LMS/CNT/S07896

2011 Groundwater Monitoring Report, Central Nevada Test Area, Subsurface Corrective Action Unit 443

April 2012

U.S. DEPARTMENT OF ENERGY | Legacy Management

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Telephone: 800.553.6847
Fax: 703.605.6900
E-mail: orders@ntis.gov
Online Ordering: *http://www.ntis.gov/help/ordermethods.aspx*

Available electronically at *http://www.osti.gov/bridge*

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Phone: 865.576.8401
Fax: 865.576.5728
Email: reports@adonis.osti.gov

LMS/CNT/S07896

2011 Groundwater Monitoring Report
Central Nevada Test Area,
Subsurface Corrective Action Unit 443

April 2012

This page intentionally left blank

Contents

Figures

Tables

Appendixes

Abbreviations

BSZ	bottom of open interval/screen zone
^{14}C	carbon-14
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAU	Corrective Action Unit
CNTA	Central Nevada Test Area
DOE	U.S. Department of Energy
ft	feet
ft msl	feet below mean sea level
^{129}I	iodine-129
LM	Office of Legacy Management
LPZ	lower piezometer
μmhos/cm	micromhos per centimeter
MV	monitoring/validation
NDEP	Nevada Division of Environmental Protection
pCi/L	picocuries per liter
PZ	piezometer
RDL	required detection limit
s.u.	standard unit
TOC	top of casing
TSZ	top of open interval/screen zone
UPZ	upper piezometer

Executive Summary

The Central Nevada Test Area was the site of a 0.2- to 1-megaton underground nuclear test in 1968. The surface of the site has been closed, but the subsurface is still in the corrective action process. The corrective action alternative selected for the site was proof-of-concept and monitoring with institutional controls. Annual sampling and hydraulic head monitoring are conducted as part of the subsurface corrective action strategy. The site is currently in the third year of the 5-year proof-of-concept period that is intended to validate the compliance boundary.

Analytical results from the 2011 monitoring are consistent with those of previous years. Tritium remains at levels below detection in all wells. Water levels continue to rise in the reentry well UC-1-P-2SR that was drilled into the chimney shortly after the detonation, demonstrating the very low permeability of the volcanic rocks. Water level data from the new wells MV-4 and MV-5 and recompleted well HTH-1RC indicate that hydraulic heads are still recovering from installation and testing. Data from wells MV-4 and MV-5 also indicate that head levels do not recover after yearly sampling events during which several thousand gallons of water are purged. It is recommended that low-flow sampling methods be adopted for these wells to allow head levels to recover to steady-state conditions. Despite the lack of steady-state groundwater conditions, hydraulic head data collected from alluvial wells installed in 2009 continue to support the conceptual model that the southeast-bounding graben fault acts as a barrier to flow at the site.

This page intentionally left blank

1.0 Introduction

This report presents the 2011 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 CNTA was transferred from the DOE Office of Environmental Management to 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 (1996, as amended) and all applicable Nevada Division of Environmental Protection (NDEP) policies and regulations. 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 from December 2010 through December 2011. It also represents the third year of the enhanced monitoring network and the 5-year proof-of-concept monitoring period that is intended to validate the compliance boundary.

2.0 Site Location and Background

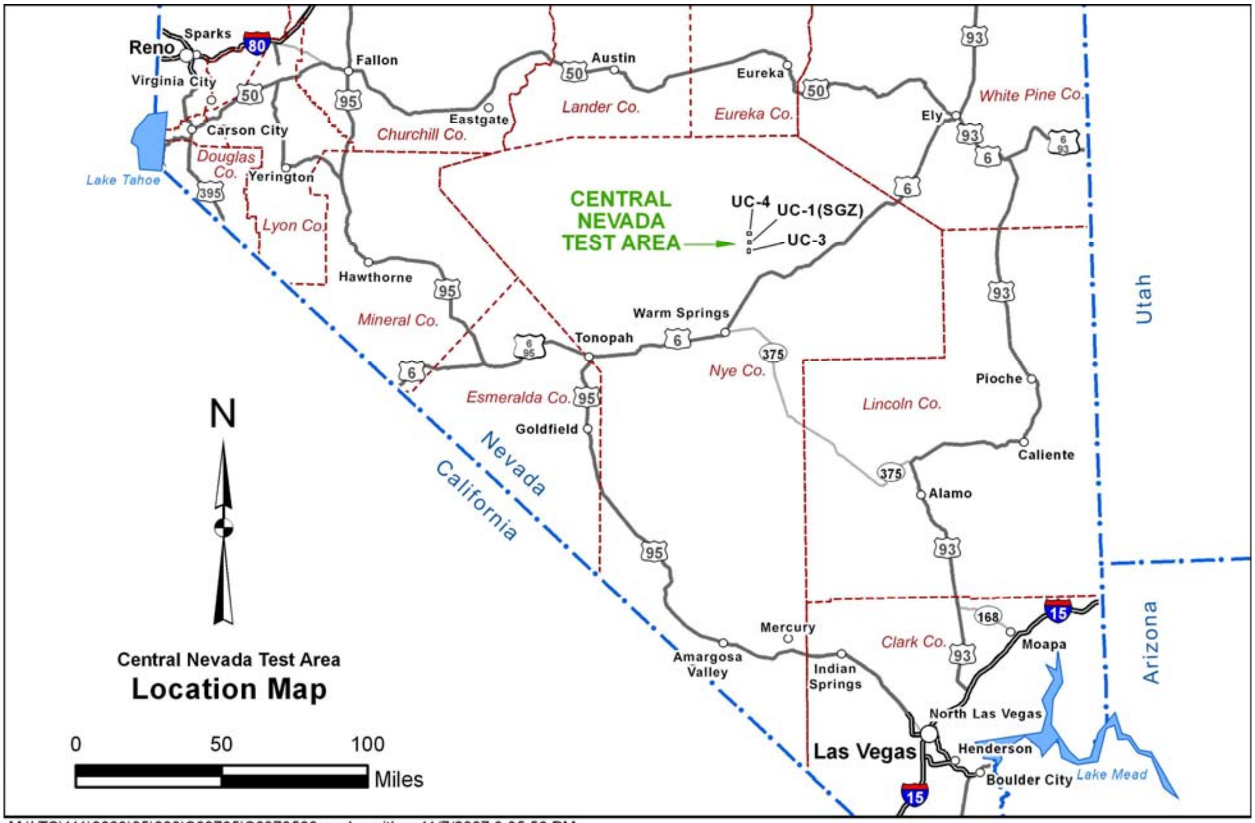
CNTA is north of U.S. Highway 6, approximately 30 miles north of Warm Springs in Nye County, Nevada (Figure 1). The U.S. Atomic Energy Commission (predecessor to DOE) acquired CNTA in the early 1960s to develop sites for underground nuclear testing that could serve as alternatives to the Nevada National Security Site (formerly known as the Nevada Test Site). Three emplacement boreholes—UC-1, UC-3, and UC-4—were drilled at CNTA for underground nuclear weapons testing. The initial underground nuclear test, 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 Faultless test was estimated to be 0.2 to 1 megaton. The test resulted in a down-dropped fault block that extends to land surface (Figure 2). No further nuclear testing was conducted at CNTA, and the site was decommissioned as a testing facility in 1973.

2.1 Summary of Corrective Action Activities

Surface and subsurface contamination resulted from the underground nuclear test 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 was developed and approved for CAU 443 in 1999 (DOE 1999). The objectives outlined in that document are as follows:

- Determine the characteristics of the groundwater flow system, sources of contamination, and 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.
- Develop stochastic predictions of the contaminant boundary, at an acceptable level of uncertainty.



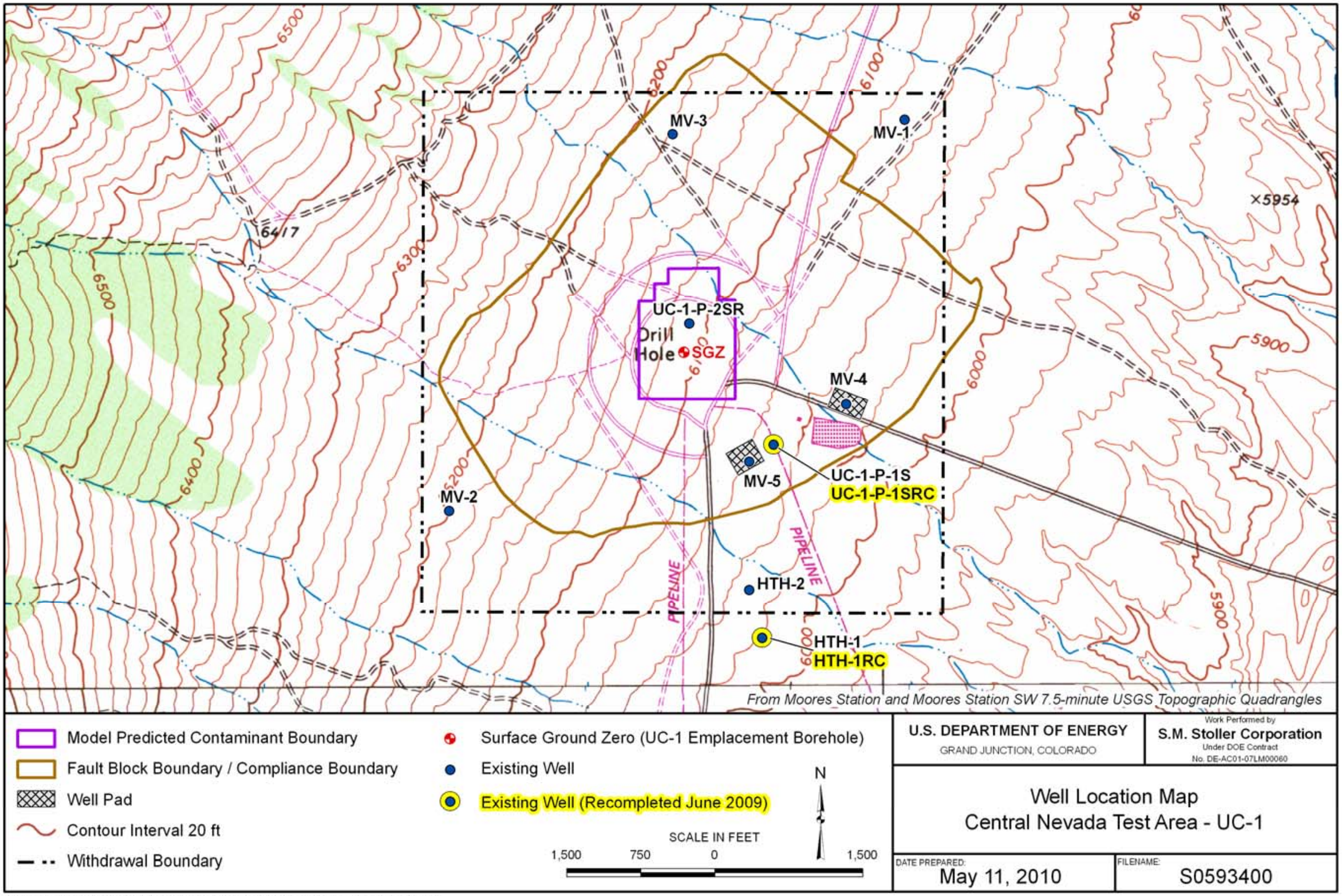
M:\LTS\111\0083\05\000\S03765\S0376500.mxd smithw 11/7/2007 3:35:56 PM

Figure 1. CNTA Location Map

These objectives were accomplished by conducting a corrective action investigation. As part of the investigation, site data were used to develop a numerical flow and transport model, which was then used to calculate a site contaminant boundary (Pohlmann et al. 1999, Pohll et al. 2003).

Results of the corrective action investigation 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 low (due to very low hydraulic conductivities) and that the contaminant boundary would be very small (within two to three radii of the cavity from the working point [DOE 2004]). A compliance boundary that factored in modeling results and associated uncertainties, especially with respect to the nuclear test's potential effects within the down-dropped fault block, was negotiated. The compliance boundary corresponds approximately to the surface expression of the fault block and is generally contained 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 monitoring/validations wells (MV-1, MV-2, and MV-3) were installed in 2005 to monitor radioisotopic concentrations and hydraulic heads in groundwater and to validate the flow and transport model. Hydraulic heads observed in these wells were in significant disagreement with those predicted by the groundwater flow model, which meant that the model could not be validated. Instead of additional modeling, DOE proposed a revised corrective action/closure process in which the monitoring network would be enhanced by installing two new monitoring



M:\LTS\111\0083\05\002\S05934\S0593400.mxd smithw 5/11/2010 8:19:56 AM

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

wells (MV-4 and MV-5), recompleting the existing wells HTH-1 (in the volcanic section) and UC-1-P-1S[1] (in the 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 a CADD/CAP addendum (DOE 2008a) that was approved by NDEP (NDEP 2008).

The revised corrective action/closure process was designed to enhance the monitoring of the alluvial aquifer. The alluvial aquifer was previously not monitored except for water levels in the upper piezometers of wells MV-1, MV-2, and MV-3. Hydraulic heads from different depths at these locations (upper piezometer, lower piezometer, and well) indicate that the most likely transport direction from the UC-1 detonation zone is down, toward densely welded tuff units below the detonation cavity. The well network was designed to monitor this most likely potential transport pathway. However, given the potential for processes like prompt injection and convective mixing in the nuclear chimney, migration into the alluvial aquifer cannot be ruled out. Alluvial wells are typically more productive than those in the deeper volcanic section, making the alluvial aquifer the most likely source for future groundwater development and, therefore, the most likely access path to potential receptors.

Two wells (MV-4 and MV-5) were installed, and two existing wells (HTH-1 and UC-1-P-1S) were recompleted in 2009 for the dual purposes of monitoring the alluvial aquifer and validating the compliance boundary at the site. The MV-4 and MV-5 wells were designed and positioned not only to monitor for potential contaminant migration in the alluvial aquifer but also to confirm that the southeast-bounding graben fault acts as a flow barrier. The wells were drilled in locations where they would penetrate the downthrown block within the graben and cross the fault into the upthrown block outside the graben. The wells were dually completed with a piezometer in the shallow alluvial aquifer within the graben (downthrown block) and a well in the lower alluvial aquifer outside the graben (upthrown block). The wells were completed with dedicated electric submersible pumps for collecting groundwater samples and aquifer testing. Monitoring of the existing wells MV-1, MV-2, and MV-3 was also enhanced in 2009 by removing the electric submersible pumps and installing low-flow bladder pumps. Results from the drilling program are provided in the Well Completion Report for CAU 443 (DOE 2009a).

Well UC-1-P-1S was recompleted to provide a reliable monitoring location within the upper alluvial aquifer inside the graben (downthrown block). An electric submersible pump was installed in the recompleted well, UC-1-P-1SRC,[2] for collecting groundwater samples.
Well HTH-1 was recompleted with two piezometers (upper and lower alluvial aquifer) and a well (upper volcanic section) to allow the monitoring of three hydrostratigraphic units at this location. Hydraulic head data from the well and piezometers can be used to determine the vertical flow direction within the alluvial aquifer and between the upper volcanic section and lower alluvial aquifer. The horizontal flow direction in the lower alluvial aquifer southeast of the graben can be estimated using head data from the HTH-1 lower piezometer along with head data from the MV-4 and MV-5 wells. A low-flow bladder pump was installed in the HTH-1RC well for collecting water samples from the volcanic section south of the detonation (DOE 2009a). Initial monitoring results from HTH-1RC support a previous identification (based on flow logging) of an upward hydraulic gradient from the volcanic section to the alluvium (DOE 2010a). Refer to Figure 2 for a map of the locations included in the enhanced monitoring network.

[1] *P* designates the post-shot hole; *S*, the substitute hole.
[2] *RC* indicates that the well has been recompleted.

The revised corrective action/closure process, as outlined in the CADD/CAP addendum (DOE 2008a), indicated that aquifer tests would be performed on the new wells MV-4 and MV-5 and on the recompleted well HTH-1RC. This strategy was modified slightly because the original well design for HTH-1RC was changed to include two piezometers and did not allow for the installation of a submersible pump or aquifer testing. To accommodate this change, an aquifer test was conducted on the recompleted well UC-1-P-1SRC. The results from aquifer tests suggest that the hydraulic conductivity of the alluvial aquifer decreases with depth, grading from a productive aquifer in the upper alluvium (hydraulic conductivity of 1.0 meter per day) to a poor producer in the lower alluvium (hydraulic conductivity of 0.00012 to 0.0005 meter per day). The decreasing hydraulic conductivity within the alluvial aquifer may be more a function of depth and overburden compression from the down-drop fault block rather than sediment grain size. The low hydraulic conductivity of the lower part of the alluvial aquifer is more comparable to the results from densely welded tuff units tested in wells MV-1, MV-2, and MV-3 (8.5×10^{-6} to 6.7×10^{-5} meter per day) and is likely similar to the hydraulic conductivity of the upper part of the underlying volcanic sediments. A more detailed summary of the results from the hydrologic testing is provided in the Hydrologic Testing Report for CAU 443 (DOE 2010b).

3.0 Geologic and Hydrologic Setting

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 stratigraphic units—a thick sequence of Quaternary- and Tertiary-age alluvial deposits (alluvium) underlain by a thick section of Tertiary-age volcanic rocks (volcanics). Log information from wells MV-1, MV-2, and MV-3 indicates that the thickness of the alluvium in the vicinity of UC-1 (location of the Faultless test) ranges from 1,960 to 2,410 ft. The Tertiary volcanics below the alluvium include tuffaceous sediments, welded and nonwelded tuffs, and rhyolite lavas.

The Faultless test took place in the very low permeability volcanic section, creating a cavity and a subsequent collapse chimney that extends into the overlying alluvium. The reentry well, UC-1-P-2SR, was directionally drilled into the chimney from a surface location approximately 300 ft north of surface ground zero a few weeks after the detonation in 1968. We do not have a copy of the directional survey for well UC-1-P-2SR, which began to build angle below 1,300 ft (per hole history data) in order to intersect the chimney. Elevations for well UC-1-P-2SR are not corrected for total vertical depth; consequently, elevations below a depth of 1,300 ft (4,800 feet above mean sea level [ft msl]) are artificially low by up to a few percent. Well UC-1-P-2SR was perforated from measured depths of 1,148 to 2,790 ft.

The water levels in UC-1-P-2SR are still recovering from the dewatering effects of the detonation (Figure 4). The water level has increased over 1,800 ft in the last 40 years and is expected to rise another 175 to 180 ft to the elevation of water levels in the alluvial aquifer in this area (from the elevation of 5,590 ft msl measured in mid-2011 to approximately 5,765 to 5,770 ft msl). The rate of water level rise in UC-1-P-2SR is decreasing as the recovery proceeds, indicating that it will be a number of decades before water levels stabilize (Figure 5).

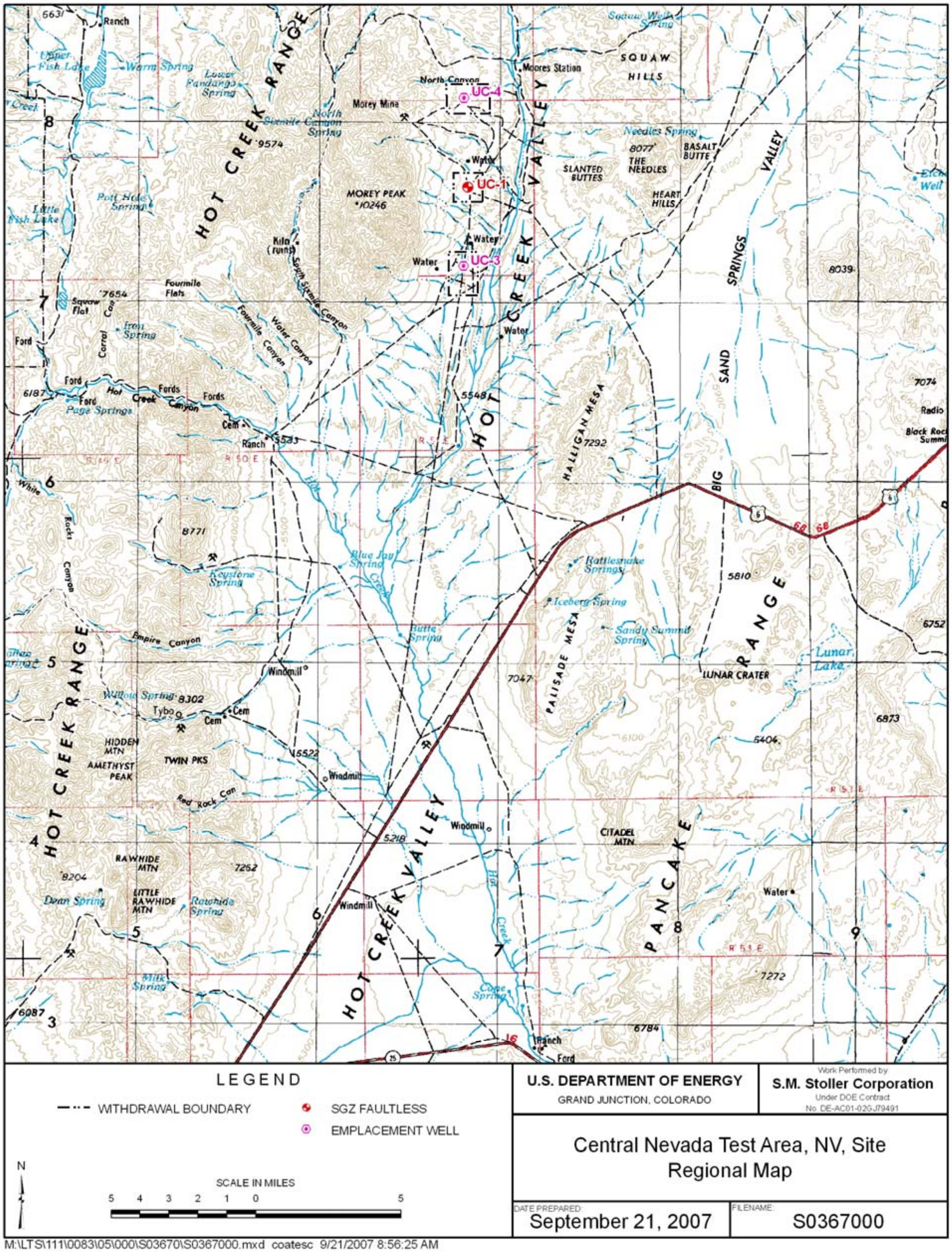
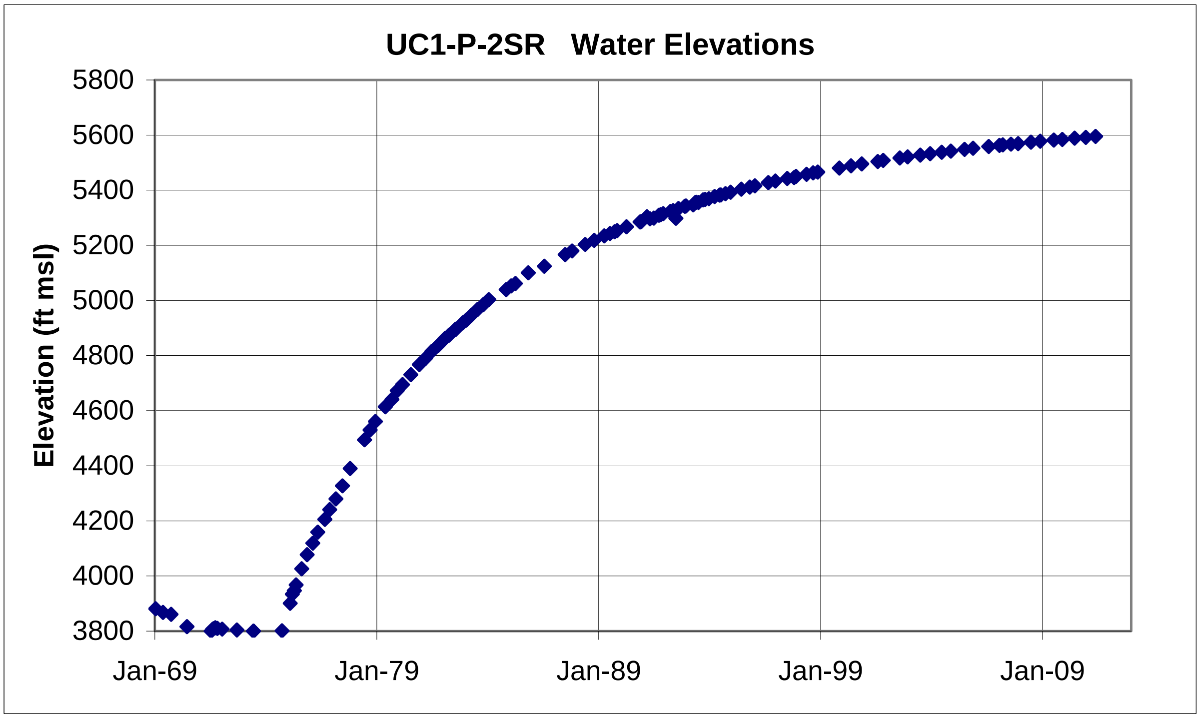
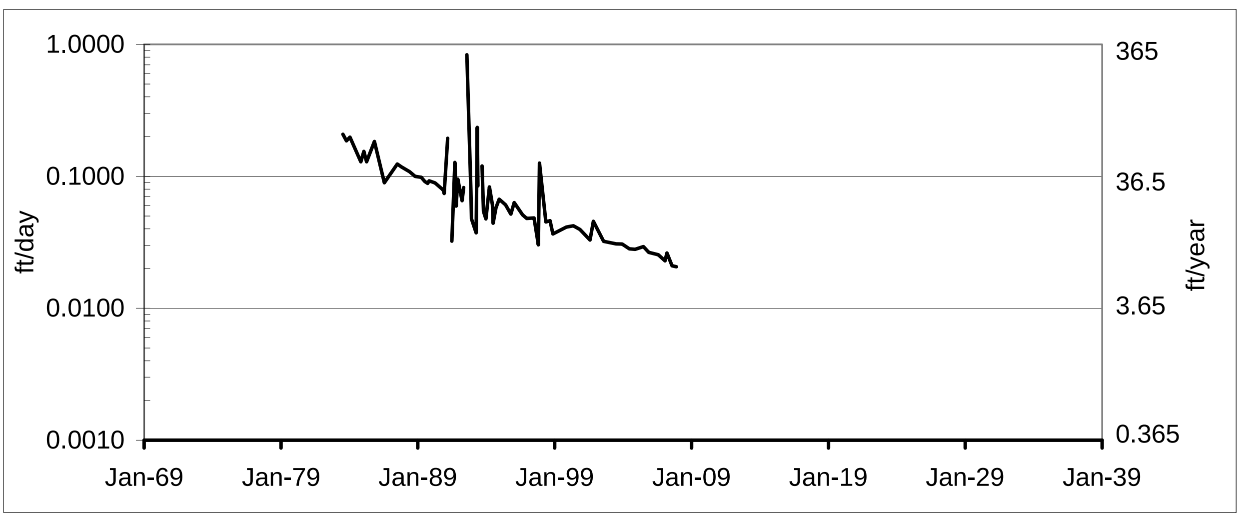


Figure 3. Physiographic Features Near CNTA



Note: Well was directionally drilled below 4,800 ft msl (no directional survey available). Actual elevations of water levels in the directional portion of the well (below 4,800 ft msl) were greater than depicted.

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



Note: The *y* axis is logarithmic.

Figure 5. Declining Rate of Water Level Increase in Well UC-1-P-2SR

4.0 Monitoring Objectives and Activities

The monitoring activities as specified in the CADD/CAP addendum (DOE 2008a) include the collection of hydraulic head data and groundwater samples for radioisotopic analyses. The two major objectives of the annual monitoring program are to (1) detect any migration of contaminants from the detonation zone and (2) evaluate the overall stability (quasi-steady state) of the groundwater flow system to ensure that monitoring wells are located along potential migration pathways. The *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (DOE 2008b) is used to guide quality assurance and quality control of the annual monitoring.

The monitoring activities consisted of annual sampling and downloading transducer data in monitoring network wells. The analytical results obtained from the annual sampling were validated in accordance with the *Environmental Procedures Catalog* (LMS/PRO/S04325), "Standard Practice for Validation of Laboratory Data." All analyses were completed, and the samples were prepared and analyzed in accordance with accepted procedures that were based on the specified methods. Required detection limits (RDLs) for the parameters being monitored were established in the CADD/CAP (DOE 2004). The radiochemical minimum detectable concentration values reported by the laboratory were less than the RDLs for all analytes except tritium. The LM-contract-required RDL for tritium is 400 pCi/L, this is slightly higher than the limit of 300 pCi/L established in the CADD/CAP. A record of technical change has been submitted to NDEP to address this change in the CADD/CAP and CADD/CAP Addendum. The laboratory radiochemical minimum detectable concentration reported with these data is an *a priori* estimate of the detection capability of a given analytical procedure, not an absolute concentration that can or cannot be detected. A copy of the Data Validation Package is maintained in the LM records and is available on request.

4.1 Radioisotope Monitoring

Water sampling at the site occurred in May 2011. Wells with submersible pumps (HTH-2, MV-4, MV-5, and UC-1-P-1SRC) were purged prior to sample collection. Wells with bladder pumps (MV-1, MV-2, MV-3, and HTH-1RC) were purged to remove stagnant water from the bladder pump tubing prior to sample collection. The *Fluid Management Plan, Central Nevada Test Area Corrective Action Unit 443* (DOE 2009b) was used to guide the handling and discharge of the monitor well purge water during the annual monitoring.

Groundwater samples from the 2011 sampling event were analyzed for tritium. During the 5-year proof-of-concept period that began with the 2009 sampling event, the CADD/CAP addendum (DOE 2008a) specifies that water samples will be analyzed for tritium every year and for carbon-14 (^{14}C) and iodine-129 (^{129}I) in the first and fifth years. Tritium is currently the primary analyte of concern because of its initial abundance and mobility. After a few hundred years, tritium will decay to insignificant levels (it has a half-life of 12.3 years), and the longer-lived radionuclides, ^{14}C and ^{129}I, will become the primary focus of long-term post-closure monitoring. The ^{14}C and ^{129}I analyses will provide baseline levels of these constituents for comparison with long-term monitoring results. Inadequate sample volumes were collected in 2009 for ^{129}I analysis, and, as a result, water samples collected in 2010 were analyzed for ^{129}I.

The CADD/CAP (DOE 2004) established groundwater compliance levels for CNTA of 20,000 picocuries per liter (pCi/L) for tritium, 2,000 pCi/L for ^{14}C, and 1 pCi/L for ^{129}I. Transport modeling (Pohlmann et al. 1999, Pohll et al. 2003) was used to establish a contaminant boundary (DOE 2004) at which predicted concentrations of these constituents would remain below current compliance levels. The contaminant boundary is well within the compliance boundary (Figure 2), the boundary beyond which compliance levels of these constituents are not to be exceeded. Although the flow model was not validated by data from wells MV-1, MV-2, and MV-3, the model-predicted contaminant boundary is supported by hydraulic conductivity data from these wells.

4.2 Radioisotopic Results

Radioisotopic sampling results for 2011 are presented in Table 1 along with the results from previous sampling events dating back to 2006. A sample was not collected from well HTH-2 during this monitoring event because the dedicated pump failed to operate. Tritium concentrations for 2011 are below detection limits, as in previous sampling events. Appendix A provides the field parameter measurements obtained during well purging activities.

4.3 Hydraulic Head Monitoring

Transducers are installed in all wells and piezometers in the network to monitor hydraulic head. The transducer data (accessible daily through real-time telemetry) are calibrated to manual water level measurements taken during sampling events and site inspections. 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. 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."

4.4 Hydraulic Head Results

Table 2 lists the most recent water level data (September 2011) from site wells and piezometers, along with the screened interval elevations, and the screened geologic unit. Piezometers are distinguished from the wells at these monitoring locations by the notation "PZ." For locations with two piezometers, "UPZ" and "LPZ" are used to denote the upper piezometer and lower piezometer, respectively.

Table 1. Radioisotopic Sampling Results

Well Name	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)
MV-1	2/14/2006[b]	<RDL (1.12E-02)	<RDL (1.51E-7)	<RDL (<3)
	9/21/2006[b]	<RDL (5.61E-02)	<RDL (2.9E-7)	<RDL (<45)
	2/22/2007	NS	NS	NS
	10/10/2007	<RDL (7.40E-03[d])	<RDL (5.7E-11)	<313
	3/19/2008	NS	NS	PF
	6/26/2009	<RDL (2.46E-02)	NR	<370
	6/09/2010	NS	<RDL (10.4E-10)	<360
	6/09/2010[c]	NS	<RDL (10.8E-10)	<360
	5/10/2011	NS	NS	<340
MV-2	3/16/2006[b]	<RDL (9.92E-02)	<RDL (2.58E-7)	<RDL (<3)
	9/22/2006[b]	<RDL (1.3E-02)	<RDL (2.6 E-7)	<RDL (<45)
	2/22/2007	<RDL (1.54E-03[d])	<RDL (9.7E-11)	<357
	2/22/2007[c]	<RDL (1.84E-03[d])	<RDL (11.1E-11)	<353
	3/19/2008	NS	NS	<320
	6/26/2009	<RDL (5.55E-03)	NR	<380
	6/08/2010	NS	<RDL (10.9E-10)	<360
	5/11/2011	NS	NS	<340
MV-2LPZ[a] – Sample depth 490 ft	8/5/2008	NS	NS	<8,000
MV-2LPZ[a] – Sample depth 3,471 ft	8/5/2008	NS	NS	<8,000
MV-3	3/16/2006[b]	<RDL (3.95E-02)	<RDL (2.10E-7)	<RDL (<3)
	9/22/2006[b]	<RDL (5.11E-02)	<RDL (2.2 E-7)	<RDL (<45)
	2/22/2007	<RDL (1.01E-02[d])	<RDL (14.0E-11)	<359
	3/19/2008	NS	NS	<320
	6/25/2009	<RDL (3.87E-02)	NR	<380
	6/08/2010	NS	<RDL (14.2E-9)	<370
	5/10/2011	NS	NS	<340
MV-4	6/24/2009	<RDL (9.17E-04)	NR	<370
	8/30/2010	NS	<RDL (7.5E-11)	<330
	5/10/2011	NS	NS	<340
	5/10/2011[c]	NS	NS	<330
MV-5	6/25/2009	<RDL (2.30 E-03)	NR	<370
	5/26/2010	NS	<RDL (5.7E-11)	<360
	5/11/2011	NS	NS	<330
HTH-1RC	6/25/2009	<RDL (2.75E-03)	NR	<390
	6/09/2010	NS	<RDL (11.0E-11)	<360
	5/11/2011	NS	NS	<340
HTH-2	6/25/2009	<RDL (7.98E-02)	NR	<380
	6/09/2010	NS	PF	PF
	5/11/2011	NS	NS	PF
UC-1-P-1SRC	6/24/2009	<RDL (1.07E-01)	NR	<360
	5/22/2010	NS	<RDL (5.2E-11)	<370
	5/10/2011	NS	NS	<330

[a] Sample was collected from lower piezometer of MV-2 using a depth-specific bailer; sample depths are provided with the well name.
[b] Sample results were obtained from the Desert Research Institute Monitoring Report (DRI 2006).
[c] Duplicate sample.
[d] Estimated based on sample volume of 200 milliliters.
NR = not analyzed because of insufficient sample volume.
NS = not sampled because the radioisotope was not part of the analytical suite.
PF = pump failed and a sample could not be collected.
<RDL = below RDL (laboratory result in parentheses; RDL is 300 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I [DOE 2004])

Table 2. Construction and 2011 Hydraulic Head Data for Wells in the CNTA Monitoring Network

Well/ Piezometer	TSZ Elevation[a] (ft)	BSZ Elevation[a] (ft)	Geologic Unit	TOC Elevation[a] (ft)	Date	Water Depth (ft)	Water Level Elevation[a] (ft)
MV-1UPZ	5,190.19	5,130.19	Alluvium	6,069.94	9/05/2011	317.49	5,752.45
MV-1LPZ	3,067.19	3,007.19	Volcanics	6,069.88	9/05/2011	37.26	6,032.62
MV-1	2,319.19	2,159.63	Volcanics	6,070.54	9/05/2011	506.76	5,563.78
MV-2UPZ	5,229.73	5,179.73	Alluvium	6,190.62	9/07/2011	405.70	5,784.92
MV-2LPZ	2,643.23	2,583.23	Volcanics	6,190.35	9/07/2011	394.76	5,795.59
MV-2	3,150.24	2,987.49	Volcanics	6,190.62	9/07/2011	354.42	5,836.19
MV-3UPZ	5,286.98	5,226.98	Alluvium	6,167.75	9/05/2011	373.86	5,793.89
MV-3LPZ	2,866.98	2,746.98	Volcanics	6,167.70	9/05/2011	190.97	5,976.73
MV-3	2,120.98	1,959.23	Volcanics	6,168.28	9/05/2011	600.35	5,567.93
MV-4[b]	4,300.32	3,996.22	Alluvium	6,019.65	9/07/2011	508.56	5,511.09
MV-4PZ[b]	5,101.20	5,041.20	Alluvium	6,019.45	9/07/2011	275.22	5,744.23
MV-5[b]	4,203.12	3,878.69	Alluvium	6,041.69	9/07/2011	560.58	5,481.11
MV-5PZ[b]	5,023.17	4,963.17	Alluvium	6,040.87	9/07/2011	288.84	5,752.03
HTH-1UPZ[b]	5,032.63	4,972.63	Alluvium	6,011.23	9/05/2011	542.73	5,468.50
HTH-1LPZ[b]	4,112.66	4,052.66	Alluvium	6,011.26	9/05/2011	540.99	5,470.27
HTH-1RC[b]	3,653.90	3,353.60	Volcanics	6,011.65	9/05/2011	491.92	5,519.73
HTH-2	5,521.70	5,025.70	Alluvium	6,026.44	9/05/2011	556.23	5,469.64
UC-1-P-1SRC[b]	5,519.55	5,457.81	Alluvium	6,031.59	9/07/2011	281.71	5,749.88
UC-1-P-2SR[c]	4,936[c]	3,294[c]	Chimney	6,084	5/25/2011	488.34[c]	5,590.73[c]

[a] All elevations reported in units of feet above mean sea level.
[b] Added in 2009.
[c] Elevations not true-vertical-depth corrected (no directional survey available). Primarily affects screened interval.
BSZ = bottom of open interval/screen zone
TOC = top of casing
TSZ = top of open interval/screen zone

Figure 6 through Figure 9 present hydrographs of the hydraulic head data. A continuous line indicates water levels from a transducer. The hydrographs are grouped by comparable monitored interval and location: alluvial wells southeast of the southeast-bounding graben fault, including well HTH-1RC in the upper volcanic section (Figure 6); alluvial wells northwest of the southeast-bounding graben fault (Figure 7); the volcanic section with open intervals near the detonation level (Figure 8); and the volcanic section with open intervals below the detonation level (Figure 9). Data gaps in the hydrographs are the result of transducers being removed for well-site activities or for the replacement of damaged transducers or cable.

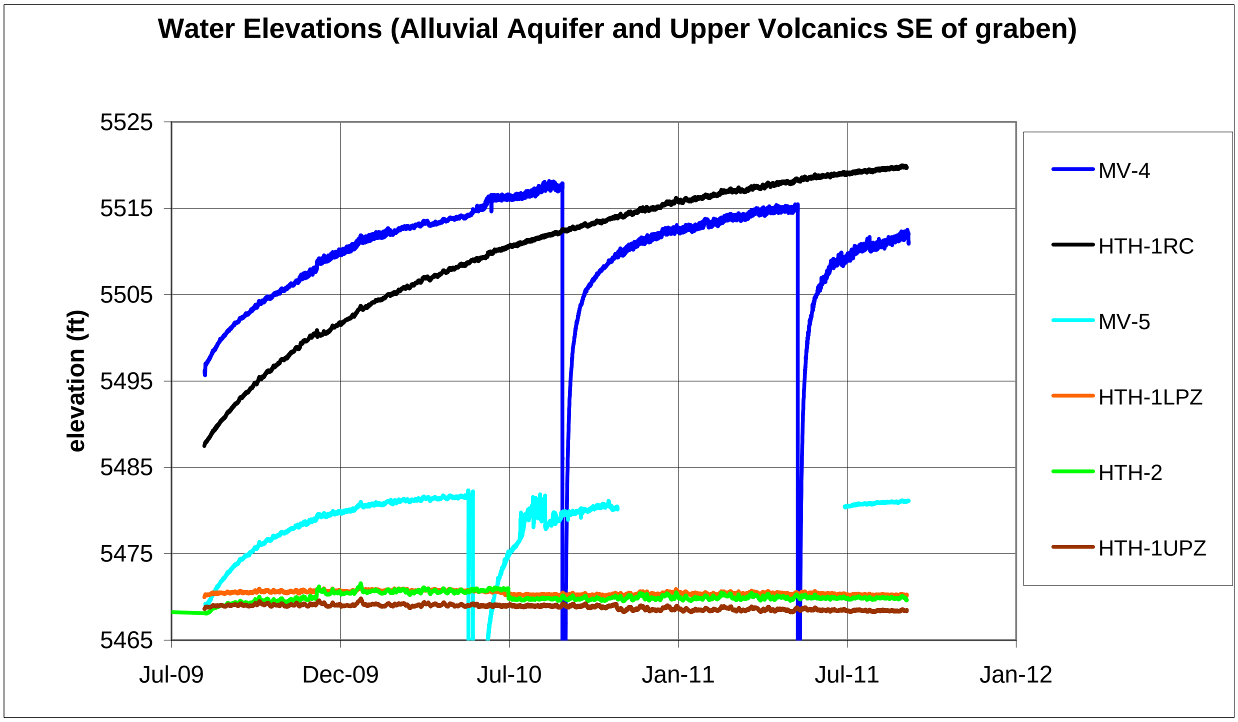


Figure 6. Water Level Elevations for the Alluvial Wells and Well HTH-1RC (Upper Volcanics) Southeast of the Down-Dropped Graben at the Screened Horizon

Figure 6 shows the hydrographs of alluvial wells and piezometers southeast of the graben (MV-4, MV-5, HTH-2, HTH-1UPZ, and HTH-1LPZ) along with well HTH-1RC (screened in the upper volcanic section below the alluvium). These data indicate that wells MV-4 and MV-5 (data gap from November 2010 through June 2011) are still recovering from the 2010 aquifer testing and from the 2011 yearly sampling event. The low permeability of the alluvium at this depth will require a switch to low-flow sampling methods to achieve steady-state head conditions. Based on the slow recovery of MV-4, it will likely take 3 to 5 years to equilibrate to steady-state conditions after switching to low-flow sampling (past the end of the 5-year proof-of-concept period). Well MV-5 recovers faster and should equilibrate in about 2 years. Water levels in well HTH-1RC continue to equilibrate after the recompletion in 2009 at approximately the same rate as MV-4. Prior to its recompletion, HTH-1 was perforated across its entire saturated section and displayed a composite water level that could not be attributed to one particular hydrogeologic unit. The recompletion isolated zones in the upper and lower alluvium (HTH-1UPZ and HTH-1LPZ) and in the upper volcanic section (HTH-1RC). The hydraulic head in the volcanic portion of HTH-1 is higher than water levels measured in both the upper and lower alluvial piezometers at this location. This observation confirms that an upward gradient from the volcanic section to the alluvium exists in this area, as indicated by flow logging performed by Desert Research Institute in HTH-1 prior to the well's recompletion (DOE 2008a).

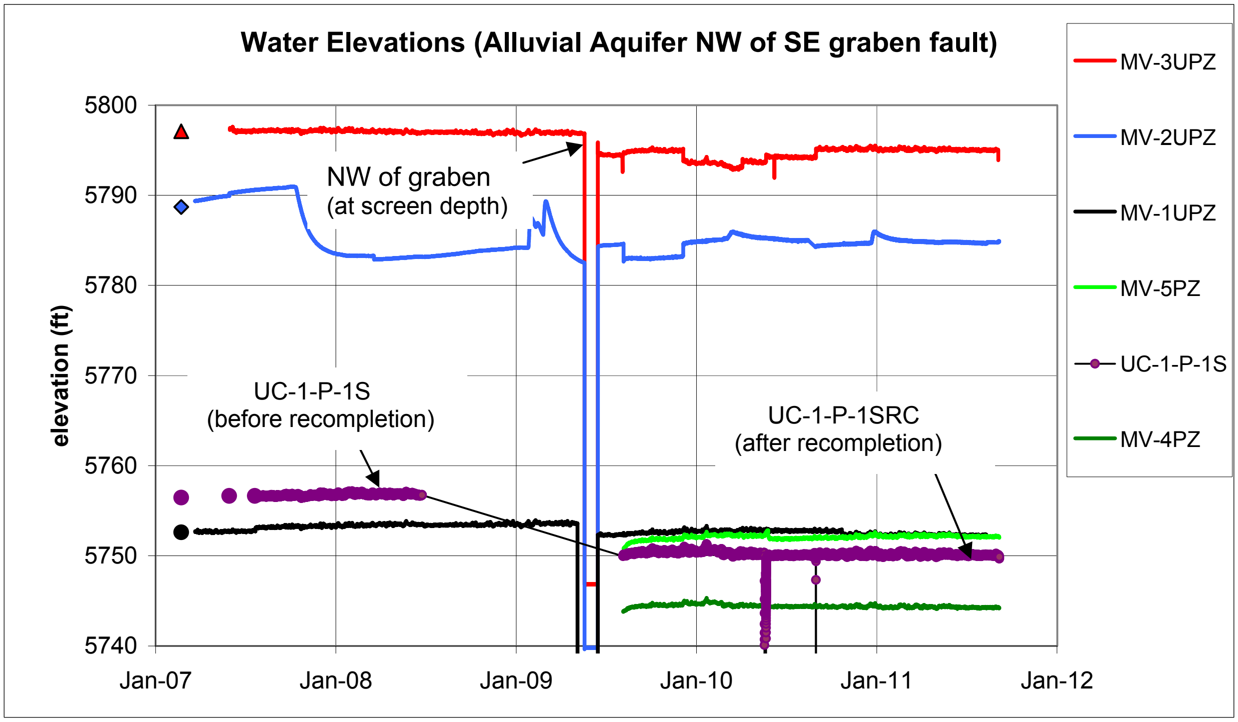


Figure 7. Water Level Elevations for the Alluvial Wells Northwest of the Southeast-Bounding Graben Fault

Figure 7 shows the hydrographs of alluvial piezometers and wells within and northwest of the graben. The data shown for MV-2UPZ from December 5, 2009, through August 30, 2010, were retrieved at the factory from a transducer that had stopped functioning. Data from this period were plotted as a straight line in the 2010 monitoring report. Erratic water levels in MV-2UPZ (Figure 7) are attributed to damage during its installation. The lower hydraulic heads observed after mid-2009 in MV-1UPZ and MV-3UPZ are the result of attempts to further develop these piezometers. The recompletion of UC-1-P-1S resulted in a roughly 7- to 8-ft decrease in hydraulic head (Figure 7). This suggests that the well is now isolated from the influence of deeper horizons where hydraulic heads have typically been larger. The hydraulic heads in MV-4PZ and MV-5PZ (screened inside the down-dropped graben block) are approximately 250 ft higher than those in the MV-4 and MV-5 wells that are screened outside the graben to the southeast (Figure 6). Heads in the MV-5PZ declined by almost 1 ft after the May 2010 pump testing but have since recovered to pretest levels. Given these results, alluvial aquifer hydrographs were separated into two groups based on their screened location relative to the southeast-bounding graben fault. Hydraulic head data from the MV-4 and MV-5 wells and piezometers continue to support the conceptual model that the southeast-bounding graben fault acts as a barrier to flow at the site.

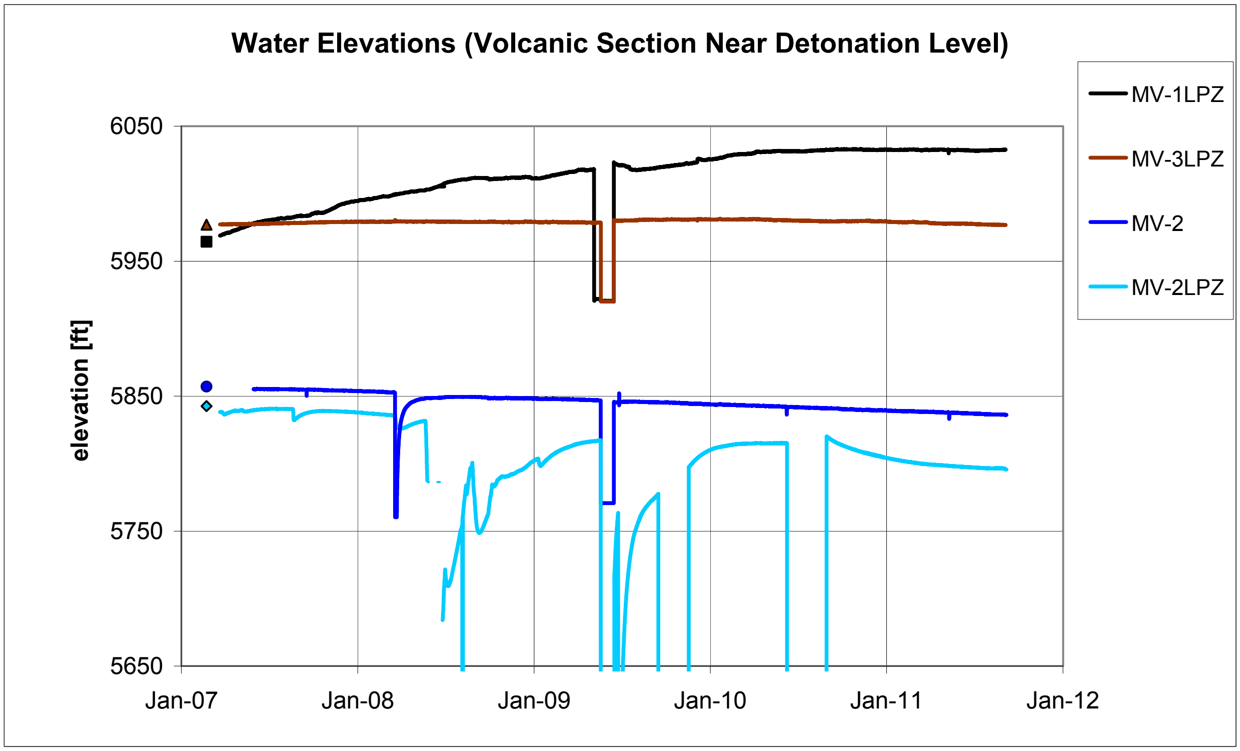


Figure 8. Water Level Elevations for the Well and Piezometers Screened in the Volcanic Section, at or Near the Level of the Detonation

Figure 8 shows the hydrographs of wells and piezometers with open intervals near the detonation level. Water levels in MV-1LPZ have stabilized over the past year. On August 5, 2008, Desert Research Institute ran a temperature log, collected a bailed sample, and measured the depth of MV-2LPZ to investigate the cause of rapid water level declines and recoveries at this location. Sediment was found 75 ft above the top of the screened interval. In the summer of 2009, MV-2LPZ was further developed, lowering the sediment fill to the top of the screen. The transducer was not functioning in MV-2LPZ from September to November of 2009 and from June to the end of August 2010. The head level in MV-2LPZ had apparently stabilized in early 2010, though during the summer of 2010, when no transducer was monitoring its water level, it rose above the stabilized level and has since been decreasing. The removal of sediment from MV-2LPZ may not have completely solved the erratic head changes in this piezometer, but head levels have been steadily declining (at a decreasing rate) over the past year. The head levels in the MV-2 well have declined at a steady rate of about 5 ft per year for the past 4 years.

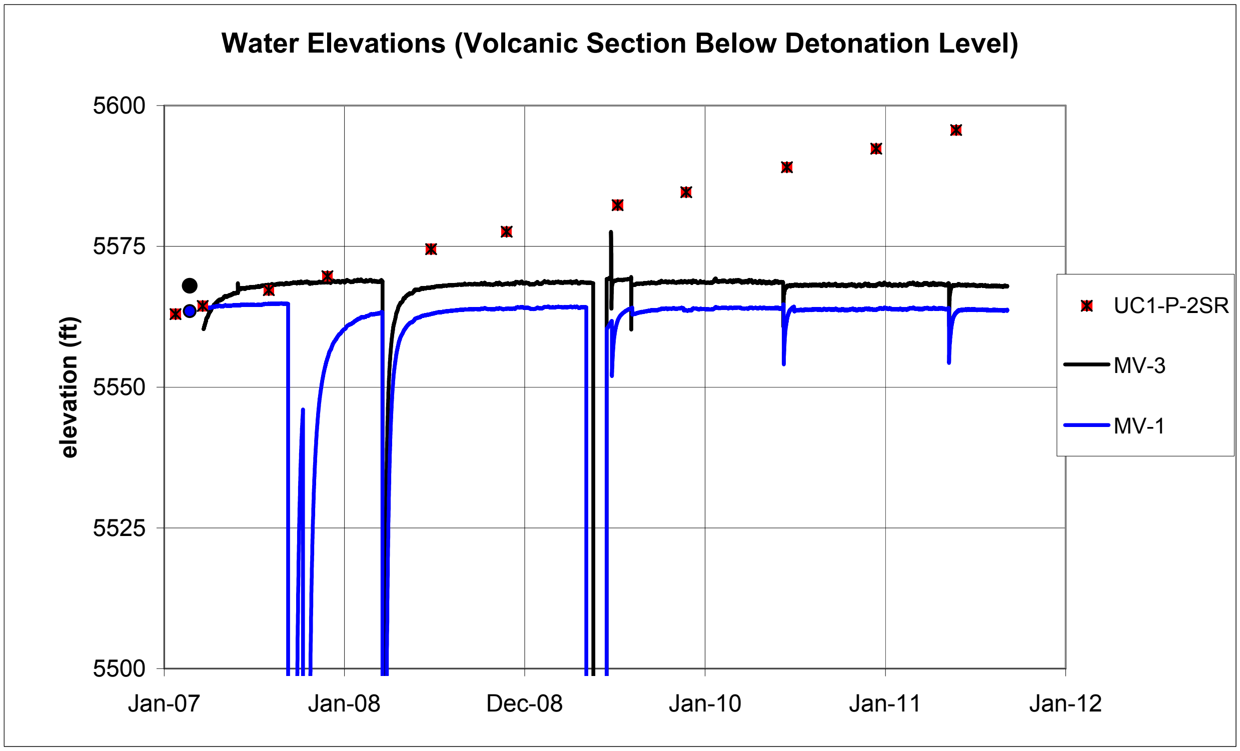
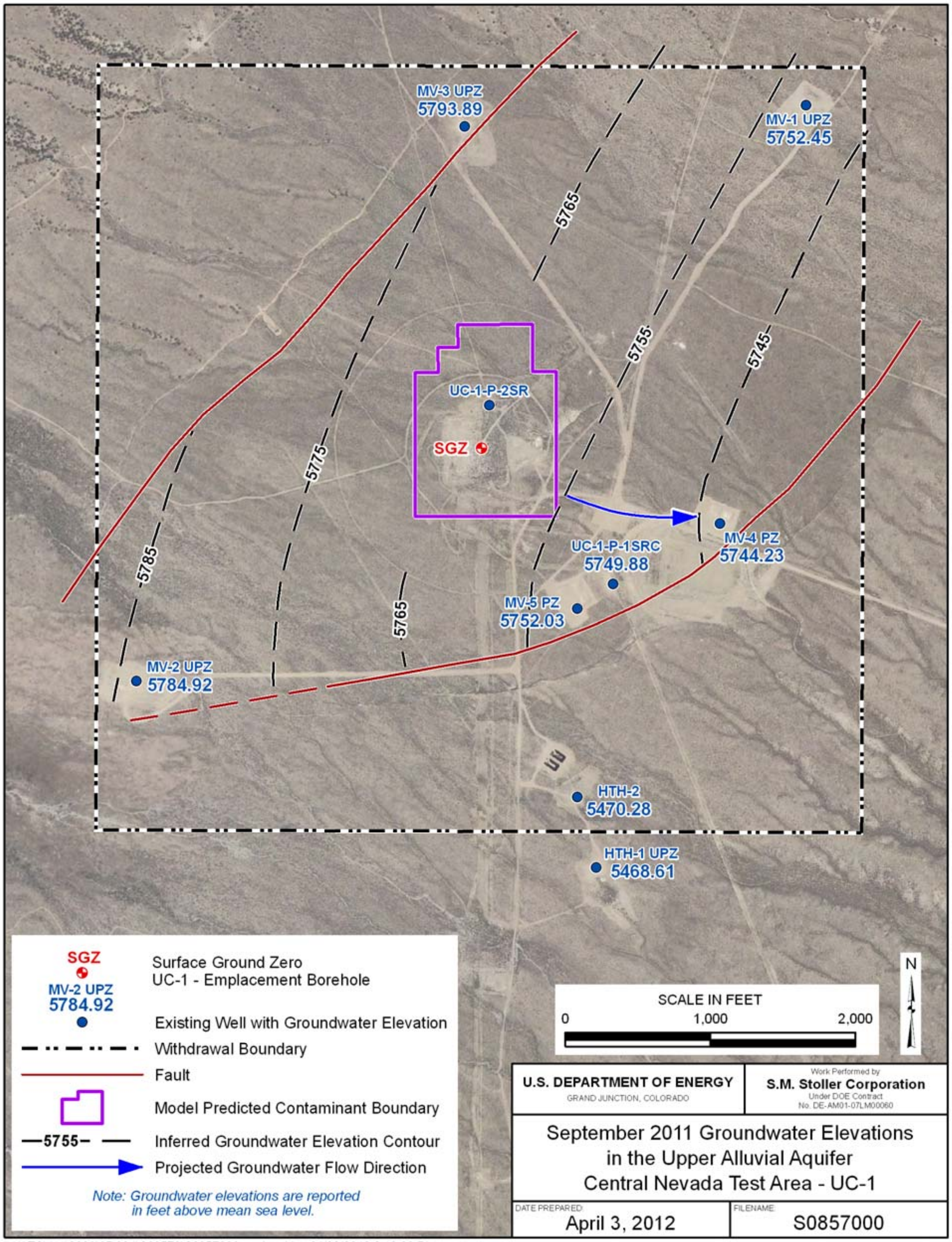


Figure 9. Water Level Elevations for the Wells Screened in the Volcanic Section Below the Level of the Detonation
(Water level elevations for reentry well UC-1-P-2SR [drilled into the chimney] are shown for reference.)

Figure 9 shows the hydrographs of wells with open intervals below the detonation level and reentry well UC-1-P-2SR (perforated from measured depths of 1,178 to 2,790 ft). The composite head level from UC-1-P-2SR (chimney and alluvium overlying the detonation area) is higher than in the densely welded tuff units below the detonation zone and continues to increase. The composite head level (5,590.73 ft msl on May 25, 2011) continues to increase (approximately 7.5 ft per year during this monitoring period), though at a declining rate over the long term. It will likely be a number of decades before UC-1-P-2SR reaches a steady-state head level.

A hand-contoured potentiometric map of the upper part of the alluvial aquifer within the graben (Figure 10) was constructed using the September 2011 head levels from MV-4PZ, MV-5PZ, UC-1-P-1SRC, MV-1UPZ, and MV-2UPZ, all of which are screened at depths ranging from 600 to 1,000 ft. Contouring of the potentiometric surface (Figure 10) was restricted to the area within the graben. It should be noted that there is an inherent degree of uncertainty in the depiction of groundwater flow directions when the minimum number of three points is used.



M:\LTS\111\0083\05\004\S08570\S0857000.mxd smithw 04/03/2012 2:12:29 PM

Figure 10. Potentiometric Map for the Upper Part of the Alluvial Aquifer, CNTA

Reentry well UC-1-P-2SR is not completed in the upper part of the alluvium but in the chimney. The interpretation shown on Figure 10 suggests that horizontal flow in the upper part of the alluvial aquifer is generally to the east-southeast and is likely deflected by the southeast-bounding graben fault. The new wells MV-4 and MV-5 were completed in the lower part of the alluvial aquifer outside the graben block (at depth) to confirm that the southeast-bounding graben fault acts as a flow barrier and for compliance monitoring at a depth nearer the detonation zone.

5.0 Site Inspection and Supplemental Site Activities

A site inspection was conducted during the May sampling event to inspect roads, well heads, the mud pit cap, and the monument at SGZ for signs of damage. The re-vegetation of the well pads (Fall 2010) was observed to be progressing as expected. The roads, well heads, and monument were also observed as being in good condition at the time of the inspection.

6.0 Summary and Recommendations

The 2009 drilling program enhanced the CNTA monitoring network with seven new monitoring points (wells and piezometers) in the alluvial aquifer and one in the upper volcanic section. Detection monitoring results indicate that radioisotope levels in groundwater continue to remain below detection limits. Water level data from the new wells, MV-4 and MV-5, and recompleted well HTH-1RC indicate that hydraulic heads are still recovering from installation and testing. The data from wells MV-4 and MV-5 also indicate that head levels do not recover after yearly sampling events during which several thousand gallons of water are purged. It is recommended that low-flow sampling methods be adopted to allow head levels to recover to steady-state conditions. Continued monitoring indicates that head changes in MV-2LPZ were not completely eliminated by the additional development activities, though no sudden head changes were observed during the past year. The submersible pumps in wells MV-1, MV-2, and MV-3 were removed and replaced with low-flow bladder pumps. Large drawdowns previously seen in wells MV-1, MV-2, and MV-3 during past sampling events with submersible pumps were limited to a few feet in recent sampling events using low-flow sampling methods.

LM recommends that the following activities be performed during the next annual monitoring period:

- Remove electric submersible pumps from wells MV-4, MV-5, and UC-1-P-1SRC, and replace them with low-flow bladder pumps.
- Replace the electric submersible pump in well HTH-2.
- Sample well UC-1-P-2SR and install a pressure transducer.

7.0 References

DOE (U.S. Department of Energy, Nevada Operations Office), 1999. *Corrective Action Investigation Plan for the Central Nevada Test Area Subsurface Sites (Corrective Action Unit No. 443)*, DOE/NV-483-Rev. 1, Las Vegas, Nevada, February.

DOE (U.S. Department of Energy, National Nuclear Security Administration/Nevada Site Office), 2001. *Closure Report for Corrective Action Unit 417: Central Nevada Test Area Surface*, *Nevada*, DOE/NV-743, Rev. 1, Las Vegas, Nevada, November.

DOE (U.S. Department of Energy, National Nuclear Security Administration/Nevada Site Office), 2004. *Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 443: Central Nevada Test Area (CNTA)—Subsurface*, Rev. 0, DOE/NV-977, Las Vegas, Nevada.

DOE (U.S. Department of Energy), 2007. *Corrective Action Plan Path Forward Proposal, Central Nevada Test Area*, Office of Legacy Management, Grand Junction, Colorado, April.

DOE (U.S. Department of Energy), 2008a. *Addendum to: Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for Corrective Action Unit (CAU) 443: Central Nevada Test Area (CNTA) – Subsurface Central Nevada Test Area, Nevada*, *DOE/NV-977*, DOE−LM/1555-2007, Office of Legacy Management, Grand Junction, Colorado, January.

DOE (U.S. Department of Energy), 2008b. *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites*, LMS/PLN/S04351, Office of Legacy Management, Grand Junction, Colorado.

DOE (U.S. Department of Energy), 2009a. *Well Completion Report for Corrective Action Unit 443 Central Nevada Test Area Nye County, Nevada*, LMS/CNT/S05827, Office of Legacy Management, Grand Junction, Colorado, December.

DOE (U.S. Department of Energy), 2009b. *Fluid Management Plan Central Nevada Test Area Corrective Action Unit 443*, LSM/CNT/S03736, Office of Legacy Management, Grand Junction, Colorado, January.

DOE (U.S. Department of Energy), 2010a. *2009 Groundwater Monitoring Report Central Nevada Test Area, Corrective Action Unit 443*, LMS/CNT/S05935, Office of Legacy Management, Grand Junction, Colorado, September.

DOE (U.S. Department of Energy), 2010b. *Hydrologic Testing Report Central Nevada Test Area, Corrective Action Unit 443*, LMS/CNT/S06916, Office of Legacy Management, Grand Junction, Colorado, November.

DRI (Desert Research Institute), 2006. *Central Nevada Test Area Monitoring Report*, Publication No. 45222, DOE/NV/13609-52, September.

NDEP (Nevada Division of Environmental Protection), 2008. *Approval of Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) Addendum to: Corrective Action Unit (CAU) 443: Central Nevada Test Area (CNTA) – Subsurface Central Nevada Test Area, Nevada, DOE/NV-977*, DOE−LM/1555-2007, January 17.

Pohll, G., K. Pohlmann, J. Daniels, A. Hassan, and J. Chapman, 2003. *Contaminant Boundary at the Faultless Underground Nuclear Test*, Desert Research Institute Publication No. 45196, U.S. Department of Energy, Nevada Operations Office Report DOE/NV/13609-24, Las Vegas, Nevada.

Pohlmann, K.F., J. Chapman, A. Hassan, and C. Papelis, 1999. *Evaluation of Groundwater Flow and Transport at the Faultless Underground Nuclear Test, Central Nevada Test Area*, Publication No. 45184, U.S. Department of Energy, Nevada Operations Office report DOE/NV/13609-13, Las Vegas, Nevada: Desert Research Institute, Division of Hydrologic Sciences.

This page intentionally left blank

Appendix A

Well Purging Data

Table A−1. Monitor Well Purge Data

Well Identification	Date Sampled	Purged Volume (gallons)	Temperature (°C)	pH (s.u.)	Specific Conductance (µmhos/cm)
HTH-1RC	5/11/2011	6.2	17.1	8.30	630
HTH-2	NS	NS	NS	NS	NS
MV-1	5/10/2011	9.2	14.3	9.54	705
MV-2	5/11/2011	7.6	15.3	10.30	1035
MV-3	5/10/2011	10	14.2	7.30	950
MV-4	5/10/2011	1900	27.0	9.73	380
			27.1	9.73	380
			27.2	9.73	380
MV-5	5/11/2011	2030	26.8	10.17	670
			26.8	10.16	670
			26.9	10.15	665
UC-1-P-1SRC	5/10/2011	370	17.4	7.52	370
			18.0	7.51	370
			18.1	7.50	365

s.u. = standard unit
µmhos/cm = micromhos per centimeter
NS = the well was not sampled (due to pump failure)

This page intentionally left blank

Appendix B

NDEP Correspondence with Record of Review and Response to Comments

This page intentionally left blank

March 26, 2012

Mr. Mark Kautsky
Site Manager
U. S. Department of Energy
Office of Legacy Management
2597 B ¾ Road
Grand Junction, CO 81503

RE: Draft 2011 Groundwater Monitoring Report, Subsurface Corrective Action Unit 443, Central Nevada Test Area, Nevada
Federal Facility Agreement and Consent Order

Dear Mr. Kautsky:

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) has reviewed the U. S. Department of Energy, Office of Legacy Management's (OLM) *Draft 2011 Groundwater Monitoring Report, Subsurface Corrective Action Unit 443, Central Nevada Test Area, Nevada* (Report) received on March 14, 2012. The NDEP has the following comments on the Report which should be addressed in the Final version of the Report:

1. Page 8, Section 4.0, Second Paragraph, Sixth Sentence: As was discussed with the OLM in regards to the Revised Draft 2011 Groundwater Monitoring Report for the Project Shoal Area Subsurface Site (CAU 447), some statement may want to be made that the required detection limit (RDL) for tritium established in the 2004 Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) is currently being revised through the Record of Technical Change (ROTC) process.

2. Page 10, Table 1: The entries for Carbon-14 for MV-1 on 10/10/2007 and MV-3 on 2/22/2007 have a footnote indicator/symbol of a plus sign or cross but there is no "definition" for this symbol in the legend of the table. Either a definition should be added in the legend or the symbol removed from the table.

3. Page 10, Table 1: It is not clear why the tritium results for MV-1 on 2/14/2006 and 9/21/2006, for MV-2 on 3/16/2006 and 9/22/2006 and MV-3 on 3/16/2006 and 9/22/2006 are not in parenthesis with "<RDL" preceding the parenthesis because these tritium levels are below the RDL of 300 pCi/l for tritium. This comment is based on how the results for Carbon-14 and Iodine-129 are reported in Table 1.

4. Page 10, Table 1: Based on the text in Section 4.2 on page 9, the 5/11/2011 date for HTH-2 should have a "c" notation.

If you would like to discuss these comments, please contact Chris Andres at 702-486-2850, ext. 232.

Sincerely,

T. H. Murphy
Chief
Bureau of Federal Facilities

cc: FFACO Group, PSG, NNSA/NSO, Las Vegas, NV
N-I Central Files, MS, NSF 156, Las Vegas, NV
NSTEC Correspondence Control, MS NLV008, Las Vegas, NV
R. F. Boehlecke, NNSA/NSO, Las Vegas, NV
Jeffrey Fraher, DTRA/CXTS, Kirtland AFB, NM
J. B. Chapman, DRI, Las Vegas, NV
D. Crawford, Stoller, Grand Junction, CO
R. Findley, Stoller, Grand Junction, CO
R. Hutton, Stoller, Grand Junction, CO

Record of Review

Due Date	Review No.	Project	Type of Review
04/27/2012	1	Offsites Project	Technical

Document Title and\or Number and Revision
2011 Groundwater Monitoring Report, Central Nevada Test Area, Nevada, Site, Subsurface Corrective Action Unit 443

Author
Mark Kautsky

Author's Organization	Author's Phone
Legacy Management	(970) 248-6018

Reviewer
T. H. Murphy

Reviewer's Organization	Reviewer's Phone
Nevada Division of Environmental Protection	(702) 486-2863

Reviewers' Recommendation

- ☐ Release Without Comment
- ☐ Consider Comments
- ☐ Resolve Comments and Reroute for Review

Signature of Reviewer and Date

- ☒ Comments Have Been Addressed

Mark Kautsky
Mark Kautsky
2012.04.24 07:24:24 -06'00'

Signature of Author and Date

- ☒ Comment Resolution Satisfactory
- ☐ Comment Resolution Unsatisfactory

Christine Andres 4/25/12

Signature of Reviewer and Date

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
1.	Page 8, Section 4.0, Second Paragraph, Sixth Sentence: As was discussed with the OLM in regards to the Revised Draft 2011 Groundwater Monitoring Report for the Project Shoal Area Subsurface Site (CAU447), some statement may want to be made that the required detection limit (RDL) for tritium established in the 2004 Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) is currently being revised through the Record of Technical Change (ROTC) process.	Y	1	The sentence was modified and a sentence added to be consistent with the Shoal Monitoring Report, as requested. The change is provided below: "The LM-contract-required RDL for tritium is 400 pCi/L, this is slightly higher than the limit of 300 pCi/L established in the CADD/CAP. A record of technical change has been submitted to NDEP to address this change in the CADD/CAP and CADD/CAP Addendum."
2.	Page 10, Table 1: The entries for Carbon-l4 for MV-1 on 10/10/2007 and MV-3 on 2/22/2007 have a footnote indicator/symbol of a plus sign or cross but there is no "definition" for this symbol in the legend of the table. Either a definition should be added in the legend or the symbol removed from the table.	Y	2	The footnote notation/symbol was changed to "d" for all Carbon-14 samples in 2007, indicating the sample results were based on an estimated sample volume of 200 milliliters. The change was made for the Carbon-14 samples collected in 2007, as requested.
3.	Page 10, Table 1: It is not clear why the tritium results for MV-1 on 2/14/2006 and 9/21/2006, for MV-2 on 3/16/2006 and 9/22/2006 and MV-3 on 3/16/2006 and 9/22/2006 are not in parenthesis with "<:RDL"	Y	3	The term "<RDL" was added to the 2006 tritium results, as requested.

Library Distribution List

	Copies
U.S. Department of Energy National Nuclear Security Administration Nevada Site Office Technical Library P.O. Box 98518, M/S 505 Las Vegas, NV 89193-8518 702-295-3521	1 (Uncontrolled)
U.S. Department of Energy Office of Scientific and Technical Information P.O. Box 62 Oak Ridge, TN 37831-0062 865-576-8401	1 (Uncontrolled, electronic copy)
Southern Nevada Public Reading Facility c/o Nuclear Testing Archive P.O. Box 98521, M/S 400 Las Vegas, NV 89193-8521	2 (Uncontrolled, electronic copies)
Manager, Northern Nevada FFACO Public Reading Facility c/o Nevada State Library & Archives 100 N Stewart Street Carson City, NV 89701-4285 775-684-3313	1 (Uncontrolled, electronic copy)
Librarian Tonopah Public Library 167 Central Street Tonopah, NV 89049 775-482-3374	1 (Uncontrolled)

This page intentionally left blank