

2008 Groundwater Monitoring Report Central Nevada Test Area, Corrective Action Unit 443

March 2009
Rev. 1



U.S. DEPARTMENT OF
ENERGY

Office of
Legacy Management

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1.0 Introduction

This report presents the 2008 groundwater monitoring results collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) for the Central Nevada Test Area (CNTA) Subsurface Corrective Action Unit (CAU) 443. Responsibility for the environmental site restoration of the CNTA was transferred from the DOE Office of Environmental Management (DOE-EM) to DOE-LM on October 1, 2006. The environmental restoration process and corrective action strategy for CAU 443 are conducted in accordance with the Federal Facility Agreement and Consent Order (FFACO 2005) entered into by DOE, the U.S. Department of Defense, and the State of Nevada. The corrective action strategy for the site includes proof-of-concept monitoring in support of site closure.

This report summarizes investigation activities associated with CAU 443 that were conducted at the site during fiscal year 2008. This is the second groundwater monitoring report prepared by DOE-LM for the CNTA.

2.0 Site Location and Background

The CNTA is located north of U.S. Highway 6, approximately 30 miles north of Warm Springs in Nye County, Nevada (Figure 1). Three emplacement boreholes, UC-1, UC-3, and UC-4, were drilled at the CNTA for underground nuclear weapons testing. The initial underground nuclear test, Project Faultless, was conducted in borehole UC-1 at a depth of 3,199 feet (ft) (975 meters) below ground surface on January 19, 1968. The yield of the Project Faultless test was estimated to be 0.2 to 1 megaton (DOE 2004). The test resulted in a down-dropped fault block visible at land surface (Figure 2). No further nuclear testing was conducted at the CNTA, and the site was decommissioned as a testing facility in 1973.

Surface and subsurface contamination resulted from the underground nuclear testing at CNTA. Contamination at the surface was identified as CAU 417. Surface restoration was completed in 1999 and the remediation activities are described in the *Closure Report for Corrective Action Unit 417: Central Nevada Test Area Surface Nevada* (DOE 2001). Contamination in the subsurface is identified as CAU 443. The corrective action process for the subsurface CAU 443 has not yet been completed. Site restoration activities associated with CAU 443 are summarized in the remainder of this section.

A Corrective Action Investigation Plan (CAIP) was developed and approved for CAU 443 in 1999. The CAIP outlined the specific objectives of the Corrective Action Investigation (CAI). The objectives outlined in the CAIP are provided below:

- Determine the characteristics of the groundwater flow system, the sources of contamination, and the transport processes to acceptable levels of uncertainty;
- Develop a credible numerical model of groundwater flow and contaminant transport for the UC-1 Subsurface Corrective Action Site and downgradient areas; and
- Develop stochastic predictions of the contaminant boundary at an acceptable level of uncertainty (DOE 1998).

These objectives were accomplished using existing data to develop a numeric model and predict the contaminant boundary for the site (Pohlmann et al. 1999).

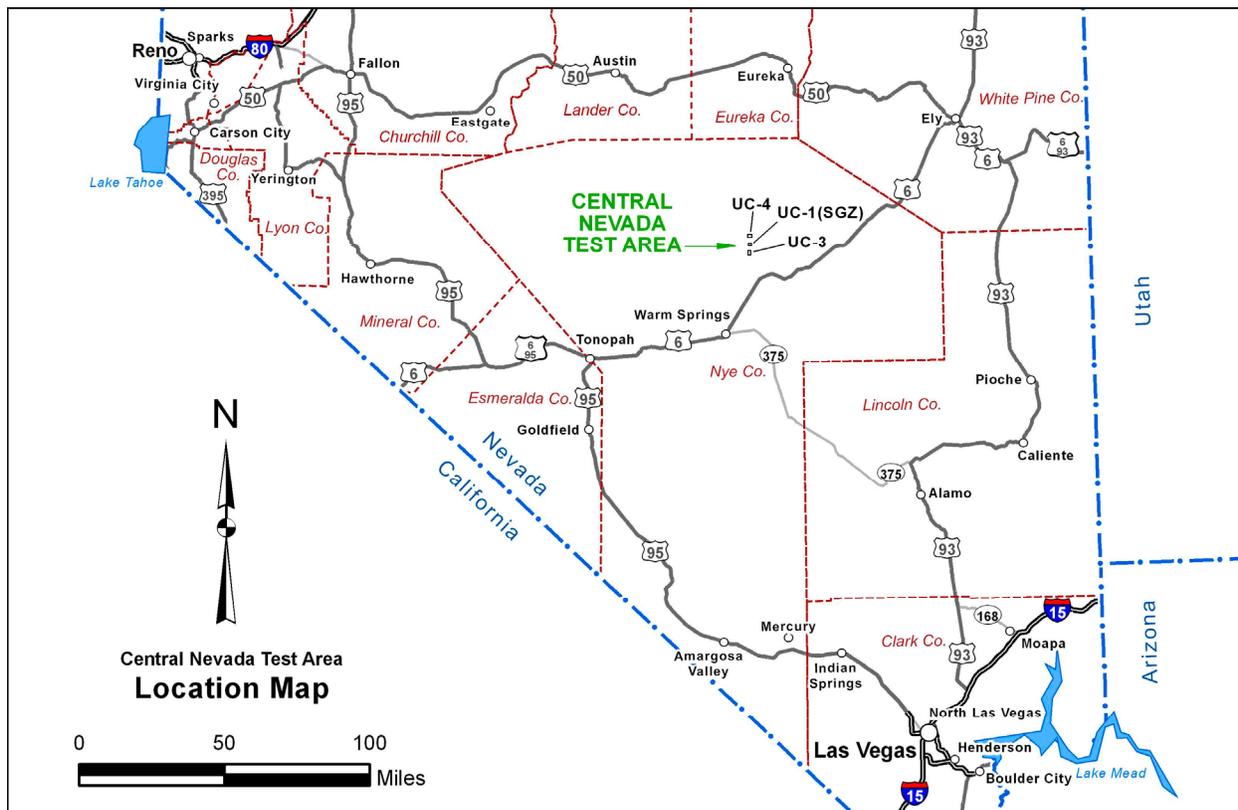


Figure 1. Central Nevada Test Area Location Map

Results of the CAI and the corrective action evaluation were presented in the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) (DOE 2004). Modeling indicated that groundwater velocities at the site were very slow (due to very low hydraulic conductivities) and predicted that the contaminant boundary would be very small (between two and three radii of the cavity from the working point [DOE 2004]). A compliance boundary was negotiated; it factored in modeling results as well as associated uncertainties, especially with respect to the potential effects of the nuclear test within the down-dropped fault block. The compliance boundary corresponds approximately to the boundaries of the fault block and is contained fully within the land withdrawal boundary (Figure 2). The preferred corrective action alternative selected in the CADD/CAP was proof of concept and monitoring with institutional controls.

Three wells (MV-1, MV-2, and MV-3) were installed in 2005 for the dual purpose of monitoring radioisotopic concentrations in groundwater and head levels, and validating the flow and transport model. Hydraulic heads observed in these wells were in significant disagreement with heads predicted by the groundwater flow model, meaning the model could not be validated. Instead of additional modeling, DOE proposed a new corrective action strategy in which the monitoring network will be enhanced by installing two new alluvial monitor wells, possibly recompleting existing wells HTH-1 (volcanic section) and UC-1-P-1S (upper alluvium), and initiating a new 5-year proof-of-concept monitoring period to validate the compliance boundary (DOE 2007). The revised approach is described in the CADD/CAP addendum (DOE 2008) that was approved by NDEP (NDEP 2008). Table 1 shows a comparison of the previous and proposed monitoring networks from the CADD/CAP addendum.

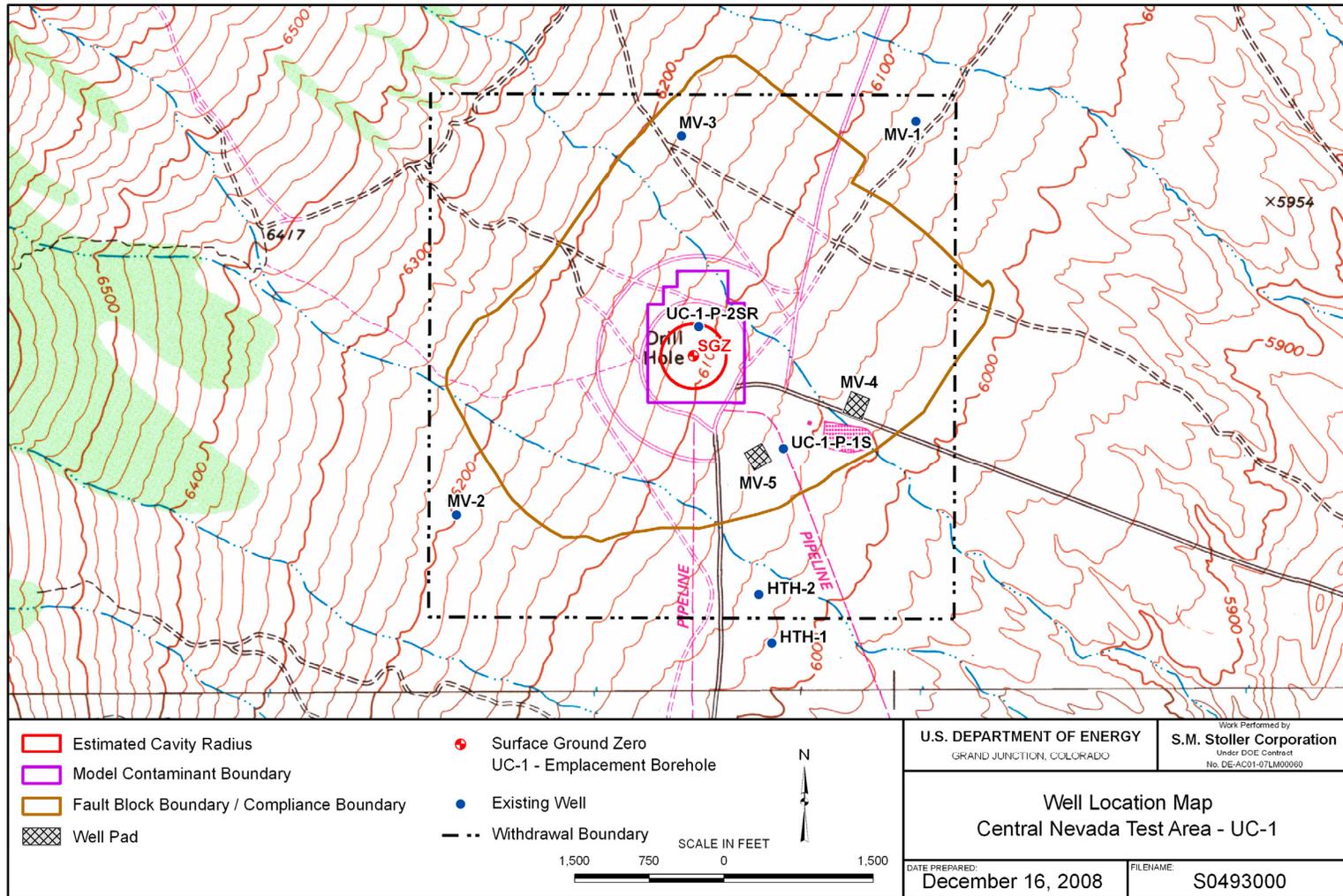


Figure 2. Location Map of Monitoring Wells and Boundaries at the CNTA

Table 1. Summary of the Previous and Proposed Monitoring Networks.

Location	Previous Network	Proposed Network	Screened/Open Unit
MV-1-Upper Piezometer	Head	Head	Alluvium
MV-1-Lower Piezometer	Head	Head	Volcanics (tuffaceous sediments)
MV-1-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
MV-2-Upper Piezometer	Head	Head	Alluvium
MV-2-Lower Piezometer	Head	Head	Volcanics (DWtuff)
MV-2-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
MV-3-Upper Piezometer	Head	Head	Alluvium
MV-3-Lower Piezometer	Head	Head	Volcanics (tuffaceous sediments)
MV-3-Well	Head/Radionuclides	Head/Radionuclides	Volcanics (DWtuff)
HTH-2	Not Sampled	Head/Radionuclides	Alluvium
HTH-1	Not Sampled	Radionuclides	Volcanics
UC-1-P-1S	Not Sampled	Head	Alluvium
MV-4 (New Well)-Piezometer	Not Installed	Head	Alluvium
MV-4 (New Well)-Well	Not Installed	Head/Radionuclides	Alluvium
MV-5 (New Well)- Piezometer	Not Installed	Head	Alluvium
MV-5 (New Well)- Well	Not Installed	Head/Radionuclides	Alluvium

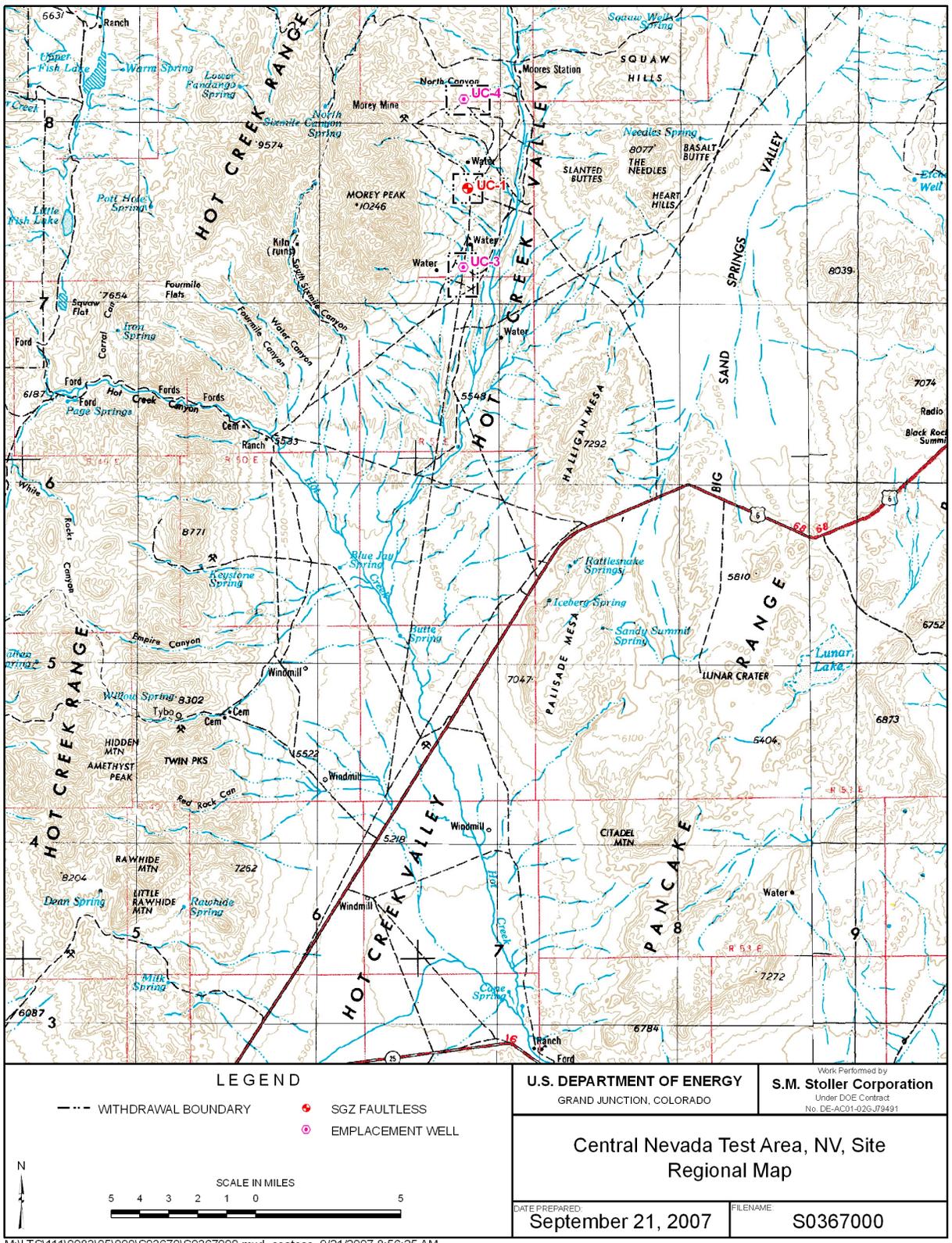
DWtuff = Densely welded tuff.

Note: Head data from well UC1-P-2SR is measured by USGS.

The data presented in this report represent a transition from the old corrective action strategy to the new corrective action strategy, which includes enhancement of the monitoring network within the alluvium, possible recompletion of existing wells, and a new 5-year proof-of-concept monitoring period intended to validate the compliance boundary. The new 5-year proof-of-concept monitoring period will begin upon completion of the new monitor wells and collection of samples for analysis. Some of the data presented in this report (data from well MV-1) were collected in 2007 under the requirements of the original CADD/CAP and were not available at the time last year's monitoring report was prepared. Drill pads for the new monitor wells were constructed at the site in August and September 2008. Refer to Figure 2 for a map showing the pad locations for the proposed alluvial wells.

3.0 Geologic and Hydrologic Setting

The CNTA is in Hot Creek Valley (Figure 3), a north-south trending graben that is 68 miles long and located in the Basin and Range physiographic province. Hot Creek Valley varies in width from 5 to 19 miles and contains two major units—a thick sequence of Quaternary- and Tertiary-age alluvial deposits (“alluvium”) underlain by a thick section of Tertiary-age volcanic rocks (“volcanics”). In the immediate vicinity of UC-1 (the Faultless test), the thickness of alluvium ranges from 1,960 ft to 2,410 ft, based on logs of the three monitoring/validation (MV) wells installed in 2005. The Tertiary volcanics below the alluvium include tuffaceous sediments, welded and nonwelded tuffs, and rhyolite lavas.



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Figure 3. Physiographic Features Near the Central Nevada Test Area

The cavity created by the Faultless test in the Tertiary volcanics resulted in a collapse chimney that extends upward into the alluvium. Water in the reentry well, UC-1-P-2SR, drilled into the chimney, has not yet recovered to pre-test levels (Figure 4) due to the very low permeability of the volcanic section. The depressed water levels in and near the test cavity inhibit the movement of contamination both horizontally and vertically away from the detonation zone.

The most likely migration path for contamination moving away from the detonation zone is downward to more permeable densely welded tuff (DWT) units. Regional hydrologic data, supported by head measurements in the MV wells, suggest that the flow direction in the DWT below the detonation is to the north-northeast, toward Railroad Valley. The DWT units at the MV wells were found to be thinner and less permeable than expected.

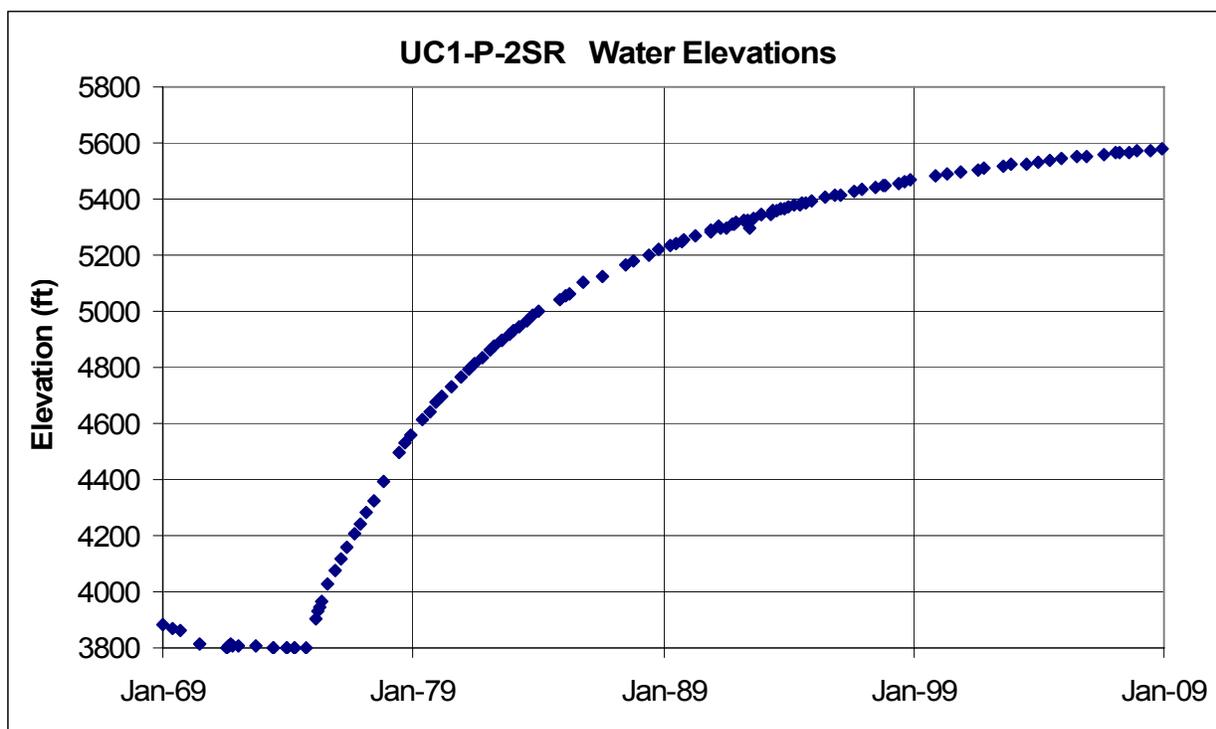


Figure 4. Water Elevations in Reentry Well UC-1-P-2SR
http://nevada.usgs.gov/doe_nv/sitepage_temp.cfm?site_id=383806116125951

4.0 Monitoring Objectives

The two major objectives of the monitoring are (1) analytical monitoring for radionuclides to identify any releases of contamination from the test cavity itself and (2) hydraulic head monitoring to ensure the overall stability (quasi-steady state) of the flow system. The 2008 monitoring network at CNTA consisted of wells MV-1, MV-2, and MV-3 and piezometers MV-1UPZ, MV1-LPZ, MV-2UPZ, MV2-LPZ, MV-3UPZ, and MV3-LPZ. Well locations are shown in Figure 2. The unit in which the wells and piezometers are screened and the screen zone depths are presented in Table 2.

Table 2. Construction and Head Data for Wells at CNTA

Well/Piezometer	TOC (ft)	Water Depth (ft)	Date	Elevation Water Level (ft)	Elevation TSZ (ft)	Elevation BSZ (ft)	Open Unit
MV-1-UPZ	6,069.97	316.77	6/24/2008	5,753.20	5,190.19	5,130.19	Alluvium
MV-1-LPZ	6,069.91	63.2	6/24/2008	6006.7	3,067.19	3,007.19	Volcanics
MV-1	6,069.94	507.07	6/24/2007	5,562.87	2,319.19	2,159.63	Volcanics
MV-2-UPZ	6,190.68	407.3	6/25/2008	5,783.38	5,229.73	5,179.73	Alluvium
MV-2-LPZ	6,190.42	436.2	8/05/2008	5754.2	2,643.23	2,583.23	Volcanics
MV-2	6,190.45	341.55	6/25/2008	5,848.89	3,150.24	2,987.49	Volcanics
MV-3-UPZ	6,167.67	370.64	6/25/2008	5,797.03	5,286.98	5,226.98	Alluvium
MV-3-LPZ	6,167.62	187.99	6/25/2008	5,979.63	2,866.98	2,746.98	Volcanics
MV-3	6,167.64	600.25	6/25/2008	5,567.39	2,120.98	1,959.23	Volcanics
HTH-1	6,011.70	537.92	6/25/2008	5,473.78	5,961.70	2,316.70	Both
HTH-2	6,025.70	556.13	6/25/2008	5,469.57	5,521.70	5,025.70	Alluvium
UC-1-P-1S ^a	6,031.20	274.45	6/24/2008	5,756.75	5,507.20	Unknown	Alluvium ^b

TOC = Top of casing (well/piezometer).

TSZ, BSZ (top and bottom of open interval, screened or perforated).

^aHole directionally drilled to get to test cavity/chimney; due to drilling problems, completion data are not certain.

^bAlluvium with possible contribution from volcanics.

4.1 Radioisotopic Monitoring

Groundwater samples are collected yearly from the MV wells and analyzed for radionuclides. Tritium is the primary analyte of concern due to its mobility and abundance in the first 100-year post-shot monitoring period. If migration were to occur, tritium would likely be the first contaminant to arrive at a monitoring location. However, because of tritium's short half-life, monitoring of C-14 and I-129 will also be conducted in support of long-term post-closure monitoring; data for these latter two radionuclides collected in the near term will provide a background/baseline for post-closure monitoring. Monitoring of C-14 and I-129 was conducted in 2006 and 2007; additional rounds of data will be collected during the first and last year of the proof-of-concept monitoring period. These data will serve as the baseline data set for C-14 and I-129. After the proof-of-concept monitoring phase has ended, the long-term monitoring requirements will be presented in the site Closure Report.

The CADD/CAP established groundwater compliance levels for the site of 20,000 picocuries per liter (pCi/L) tritium, 2,000 pCi/L C-14, and 1 pCi/L I-129 (DOE 2004; page 41). These levels are not to be exceeded outside the compliance boundary; the transport modeling predicts that concentrations of these constituents will remain below current detection limits at the contaminant boundary (DOE 2004), which is well within the compliance boundary (see Figure 2). Although validation of the flow model was unsuccessful, groundwater monitoring data obtained support the lack of contaminant migration beyond the model-predicted contaminant boundary at this time.

4.2 Hydraulic Head Monitoring

Hydraulic head is monitored at the site by transducers installed in the MV wells and piezometers, well HTH-1, and well HTH-2. As stated in the CADD/CAP, "Hydraulic head will be used to

monitor the quasi steady-state of the groundwater system; i.e., to determine if mean hydraulic head values remain constant through time, given fluctuations caused by natural temporal stresses and stresses related to well drilling, construction, and testing (DOE 2004; page 74). This requires first determining when heads have stabilized following drilling and testing activities, then quantifying the natural mean and temporal variation in hydraulic head, and finally comparing subsequent monitoring measurements to that range.”

5.0 Monitoring Results

The monitoring conducted in fiscal year 2008 at CNTA consisted of sampling well MV-1 in October 2007, annual sampling in March 2008, investigation of the lower piezometer associated with well MV-2 in August 2008, and installation of telemetry in September 2008. The monitoring activities included the analysis of samples collected from the original CADD/CAP monitoring network for tritium and collection of hydraulic head measurements. The 2007 monitoring program also required the measurement of carbon-14 and iodine-129 activities from the MV monitor wells. Due to pump problems associated with MV-1 in 2007, samples could not be collected in time for last year’s monitoring report and are presented here; again due to pump problems, samples could not be collected from MV-1 in March 2008. It is planned that the pump in well MV-1 will be replaced as part of the drilling program scheduled to begin in April 2009. Radioisotopic data are presented in Section 5.1. Head measurements are presented in Section 5.2.

5.1 Radioisotopic Results

The DOE-LM Sampling and Analysis Plan (DOE 2006) was used to guide the use of standard operating procedures to ensure quality assurance and quality control of the monitoring program at CNTA. Monitoring conducted in October 2007 and March 2008 included purging the monitor wells with dedicated submersible pumps prior to collection of samples. The monitor well purging process is intended to remove stagnant water from the well bore to acquire a sample that is representative of water within the adjacent geologic formation. Because of low production rates from wells MV-2 and MV-3 (and MV-1 in 2007), it was not possible to purge a full well volume from these wells. Instead, a modified procedure was used to collect representative water samples. These wells were purged until a well-screen volume was removed and drawdown in the well was below the lift capacity of the pump. The wells were then allowed to recover overnight, and they were sampled the following day. Field parameter measurements obtained during well purging activities are provided in Appendix A.

An investigation of the lower piezometer associated with well MV-2 was conducted in August 2008 and included collection of samples for laboratory analysis and well logging activities. Field activities were conducted to investigate rapid changes in head data observed in May/June 2008 (See Section 5.2, Figure 7). The sampling and logging activities were conducted by DRI. It was planned that samples would be collected from within the screened interval of the piezometer using a depth specific bailer; however, samples could not be collected from that interval because sediment was present 75 ft above the screen zone. It is assumed that the sediment settled from drilling fluid that remained in the piezometer due to difficulties during development after installation in 2005. Water samples were collected in the piezometer from just above the sediment at a depth of 3,471 ft bgs to confirm that the water chemistry was indicative of the volcanic section and not from a shallower leak in the tubing. Logging was also conducted

by DRI and included a temperature log and caliper log to investigate the possibility of a breach in the piezometer casing. The caliper log showed that the piezometer tubing is in gauge and the temperature log indicated temperature variations that are consistent with well construction and lithology changes. This supports a determination that the piezometer tubing is not damaged and that flow into the MV-2 well during yearly sampling events is from the screened interval of the well and not compromised by a leak in the piezometer. It is planned that the piezometer will be developed further during the spring 2009 drilling project.

Radioisotopic sampling results are presented in Table 3. Tritium results for 2007 continue to be below detection limits as in previous sampling rounds. Estimated activities of C-14 and I-129 are comparable to previous sampling results and continue to provide a baseline for long-term monitoring. Data used to calculate the radioisotope activities are provided in Appendix B.

Table 3. Radioisotopic Sampling Results

Well name	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-1	2/14/2006 ^c	<RDL (0.0112)	<RDL (1.51E-7)	<3
	9/21/2006 ^c	<RDL (0.0561)	<RDL (2.9E-7)	<45
	2/22/2007	NS	NS	NS
	10/10/2007	<RDL (7.40E-03 ^a)	<RDL (5.7E-11 ^a)	<313
	3/19/2008	NS	NS	NS ^d
MV-2	3/16/2006 ^c	<RDL (0.0992)	<RDL (2.58E-7)	<3
	9/22/2006 ^c	<RDL (0.013)	<RDL (2.6 E-7)	<45
	2/22/2007	<RDL (1.54E-3 ^a)	<RDL (9.7E-11)	<357
	2/22/2007 ^e	<RDL (1.84E-3 ^a)	<RDL (11.1E-11)	<353
	3/19/2008	NS	NS	<320
MV-3	3/16/2006 ^c	<RDL (0.0395)	<RDL (2.10E-7)	<3
	9/22/2006 ^c	<RDL (0.0511)	<RDL (2.2 E-7)	<45
	2/22/2007	<RDL (0.0101 ^a)	<RDL (14.0E-11)	<359
	3/19/2008	NS	NS	<320
MV-2L ^b – Sample depth 490 ft	8/5/2008	NS	NS	<8,000
MV-2L ^b – Sample depth 3,471 ft	8/5/2008	NS	NS	<8,000

^aEstimated based on sample volume of 200 milliliters.

^bIndicates sample was collected from lower piezometer of MV-2 using a depth specific bailer – sample depths are provided with the well name.

^cIndicates sample results were obtained from DRI Monitoring Report, dated September 2006.

^dIndicates well was not sampled because of pump failure.

^eIndicates a duplicate sample.

NS = not sampled.

<RDL = below required detection limit with laboratory result in parentheses; RDL is 300 pCi/L for tritium, 5 pCi/L for C-14, and 0.1 pCi/L for I-129 (DOE 2004).

5.2 Hydraulic Head Results

The hydrographs of hydraulic head data are presented in Figure 5 through Figure 7. They are grouped by the relative depth of open interval: alluvial wells, upper open interval in the volcanic section, and lower open interval in the volcanic section. To increase the monitoring capabilities at the site, telemetry was installed in the lower piezometers of wells MV-1, MV-2, and MV-3, and the main well of MV-2. The telemetry was installed because of the rapid head changes observed in the lower piezometer of MV-2 (Figure 7).

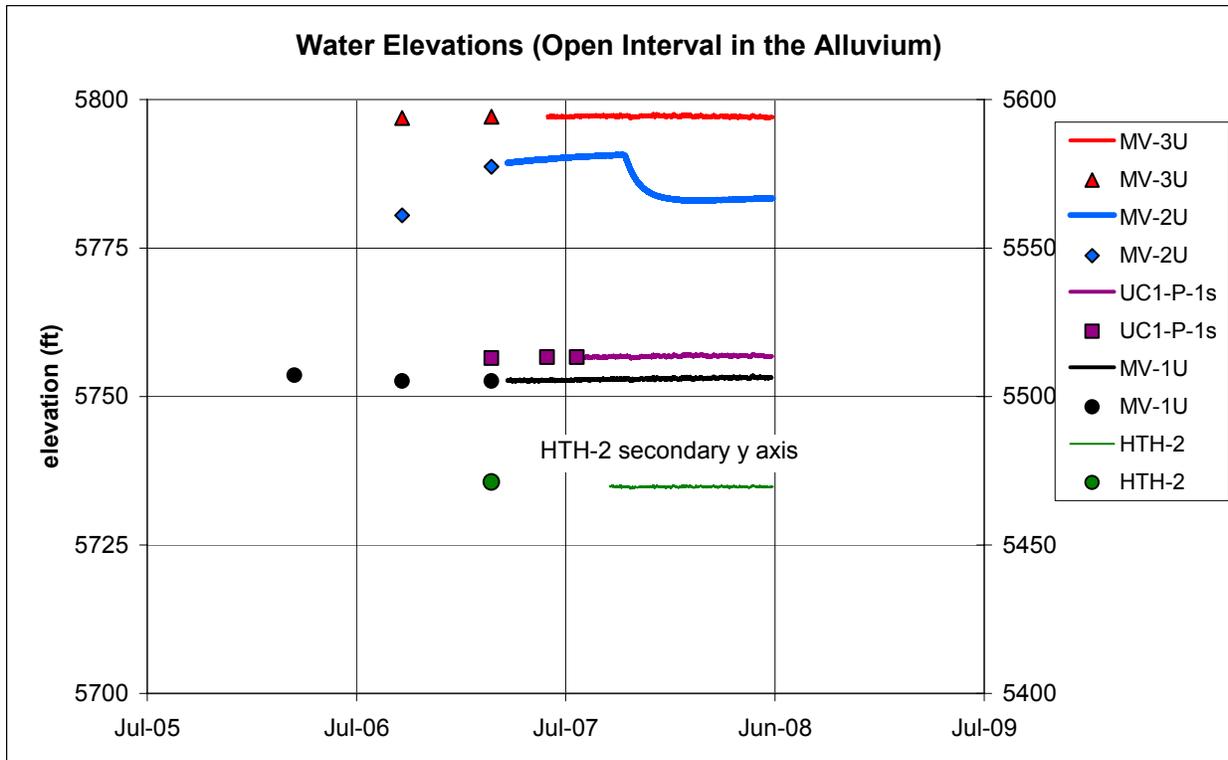


Figure 5. Water Level Elevations for the Alluvial Wells and UC1-P-1S. A continuous line indicates water levels from a transducer. Well HTH-2 uses the secondary scale on the right.

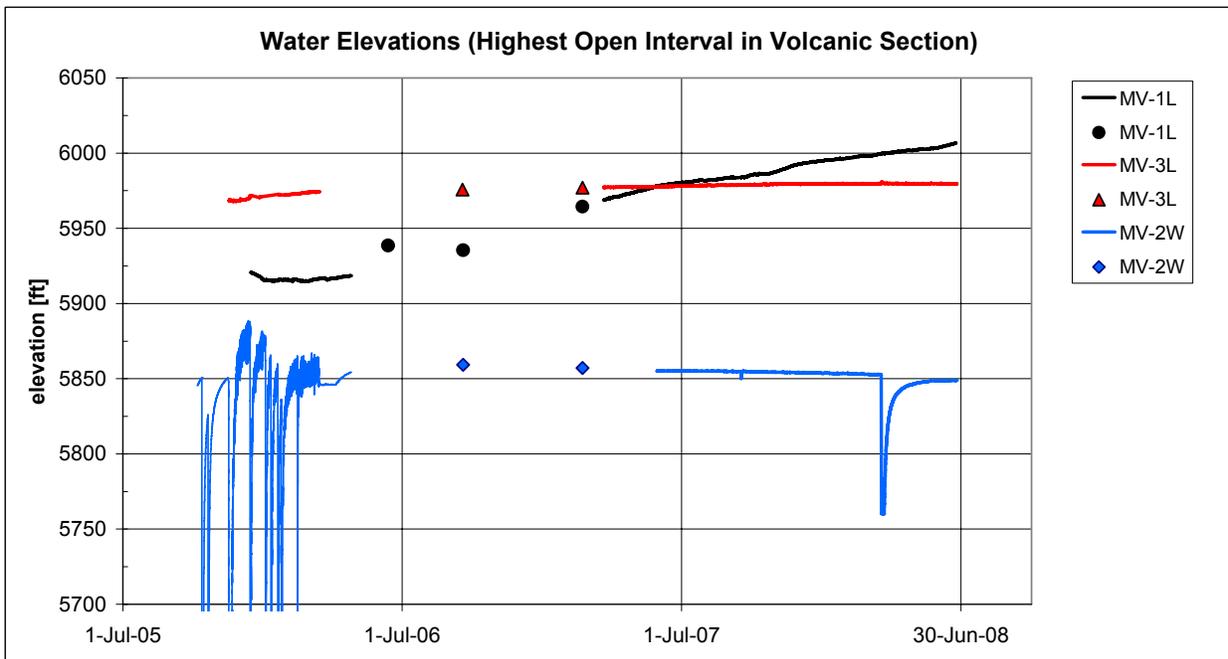


Figure 6. Water Level Elevations for the MV Well/Piezometers with the Highest Open Interval in the Volcanic Section. A continuous line indicates water levels from a transducer. "L" indicates lower piezometer, and "W" indicates the main well.

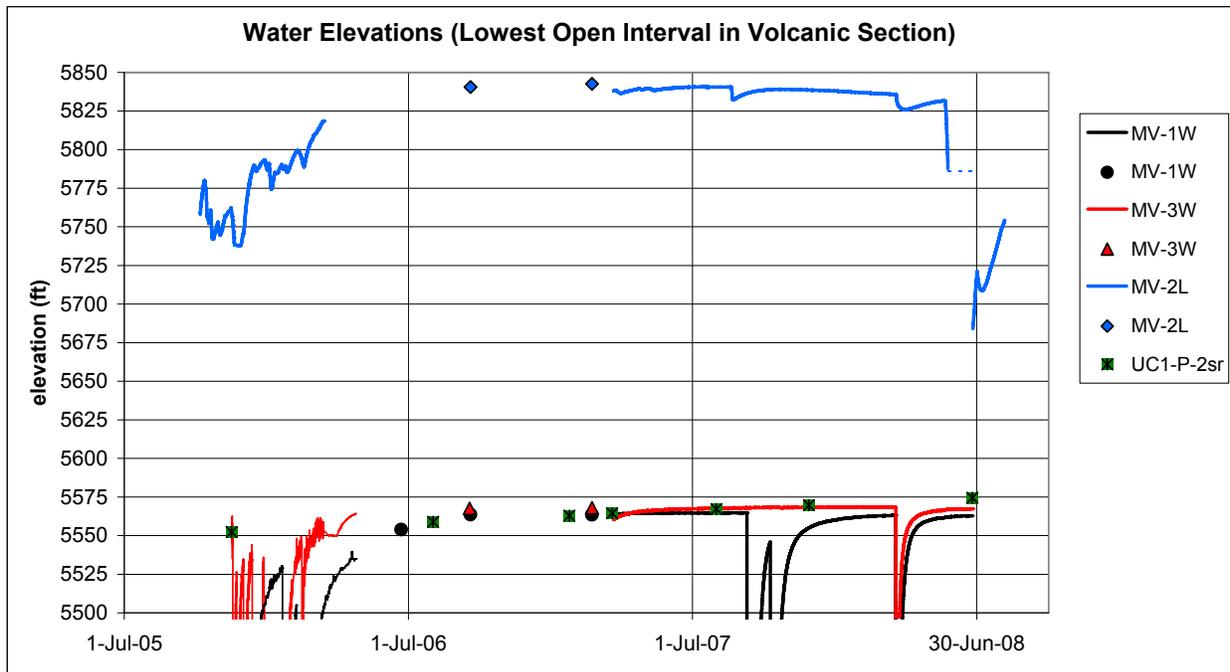


Figure 7. Water Level Elevations for the MV Wells/Piezometer with the Lowest Open Interval in the Volcanic Section. A continuous line indicates water levels from a transducer.

Water levels in the alluvium are monitored by the upper (U) piezometers in the MV wells and well HTH-2. Difficulties encountered during installation and development of the MV-2 upper piezometer, are believed to be contributing factors in the slow return of water level to a relative equilibrium after installation and the subsequent 5 ft water level drop that occurred from late October 2007 through January 2008. The water level data from well UC1-P-1S are plotted with data from the alluvial wells, though the UC1-P-1S drilling history is complicated, and groundwater in that well may be in communication with groundwater in the volcanic section.

Wells in the volcanic section are slow to recover from pumping (at sampling events) due to the low permeability of the formation. The highest open intervals in the volcanic section at the MV well clusters are the MV-2 main well (W), and the MV-1 and MV-3 lower (L) piezometers (Figure 6). The head level in the MV-1 lower piezometer has been rising about 1 ft every 12 days since it was installed and developed (black, Figure 6). The lowest open intervals in the volcanic section at the MV well clusters are the MV-2 lower piezometer and the MV-1 and MV-3 main wells (Figure 7). The pump in well MV-1 (black, Figure 7) was not functioning during the March 2007 sampling event. The pump was replaced and sampling was complete in October 2007. The hydraulic head in the MV-2 lower piezometer (blue, Figure 7) dropped at least 150 ft in late May to early June 2008 and has since been recovering. As with the MV-2 upper piezometer, difficulties encountered during installation and development of the MV-2 lower piezometer are believed to be the main contributing factor. The sediment at the bottom of the piezometer was recently (July 2008) tagged at 75 ft above the top of the screen. Methods to further develop the MV-2 lower piezometer (1.9 inch inner diameter and 3,550 ft to the top of the screen) are currently being investigated.

6.0 Summary

Detection monitoring results indicate that radioisotope levels in groundwater continue to remain below compliance levels. Water level data indicate that hydraulic heads are beginning to stabilize at most locations from well drilling, development, and aquifer testing. Head drops in the MV-2 piezometers are being investigated and are believed to be associated with difficulties encountered during well installation and development. The slow recovery of water levels after sampling events supports the interpretation of extremely low hydraulic conductivities in the vicinity of the test cavity.

7.0 References

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Appendix A

Well Purging Data

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Table A-1. Well Purging Data

Time	Total Vol. Purged (gal)	Temp (°C)	Spec. Cond. (µmhos/cm)	pH (s.u.)	ORP (mV)
Well MV-1: 10/9/07					
1119	326				
1152	250	23.77	726	8.89	-251.4
1324	80	Pump shut off			
1422	30	18.46	785	7.74	-196.3
1720	72	17.55	803	7.63	-184.1
Well MV-1: 10/10/07					
1105	24	16.92	814	8.60	-266.3
1108	16	17.08	826	8.65	-291.8
1114	33	21.35	695	9.09	-297.0
1126	66	21.42	643	9.07	-306.1
1130	Pump shut off				
1340	19	15.86	809	8.11	-123.1
1342	18	Pump shut off			
934 Total gallons purged prior to sampling					
Well MV-2: 3/18/08; Purged well for 3 hours for volume of 1,200 gallons					
Well MV-2: 3/19/08					
0935	start	20.6	1086	9.75	133
0950	45	20.8	1030	9.77	109
1005	30	19.6	1038	9.76	119
Total volume purged = 1,275 gallons					
Well MV-3: 3/18/08; Purged well for 2 ½ hours for volume of 1,800 gallons					
Well MV-3: 3/19/08					
1053	160	21.8	737	7.32	-68
1058	50	22.0	732	7.16	-151
1103	50	22.7	675	7.67	-127
1108	50	22.8	679	7.90	-116
1113	40	23.2	691	7.97	-217
1118	35	23.3	693	7.99	-230
Total volume purged = 2,185 gallons					

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Appendix B

Carbon-14 Radioisotope Calculation Data

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Table B-1. Carbon-14 Radioisotope Calculation Data

Well ID	Sample Date	Mass C (mg)	$\delta^{13}\text{C}$ (‰)	^{14}C (pmc)	Fraction mc	+/- 1 s	$\mu\text{Ci}/\text{mg C}^{\text{a}}$	$\text{pCi}/\text{L}^{\text{b}}$
MV-1	10/10/2007	2.12	-5.7	11.38	0.1138	0.0011	6.98E-10	7.40E-3

^aModern ^{14}C standard at 1950 AD has activity of 13.6 dpm/gram C = 0.000227 dps/mg C ($1 \mu\text{Ci} = 3.7 \times 10^4 \text{ dps}$); therefore, modern ^{14}C standard at 1950 AD has activity of $6.135 \times 10^{-9} \mu\text{Ci}/\text{mg}$. Result obtained by multiplying (fraction mc) x ($6.135 \times 10^{-9} \mu\text{Ci}/\text{mg}$).

^bAssumes 200 mL sampled used to obtain mass of carbon.

pmc = percent modern carbon; mc = modern carbon; s = standard deviation

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