LMS/CNT/S15655

2016 Postclosure Groundwater Monitoring and Inspection Report, Central Nevada Test Area, Nevada, Subsurface Corrective Action Unit 443

December 2017

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

bgs	below ground surface
BLM	U.S. Bureau of Land Management
^{14}C	carbon-14
CADD/CAP	Corrective Action Decision Document/Corrective Action Plan
CAS	corrective action sites
CAU	Corrective Action Unit
CNTA	Central Nevada Test Area
DOE	U.S. Department of Energy
FFACO	Federal Facility Agreement and Consent Order
ft	feet
ft msl	feet above mean sea level
^{129}I	iodine-129
ICs	institutional controls
LM	Office of Legacy Management
LPZ	lower piezometer
m/day	meters per day
MCL	maximum contaminant levels
MDC	minimum detectable concentrations
MV	monitoring/validation
NDEP	Nevada Division of Environmental Protection
pCi/L	picocuries per liter
PZ	piezometer
RDL	required detection limit
SAP	*Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351)
SDWA	Safe Drinking Water Act
SGZ	surface ground zero
UPZ	upper piezometer

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Executive Summary

The Central Nevada Test Area, Nevada, Site, was the site of a 0.2- to 1-megaton underground nuclear test in 1968, which resulted in residual contamination at and near the detonation depth of approximately 3200 feet (ft) below ground surface. Subsurface corrective action activities were completed in 2015 and *Closure Report, Central Nevada Test Area, Subsurface Corrective Action, Unit 443* (LMS/CNT/S12760) (Closure Report) was approved in 2016. These activities were conducted in accordance with the Federal Facility Agreement and Consent Order (1996, as amended) and all applicable Nevada Division of Environmental Protection policies and regulations. The Closure Report established the long-term postclosure monitoring program and site inspection requirements for the site. The postclosure monitoring program is designed to (1) assess the effectiveness of the compliance boundary by monitoring for the radioisotopes of interest and (2) evaluate the effectiveness of monitoring locations within the groundwater flow system by monitoring water elevations to ensure that monitoring wells are located along the potential migration pathways. This includes annual site inspections to maintain the institutional controls and ensure protectiveness of the site.

The sample analytical results indicate tritium was not detected above the laboratory-required minimum detectable concentrations in all sampled wells in the monitoring network. These sample results combined with past results support the determination that radioisotopes of interest (tritium, carbon-14, and iodine-129) have not migrated outside the compliance boundary. Water elevations continue to support interpreted flow directions and the adequacy of the monitoring network at the site. Water levels in the reentry well UC-1-P-2SR are still recovering from the dewatering effects of the detonation. Water levels in this well have risen 100 ft since 2002 (5 ft in 2016) and are projected to rise another 145 ft over the next 50 years (based on current trends). The currently depressed water levels in this area direct groundwater flow in the alluvial aquifer near surface ground zero toward the chimney. In the volcanic section, water level data from well UC-1-P-2SR also indicate a downward gradient from the source zone to the densely welded tuff units below the detonation. The downward gradient could increase as water levels continue to recover in the chimney. Water level data from the piezometer (screened inside the graben) and well (screened outside the graben) at the monitoring/validation (MV) locations MV-4 and MV-5 continue to confirm that the southeast-bounding graben fault acts as a barrier to groundwater flow.

This report and the Closure Report are available on the LM public website at https://www.lm.doe.gov/CNTA/Sites.aspx. Data collected during previous monitoring events (including sample analytical results and water level data) are available on the Geospatial Environmental Mapping System (GEMS) website at https://gems.lm.doe.gov/#site=CNT.

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1.0 Introduction

This report presents the groundwater monitoring data collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) from the Central Nevada Test Area (CNTA), Nevada, Site, Subsurface Corrective Action Unit (CAU) 443 in Nye County, Nevada (Figure 1). The site was the location of an underground nuclear test in 1968, which resulted in residual contamination at and near the detonation depth of approximately 3200 feet (ft) below ground surface (bgs) that requires long-term monitoring. Responsibility for the environmental restoration and long-term monitoring was transferred from the DOE, National Nuclear Security Administration, Nevada Field Office to LM on October 1, 2006. The environmental restoration and site closure process were completed in 2015 in accordance with the Federal Facility Agreement and Consent Order (State of Nevada et al. 1996) (as amended) (FFACO) and all applicable Nevada Division of Environmental Protection (NDEP) policies and regulations. The *Closure Report, Central Nevada Test Area, Subsurface Corrective Action, Unit 443* (LMS/CNT/S12760) (DOE 2016a) (Closure Report) describes LM's plan for the long-term postclosure monitoring of radioisotope concentrations and water elevations, inspecting the site and maintaining the institutional controls (ICs), evaluating and reporting data, and documenting the site's records and data management processes (DOE 2016a).

The purpose of the postclosure monitoring is to monitor the groundwater for the potential migration of contamination, evaluate the effectiveness of the monitoring network with respect to groundwater flow directions, and ensure that the ICs are protective of the site and human health and the environment. This report summarizes the results of the monitoring and site inspection activities conducted during the April 2015 through July 2016 reporting period.

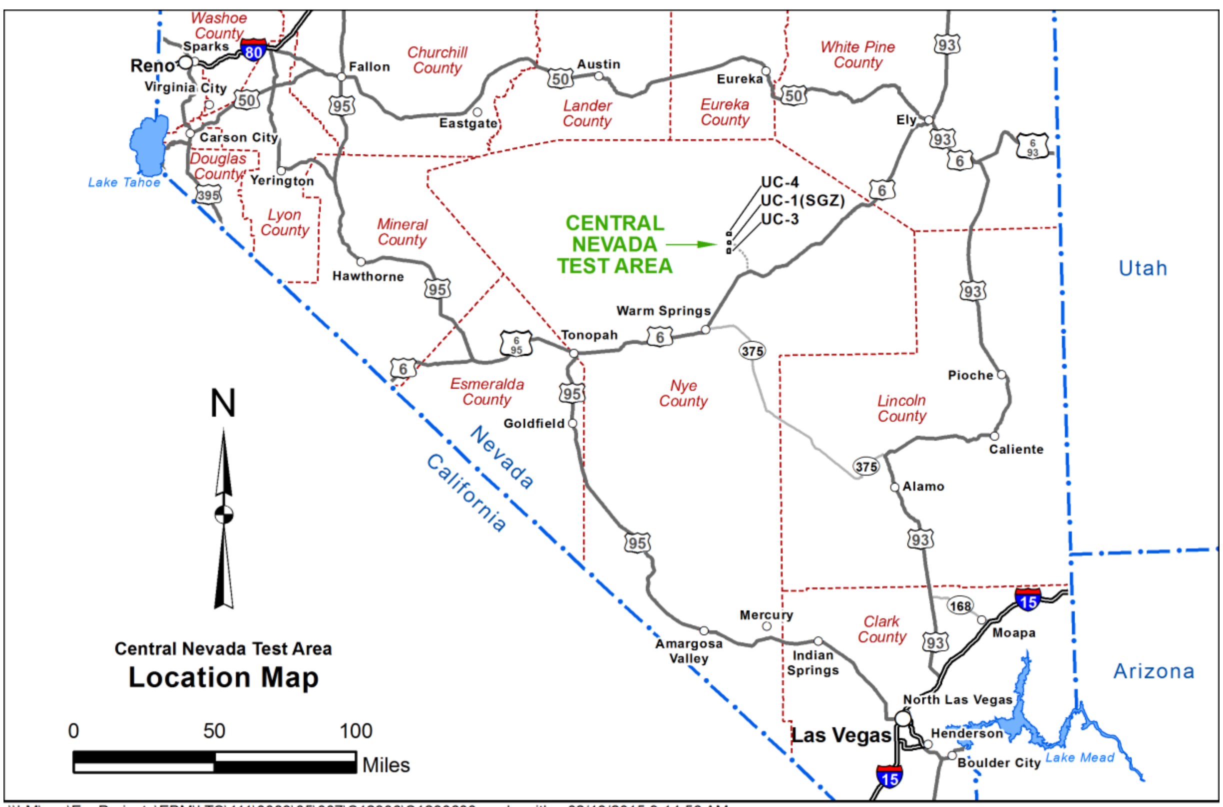

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Figure 1. CNTA Location Map Showing Emplacement Boreholes UC-1, UC-3, and UC-4

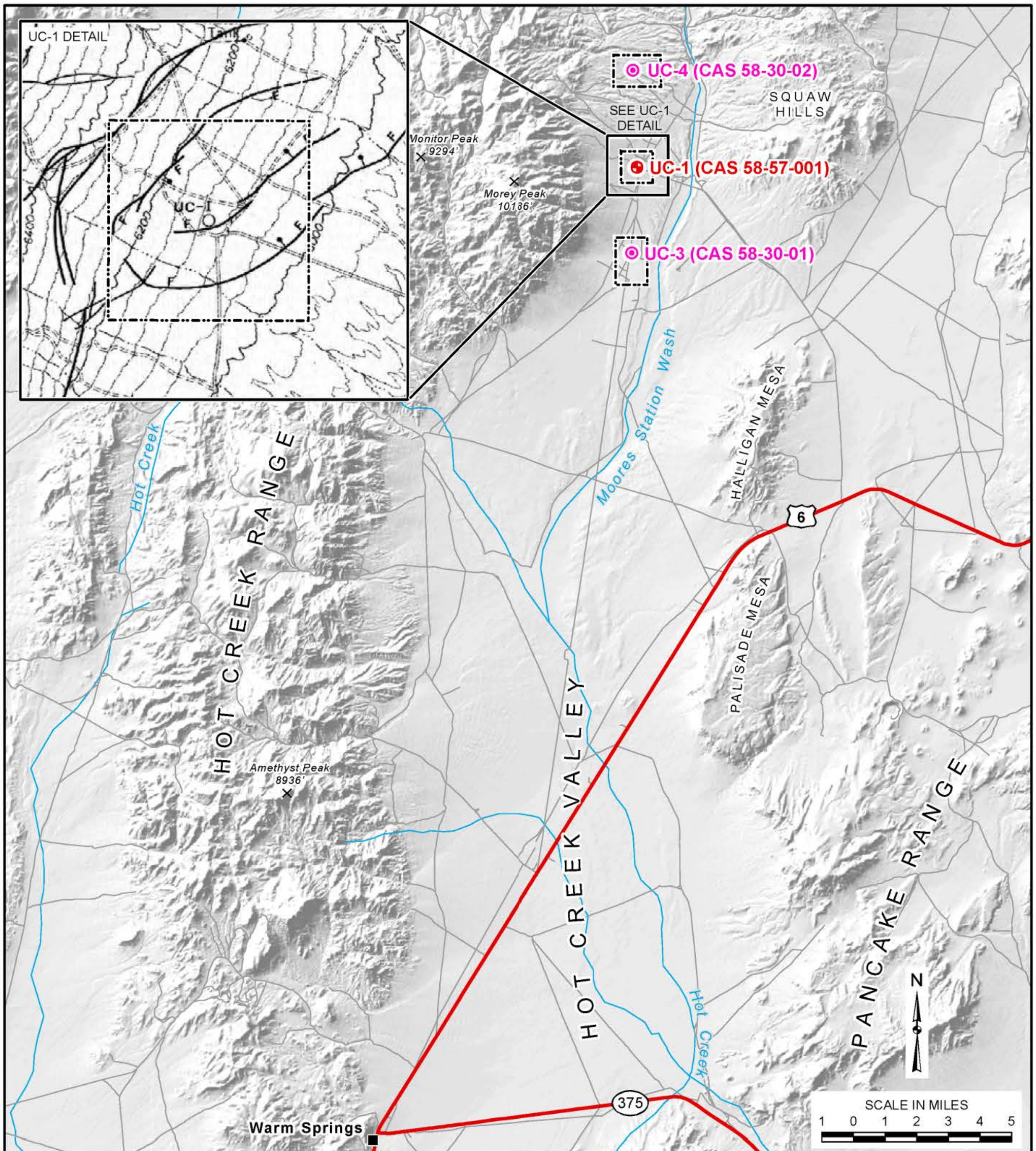
2.0 Site Background

The U.S. Atomic Energy Commission (predecessor to DOE) acquired the CNTA site through two separate land withdrawals from the U.S. Bureau of Land Management (BLM) in the late 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 (Figure 1). The land withdrawals for these boreholes were authorized through Public Land Orders 4338 and 4748 in 1967 and 1969, respectively. The initial land withdrawal, Public Land Order 4338, included approximately 640 acres for land surrounding the UC-1 emplacement borehole. The second land withdrawal, Public Land Order 4748, was for two separate parcels of land totaling approximately 1920 acres for land surrounding the UC-3 and UC-4 emplacement boreholes (Figure 2). The underground nuclear test, identified as Faultless, was conducted in borehole UC-1 at a depth of 3199 ft bgs on January 19, 1968. The nuclear device had a reported yield that was estimated to be 0.2 to 1 megaton (DOE 2015a). The test resulted in a down-dropped fault block (also referred to as a subsidence graben) that extends to land surface (Figure 3). Two additional tests were planned (UC-3 and UC-4 boreholes), but neither was completed, and no further nuclear testing was conducted at CNTA. The UC-3 and UC-4 boreholes were abandoned, secured at the surface by a welded steel plate and a concrete cap, and the site was decommissioned as a testing facility in 1973.

The underground nuclear test resulted in residual contamination at and near the detonation depth. The intense heat of the detonation vaporized a volume of rock, temporarily creating an approximately 100-meter radius cavity surrounded by material damaged by the associated pressure pulse (based on maximum yield in DOE 2015a and Pawloski 1999 EQ. 1). In seconds to hours, the overlying material collapsed into the void space, forming a collapse chimney. The former cavity, now the lower part of the collapse chimney and the surrounding damaged zone are together referred to as the detonation zone. The detonation zone is contaminated by residual radioactive isotopes, with higher concentrations located at the bottom of the former cavity, which contains the majority of radioactive fission products, uranium, plutonium, and tritium (DOE 2005). The rest of the detonation zone is contaminated by lower concentrations of mobile radioisotopes, such as tritium. The mobile radioisotopes in the detonation zone are a source of contamination (source zone) that could potentially migrate with groundwater. The remaining subsurface contamination is identified as CAU 443.

2.1 Geologic and Hydrologic Setting

CNTA is in the northern portion of the Hot Creek Valley (Figure 2), a north-south trending graben that is 68 miles long and located in the Basin and Range physiographic province. Surface and subsurface geologic data indicate that CNTA is within the Hot Creek Valley caldera complex, which contains several overlapping volcanic cauldrons. This caldera complex has been disrupted by basin-and-range style, normal faulting that formed the Hot Creek Valley graben. 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 (volcanic sediments). Borehole lithologic information obtained from groundwater monitoring wells installed at the site (Figure 3) indicates that the thickness of the alluvium in the vicinity of UC-1 (location of the Faultless test) ranges from 1960 to 2410 ft (DOE 2006). The volcanic section below the alluvium includes tuffaceous sediments (volcanic sediments), densely welded and non-welded tuffs, and rhyolite lavas.



LEGEND

- SGZ Faultless (UC-1)
- Emplacement Boreholes (UC-3 and UC-4)
- Fault with Dip Direction
- Withdrawal Boundary
- City or Town
- Highway
- Road
- Drainage/Wash

U.S. DEPARTMENT OF ENERGY OFFICE OF LEGACY MANAGEMENT	Work Performed by Navarro Research & Engineering, Inc. Under DOE Contract Number DE-LM0000421
Central Nevada Test Area, NV, Site Regional Map	
DATE PREPARED: February 28, 2017	FILE NAME: S1565700

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Figure 2. CNTA Regional Location Map

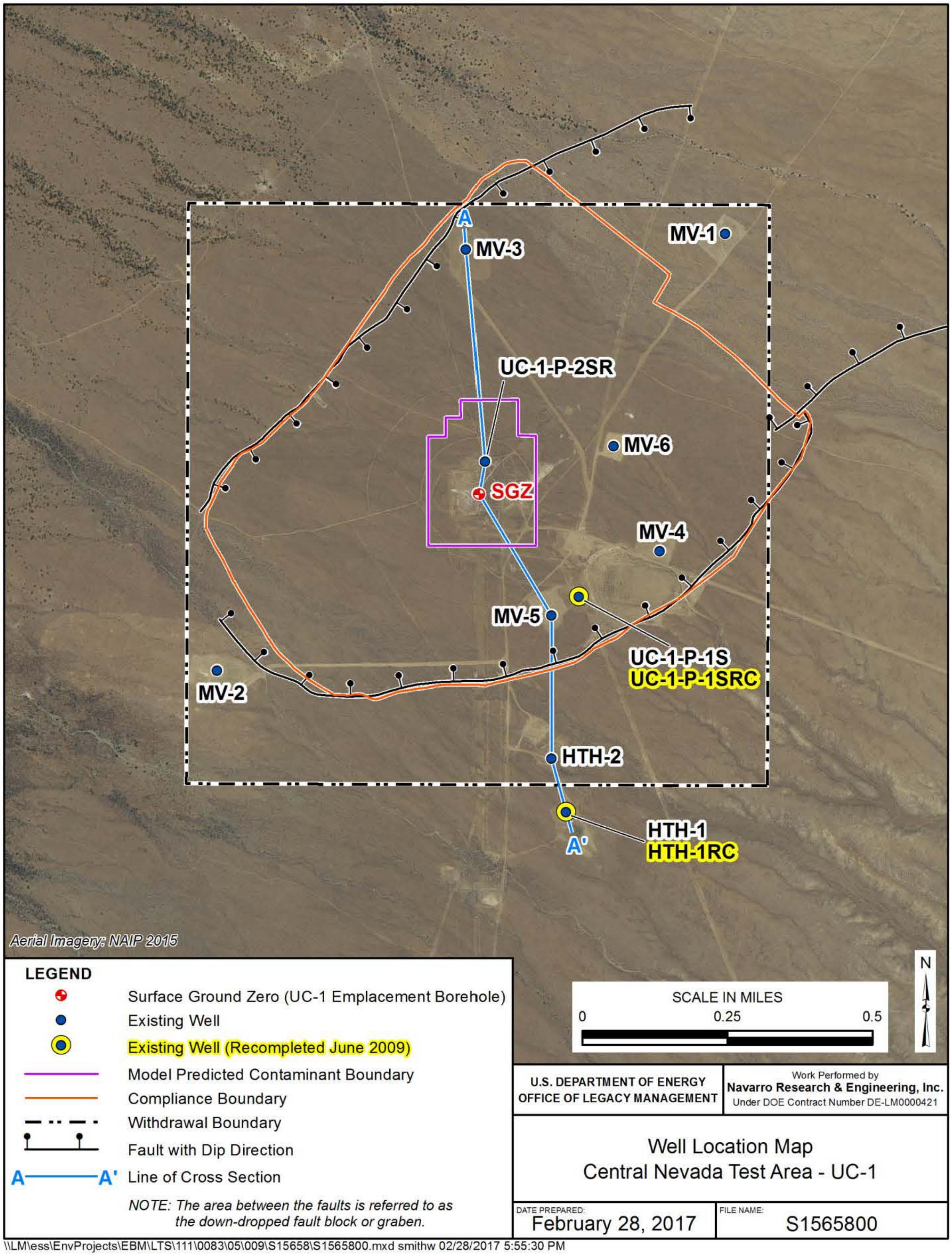

Figure 3. CNTA UC-1 Site Map with Well Locations

The underground nuclear test triggered numerous small earthquakes and aftershocks that resulted in surface subsidence and surface rupture along preexisting faults (see UC-1 site detail in Figure 2), caused strike-slip movement along previously unknown subsurface faults, and induced seismic activity as far away as 24 miles (McKeown and Dickey 1969). The test created a down-dropped fault block (also referred to as a subsidence graben) elongated to the northeast and parallel to preexisting faults in the Quaternary valley-fill deposits (Figure 3). Maximum surface displacement after the test was 14.8 ft. In some places along the south side of the graben, dip on the faults is 77 degrees to the north, based on fault intercepts in post-shot boreholes and post-shot map data. High-speed photography showed that subsidence occurred along the preexisting graben faults immediately following the test, indicating that subsidence resulted from the immediate release of tectonic stress that was triggered by the underground test, and not from the collapse of the former cavity (McKeown et al. 1968; McKeown and Dickey 1969). Figure 4 is a cross section of the UC-1 site depicting the former cavity and chimney with faults and lithologic units.

The Faultless test took place in the low-permeability volcanic sediments (Figure 4). It was estimated that the chimney extends into the overlying alluvium to a depth of approximately 1200 ft bgs. This estimate is based on drilling records that indicate a loss of circulation while drilling at this depth. Well UC-1-P-2SR began to deviate from vertical at a depth below 1500 ft bgs (elevation of 4600 feet above mean sea level [ft msl]) to intercept the chimney as planned. The well was drilled to a measured depth of 3554 ft bgs (3513 true vertical depth) and perforated from measured depths of 1148 to 2792 ft bgs (1148 to 2760 ft true vertical depth). The water level in the chimney is still recovering from the dewatering effects of the detonation. The water level in reentry well UC-1-P-2SR (elevation of 5620 ft msl in mid-2016) has increased more than 1800 ft in the last 40 years (Figure 5) and is expected to rise another 145 ft in the next 50 years (based on current trends) to eventually reach the water level in the alluvial aquifer in this area (elevation of approximately 5765 ft msl). The rate of water level rise in UC-1-P-2SR is decreasing as the recovery proceeds, and it is estimated that it will be a number of decades before the water level stabilizes.

Groundwater depth in the alluvium varies at the UC-1 site. Water levels in the alluvial aquifer within the graben are about 250 ft higher than those in the alluvium south of the southeast-bounding graben fault (Figure 4). Groundwater flow in the alluvial aquifer is controlled on a large scale by topography, which slopes from northwest to southeast in the vicinity of the site. Horizontal flow in the upper alluvium is toward the chimney, where the water level in well UC-1-P-2SR is still recovering from the detonation (Figure 4). Away from the influence of the chimney, horizontal flow is to the east-southeast and is likely diverted to the east-northeast by the southeast-bounding graben fault, which acts as a barrier to flow (DOE 2016a). Aquifer test results suggest that the hydraulic conductivity of the alluvial aquifer decreases with depth, grading from a productive aquifer in the upper alluvium tested in well UC-1-P-1SRC (hydraulic conductivity of 1.0 meters per day [m/day]) to a poor producer in the lower alluvium tested in wells MV-4 and MV-5 (hydraulic conductivity of 1.2×10^{-4} to 5.0×10^{-4} m/day). The low hydraulic conductivity of the lower part of the alluvial aquifer is more comparable to that of the densely welded tuff units tested in the MV-1, MV-2, and MV-3 wells (8.5×10^{-6} to 6.7×10^{-5} m/day) and is likely similar to the hydraulic conductivity of the upper part of the underlying volcanic sediments (DOE 2010).

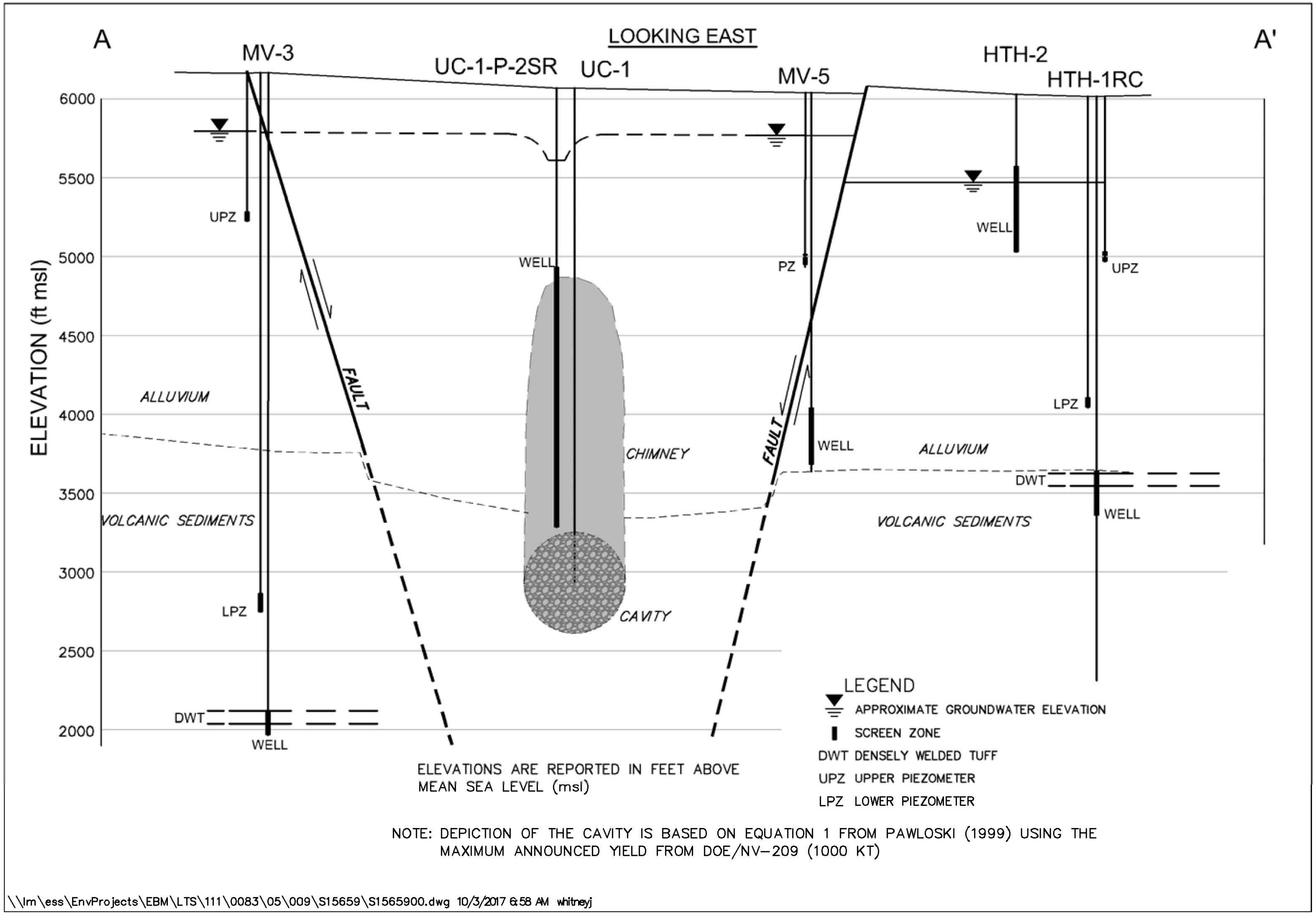

Figure 4. Cross Section View of A-A' Looking East

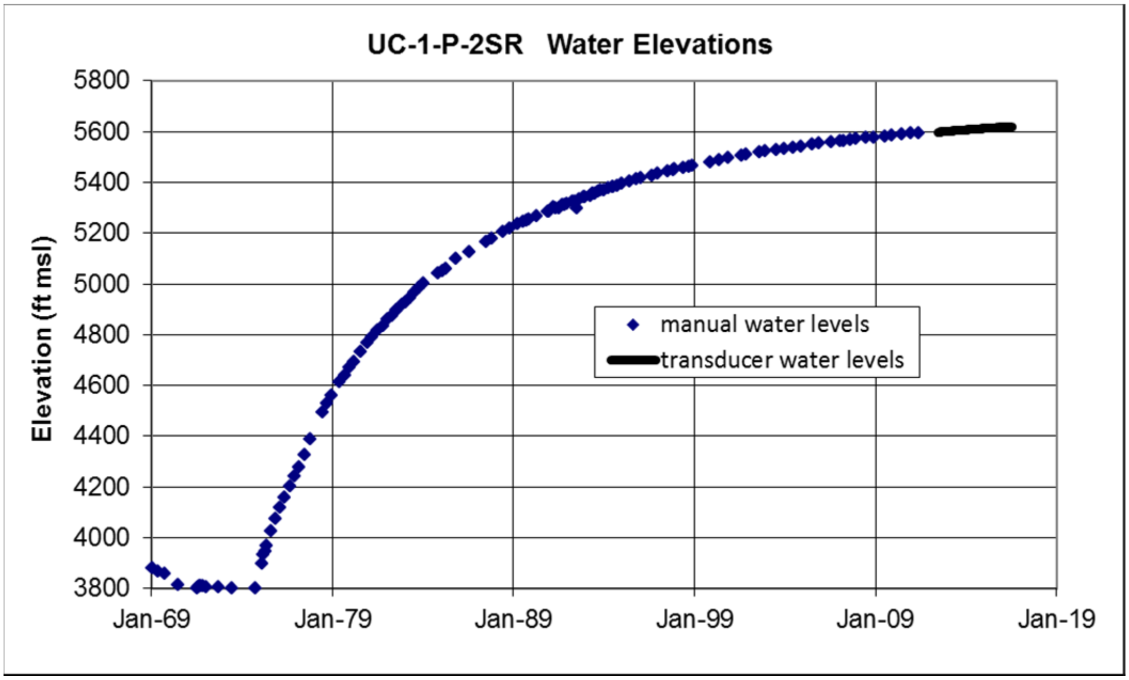

Figure 5. Water Elevations in Reentry Well UC-1-P-2SR
(http://nevada.usgs.gov/doe_nv/sitepage_temp.cfm?site_id=383806116125951)

Water elevations in the volcanic sediments are highest at the detonation depth, likely due to a detonation-related pressure response. This is most evident inside the graben where the water elevation is approximately 6015 ft msl in the MV-1 lower piezometer (LPZ) that is screened at the detonation depth. The water elevations at the site suggest that the most likely flow direction from the source zone is down, toward the densely welded tuff units (elevations of about 5560 ft msl). Wells MV-1, MV-2, and MV-3 are screened in densely welded tuff units near and below the source zone. Water elevations from these wells and interpretations on the geometry of the major graben faults at these depths, suggest a flow direction that is to the northeast in the densely welded tuff units. Aquifer tests performed on the MV-1, MV-2, and MV-3 wells indicate low hydraulic conductivity values ranging from 8.5×10^{-6} to 6.7×10^{-5} m/day (Lyles et al. 2006). The low hydraulic conductivities and anomalously long water level recovery time in UC-1-P-2SR (chimney) (Figure 5), is consistent with a detonation zone surrounded by low-permeability material.

3.0 Summary of Corrective Action Activities

Subsurface corrective action activities were completed in 2015, and are summarized in the Closure Report (DOE 2016a). The subsurface CAU 443 consists of three corrective action sites (CAS) UC-1 Cavity CAS 58-57-001, Emplacement Well UC-3 CAS 58-30-01, and Emplacement Well UC-4 CAS 58-30-02 (Figure 2). It was concluded during the corrective actions that the CAS associated with the UC-3 and UC-4 emplacement boreholes would require no further action and that corrective actions would focus on the UC-1 former cavity as the source of contamination for CAU 443 (DOE 1999). The corrective action alternative selected for UC-1 is proof-of-concept and monitoring with ICs (DOE 2004). The selected corrective action included establishing a monitoring program, use restrictions, and other ICs to protect human health and the environment.

The Closure Report provides justification for closure of CAU 443 and a summary of completed closure activities; describes the selected corrective action alternative; provides an implementation plan for long-term monitoring with well network maintenance and approaches/policies for ICs; and presents the contaminant, compliance, and use-restriction boundaries for the site (DOE 2016a). The environmental restoration and site closure process was conducted in accordance with the FFACO and all applicable NDEP policies and regulations.

3.1 Institutional Controls and Site Boundaries

The term "institutional controls," or "ICs," is used to broadly define the instruments (documents) and mechanisms (physical features) that are maintained to ensure long-term protectiveness of a site (DOE 2015b). ICs are part of the final remedy for CNTA, which was approved by NDEP in March 2016 (NDEP 2016). CNTA site lands are under federal jurisdiction, which controls land use. These lands (currently 2560 acres) are administered by BLM and the U.S. Forest Service as part of the Toiyabe National Forest, and current land use includes livestock grazing, ranching, and recreation. The total acreage is currently withdrawn from all forms of appropriation associated with mining laws and leasing through Public Land Orders 4338 and 4748, which prohibit future oil and gas leasing or mineral claims at the site. LM monitors the Nevada State websites responsible for leasing, mineral claims, and well permitting to ensure new activities do not impact the site. This includes inspecting the site annually for evidence of land use changes or significant land disturbances. It also includes evaluating the site roads and inspecting the monitoring network, the concrete caps that cover the UC-3 and UC-4 emplacement boreholes (Figure 2), and the UC-1 monument for signs of damage, natural deterioration from weather, or vandalism.

LM is working with BLM to expand the subsurface restrictions at the UC-1 site by expanding the UC-1 land withdrawal boundary to fully encompass the compliance boundary. The compliance boundary is the area within which the radioisotopes with concentrations above the Safe Drinking Water Act (SDWA) standards are to remain (DOE 2004). The compliance boundary is considerably larger than the model-predicted contaminant boundary that delineates the probable (95th percentile) extent of radioisotope-contaminated groundwater from the underground nuclear test would migrate over a 1000-year time period (Pohll et al. 2003). The lateral extent of contaminated groundwater in the subsurface represents the contaminant boundary perimeter when projected to the surface. Contaminated groundwater is defined as water with radioisotope concentrations that exceed the SDWA standards (FFACO 1996). The contaminant and compliance boundaries were approved in the Closure Report (DOE 2016a).

3.2 Migration Pathways and Monitoring Network

The monitoring well network is designed to monitor both the most likely transport path (densely welded tuff) near and below the source zone, and the most likely access path, the higher-permeability alluvial aquifer above the source zone (Table 1). The well network that monitors for the presence of radioisotopes in the densely welded tuff units includes wells MV-1, MV-2, MV-3, and HTH-1RC. Well HTH-1RC is screened above the detonation depth, but the original well casing remains open below the HTH-1RC well screen, allowing contribution from the volcanic section below the detonation depth (Figure 4). The MV-1 well is completed in the densely welded tuff below the detonation depth and is in the most likely flow direction from the source zone. The wells completed in densely welded tuff units are monitored for radioisotopes less frequently because of the low permeability and limited potential transport distances. Well UC-1-P-2SR is a near-field monitoring well that is screened in the chimney and upper portion of the alluvium (Figure 4).

Table 1. Monitoring Network with Zones of Completion and Unit Monitored

<table>
<tr><th>Monitoring Wells / Piezometers</th><th>TOC Elevation[a] (ft)</th><th>TSZ Elevation[a] (ft)</th><th>BSZ Elevation[a] (ft)</th><th>Screen Length (ft)</th><th colspan="2">Lithologic Unit Monitored</th></tr>
<tr><td>MV-1UPZ</td><td>6069.98</td><td>5190</td><td>5130</td><td>60</td><td rowspan="9">Upper</td><td rowspan="13">Alluvium</td></tr>
<tr><td>MV-2UPZ</td><td>6190.66</td><td>5230</td><td>5180</td><td>50</td></tr>
<tr><td>MV-3UPZ</td><td>6167.75</td><td>5287</td><td>5227</td><td>60</td></tr>
<tr><td>MV-4PZ</td><td>6019.45</td><td>5101</td><td>5041</td><td>60</td></tr>
<tr><td>MV-5PZ</td><td>6040.85</td><td>5023</td><td>4963</td><td>60</td></tr>
<tr><td>MV-6</td><td>6053.84</td><td>5215</td><td>5052</td><td>163</td></tr>
<tr><td>UC-1-P-1SRC</td><td>6031.58</td><td>5520</td><td>5458</td><td>62</td></tr>
<tr><td>HTH-2</td><td>6026.05</td><td>5522</td><td>5026</td><td>496</td></tr>
<tr><td>HTH-1UPZ</td><td>6011.27</td><td>5033</td><td>4973</td><td>60</td></tr>
<tr><td>HTH-1LPZ</td><td>6011.31</td><td>4113</td><td>4053</td><td>60</td><td rowspan="3">Lower</td></tr>
<tr><td>MV-4</td><td>6019.57</td><td>4300</td><td>3996</td><td>304</td></tr>
<tr><td>MV-5</td><td>6041.85</td><td>4203</td><td>3879</td><td>324</td></tr>
<tr><td>UC-1-P-2SR[b]</td><td>6080.51</td><td>4933</td><td>3320</td><td>1644</td><td>Chimney</td></tr>
<tr><td>MV-1LPZ</td><td>6069.91</td><td>3067</td><td>3007</td><td>60</td><td rowspan="2">Tuffaceous Sediments</td><td rowspan="7">Volcanic</td></tr>
<tr><td>MV-3LPZ</td><td>6167.69</td><td>2867</td><td>2747</td><td>120</td></tr>
<tr><td>MV-1</td><td>6070.57</td><td>2319</td><td>2160</td><td>160</td><td rowspan="5">Densely Welded Tuff</td></tr>
<tr><td>MV-2LPZ</td><td>6190.39</td><td>2643</td><td>2583</td><td>60</td></tr>
<tr><td>MV-2</td><td>6190.66</td><td>3150</td><td>2987</td><td>163</td></tr>
<tr><td>MV-3</td><td>6168.27</td><td>2121</td><td>1959</td><td>162</td></tr>
<tr><td>HTH-1RC</td><td>6011.70</td><td>3654</td><td>3354</td><td>300</td></tr>
</table>

Notes:
Coordinate system used herein is U.S. State Plane System 1927 (Nevada Central Zone), Vertical Datum, NGVD29.
[a] All elevations are corrected for true vertical depth and reported in units of ft msl.
[b] UC-1-P-2SR well is perforated, not screened.

Abbreviations:
BSZ = bottom of open interval/screen zone
TOC = top of casing
TSZ = top of open interval/screen zone

The alluvial aquifer monitoring network includes wells and piezometers that surround the portion of the chimney that extends into the alluvium. The alluvial monitoring network includes wells MV-4, MV-5, MV-6, UC-1-P-1SRC, and HTH-2, and piezometers MV-1UPZ and MV-4PZ (Table 1). Wells MV-4, MV-5, MV-6 and UC-1-P-1SRC will be sampled at an increased frequency because of their proximity to the chimney. Well HTH-2 will be sampled less frequently because it is outside the graben and further from the chimney. The piezometers MV-4PZ and MV-1UPZ are not designed to be efficiently sampled and have a small diameter casing (1.9-inch inside diameter); these will be sampled on a less frequent schedule. Table 1 provides the zone of completion (top and bottom) with elevations and lithologic unit monitored by wells and piezometers in the monitoring network. Piezometers are distinguished from the wells by the notation "PZ." For locations with two piezometers, "UPZ" and "LPZ" are used to denote the upper piezometer and lower piezometer, respectively.

3.3 Action Levels

The Closure Report (DOE 2016a) established the compliance levels and the laboratory-required minimum detectable concentrations (MDC) for the radioisotopes of interest (tritium, carbon-14 [^{14}C], and iodine-129 [^{129}I]). The compliance levels for these radioisotopes are consistent with the current SDWA maximum contaminant levels (MCL) of 20,000 picocuries per liter (pCi/L) for tritium, 2000 pCi/L for ^{14}C, and 1 pCi/L for ^{129}I. The laboratory required MDC is 400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I. The laboratory required MDC are also referred to as the laboratory required detection limit (RDL) used in previous groundwater monitoring reports (DOE 2015c). The compliance levels and laboratory-required MDCs were used to establish the action levels for the site (Table 2). If an action level is exceeded, LM will provide the required notifications to NDEP within 90 days of receiving the laboratory analytical results. Table 2 provides the laboratory-required MDCs, compliance levels/MCLs, and action levels with the NDEP notification requirements.

Table 2. Monitoring Network with Action Levels for Radioisotopes of Interest

<table>
<tr><th rowspan="3">Monitoring Wells / Piezometers</th><th colspan="5">Action Levels for Radioisotopes of Interest</th><th rowspan="3" colspan="2">Lithologic Unit Monitored</th></tr>
<tr><th>Inside Contaminant Boundary</th><th colspan="3">Outside Contaminant Boundary, but Inside Compliance Boundary</th><th>Outside Compliance Boundary</th></tr>
<tr><th>>MCL</th><th>>2x MDC</th><th>>0.5 MCL</th><th>>MCL</th><th>>2x MDC</th></tr>
<tr><td>MV-1UPZ</td><td></td><td></td><td></td><td></td><td>Notify NDEP 3</td><td rowspan="11">Upper</td><td rowspan="15">Alluvium</td></tr>
<tr><td>MV-2UPZ</td><td></td><td></td><td></td><td></td><td>Notify NDEP 3</td></tr>
<tr><td>MV-3UPZ</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>MV-4PZ</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>MV-5PZ</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>MV-6</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>UC-1-P-1SRC</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>UC-1-P-2SR (depth 780 ft)</td><td>Notify NDEP 1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>UC-1-P-2SR (depth 1200 ft)</td><td>Notify NDEP 1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTH-2</td><td></td><td></td><td></td><td></td><td>Notify NDEP 3</td></tr>
<tr><td>HTH-1UPZ</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTH-1LPZ</td><td></td><td></td><td></td><td></td><td></td><td rowspan="3">Lower</td></tr>
<tr><td>MV-4</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>MV-5</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>UC-1-P-2SR (depth 1591 ft)</td><td>Notify NDEP 1</td><td></td><td></td><td></td><td></td><td rowspan="2">Chimney</td></tr>
<tr><td>UC-1-P-2SR (depth 2192 ft)</td><td>NA</td><td></td><td></td><td></td><td></td><td rowspan="8">Volcanic</td></tr>
<tr><td>MV-1LPZ</td><td></td><td></td><td></td><td></td><td></td><td rowspan="2">Tuffaceous Sediments</td></tr>
<tr><td>MV-3LPZ</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-1</td><td></td><td></td><td></td><td></td><td>Notify NDEP 3</td><td rowspan="5">Densely Welded Tuff</td></tr>
<tr><td>MV-2LPZ</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-2</td><td></td><td></td><td></td><td></td><td>Notify NDEP 3</td></tr>
<tr><td>MV-3</td><td></td><td>Notify NDEP 1</td><td>Notify NDEP 2</td><td>Notify NDEP 3</td><td></td></tr>
<tr><td>HTH-1RC</td><td></td><td></td><td></td><td></td><td>Notify NDEP 3</td></tr>
</table>

Notes:
All notifications (email or telephone call) shall be within 90 calendar days of receiving analytical data from laboratory.
Radioisotopes of Interest are tritium, ^{14}C, and ^{129}I.
MCL are SDWA maximum contaminant levels: 20,000 pCi/L for tritium, 2000 pCi/L for ^{14}C, and 1 pCi/L for ^{129}I.
>0.5 MCL are concentrations greater than 10,000 pCi/L for tritium, 1000 pCi/L for ^{14}C, and 0.5 pCi/L for ^{129}I.
MDC levels required by laboratory are: 400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I.
>2x MDC are concentrations greater than 800 pCi/L for tritium, 10 pCi/L for ^{14}C, and 0.2 pCi/L for ^{129}I.
Notify NDEP 1 indicates only notification, no action, is required.
Notify NDEP 2 indicates the sampling plan (sampling locations and frequency) should be modified in consultation with NDEP.
Notify NDEP 3 indicates a new strategy / path forward (new monitoring wells may be required) should be developed in consultation with NDEP.
NA indicates no action required because the sample location is inside the contaminant boundary and has detections above the MCL.

4.0 Postclosure Monitoring and Results

The Closure Report (DOE 2016a) established the long-term postclosure monitoring program and site inspection requirements for the site. The postclosure monitoring program is designed to (1) assess the effectiveness of the compliance boundary by monitoring for the radioisotopes of interest and (2) evaluate the effectiveness of monitoring locations within the groundwater flow system by monitoring water elevations to ensure that monitoring wells are located along the potential migration pathways. This includes annual site inspections to maintain the ICs and ensure protectiveness of the site. The long-term monitoring program will be reviewed periodically and will be revised as necessary to adequately track changes in radioisotope concentrations and stability of the flow system over time.

The postclosure monitoring program was initiated after NDEP approved the Closure Report in 2016. The 2016 sampling program was specified in the July 2016 Environmental Sampling notification letter (DOE 2016b) that was provided to NDEP. Section 4.1 provides the results from the site inspection and Sections 4.2 through 4.5 describe results from the monitoring program.

4.1 Site Inspection and Maintenance Activities

Site inspections (also conducted as part of the postclosure inspection of CAU 417) are conducted annually to look for evidence of land use changes or significant land disturbances and to ensure that the ICs are maintained and continue to be effective. This includes evaluating the site roads and inspecting the monitoring network well boxes, the concrete caps that cover the UC-3 and UC-4 boreholes, and the UC-1 monument plaque at surface ground zero (SGZ) for signs of damage, natural deterioration from weather, or vandalism. The annual site inspection was conducted during the July 2016 monitoring event. The UC-1 site features (roads, wellheads, and monument at SGZ) and concrete cap that covers the UC-3 borehole were all in good condition at the time of the inspection. The concrete cap that covers the UC-4 borehole has some deterioration from weathering that is typical for the age of the concrete. The weathering is considered cosmetic, because a steel plate welded to the borehole casings beneath the concrete prevents access to the borehole. Appendix A provides photographs of the UC-1 monument at SGZ and the concrete caps that cover the UC-3 and UC-4 boreholes.

Additional inspection and maintenance activities and the results are provided below:

- The State of Nevada, Division of Water Resources website was accessed to determine if any new groundwater wells had been permitted within 5 miles of the UC-1 site. No new groundwater wells were permitted in the search area during this reporting period (NDWR 2017).
- The University of Nevada, Reno website was accessed to determine if any oil and gas wells had been permitted within 5 miles of the UC-1 site. No oil and gas wells were permitted in the search area during this reporting period (UNR 2017).
- The LM public website was updated during this reporting period to include the updated Fact Sheet and the Closure Report (DOE 2016a), which can be accessed at https://www.lm.doe.gov/CNTA/Sites.aspx.

4.2 Water Level Monitoring

Water depths are measured manually at all wells and piezometers in the monitoring network (Table 3) during scheduled monitoring events and site inspections, using an electric water level tool. Water depths are also recorded more frequently using pressure transducers to detect short-term and long-term pressure changes within the different hydrostratigraphic units. Water levels are measured according to the procedures specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351) (SAP). The well and piezometer top of casing elevations are used to convert the water depths to water elevations, also referred to as hydraulic head in previous reports. The water elevations are used to monitor the quasi-steady state of the groundwater system and to evaluate the effectiveness of the monitoring well network with respect to potential migration pathways. Hydrographs of the water elevations are maintained and evaluated for wells completed in the same lithologic unit, having similar depths, or having similar locations (inside the graben or outside the graben).

Table 3. Monitoring Network July 2016 Water Depths and Water Elevations

Monitoring Wells / Piezometers	Date Measured	Water Depth (ft)	TOC Elevation[a] (ft)	Water Elevation[a] (ft)	Lithologic Unit Monitored	
MV-1UPZ	7/26/2016	317.55	6069.98	5752.43	Upper	Alluvium
MV-2UPZ	7/26/2016	402.85	6190.66	5787.81		
MV-3UPZ	7/26/2016	372.78	6167.75	5794.97		
MV-4PZ	7/26/2016	275.40	6019.45	5744.05		
MV-5PZ	7/26/2016	289.25	6040.85	5751.60		
MV-6	7/26/2016	313.05	6053.84	5740.79		
UC-1-P-1SRC	7/26/2016	281.59	6031.58	5749.99		
HTH-2	7/26/2016	557.20	6026.05	5468.85		
HTH-1UPZ	7/26/2016	543.78	6011.27	5467.49		
HTH-1LPZ	7/26/2016	541.89	6011.31	5469.42	Lower	
MV-4	7/26/2016	504.82	6019.57	5514.75		
MV-5	7/26/2016	560.10	6,041.85	5481.75		
UC-1-P-2SR	7/26/2016	461.10[b]	6080.51	5619.41[b]	Chimney	
MV-1LPZ	7/26/2016	55.00	6069.91	6014.91	Tuffaceous Sediments	Volcanic
MV-3LPZ	7/26/2016	204.76	6167.69	5962.93		
MV-1	7/26/2016	508.58	6070.57	5561.99	Densely Welded Tuff	
MV-2LPZ	7/26/2016	411.30	6190.39	5779.09		
MV-2	7/26/2016	376.94	6190.66	5813.72		
MV-3	7/26/2016	602.42	6168.27	5565.85		
HTH-1RC	7/26/2016	485.72	6011.70	5525.98		

Notes:
Coordinate system used herein is U.S. State Plane System 1927 (Nevada Central Zone), Vertical Datum, NGVD29.
[a] All elevations are corrected for true vertical depth corrected and reported in units of ft msl.
[b] UC-1-P-2SR water level and water elevation are a composite of the chimney and alluvium, in which it's perforated.

Abbreviation:
TOC = top of casing

4.3 Water Level Monitoring Results

Water depths were measured manually in the site wells and piezometers, and the transducer data were downloaded on July 26, 2016. The water elevations are presented as hydrographs from 2009 through the present. Water depths collected using a water level tool appear as individual symbols, and water depths collected with transducers appear as lines because the data is recorded every few hours. The hydrographs (Figure 6 through Figure 9) 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 depth (Figure 8); and the volcanic section with open intervals below the detonation depth (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. Abrupt changes in the data (e.g., Figure 7 data from MV-2UPZ in mid- and late-2009) are the result of imprecise readings at locations where manual water depth measurements are difficult to collect. The water elevations from wells and piezometers completed in the upper alluvial unit were contoured to provide a potentiometric surface within the graben (Figure 10). The water elevations are presented as hydrographs from when monitoring began in 2007 through July 2016 in Appendix B (Figures B-1 through B-4).

Figure 6 shows hydrographs from January 2009 through July 2016 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 water levels in wells MV-4 and MV-5 have only recently recovered from the 2010 aquifer testing and from the 2011 yearly sampling event during which several thousand gallons of water were purged. Low-flow bladder pumps were installed in wells MV-4 and MV-5 during the November 2013 sampling event to reduce the well purge volumes and the impact purging has on the water levels during sampling (DOE 2014). Water levels in well HTH-1RC continue to equilibrate after the recompletion in 2009. Prior to its recompletion, HTH-1 had been perforated across its entire saturated section, and its water level was a composite of several hydrostratigraphic units. The recompletion isolated zones in the upper and lower alluvium (HTH-1UPZ and HTH-1LPZ) and in the volcanic section (HTH-1RC). HTH-1RC isolated a densely welded tuff unit above the detonation depth, but the original well casing remains open below an obstruction at 2812 ft bgs (elevation of about 3200 ft msl) to the original depth of 3704 ft bgs (elevation of about 2300 ft msl), allowing contribution from the volcanic section below the detonation zone (Figure 4). The water elevation in the volcanic section (HTH-1RC) is higher than water elevations in both the upper and lower alluvial piezometers (HTH-1UPZ and HTH-1LPZ). This observation confirms that an upward gradient from the volcanic section to the alluvium exists in this area, as had been indicated by flow logging performed by Desert Research Institute in HTH-1 prior to the well's recompletion (DOE 2008). This hydrograph of water elevation is also presented in Appendix B as Figure B-1.

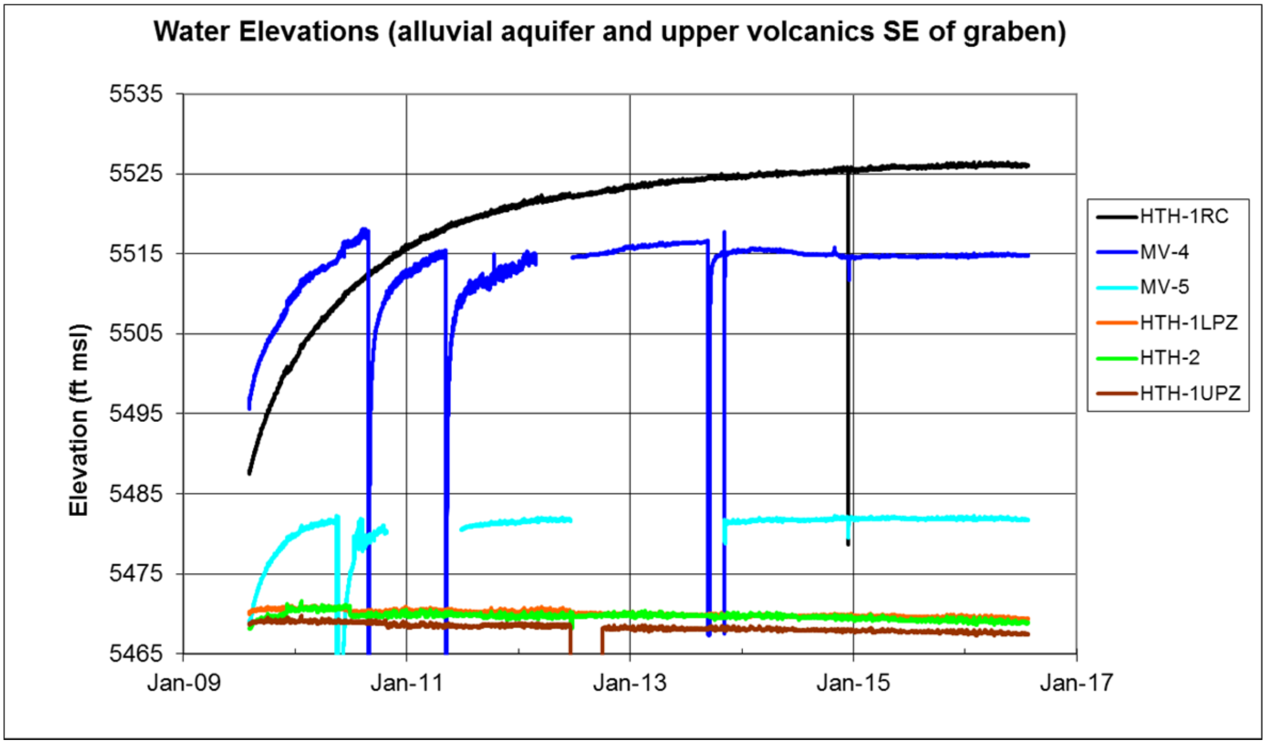

Figure 6. Water Elevations for the Alluvial Wells and Well HTH-1RC (Upper Volcanics) Southeast of the Down-Dropped Graben at the Screened Horizon

Figure 7 shows hydrographs from January 2009 through July 2016 of alluvial piezometers and wells within and northwest of the graben. Erratic water levels in upper piezometer MV-2UPZ (Figure 7) are attributed to damage during its installation. The lower water elevations observed after mid-2009 in the upper piezometers MV-1UPZ and MV-3UPZ are the results of attempts to further develop these piezometers. The recompletion of well UC-1-P-1S resulted in a screened interval about 400 ft above the previous open interval and a roughly 7 to 8 ft decrease in water elevation (Figure 7 and Figure B-2 in Appendix B). The new completion is more isolated from the influence of deeper horizons where water elevations have been higher. The water elevations in the piezometers MV-4PZ and MV-5PZ (screened inside the graben) 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). Given these results, alluvial aquifer hydrographs were separated into two groups based on their screened location relative to the southeast-bounding graben fault. Water elevations 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. Data are not available from well MV-6 for the time period of January 2016 through July 2016 because the battery in the transducer failed and the data could not be recovered. Figure B-2 in Appendix B provides the water elevation as hydrographs from when monitoring began in 2007 through July 2016.

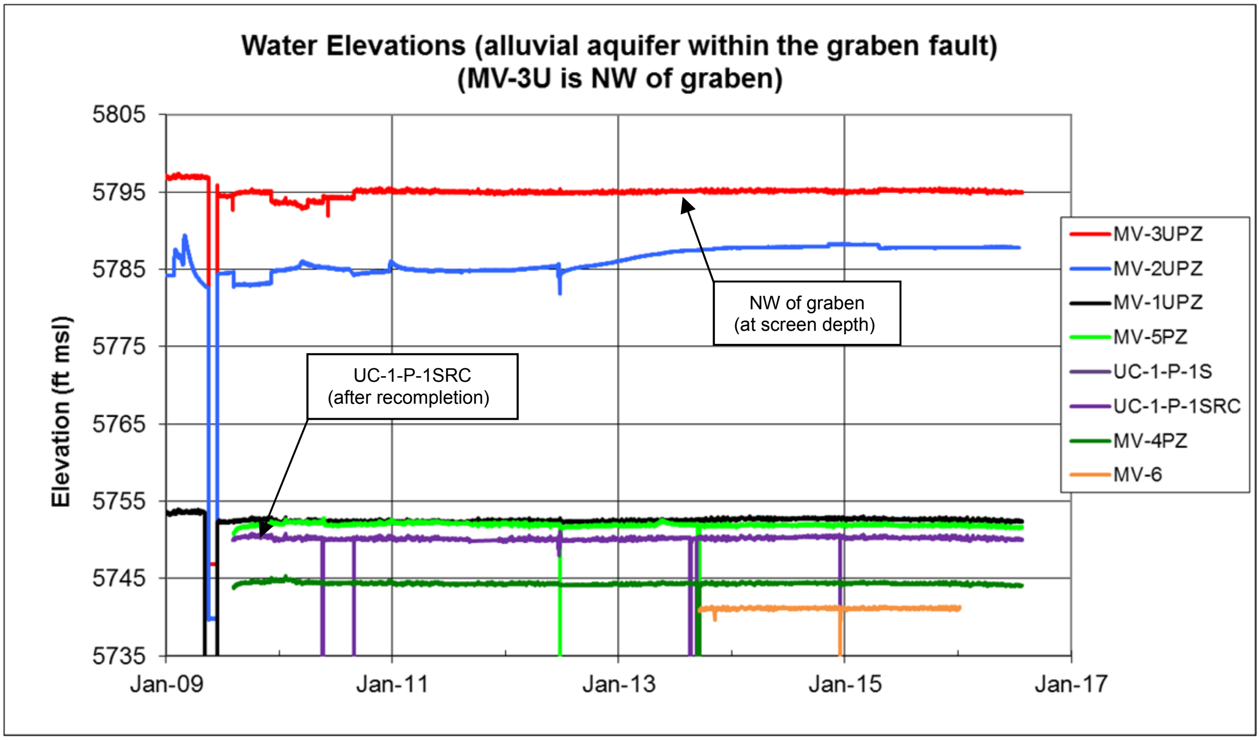

Figure 7. Water Elevations for the Alluvial Wells Northwest of the Southeast-Bounding Graben Fault

Figure 8 shows hydrographs from January 2009 through July 2016 of the well and piezometers with open intervals near the detonation depth. Water elevations in the well and piezometers at this depth have been declining since their installation in 2005 except for MV-1LPZ which had a rising water elevation after installation until 2011. Water elevations in MV-2LPZ have been decreasing at about the same rate (about 5 ft/year) as the other wells and piezometers screened in the volcanic section since 2012. The declining water elevations (highest observed in the volcanic section) are attributed to a slow release of the detonation-related pressure response that persists due to the low permeability of the volcanic section.

The highly variable water levels in the MV-2LPZ (Figure 8) were investigated by Desert Research Institute on August 5, 2008. They ran a temperature log, collected a bailed sample, and measured the depth of the lower piezometer (MV-2LPZ). It was determined that sediment had filled MV-2LPZ to a depth 75 ft above the top of the screened interval. Additional development of this piezometer in the summer of 2009 lowered the sediment fill to the top of the screened interval. Water elevations in MV-2LPZ appeared to recover in 2010 from the development, then steadily declined (at a decreasing rate) through 2011 and into 2012, when the water level dropped approximately 10 ft after well MV-2 was sampled. After this monitoring event, the water levels in the lower piezometer MV-2LPZ recovered and then reverted to a decreasing trend. The proximity of the MV-2LPZ screened interval to the northwest-bounding graben fault is believed to be the cause of its erratic water levels. It is expected that water levels southeast of this fault (within the graben) are higher than water levels to the northwest, outside the graben. The abrupt water level increase (MV-2LPZ) in June 2010 followed by an abrupt decrease in June 2012 is the result of the installation (2010) and subsequent removal (2012) of a direct-read transducer with a ¼-inch cable. The transducer was placed more than 200 ft below water in case another sudden water level drop like the one in 2008 were to occur. The slow recovery of water levels in MV-2LPZ in response to what should be minor perturbations attests to the low permeability of the section. Figure B-3 in Appendix B provides the water elevations as hydrographs from when monitoring began in 2007 through July 2016.

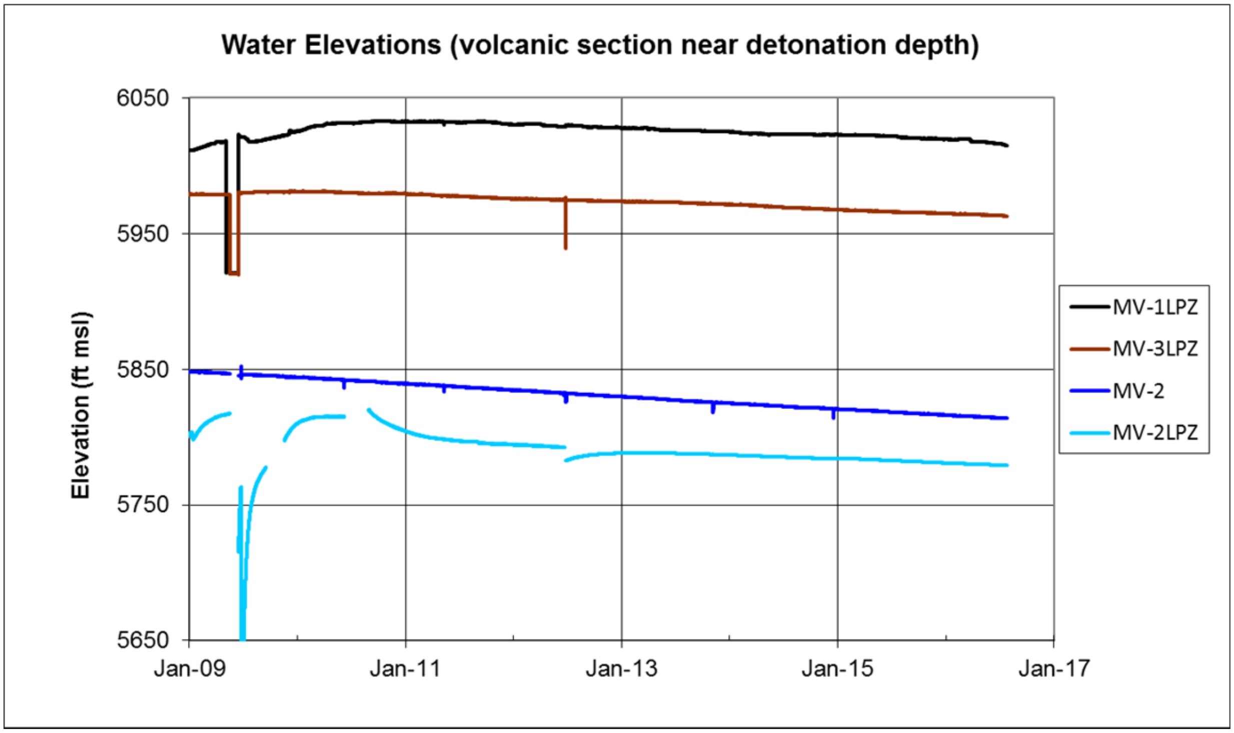

Figure 8. Water Elevations for the Well and Piezometers Screened in the Volcanic Section at or near the Depth of the Detonation

Figure 9 shows hydrographs from January 2009 through July 2016 of wells with open intervals below the detonation depth and reentry well UC-1-P-2SR. The composite water level from UC-1-P-2SR (chimney and alluvium overlying the former cavity) is higher than in the densely welded tuff units below the detonation zone. The composite water elevation of 5619 ft msl measured in July 2016 (Table 3) continues to increase, though at a long-term decreasing rate. Well UC-1-P-2SR has perforations as high as 1148 ft bgs in the alluvium, and its water level is expected to eventually reach a steady-state elevation of approximately 5765 ft msl (similar to other alluvial wells and piezometers within the graben). Figure B-4 in Appendix B provides the water elevations as hydrographs from when monitoring began in 2007 through July 2016.

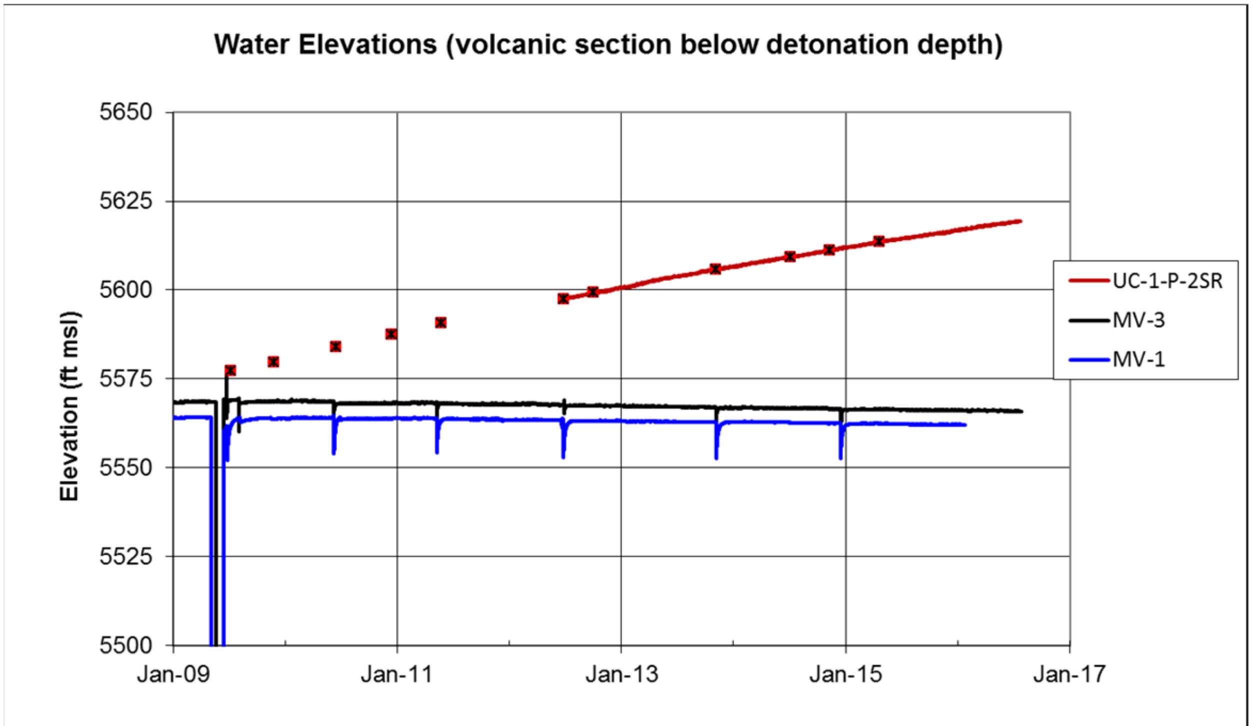

Figure 9. Water Elevations for the Wells Screened in the Volcanic Section Below the Depth of the Detonation
(Water elevations for reentry well UC-1-P-2SR [drilled into the chimney] are shown for reference.)

A potentiometric map of the upper part of the alluvial aquifer within the graben (Figure 10) was constructed using the July 2016 water levels from MV-4PZ, MV-5PZ, MV-6, UC-1-P-1SRC, MV-1UPZ, and MV-2UPZ, all of which are screened at depths ranging from 600 to 1000 ft bgs. Contouring of the potentiometric surface (Figure 10) was restricted to the area within the graben. Contours near SGZ are based on the composite water level from well UC-1-P-2SR. The interpretation shown on Figure 10 suggests that horizontal flow in the upper alluvium is toward the chimney near SGZ. Away from the influence of the chimney, horizontal flow is to the east-southeast and is likely deflected by the southeast-bounding graben fault that is acting as a barrier to flow. As drawn, the contours indicate a dip reversal between the chimney and MV-6 that could gradually go away as water elevations in the alluvium above the detonation zone recover. Groundwater flow within the graben could eventually be to the east-southeast after water levels in the reentry well UC-1-P-2SR recover. Depiction of groundwater flow directions within the graben has an inherent degree of uncertainty, given the structural complexity caused by the detonation and the limited data available within the graben.

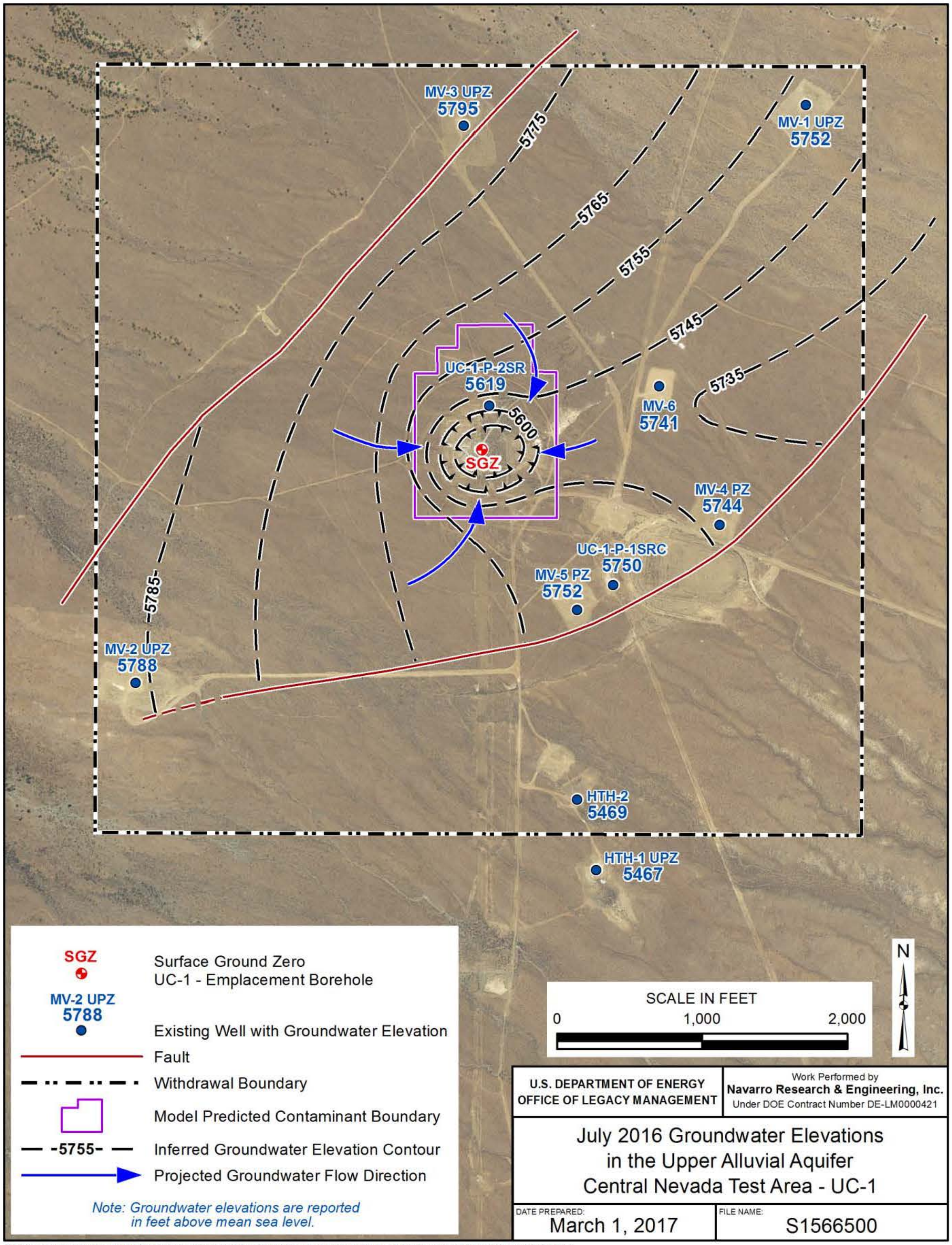

Figure 10. July 2016 Groundwater Elevations in the Upper Alluvial Aquifer CNTA—UC-1

4.4 Radioisotope Monitoring

The monitoring network and sampling frequency for the radioisotopes of interest is established in the Closure Report (DOE 2016a). The monitoring network is designed to monitor both the most likely transport path (densely welded tuff) near and below the source zone, and the most likely access path, the higher-permeability alluvial aquifer above the source zone. Since the alluvial unit is the most likely access path and has the highest groundwater velocities, the monitoring network wells completed in the alluvium are sampled at an increased frequency relative to the wells completed in the low-permeability, densely welded tuff units. Site sampling events are scheduled for every two years until 2020, when the sampling schedule changes to every three years. Water samples are collected according to the procedures specified in the SAP. The discharge and handling of monitoring well purge water are conducted in accordance with the *Fluid Management Plan, Central Nevada Test Area Corrective Action Unit 443* (DOE 2009).

The radioisotopes of interest for the long-term postclosure monitoring program are tritium, ^{14}C, and ^{129}I (DOE 2016a). Water samples will be analyzed for tritium during each scheduled sampling event. Water samples collected in 2020 will also be analyzed for ^{14}C and ^{129}I. These radioisotopes will be included in the analytical suite every 12 years starting in 2020. Tritium is currently the primary analyte of concern because of its initial abundance and mobility. After a few hundred years, tritium (with a half-life of 12.3 years) will decay to insignificant levels, and the longer-lived radioisotopes, ^{14}C (with a 5730-year half-life) and ^{129}I (with a 1.57×10^7-year half-life), will become the primary focus of the long-term postclosure monitoring. The Closure Report established compliance levels and laboratory-required MDC for the radioisotopes of interest (tritium, ^{14}C, and ^{129}I), which were used to establish action levels for the long-term postclosure monitoring program (DOE 2016a).

4.5 Radioisotope Results

Groundwater samples were collected from wells completed in the alluvium (MV-4, MV-5, MV-6, and UC-1-P-1SRC) and volcanic section (MV-1, MV-2, MV-3, and HTH-1RC) during the postclosure sampling event conducted July 26–27, 2016 (Table 4). Monitoring wells MV-1, MV-2, MV-3, MV-4, MV-5, and HTH-1RC, which are completed with bladder pumps, were purged to remove stagnant water from the pump tubing prior to sample collection. Monitoring wells MV-6 and UC-1-P-1SRC were purged prior to sampling using the dedicated electric submersible pumps. Field parameters (temperature, pH, and specific conductance) were allowed to stabilize before samples were collected. Table C-1 in Appendix C provides the field parameter measurements obtained during well-purging activities.

Groundwater samples collected during the July 2016 sampling event were analyzed for tritium. Laboratory analytical results (Table 4) indicate that tritium concentrations at the sampled locations were below the laboratory-required MDC. The analytical results were validated in accordance with Section 8.0 in the *Environmental Procedures Catalog* (LMS/POL/S04325), "Standard Practice for Validation of Environmental Data." All analyses were completed, and the samples were prepared and analyzed in accordance with accepted procedures that were based on the specified methods. The laboratory radiochemical MDC 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 on the LM public website, which can be accessed at https://www.lm.doe.gov/CNTA/Sites.aspx. Table 4 presents radioisotope sampling results for 2016. Analytical results from the original Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) monitoring program beginning in 2006 through the present are provided in Appendix D (Table D-1).

Table 4. Monitoring Network July 2016 Radioisotope Sampling Results

<table>
<tr><th>Monitoring Wells / Piezometers</th><th>Date Sampled</th><th>Tritium (pCi/L)</th><th>^{14}C (pCi/L)</th><th>^{129}I (pCi/L)</th><th colspan="2">Lithologic Unit Monitored</th></tr>
<tr><td>MV-1UPZ</td><td></td><td></td><td></td><td></td><td rowspan="9">Upper</td><td rowspan="13">Alluvium</td></tr>
<tr><td>MV-2UPZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-3UPZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-4PZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-5PZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-6</td><td>7/26/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td>UC-1-P-1SRC</td><td>7/26/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td>HTH-2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTH-1UPZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>HTH-1LPZ</td><td></td><td></td><td></td><td></td><td rowspan="3">Lower</td></tr>
<tr><td>MV-4</td><td>7/26/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td>MV-5</td><td>7/26/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td>UC-1-P-2SR</td><td></td><td></td><td></td><td></td><td>Chimney</td></tr>
<tr><td>MV-1LPZ</td><td></td><td></td><td></td><td></td><td rowspan="2">Tuffaceous Sediments</td><td rowspan="8">Volcanic</td></tr>
<tr><td>MV-3LPZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-1</td><td>7/27/2016</td><td><MDC</td><td>NS</td><td>NS</td><td rowspan="6">Densely Welded Tuff</td></tr>
<tr><td>MV-2LPZ</td><td></td><td></td><td></td><td></td></tr>
<tr><td>MV-2</td><td>7/26/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td>MV-3</td><td>7/27/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td rowspan="2">HTH-1RC</td><td rowspan="2">7/26/2016</td><td><MDC</td><td>NS</td><td>NS</td></tr>
<tr><td><MDC[a]</td><td>NS</td><td>NS</td></tr>
</table>

Notes:
Shaded cells were not sampled because they were not part of the sampling network for this scheduled sampling event as established in Table 2 of the Closure Report (DOE 2016a).
[a] Duplicate sample.

Abbreviations:
NS = Not sampled because radioisotope was not part of the 2016 analytical suite established in the Closure Report.
<MDC = below laboratory-required MDC (400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I [DOE 2015c; DOE 2016a]).

5.0 Summary and Recommendations

The first site inspection and monitoring event under the Closure Report were conducted July 26–27, 2016. At the time of the inspection, the UC-1 site features (roads, wellheads, and UC-1 monument plaque at SGZ) all appeared to be in good condition and no unusual ground disturbances were observed. The concrete caps that cover the UC-3 and UC-4 boreholes have some deterioration from weathering, typical for the age of the concrete, and remain protective. No groundwater well or oil and gas permits were granted within 5 miles of the UC-1 site.

The sample analytical results indicate tritium was not detected above the laboratory-required MDC in all sampled wells in the monitoring network. These sample results, along with past results, support the determination that radioisotopes of interest have not migrated outside the compliance boundary. Water elevations continue to support the interpretations of flow directions and the adequacy of the monitoring network at the site. Water levels in the reentry well UC-1-P-2SR continue to recover from the dewatering effects of the detonation. Water levels in this well have risen 100 ft since 2002 (5 ft in 2016) and are projected to rise another 145 ft over the next 50 years (based on current trends). The currently depressed water levels in this area direct groundwater flow in the alluvial aquifer near SGZ toward the chimney. In the volcanic section, water levels from well UC-1-P-2SR also indicate a downward gradient from the source zone to the densely welded tuff units below the detonation depth. The downward gradient could increase as water levels continue to recover in the chimney. Water level data from the piezometer (screened inside the graben) and well (screened outside the graben) at the MV-4 and MV-5 locations continue to confirm that the southeast-bounding graben fault acts as a barrier to groundwater flow.

LM recommends the following:

- Conduct the annual site inspections as prescribed in the Closure Report.
- Conduct the postclosure groundwater sampling in 2018 as prescribed in the Closure Report.
- Complete the next Postclosure Groundwater Monitoring and Inspection Report (2016 through 2018) after the sampling in 2018 as prescribed in the Closure Report.

6.0 References

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

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

DOE (U.S. Department of Energy), 2005. *Central Nevada Test Area, Environmental Management End State Vision, Final*, DOE/NV-954, National Nuclear Security Administration/Nevada Site Office, Las Vegas, Nevada, January.

DOE (U.S. Department of Energy), 2006. *Well Installation Report for Corrective Action Unit 443, Central Nevada Test Area, Nye County, Nevada*, DOE/NV-1102, National Nuclear Security Administration, Environmental Restoration Division, Nevada Site Office, Las Vegas, Nevada, January.

DOE (U.S. Department of Energy), 2008. *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), 2009. *Fluid Management Plan Central Nevada Test Area Corrective Action Unit 443*, LMS/CNT/S03736, Office of Legacy Management, Grand Junction, Colorado, January.

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

DOE (U.S. Department of Energy), 2014. *2013 Groundwater Monitoring Report Central Nevada Test Area, Subsurface Corrective Action Unit 443*, LMS/CNT/S11448, Office of Legacy Management, Grand Junction, Colorado, May.

DOE (U.S. Department of Energy), 2015a. *United States Nuclear Tests, July 1945 through September 1992,* DOE/NV—209-Rev 16, National Nuclear Security Administration, Nevada Field Office, September.

DOE (U.S. Department of Energy), 2015b. *Guidance for Developing and Implementing Institutional Controls for Long-Term Surveillance and Maintenance at DOE Legacy Management Sites*, DOE/LM-1414, Office of Legacy Management, January.

DOE (U.S. Department of Energy), 2015c. *2014 Groundwater Monitoring Report Central Nevada Test Area, Subsurface Corrective Action Unit 443*, LMS/CNT/S12305, Office of Legacy Management, Grand Junction, Colorado, April.

DOE (U.S. Department of Energy), 2016a. *Closure Report Central Nevada Test Area Subsurface Corrective Action Unit 443*, LMS/CNT/S12760, Office of Legacy Management, Grand Junction, Colorado, January.

DOE (U.S. Department of Energy), 2016b. *July 2016 Environmental Sampling at Central Nevada Test Area, Nevada, Site* Office of Legacy Management, Grand Junction, Colorado, July.

Environmental Procedures Catalog (LMS/POL/S04325), continually updated, prepared by Navarro Research and Engineering, Inc., for the U.S. Department of Energy Office of Legacy Management.

FFACO (Federal Facility Agreement and Consent Order), 1996 (as amended 2011). Agreed to by the State of Nevada, the U.S. Department of Energy, and the U.S. Department of Defense.

Lyles, B.F., P. Oberlander, D. Gillespie, D. Donithan, and J. Chapman, 2006. *Hydrologic Data and Evaluation for Wells Near the Faultless Underground Nuclear Test, Central Nevada Test Area*, DOE/NV/13609-49, Las Vegas, NV: Desert Research Institute, Publication No. 45219.

McKeown, F.A., D.D. Dickey, and W.L. Ellis, 1968. "Preliminary Report on the Geologic Effects of the Faultless Event," U.S. Geological Survey Report 474-65.

McKeown, F.A., and D.D. Dickey, 1969. "Fault displacements and motion related to nuclear explosions," *Bulletin of the Seismological Society of America* 59(6): 2253–2269.

NDEP (Nevada Division of Environmental Protection), 2016. *Closure Report Central Nevada Test Area Subsurface Corrective Action Unit 443 Federal Facility Agreement and Consent Order,* letter dated March 15, 2016.

NDWR (Nevada Division of Water Resources), 2017. "Nevada Division of Water Resources, Well Log Database Query Tool," https://water.nv.gov/data/welllog/index.cfm, accessed March 3, 2017.

Pawloski, G.A., 1999. Development of Phenomenological Models of Underground Nuclear Tests on Pahute Mesa, Nevada Test Site—Benham and Tybo, UCRL-ID-136003, Livermore, CA. (Using maximum yield and Equation 1, https://tinyurl.com/lmchw99).

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.

Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites (LMS/PRO/S04351), continually updated, prepared by Navarro Research and Engineering, Inc., for the U.S. Department of Energy Office of Legacy Management.

State of Nevada, DOE (U.S. Department of Energy), and DOD (U.S. Department of Defense), 1996 (as amended). *Federal Facility Agreement and Consent Order*.

UNR (University of Nevada Reno), 2017. "University of Nevada Reno, Oil and Gas Well Search" https://www.nbmg.unr.edu/Oil&Gas/WellSearch.html, accessed March 6, 2017.

Appendix A

Photographic Documentation

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Figure A-1. Photo Showing the Concrete Cap that Covers the UC-3 Emplacement Borehole

Figure A-2. Photo Showing the Concrete Cap that Covers the UC-4 Emplacement Borehole

Figure A-3. Photo Showing the UC-1 Monument Plaque on the Emplacement Borehole Casing

Appendix B

Hydrographs of Water Elevation Data: 2007 Through the Present

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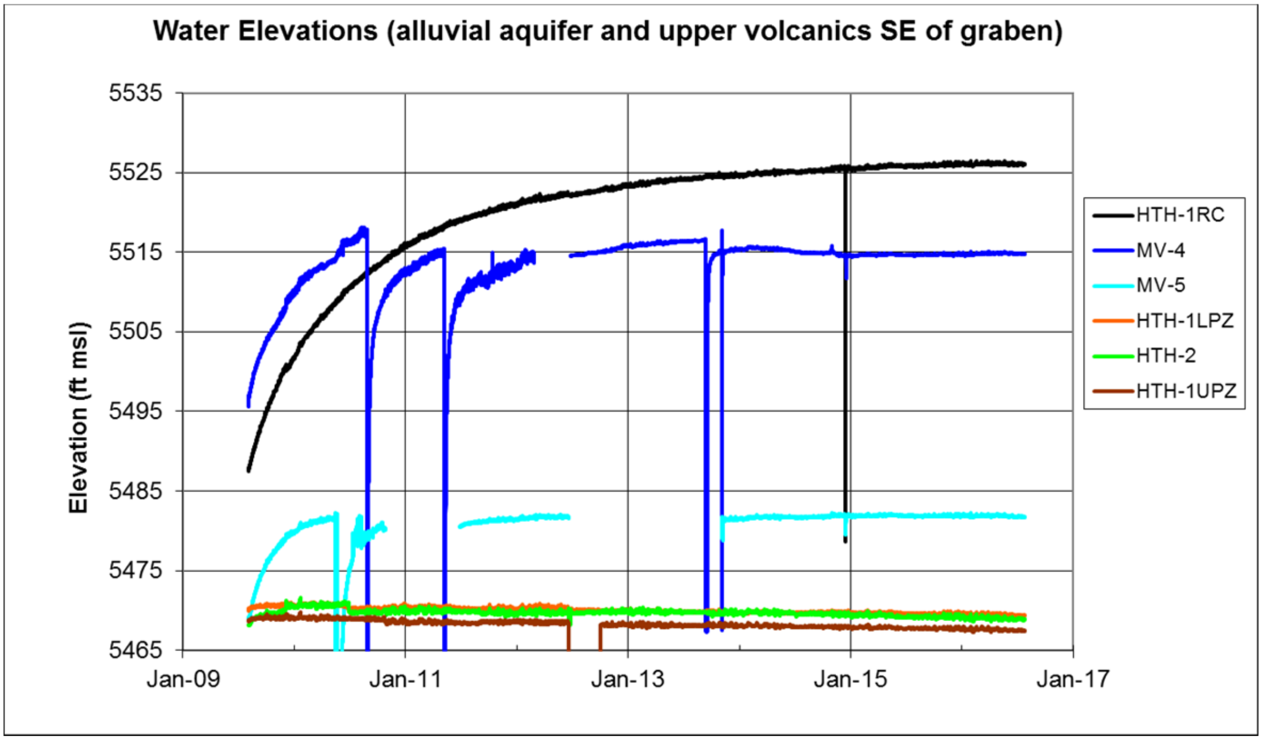

Figure B-1. Water Level Elevations for Alluvial Wells and Well HTH-1RC (upper volcanics) Southeast of the Down-Dropped Graben at the Screened Horizon

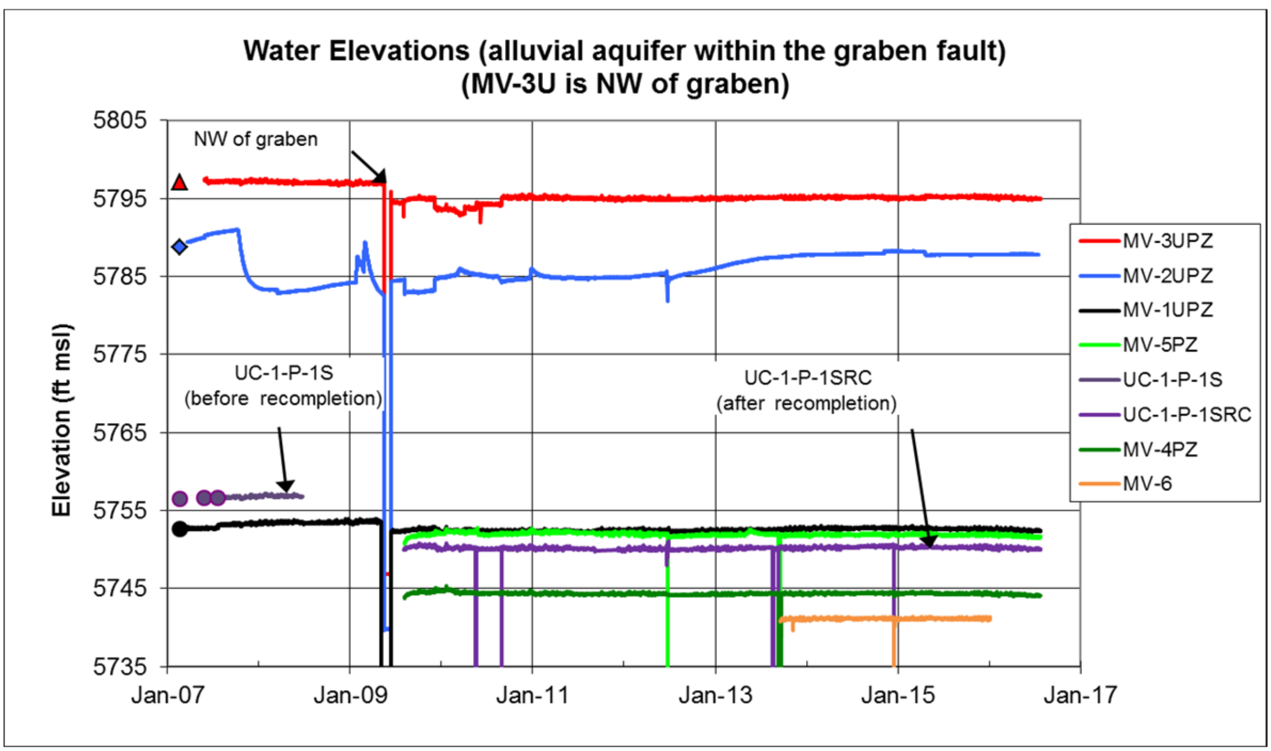

Figure B-2. Water Level Elevations for Alluvial Wells Northwest of the Southeast-Bounding Graben Fault

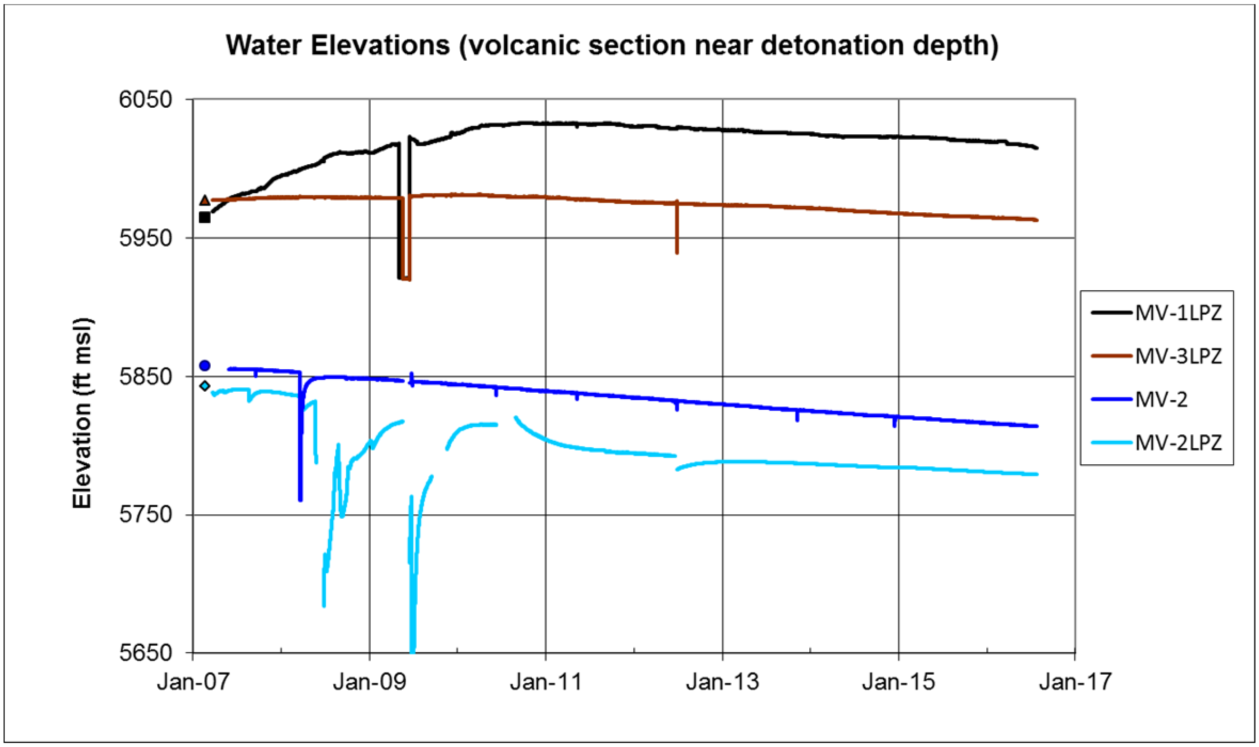

Figure B-3. Water Level Elevations for the Well and Piezometers Screened in the Volcanic Section at or near the Level of the Detonation

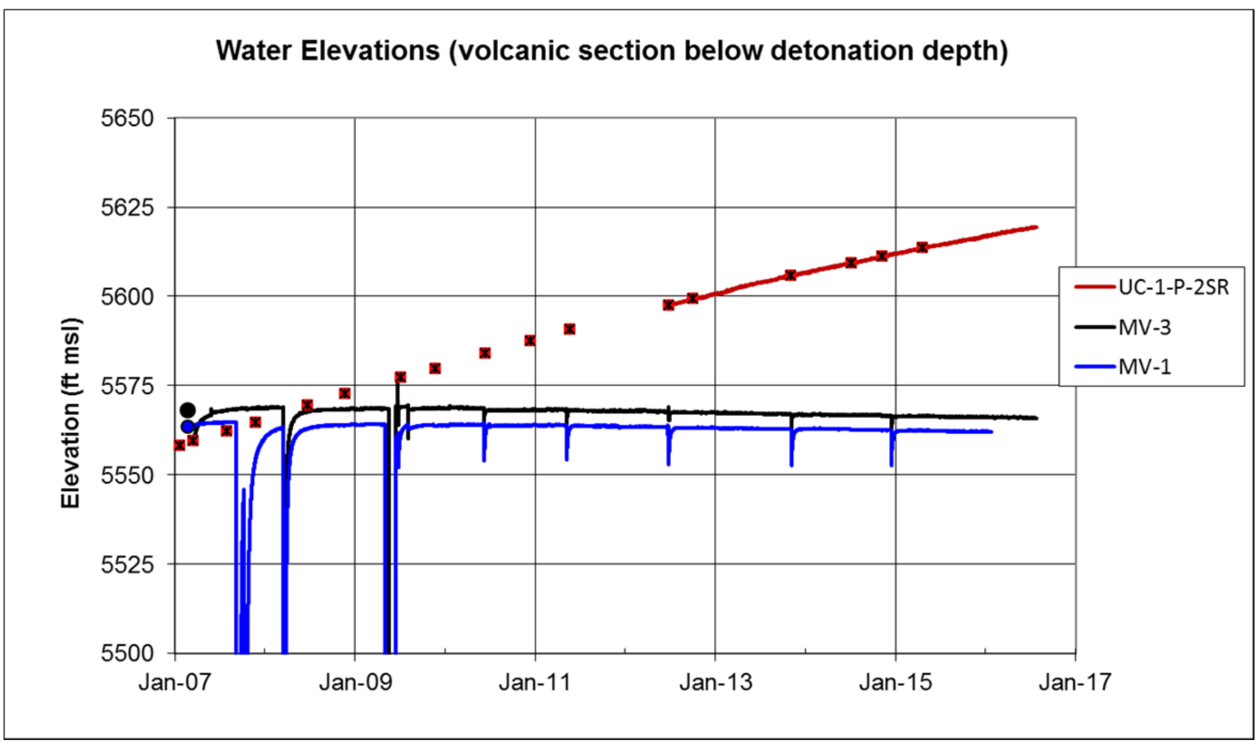

Figure B-4. Water Level Elevations for Wells Screened in the Volcanic Section Below the Level of the Detonation

Appendix C

Well Purge Data

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Table C-1. Monitoring Well Purge Data

Well Identification	Date Sampled	Purged Volume (gallons)	Temperature (°C)	pH (s.u.)	Specific Conductance (µmho/cm)
HTH-1RC	7/26/2016	6.5	17.5	7.7	564
MV-1	7/27/2016	10	17.7	9.2	461
MV-2	7/26/2016	8.1	17.8	10.8	1800
MV-3	7/27/2016	10.1	18.6	6.6	898
MV-4	7/26/2016	4.6	20.3	9.0	443
MV-5	7/26/2016	5.1	18.4	9.7	546
MV-6	7/26/2016	950	20.9	7.5	200
			20.9	7.5	200
			20.9	7.0	197
UC-1-P-1SRC	7/26/2016	600	19.4	7.2	306
			19.5	7.2	304
			18.9	7.0	301

Abbreviations:
µmho/cm = micromhos per centimeter
s.u. = standard unit

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Appendix D

Analytical Data: 2006 Through the Present

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Table D-1. Radioisotopic Sample Results

Monitoring Location	Date	^{14}C (pCi/L)	^{129}I (pCi/L)	Tritium (pCi/L)
MV-1	2/14/2006[b]	<RDL (1.12×10^{-2})	<RDL (1.51×10^{-7})	<RDL
	9/21/2006[b]	<RDL (5.61×10^{-2})	<RDL (2.90×10^{-7})	<RDL
	2/22/2007	NS	NS	NS
	10/10/2007	<RDL (7.40×10^{-3}) [d]	<RDL (5.70×10^{-11})	<RDL
	3/19/2008	NS	NS	PF
	6/26/2009	<RDL (2.46×10^{-2}) [d]	NR	<RDL
	6/09/2010	NS	<RDL (10.4×10^{-10})	<RDL
	6/09/2010[c]	NS	<RDL (10.8×10^{-10})	<RDL
	5/10/2011	NS	NS	<RDL
	6/26/2012	NS	NS	<RDL
	11/06/2013	<RDL (4.76×10^{-2}) [e]	<RDL (1.75×10^{-10})	<RDL
	12/16/2014	NS	NS	<RDL
	7/27/2016	NS	NS	<RDL
MV-2	3/16/2006[b]	<RDL (9.92×10^{-2})	<RDL (2.58×10^{-7})	<RDL
	9/22/2006[b]	<RDL (1.30×10^{-2})	<RDL (2.60×10^{-7})	<RDL
	2/22/2007	<RDL (1.54×10^{-3}) [d]	<RDL (9.70×10^{-11})	<RDL
	2/22/2007[c]	<RDL (1.84×10^{-3}) [d]	<RDL (11.1×10^{-11})	<RDL
	3/19/2008	NS	NS	<RDL
	6/26/2009	<RDL (5.55×10^{-3}) [d]	NR	<RDL
	6/08/2010	NS	<RDL (10.9×10^{-10})	<RDL
	5/11/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/07/2013	<RDL (2.20×10^{-2}) [e]	<RDL (1.24×10^{-10})	<RDL
	12/16/2014	NS	NS	<RDL
	7/26/2016	NS	NS	<RDL
MV-2LPZ[a]—Sample depth 490 ft	8/5/2008	NS	NS	<8000
MV-2LPZ[a]—Sample depth 3471 ft	8/5/2008	NS	NS	<8000
MV-3	3/16/2006[b]	<RDL (3.95×10^{-2})	<RDL (2.10×10^{-7})	<RDL
	9/22/2006[b]	<RDL (5.11×10^{-2})	<RDL (2.20×10^{-7})	<RDL
	2/22/2007	<RDL (1.01×10^{-2}) [d]	<RDL (14.0×10^{-11})	<RDL
	3/19/2008	NS	NS	<RDL
	6/25/2009	<RDL (3.87×10^{-2}) [d]	NR	<RDL
	6/08/2010	NS	<RDL (14.2×10^{-9})	<RDL
	5/10/2011	NS	NS	<RDL
	6/26/2012	NS	NS	<RDL
	11/05/2013	<RDL (6.58×10^{-2}) [e]	<RDL (7.32×10^{-10})	<RDL
	12/17/2014	NS	NS	<RDL
	7/27/2016	NS	NS	<RDL

Monitoring Location	Date	^{14}C (pCi/L)	^{129}I (pCi/L)	Tritium (pCi/L)
MV-4	6/24/2009	<RDL (9.17×10^{-4}) [d]	NR	<RDL
	8/30/2010	NS	<RDL (7.50×10^{-11})	<RDL
	5/10/2011	NS	NS	<RDL
	5/10/2011[c]	NS	NS	<RDL
	6/26/2012	NS	NS	NW
	11/07/2013	<RDL (2.54×10^{-3}) [e]	<RDL (1.80×10^{-11})	<RDL
	12/17/2014	NS	NS	<RDL
	7/26/2016	NS	NS	<RDL
MV-4PZ[a]	6/26/2012	NS	NS	<RDL
MV-5	6/25/2009	<RDL (2.30×10^{-3}) [d]	NR	<RDL
	5/26/2010	NS	<RDL (5.70×10^{-11})	<RDL
	5/11/2011	NS	NS	<RDL
	6/26/2012	NS	NS	NW
	11/07/2013	<RDL (7.81×10^{-3}) [e]	<RDL (8.90×10^{-11})	<RDL
	12/17/2014	NS	NS	<RDL
	7/26/2016	NS	NS	<RDL
MV-5PZ[a]	6/26/2012	NS	NS	<RDL
MV-6	11/06/2013	<RDL (4.87×10^{-2}) [e]	<RDL (9.00×10^{-11})	<RDL
	11/06/2013[c]	NS	NS	<RDL
	12/18/2014	NS	NS	<RDL
	7/26/2016	NS	NS	<RDL
HTH-1RC	6/25/2009	<RDL (2.75×10^{-3}) [d]	NR	<RDL
	6/09/2010	NS	<RDL (11.0×10^{-11})	<RDL
	5/11/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/08/2013	PF	PF	PF
	12/16/2014	NS	NS	<RDL
	12/16/2014[c]	NS	NS	<RDL
	7/26/2016	NS	NS	<RDL
	7/26/2016[c]	NS	NS	<RDL
HTH-2	6/25/2009	<RDL (7.98×10^{-2}) [d]	NR	<RDL
	6/09/2010	NS	PF	PF
	5/11/2011	NS	NS	PF
	6/27/2012	NS	NS	PF
	11/06/2013	<RDL (8.52×10^{-2}) [e]	<RDL (6.20×10^{-11})	<RDL
	12/17/2014	NS	NS	<RDL
UC-1-P-1SRC	6/24/2009	<RDL (1.07×10^{-1}) [d]	NR	<RDL
	5/22/2010	NS	<RDL (5.20×10^{-11})	<RDL
	5/10/2011	NS	NS	<RDL
	6/27/2012	NS	NS	<RDL
	11/06/2013	<RDL (9.54×10^{-2}) [e]	<RDL (1.08×10^{-10})	<RDL
	12/17/2014	NS	NS	<RDL
	7/26/2016	NS	NS	<RDL

Notes:
[a] Sample was collected using a depth-specific bailer; sample depths for MV-2LPZ are provided with the well name.
[b] Sample results for tritium were obtained by the enriched tritium method, and the analytical results are from the Desert Research Institute Monitoring Report (DRI 2006).
[c] Duplicate sample (not required for ^{14}C and ^{129}I).
[d] Estimated based on sample volume of 200 milliliters.
[e] Calculated based on the total alkalinity concentration.

Abbreviations:
NR = not analyzed because of insufficient sample volume
NS = not sampled because the radioisotope was not part of the analytical suite
NW = not sampled to allow water levels in the well time to recover
PF = pump failed and a sample could not be collected
<RDL = below required detection limit or laboratory-required MDC (laboratory result in parentheses; RDL is 400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I [DOE 2015c; DOE 2016a])

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Appendix E

NDEP Correspondence with Record of Review and Response to Comments

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NEVADA DIVISION OF
ENVIRONMENTAL PROTECTION

STATE OF NEVADA
Department of Conservation & Natural Resources
Brian Sandoval, Governor
Bradley Crowell, Director
Greg Lovato, Administrator

RECEIVE DOE
MAY 08 2017
GRAND JUNCTION OFFICE

May 3, 2017

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

RE: Submittal of Draft 2016 Postclosure Groundwater Monitoring and Inspection Report, Central Nevada Test Area, Nevada, Subsurface Corrective Action Unit (CAU) 443
Federal Facility Agreement and Consent Order (FFACO)

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 *Draft 2016 Postclosure Groundwater Monitoring and Inspection Report, Central Nevada Test Area, Nevada, Subsurface Corrective Action Unit (CAU) 443,* received on April 13, 2017. While this letter serves as a Notice of Completion for the April 14, 2017 FFACO **Milestone Deadline** for the "Draft 2016 Postclosure Groundwater Monitoring and Inspection Report," the NDEP has the following comments on the Report which should be addressed in the Final version:

1. Global comment: The terms, "detonation zone", "source zone", and "cavity" are used throughout this document. The term "detonation zone" is defined using "source zone", and "cavity", but these are not defined. At times they seem to be used interchangeably making the discussion confusing. Please pick one term, define it, and use it throughout the document.
2. Executive Summary, Second Paragraph, Fifth Sentence and Section 5.0, Second Paragraph, Fifth Sentence: "Water levels in this well have risen 100 ft since 2002 (5 ft in 2016) and are projected to rise another 145 ft over the next 50 years". Because there is no reference for this projection, suggest adding the following at the end of the sentence in both sections, "(based on data to date)."
3. Page 16, Section 4.3, Paragraph under Figure, Second Sentence: "**detonation area**" is not defined. Please clarify.

4. Page 16, Section 4.3, Second Paragraph below Figure, Sixth Sentence: "between the **detonation** and the MV-6". Please clarify.

5. Page 21, Section 5.0, Second Paragraph, Eighth Sentence: "The downward gradient will increase". Please change "will" to "could".

If you have any questions or comments regarding these comments, please contact me at (702) 486-2850, extension 232 or Mark McLane at extension 226.

Sincerely,

Mark McLane FOR

Christine D. Andres
Chief
Bureau of Federal Facilities

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Record of Review

Due Date	Review No.	Project	Type of Review
5/31/2017	1	1-104-1-04-613	Draft Report Technical Review - NDEP

Document Title and\or Number and Revision
Draft 2016 Postclosure Groundwater Monitoring and Inspection Report, Central Nevada Test Area, Subsurface Corrective Action Unit 443
LMS/CNT/S15655

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Reviewers' Recommendation

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

Signature of Reviewer and Date

- ☒ Comments Have Been Addressed

Mark Kautsky
2017.07.20 12:27:53 -06'00'
Signature of Author and Date

- ☒ Comment Resolution Satisfactory
- ☐ Comment Resolution Unsatisfactory

Mark McLane 7/24/17
Signature of Reviewer and Date

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
1	Global comment: The terms, "detonation zone", "source zone", and "cavity" are used throughout this document. The term "detonation zone" is defined using "source zone", and "cavity", but these are not defined. At times they seem to be used interchangeably making the discussion confusing. Please pick one term, define it, and use it throughout the document.	Y	1	The terms "detonation zone", "source zone", and "cavity" are more completely defined in Section 2.0. This included a more detail explanation of the source of contamination at the site. These changes were implemented throughout the document. Additional changes were made throughout the document to improve the consistency and organization. NDEP provided a second set of comments, which are addressed as Item No. 6 through 14 on this record of review.
2	Executive Summary, Second Paragraph, Fifth Sentence and Section 5.0, Second Paragraph, Fifth Sentence: "Water levels in this well have risen 100 ft since 2002 (5 ft in 2016) and are projected to rise another 145 ft over the next 50 years". Because there is no reference for this projection, suggest adding the following at the end of the sentence in both sections, "(based on data to date)."	Y	2	The fifth sentences of the second paragraph in the Executive Summary and the second paragraph in Section 5.0 were updated to include "(based on current trends)".
3	Page 16, Section 4.3, Paragraph under Figure, Second Sentence: "detonation area" is not defined. Please clarify.	Y	3	The wording in the second sentence of the first paragraph under Figure 8 on page 16 was changed from "detonation area" to "former cavity" to be consistent with the global comment

Record of Review (continuation)

Review No.	Project

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
				provided as Item No. 1.
4	Page 16, Section 4.3, Second Paragraph below Figure, Sixth Sentence: "between the detonation and the MV -6 ". Please clarify.	Y	4	The sixth sentence of the second paragraph in Section 4.3 below Figure 8 was revised by replacing "detonation" with "chimney". The sentence now reads as follows: "between the chimney and MV-6"
5	Page 21 , Section 5.0, Second Paragraph, Eighth Sentence: "The downward gradient will increase". Please change "will" to "could".	Y	5	The eighth sentence of the second paragraph in Section 5.0 was changed as requested. This change was also made to the eighth sentence of the second paragraph in the Executive Summary.
6	Page 2, Section 2.0, Site Background, Second Paragraph, Fourth, Fifth and Sixth sentences: Based on our phone call with OLM, it was my impression that Rex indicated that the upper chimney was the secondary source of contamination. Based on the fifth and sixth sentences the damaged zone is the secondary source. Please clarify.	Y	6	The term secondary source of contamination was not used in defining the source of contamination at the site. Instead the source of contamination was defined as the residual radioactive isotopes, with the higher concentrations being located at the bottom of the former cavity and lower concentrations of the more mobile radioisotopes being located throughout the detonation zone (cavity, chimney, and damaged zone). The sentences were revised to more clearly communicate this definition.
7	Page 5, Section 2.1, Geologic and Hydrologic Setting, Second Paragraph, Fifth sentence: "...intentionally deviate from vertical below ..." I am confused by the use of "intentionally". Was the drilling of the well planned to deviate from the vertical? Sentence is not clear in use of units, bgs and above msl. For example, "...vertical below 1500 ft (4600 feet above mean sea level [ft msl]..." The 1500 ft, should be 1500 bgs. Sixth sentence also has this same issue. Please modify these sentences appropriately.	Y	7	It was planned that well UC-1-P-2SR would deviate from vertical, so it would intercept the UC-1 chimney. The word "intentionally" was removed from the sentence and the sentence was revised to more clearly state that it was planned and to include the depths as ft bgs and elevation msl. The sixth sentence was also revised to include the depth as ft bgs, as requested.
8	Page 7, Section 2.1, Geologic and Hydrologic Setting, First Paragraph: Paragraph is using two terms for the same data, head levels and water levels. Please select one term and be consistent throughout the entire report. The figures 5 through 9 use water level elevations in the caption as does Table 3.	Y	8	The terms head levels and hydraulic head were replaced with the terms water levels, water depth, and water elevations throughout the document, and when appropriate.
9	Page 13, Section 4.2, Hydraulic Head Monitoring, First Paragraph, Fourth sentence: "...are used to convert the water level data to hydraulic head." According to information in Table 3 the water level depth not water level data is used for the conversion. In addition, Table 3 uses water level elevation not hydraulic head. Please correct the sentence with regard to	Y	9	Water level data was changed to water level depth, as requested. The terms head levels and hydraulic head were replaced with the terms water levels, water depth, and water elevations throughout the document, and when appropriate.

Record of Review (continuation)

Review No.	Project

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
	water level depth and pick one term (water level elevation or hydraulic head) and use it consistently.			
10	Page 13, Section 4.2, Hydraulic Head Monitoring, First Paragraph, Sixth sentence: "Hydrographs of the hydraulic head data..." Figures displaying hydrographs, such as, Figures 6, 7 and 8 (also Appendix B figures) have captions of water-level elevations. Please be consistent with use of terms.	Y	10	The terms head levels and hydraulic head were replaced with the terms water levels, water depth, and water elevations throughout the document, and when appropriate.
11	Page 14, Section 4.3, Hydraulic Head Results, First Paragraph, Second and Eighth sentences: The figures have captions of water-level elevations not hydraulic head. Please be consistent with use of terms.	Y	11	The terms head levels and hydraulic head were replaced with the terms water levels, water depth, and water elevations throughout the document, and when appropriate.
12	Page 14, Section 4.3, Hydraulic Heads Results, Second Paragraph, Sixth sentence: well casing depths are given in ft bgs, whereas in Table 1 elevations are given in ft above mean sea level. Please be consistent in use of measures or include both, for example xx ft bgs (xx ft above msl).	Y	12	The sentence was revised to include both ft bgs and ft msl, as requested.
13	Pages 15, 16, 17 and 18, Section 4.3, Hydraulic Heads Results, Figures 6, 7, 8 and 9 on pages 15, 16, 17 and 18, respectively: Elevation on all figures is given as ft., however in Table 3 on page 13 units are feet above mean sea level. Please put this information on the figures.	Y	13	The vertical axis title was changed on all the figures to "Elevation (ft msl)", as requested.
14	Pages B-1 and B-2, Appendix B, Hydrographs of Hydraulic Head Data: 2007 Through the Present: Figures B-1, B-2, B-3 and B-4 have water elevations shown in ft, however in Table 3 on page 13 units are feet above mean sea level. Please put this information on the figures.	Y	14	The vertical axis title was changed on all the figures to "Elevation (ft msl)", as requested.

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