37600
OBS WELL PZ1M / 60'	8/14, 0830	22.5[b]	1.0272	47928	1375	9878	16399	1.66	na	36800

Notes:
[a]Sample was collected prior to the start of the test.
[b]Sample was collected during the recovery phase of the test.
Pumping phase of test lasted 21.75 hours.
PMP = Pumping Well
OBS = Observation Well
na = Data not available
mg/L = milligrams per liter
hrs = hours
g/cm^3 = grams per cubic centimeter
µS/m = microSiemens per centimeter

Results

Analytical results from the samples collected during this test are presented in Table 2. The specific conductance data provide indicators of whether pumping from well 449 drew the brine upwards. Figure 5 is a plot of specific conductance results over the test interval.

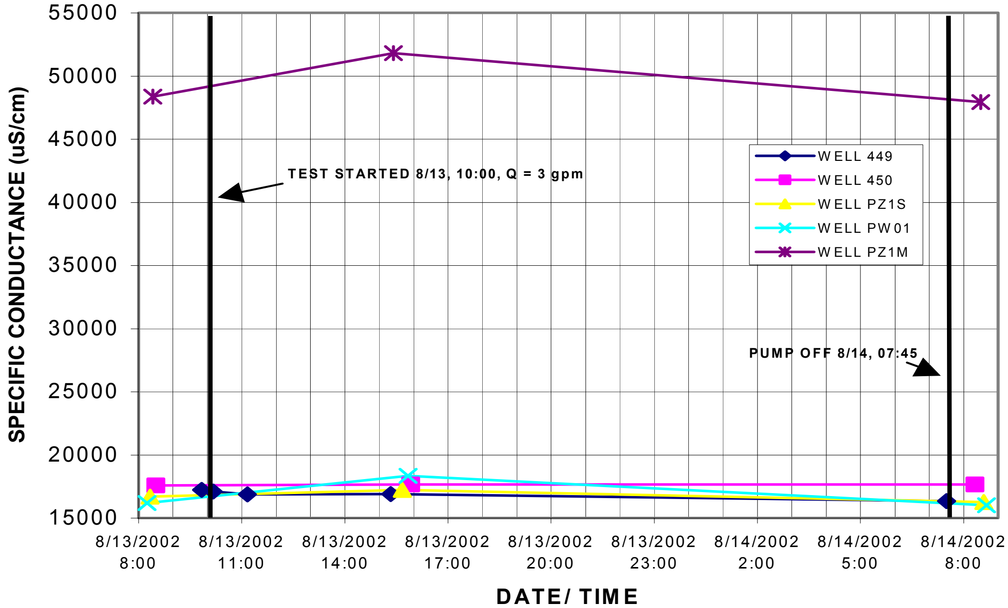
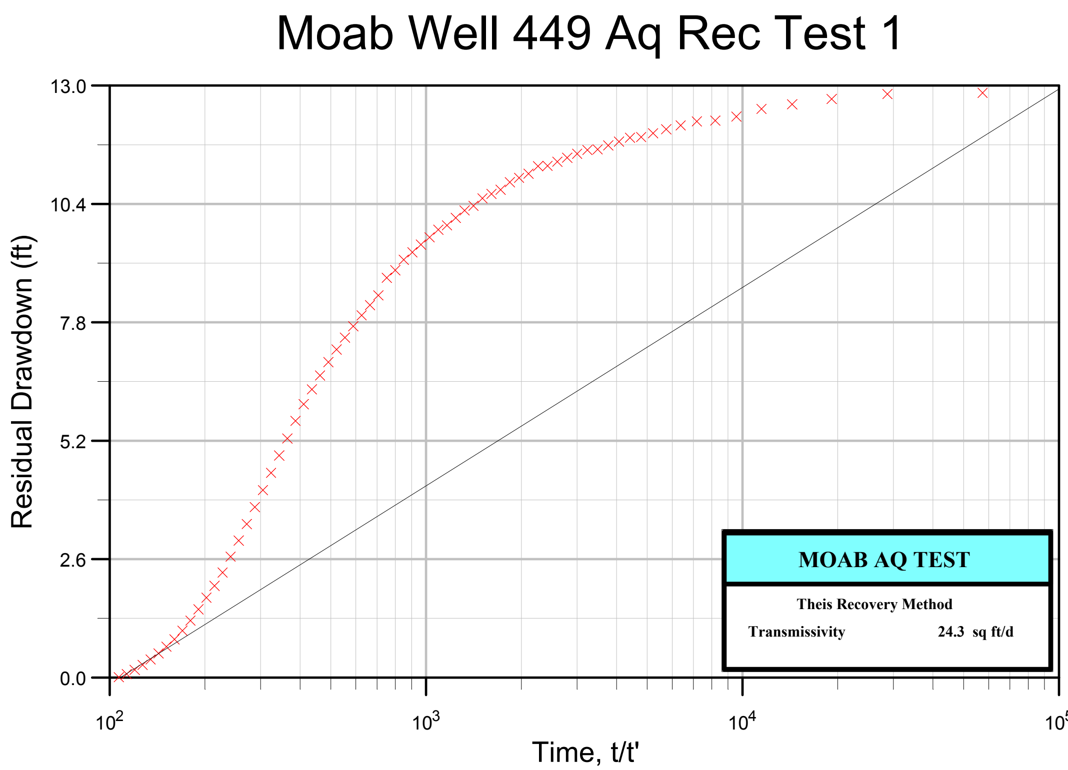


Figure 5. Specific Conductance vs. Time

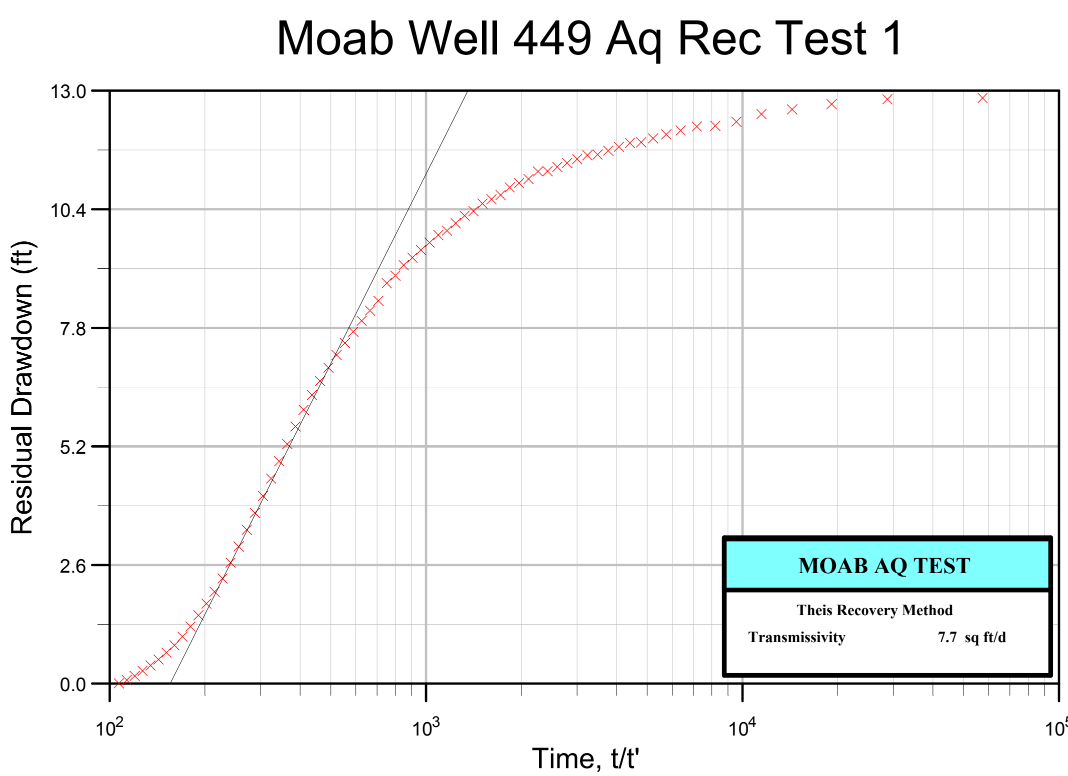
The data in Figure 5 indicate no significant changes in the specific conductance in the pumping well or observation wells during the test, suggesting no upward migration of the brine in response to the pumping during this short-term test.

During the pumping phase, no drawdown occurred in observation well 450. To estimate aquifer parameters, only the residual drawdown data collected from well 449 were analyzed. All data were analyzed using the Theis Recovery Method (1935) as discussed in Kruseman and DeRidder (1994). This method estimates the aquifer transmissivity based on late-time residual drawdown data collected from a well completed in an unconfined aquifer.

Figure 6 presents two Theis Recovery Method plots generated from the residual drawdown data collected during the August 13, 2002, short-term aquifer test. Both plots present the same data set, with the difference between the two plots being the straight-line location through the data. Plot A produces a transmissivity of 24.3 ft^2/day based on the very late-time data. Using a saturated thickness of 15 ft (which represents the approximate saturated screened interval), the estimated hydraulic conductivity is 1.6 ft/day. Plot B, which uses data points from slightly earlier time period compared to Plot A, produces a transmissivity of 7.7 ft^2/day. Again using a saturated thickness of 15 ft, the hydraulic conductivity becomes 0.5 ft/day. The lines drawn through the data in both plots are valid based on the criteria set for t (the length of time the pump was operating) and t’ (the length of time since the cessation of pumping) as described by Kruseman and DeRidder (1994).



PLOT A



PLOT B

Figure 6. Well 449 Residual Drawdown Analysis, August 13, 2002, Short-Term Aquifer Test

August 14, 2002 Short-Term Aquifer Test

After reviewing the data from the step-drawdown test, the efficiency of well 449 during the first short-term aquifer test was questioned. The specific capacity for well 449 at the end of the 21.75 hours of pumping was only 0.26 gal/min/ft, which is less than one-half of the specific capacity calculated for the 3 gal/min step (0.55 gal/min/ft) during the step-drawdown test.

The well was further developed (for approximately 3 hours), and another short-term test was started on August 14, 2002, again using a flow rate of 3 gal/min. After 20 hours of pumping, the pump was shut down and recovery test data were collected. Samples were not collected during this second test.

Results

Drawdown in well 449 during this second test was limited to 4.5 ft as opposed to the 11.5 ft of drawdown measured in the previous test (Figure 7). The resulting specific capacity of well 449 for this second test was 0.67 gal/min/ft, which is greater than the value calculated from the step-drawdown test.

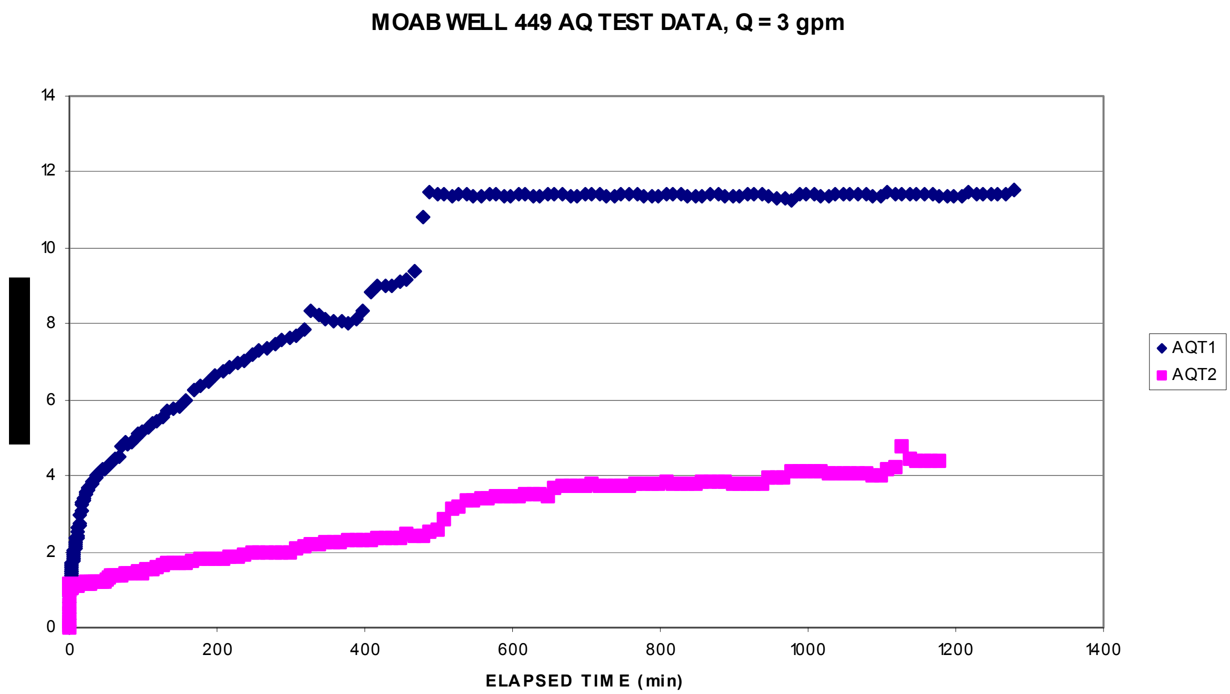


Figure 7. Comparison of the Drawdown Measured During the Well 449 Short-Term Aquifer Tests

The residual drawdown data collected from this second test were also analyzed using the Theis Recovery Method (1935) as discussed in Kruseman and DeRidder (1994) to determine the transmissivity of the aquifer. This analysis (Figure 8) produced an estimated transmissivity of 36.9 ft^2/day. Using a saturated thickness of 15 ft, the corresponding hydraulic conductivity was estimated to be 2.5 ft/day.

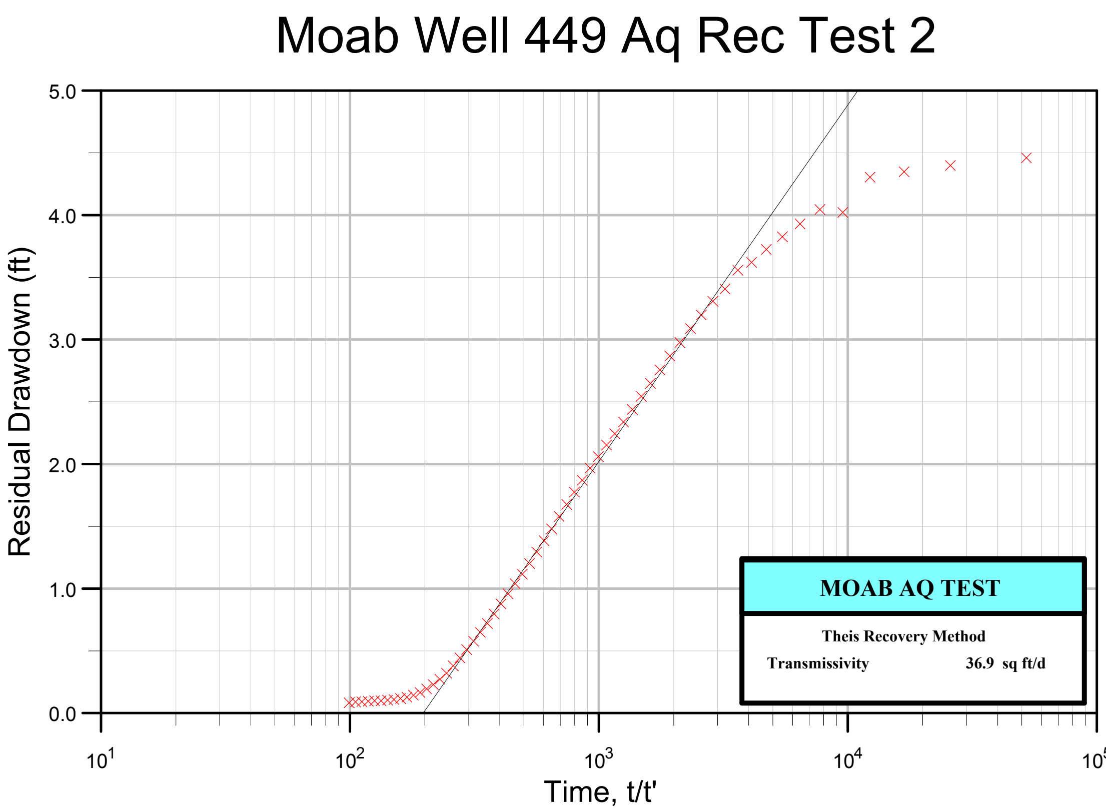


Figure 8. Well 449 Residual Drawdown Analysis, August 14, 2002, Short-Term Aquifer Test Theis Recovery Method

In addition to analyzing the residual drawdown data collected during the test recovery, drawdown data collected from pumping well 449 during the pumping phase were also analyzed to estimate the aquifer transmissivity. Analyzing the data using the Theis Method modified for unconfined conditions (Jacob 1944) resulted in a poor fit between the data and the Theis curve. Moreover, the data did not show evidence of leaky aquifer conditions.

The data were then analyzed using the Cooper and Jacob Straight Line Method (1946), which can be applied to a unconfined system when the drawdown is small compared to the aquifer saturated thickness and there is no delayed yield effect. Figure 9 is a semi-logarithmic plot of the well 449 drawdown data collected during the August 14, 2002, aquifer test. Drawing a straight line through the data between times of 40 and 300 minutes results in an estimated aquifer transmissivity of 106 ft^2/day, which corresponds to a hydraulic conductivity of 7.1 ft/day (based on a saturated thickness of 15 ft). Part of the time period selected for the straight-line solution in this case meets the minimum time criterion traditionally adopted for the Cooper-Jacob Method (Kruseman and DeRidder 1994), while a portion of it does not.

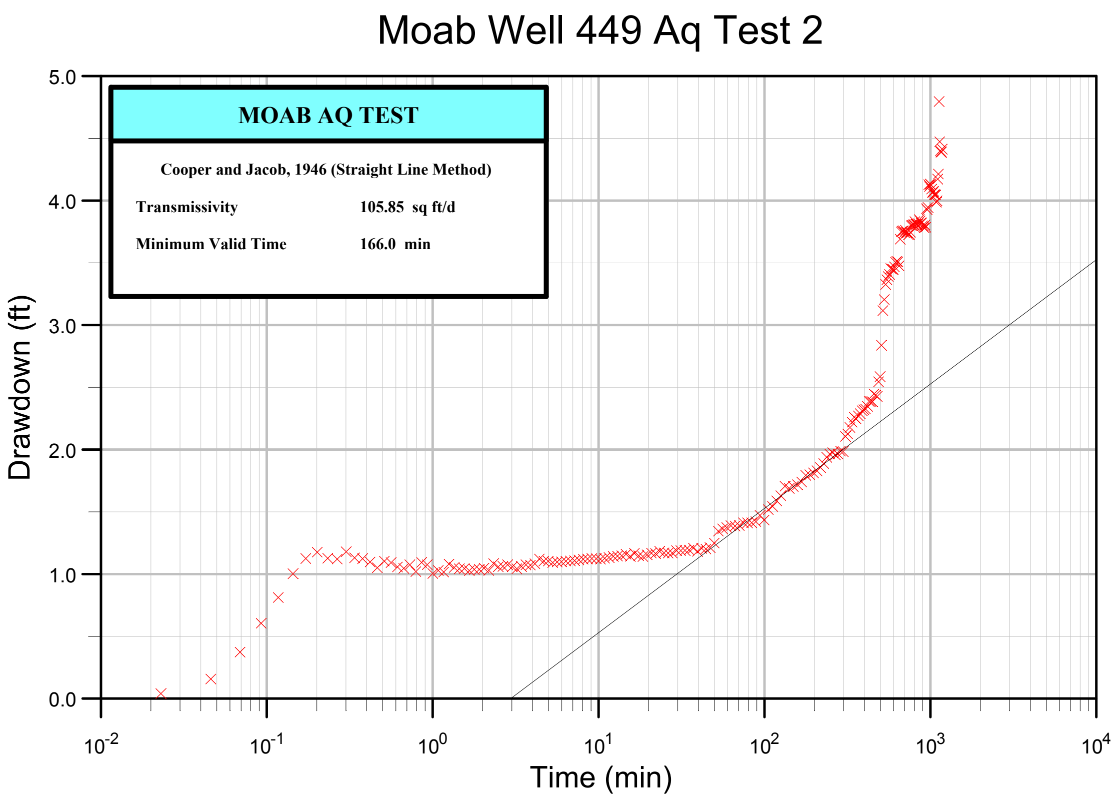


Figure 9. Well 449 Residual Drawdown Analysis, August 14, 2002, Short-Term Aquifer Test Cooper and Jacob Method

Summary

The results of tests completed under Task 1 and Task 2 of DOE (2002b) indicate:

- Well PZ1S will not sustain a flow rate greater than 0.5 gal/min.
- Well 449, installed as part of the Task 2 activities, has a sustainable flow rate of approximately 3 gal/min.
- Residual drawdown data collected during the first short-term aquifer recovery test indicate a hydraulic conductivity for the shallow (from 0 to 33 ft bgs) finer-grained aquifer that ranges from 0.5 to 1.6 ft/day. Residual drawdown data from the second aquifer test indicate a hydraulic conductivity of 2.5 ft/day. Drawdown data collected from pumping well 449 during the second test pumping phase produces an estimated hydraulic conductivity of 7.1 ft/day.
- An improvement in pumping well efficiency is expected upon applying formal well design (screen slot size and gravel pack size) techniques for the interim action pumping wells to be installed in the shallow zone.
- Pumping from a well screened over the shallow, finer-grained portion of the aquifer during a short-term aquifer test (less than 24 hours) does not result in a local increase of the specific conductance of the discharge water from the shallow aquifer.

Data collected from these initial short-term tests suggest pumping from the shallow finer-grained portion of the aquifer does not result in brine migration through the subsurface on the scale observed from pumping a well screened over the deeper, more conductive zone (DOE 2002a). However, it is important to note that these results are based on short-term aquifer tests. Ultimately, the observational method will be used to provide the long-term solution regarding brine migration.

Long-term aquifer tests, which are currently on going, will provide data that will determine whether pumping over longer periods of time will promote upward brine migration in the subsurface. In addition, the drawdown data collected from the on going long-term tests will provide critical information that can be used for the interim remedial action well field design.

Appendix A

Boring and Well Logs

MONITORING WELL COMPLETION LOG MOA01-0449

PROJECT MOAB
LOCATION Moab, UT
SITE MOAB
WELL NUMBER 0449

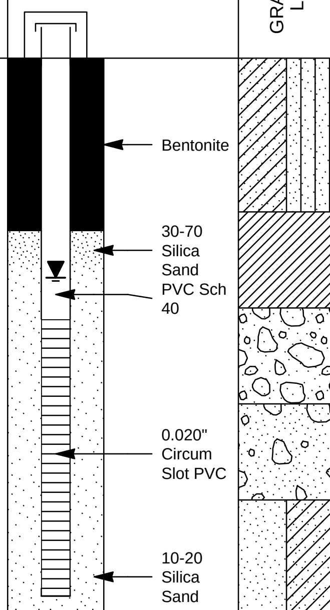
NORTH COORD. (FT) 6664483.31
EAST COORD. (FT) 2186182.58
HOLE DEPTH (FT) 29.00
WELL DEPTH (FT) 28.00

DATE DRILLED 06/27/2002
SURFACE ELEV. (FT NGVD) 3966.20
TOP OF CASING (FT) 3967.99
MEAS. PT. ELEV. (FT) 3967.99
SLOT SIZE (IN) 0.020
BIT SIZE(S) (IN) 10.8

	WELL INSTALLATION	INTERVAL (FT)		
SURFACE CASING:				
BLANK CASING:	6 in. PVC Sch 40	-1.79	to	13.6
WELL SCREEN:	6 in. 0.02 Circum Slot PVC	13.6	to	27.6
SUMP/END CAP:	6 in. PVC Sch 40	27.6	to	28.0
SURFACE SEAL:				
GROUT:				
SEAL:	Bentonite Chips	0.0	to	9.0
UPPER PACK:	30-70 Silica Sand	9.0	to	11.0
LOWER PACK:	10-20 Silica Sand	11.0	to	29.0

DRILLING METHOD AUGER
SAMPLING METHOD
DATE DEVELOPED 07/02/2002
WATER LEVEL (FT BTOC) 13.22 on 06/28/2002
LOGGED BY Pill, K.
REMARKS Geologic description taken from SMI-PZ1D2.

DEPTH (FT BGL)	ELEV. (FT NGVD)	BLOW COUNTS	SAMPLE ID.	EXTENT	WELL DIAGRAM	GRAPHIC LOG	LITHOLOGIC DESCRIPTION
	3960						0-8.0 ft. CLAYEY SAND (SC-SM); red (2.5YR 4/6), very fine to medium grained sand, subrounded to rounded to rounded, 85% quartz, 10% fine crystalline lithic fragments, 5% mica flakes, dry to slightly moist, layers of friable silty sand interbedded with slightly cohesive clayey sand. Roots and wood chips found throughout.
10							8.0-13.0 ft. CLAY (CL); reddish brown (5YR 3/3), medium plasticity, very fine to medium grained sand, subrounded to rounded, 90% quartz, 10% lithic fragments, cohesive, slightly moist.
	3950						13.0-18.0 ft. SANDY GRAVEL (GP-SP); dark reddish brown (5YR 3/3), 70% gravel and 30% sand, fine to coarse gravel, angular to subrounded various finely crystalline lithic types; medium to coarse grained sand, subrounded to rounded, 60% quartz, 40% lithic fragments, wet.
20							18.0-23.0 ft. GRAVELLY SAND (SP-GP); dark reddish brown (5YR 3/3), 70% sand, 25% gravel, and 5% silt and clay, fine to coarse grained sand, subrounded to rounded, 60% quartz, 40% lithic fragments; fine to coarse gravel, angular to subrounded, various finely crystalline types, wet.
	3940						23.0-29.0 ft. CLAYEY, GRAVELLY SAND (SP-SC); brown (7.5YR 4/3), 50% sand, 30% gravel, 20% clay, fine to coarse grained sand, subrounded to rounded, 80% quartz, 20% lithic fragments; fine to coarse gravel, subrounded to rounded, various fine crystalline lithic types, interval slightly cohesive, wet.
30							Total Depth 29.0 ft.
	3930						
40							
	3920						



MONITORING WELL COMPLETION LOG MOA01-0450

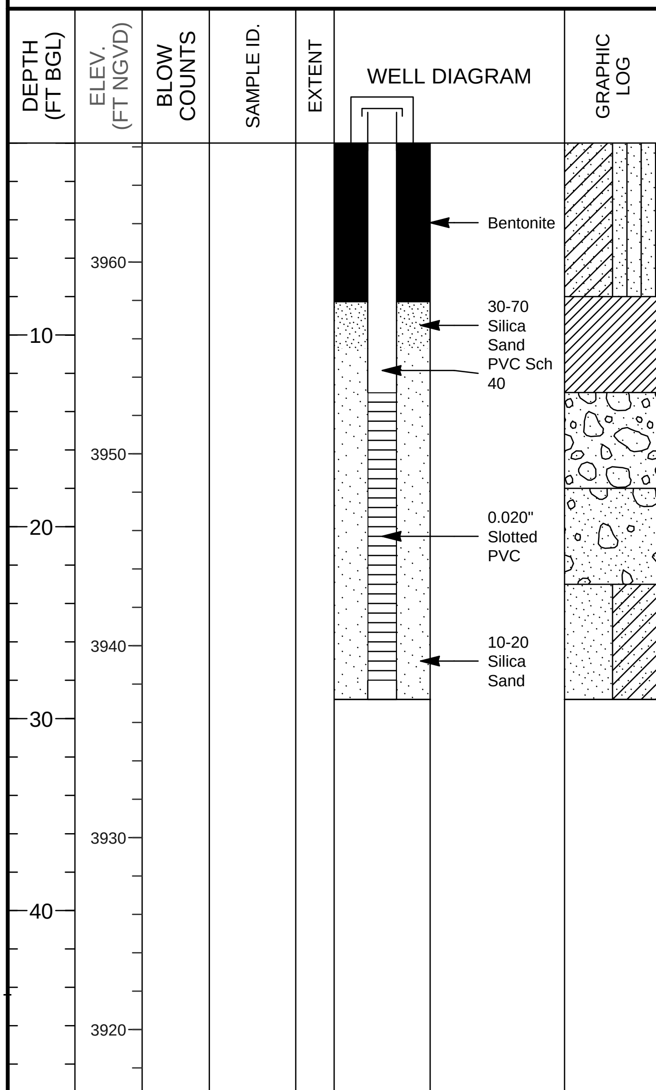
PROJECT MOAB
LOCATION Moab, UT
SITE MOAB
WELL NUMBER 0450

NORTH COORD. (FT) 6664486.27
EAST COORD. (FT) 2186171.87
HOLE DEPTH (FT) 29.00
WELL DEPTH (FT) 29.00

DATE DRILLED 06/23/2002 to 06/27/2002
SURFACE ELEV. (FT NGVD) 3966.20
TOP OF CASING (FT) 3968.16
MEAS. PT. ELEV. (FT) 3968.16
SLOT SIZE (IN) 0.020
BIT SIZE(S) (IN) 7.5

	WELL INSTALLATION	INTERVAL (FT)		
SURFACE CASING:				
BLANK CASING:	2 in. PVC Sch 40	-1.96	to	13.0
WELL SCREEN:	2 in. 0.02 Slotted PVC	13.0	to	28.0
SUMP/END CAP:	2 in. PVC Sch 40	28.0	to	29.0
SURFACE SEAL:				
GROUT:				
SEAL:	Bentonite Chips	0.0	to	8.3
UPPER PACK:	30-70 Silica Sand	8.3	to	10.7
LOWER PACK:	10-20 Silica Sand	10.7	to	29.0

DRILLING METHOD AUGER
SAMPLING METHOD
DATE DEVELOPED
WATER LEVEL (FT BGS)
LOGGED BY Karp, K.
REMARKS Geologic description taken from SMI-PZ1D2.



LITHOLOGIC DESCRIPTION

0-8.0 ft. CLAYEY SAND (SC-SM); red (2.5YR 4/6), very fine to medium grained sand, subrounded to rounded to rounded, 85% quartz, 10% fine crystalline lithic fragments, 5% mica flakes, dry to slightly moist, layers of friable silty sand interbedded with slightly cohesive clayey sand. Roots and wood chips found throughout.

8.0-13.0 ft. CLAY (CL); reddish brown (5YR 3/3), medium plasticity, very fine to medium grained sand, subrounded to rounded, 90% quartz, 10% lithic fragments, cohesive, slightly moist.

13.0-18.0 ft. SANDY GRAVEL (GP-SP); dark reddish brown (5YR 3/3), 70% gravel and 30% sand, fine to coarse gravel, angular to subrounded various finely crystalline lithic types; medium to coarse grained sand, subrounded to rounded, 60% quartz, 40% lithic fragments, wet.

18.0-23.0 ft. GRAVELLY SAND (SP-GP); dark reddish brown (5YR 3/3), 70% sand, 25% gravel, and 5% silt and clay, fine to coarse grained sand, subrounded to rounded, 60% quartz, 40% lithic fragments; fine to coarse gravel, angular to subrounded, various finely crystalline types, wet.

23.0-29.0 ft. CLAYEY, GRAVELLY SAND (SP-SC); brown (7.5YR 4/3), 50% sand, 30% gravel, 20% clay, fine to coarse grained sand, subrounded to rounded, 80% quartz, 20% lithic fragments; fine to coarse gravel, subrounded to rounded, various fine crystalline lithic types, interval slightly cohesive, wet.

Total Depth 29.0 ft.