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2014 Groundwater Monitoring Report Project Shoal Area Subsurface Corrective Action Unit 447

March 2015

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Abbreviations

AEC	U.S. Atomic Energy Commission
amsl	above mean sea level
BSZ	bottom of open interval/screen zone
^{14}C	carbon-14
CADD	Corrective Action Decision Document
CAP	Corrective Action Plan
CAU	Corrective Action Unit
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FFACO	Federal Facility Agreement and Consent Order
ft	feet
^{129}I	iodine-129
LM	Office of Legacy Management
MCL	maximum contaminant level
MDC	minimum detectable concentration
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
MV	monitoring/validation
NDEP	Nevada Division of Environmental Protection
pCi/L	picocuries per liter
PSA	Project Shoal Area
RDL	required detection limit
SCM	site conceptual model
TOC	top of casing
TVD	true vertical depth
^{234}U	uranium-234
^{238}U	uranium-238

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Executive Summary

The Project Shoal Area (PSA) in Nevada was the site of a 12-kiloton underground nuclear test in 1963. Although the surface of the site has been remediated, investigation of groundwater contamination resulting from the test is still in the corrective action process. Annual sampling and hydraulic head monitoring are conducted at the site as part of the subsurface corrective action strategy. The monitoring network was enhanced in 2014 with the installation of five new monitoring locations (wells and piezometers) at the site. The drilling program was completed in October 2014, and only limited data were available from the new locations for this reporting period.

Analytical results from the 2014 monitoring event are consistent with those of the previous year. The sample collected from well HC-4 was the only sample with tritium detected above the laboratory's detection limit. The tritium concentration was below the U.S. Environmental Protection Agency (EPA) tritium maximum contaminant level (MCL) of 20,000 picocuries per liter (pCi/L) and below the well's highest concentration of 1,130 pCi/L reported in 1998 (Pohll et al. 1998). Total uranium and gross alpha were detected in samples collected from wells HC-2, HC-4, and HC-6 at concentrations above the EPA MCLs of 30 micrograms per liter and 15 pCi/L, respectively. If the gross alpha values in these samples are adjusted by subtracting activities of the uranium isotopes, the values are less than zero, indicating that uranium accounts for all or nearly all gross alpha activity in these samples. The total uranium concentrations obtained for this monitoring period were consistent with previous results and reflect a slightly elevated natural uranium concentration, consistent with the mineralized geologic terrain. Isotopic ratios of uranium also indicate a natural source of uranium in groundwater rather than a nuclear-test-related source. Water level trends obtained from the 2014 water level data are consistent with those of previous years.

The corrective action strategy for the PSA is currently focused on revising the site conceptual model (SCM) and evaluating the adequacy of the monitoring well network. Some aspects of the SCM are known; however, two major concerns are the uncertainty in the groundwater flow direction and the cause of rising water levels in site wells west of the shear zone. Water levels have been rising in the site wells west of the shear zone since the first hydrologic characterization wells were installed in 1996. While water levels in wells west of the shear zone continue to rise, the rate of increase is less than in previous years. The SCM will be revised, and an evaluation of the groundwater monitoring network will be conducted when water levels at the site have stabilized to the agreement of both the U.S. Department of Energy Office of Legacy Management and the Nevada Division of Environmental Protection.

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1.0 Introduction

This report presents the 2014 groundwater monitoring results collected by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) at the Project Shoal Area (PSA) Subsurface Corrective Action Unit (CAU) 447 in Churchill County, Nevada. Responsibility for the environmental site restoration of the PSA 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 447 are conducted in accordance with the *Federal Facility Agreement and Consent Order (FFACO)* (NDEP 1996, as amended) and all applicable Nevada Division of Environmental Protection (NDEP) policies and regulations. The corrective action strategy for the site includes monitoring in support of future site closure. This report summarizes results from the annual groundwater monitoring program conducted through November 2014.

2.0 Site Location and Background

The PSA is south of U.S. Highway 50, approximately 30 miles southeast of Fallon, in Churchill County, Nevada (Figure 1). The Project Shoal underground nuclear test was done on October 26, 1963, as part of the Vela-Uniform program sponsored jointly by the U.S. Department of Defense and the U.S. Atomic Energy Commission (AEC). The test consisted of detonating a 12-kiloton nuclear device in granitic rock at a depth of approximately 1,211 feet (ft) below ground surface (AEC 1964). A cavity created by the test collapsed shortly after the detonation and formed a rubble chimney (Pohll et al. 1998). The radius of the cavity is reported to be 85 ft (26 meters) (Hazleton-Nuclear Science Corporation 1965).

Site deactivation and post-shot drilling activities began on October 28, 1963. Re-entry drilling indicated that the Shoal rubble chimney extended approximately 356 ft above the shot point (Hazleton-Nuclear Science Corporation 1965). The decontamination and restoration activities were minimal, because no large areas of surface radiological contamination were found during or following the test. During the cleanup effort, the emplacement shaft was covered with a concrete slab, and the particle motion, exploratory core holes, and U.S. Bureau of Mines boreholes on the site were plugged and abandoned. A radioactive materials survey conducted at the surface of the site in 1970 indicated that no radioactivity exceeded background for the area (AEC 1970).

2.1 Summary of Corrective Action Activities

Surface and subsurface contamination resulted from the underground nuclear test at PSA. To address these areas of contamination, surface and subsurface CAUs were identified, and the areas of contamination were addressed through separate corrective action processes. The surface CAU included three Corrective Action Sites that consisted of a mud pit with drilling mud impacted by petroleum hydrocarbons, a muckpile of granite that remained from excavation of the emplacement shaft, and housekeeping areas that consisted of approximately 20 rusted and empty oil cans. Remediation of the surface of CAU 416 was completed in 1998 and is summarized in the *Closure Report for CAU No. 416, Project Shoal Area* (DOE/NV 1998). NDEP approved the Closure Report on February 13, 1998, stating that no post-closure monitoring is required, and no land use restrictions apply at CAU 416 (NDEP 1998).

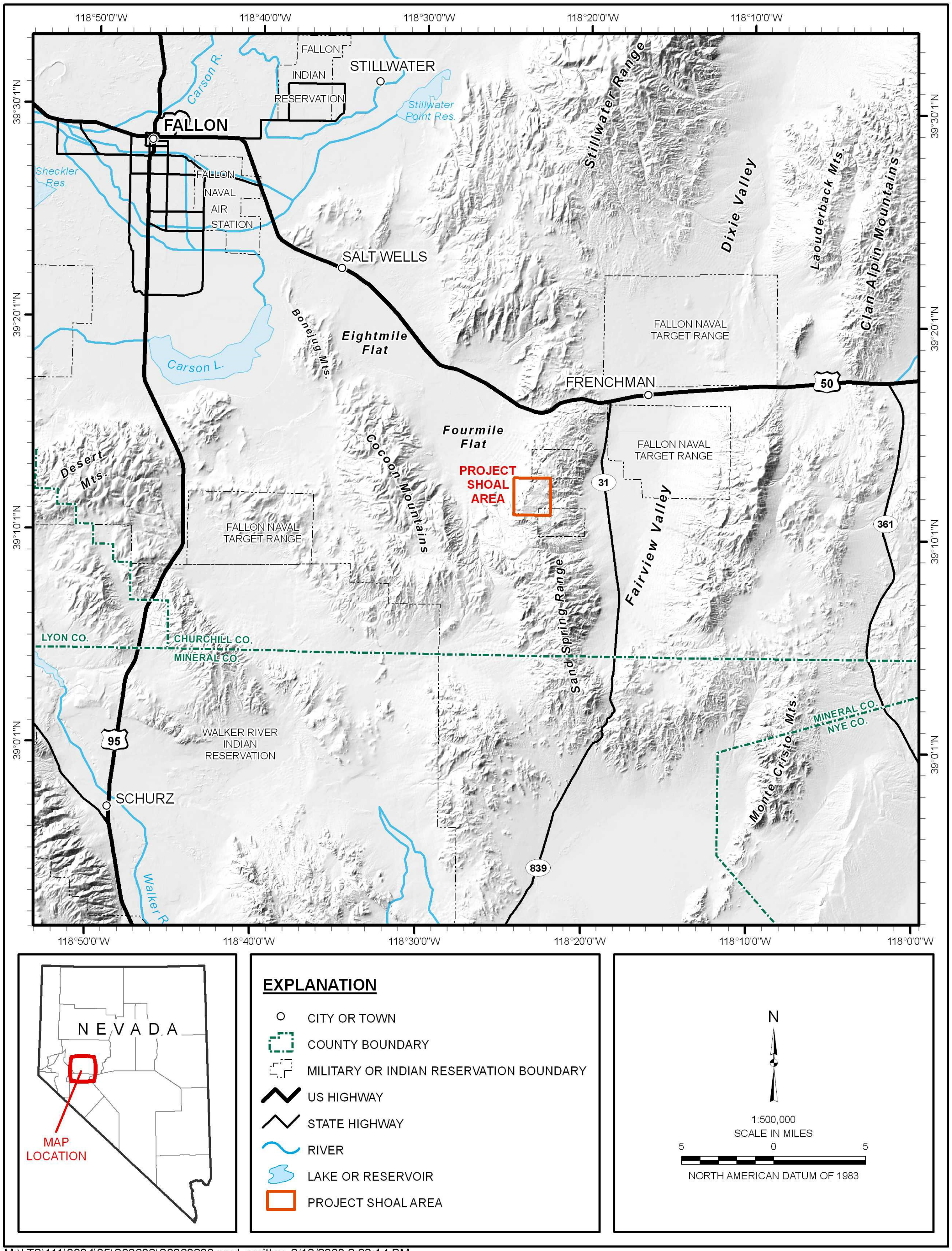

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Figure 1. Location of the Project Shoal Area

The corrective action process for the subsurface has not been completed, and there is currently no known technology to remediate the remaining subsurface radioactive contamination at the site. The original corrective action strategy for the subsurface used a groundwater flow and transport model developed by Desert Research Institute to help evaluate data and select a corrective action alternative. The model results were used to determine a contaminant boundary and establish a restricted region surrounding the site. The contaminant boundary (Figure 2) is a probabilistic forecast of the maximum extent over 1,000 years of radionuclide transport where test-related radionuclides in groundwater outside the boundary have a 5 percent or less likelihood of exceeding the radiological standards of the Safe Drinking Water Act. NDEP approved the contaminant boundary as the compliance boundary in their letter dated January 19, 2005 (NDEP 2005). The corrective action alternative selected for the site includes monitoring with institutional controls and is presented in the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP; DOE/NNSA 2006).

As part of the original corrective action strategy, three monitoring/validation (MV) wells (MV-1, MV-2, and MV-3) were installed in 2006 for the dual purpose of monitoring for contaminant migration and evaluating the flow and transport model results. The site conceptual model (SCM) is being reevaluated to address inconsistencies with the numerical model predictions and monitoring well data. Concerns with the model stem from two observations. First, the horizontal component of groundwater flow predicted by the model was primarily toward the north-northeast, whereas horizontal gradients inferred from water levels measured in site wells do not support the modeled flow direction. Second, the model incorrectly assumed that the groundwater flow system is in a steady state; in fact, water levels west of the shear zone have been rising approximately 1 to 2 ft per year during the time they have been monitored, beginning with the installation of the HC wells in the late 1990s. Water levels were not monitored at the site, except for the adjacent valleys, prior to the installation of the HC wells and later MV wells. Pursuant to the FFACO (NDEP 1996, as amended), LM began implementing a new corrective action strategy for the site in 2009.

On November 24, 2009, LM submitted an initial Short-Term Data Acquisition Plan to NDEP, detailing data collection activities that included a surface geophysical program and enhanced groundwater monitoring. The completed geophysical program included seismic and electromagnetic surveys. As part of the evaluation of data obtained from the surveys, a technical exchange meeting was conducted in March 2011 with the geophysicists who performed the surveys (Lee Liberty from Boise State University and Jim Hasbrouck from Hasbrouck Geophysics), Desert Research Institute, and NDEP to discuss the results and the potential site conceptual models. During the meeting it was agreed that further understanding of the groundwater flow system was needed for the enhancement of potential SCMs and that a new Short-Term Data Acquisition Plan was necessary to outline future activities at the site. The Surface Geophysics Report recommended that geophysical data be evaluated further and compared to existing data to assess and enhance any potential SCMs (DOE 2011b). The technical exchange and Surface Geophysics Report provided the basis for developing the new Data Acquisition Plan that was submitted to NDEP in October 2011.

The 2011 Data Acquisition Plan included further review of available reports and preparation of a detailed information resource tool that includes a summary of pertinent technical data. Analytical, hydrologic, and geologic data obtained from the evaluation of historical reports have been reviewed with existing data and collected geophysical data to help identify geologic structures that might be influencing groundwater flow at the site. These data have been assembled for three-dimensional visualization. Revisions to the SCM and enhancements to the monitoring well network will be provided to NDEP in a future addendum to the CADD/CAP (DOE/NNSA 2006).

The 2014 Data Acquisition Plan included a drilling program to enhance the monitoring well network at the site. Drilling consisted of installing two new monitoring wells (MV-4 and MV-5) and deepening the existing well HC-2 (HC-2d) (DOE 2014b). Monitoring wells MV-4 and MV-5 were dually completed with a well and piezometer to allow determination of vertical and horizontal gradients at the installed location. The well casing was removed from the existing well HC-2, and the borehole was deepened to allow installation of a new well HC-2d. The new wells and deepened well were completed with dedicated electric submersible pumps for collecting groundwater samples and conducting aquifer tests. The new wells and existing wells/piezometers were surveyed to obtain new top of casing measuring point elevations as part of the drilling program. Results from the 2014 drilling program will be provided in a Well Completion Report for CAU 447.

3.0 Geologic and Hydrologic Setting

The PSA is in the northern portion of the Sand Springs Range in west-central Nevada's Churchill County. The Sand Springs Range is the southern extension of the Stillwater Range, a north-northeast-trending fault block range that traverses Churchill County. The Sand Springs Range rises to an elevation of approximately 6,751 ft above mean sea level (amsl) and is flanked by Fourmile Flat to the west and Fairview Valley to the east (Figure 1). The Shoal site is in Gote Flat at an elevation of approximately 5,250 ft amsl and is within an area that is part of the Cretaceous-age Sand Springs granitic batholith.

The Sand Springs batholith is composed of granodiorite and granite, aplite, and pegmatite dikes; andesite dikes; rhyolite dikes; and rhyolitic intrusive breccia. Internal deformation of the Sand Springs granite is largely by high-angle normal faults and fractures distributed between two dominant structural trends that strike approximately N 50^{o} W and N 30^{o} E and are vertical to steeply dipping. Several dikes of varying composition predominantly follow the same two orientations and intrude along these lines of preexisting weakness. These orthogonal-type sets of faults and fractures appeared early in the history of the Sand Springs granite and affected much of the subsequent structural and chemical evolution of this large intrusion (Beal et al. 1964).

The water table beneath the site (near surface ground zero and west of the shear zone) occurs at depths ranging from approximately 965 to 1,090 ft below ground surface, and groundwater moves primarily through fractures in the granite. Recharge occurs by infiltration of precipitation on the mountain range, and regional discharge occurs in the adjacent valleys. A shear zone, located about 1,500 ft east of surface ground zero (Figure 2 and Figure 3), is interpreted as a barrier to groundwater flow on the basis of disparate head levels in wells separated by the shear zone (Carroll et al. 2001). Groundwater within Fairview Valley to the east has been used for ranching, seasonal residential purposes, and military purposes within the last 5 years.

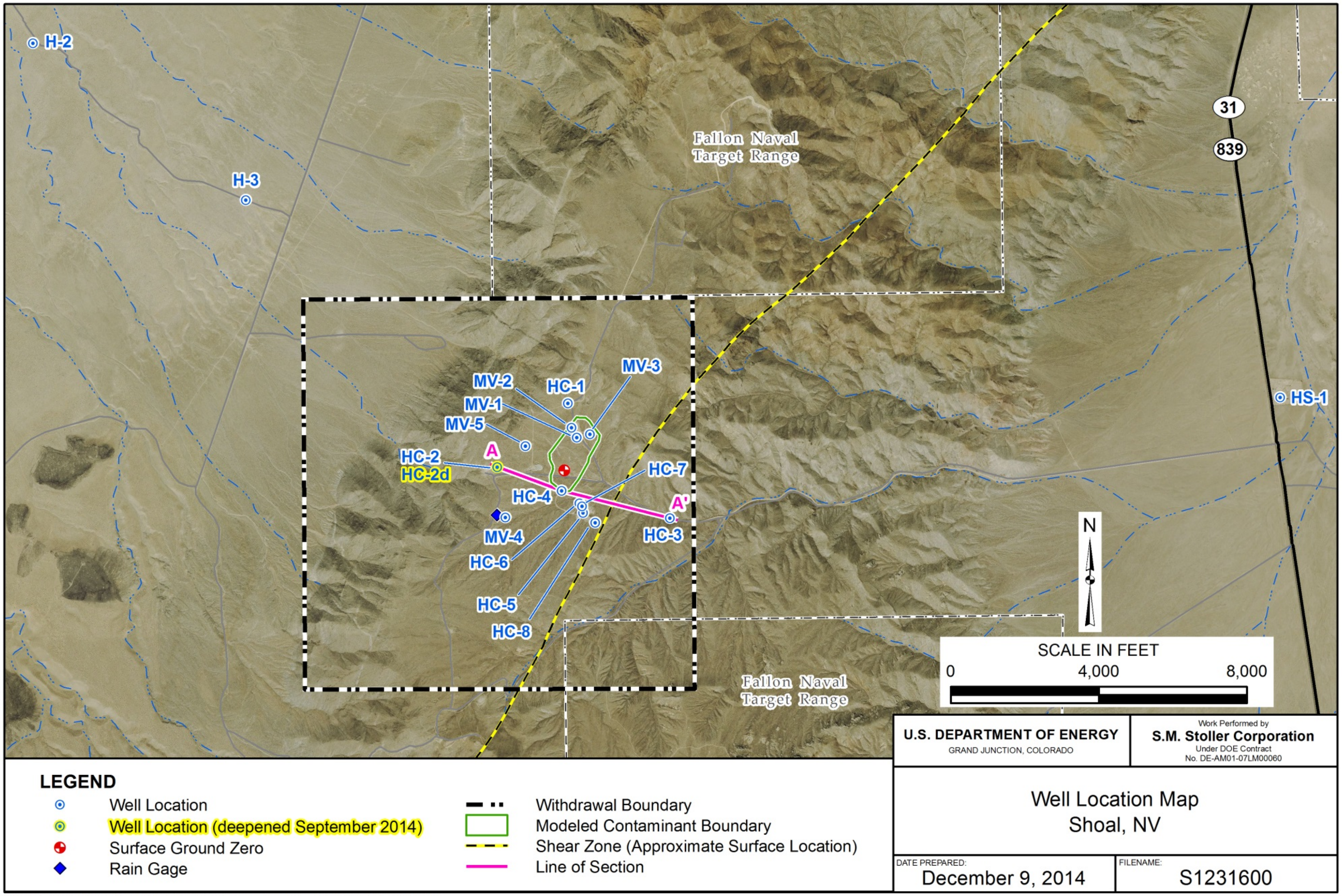

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Figure 2. Well Locations, Shoal, Nevada

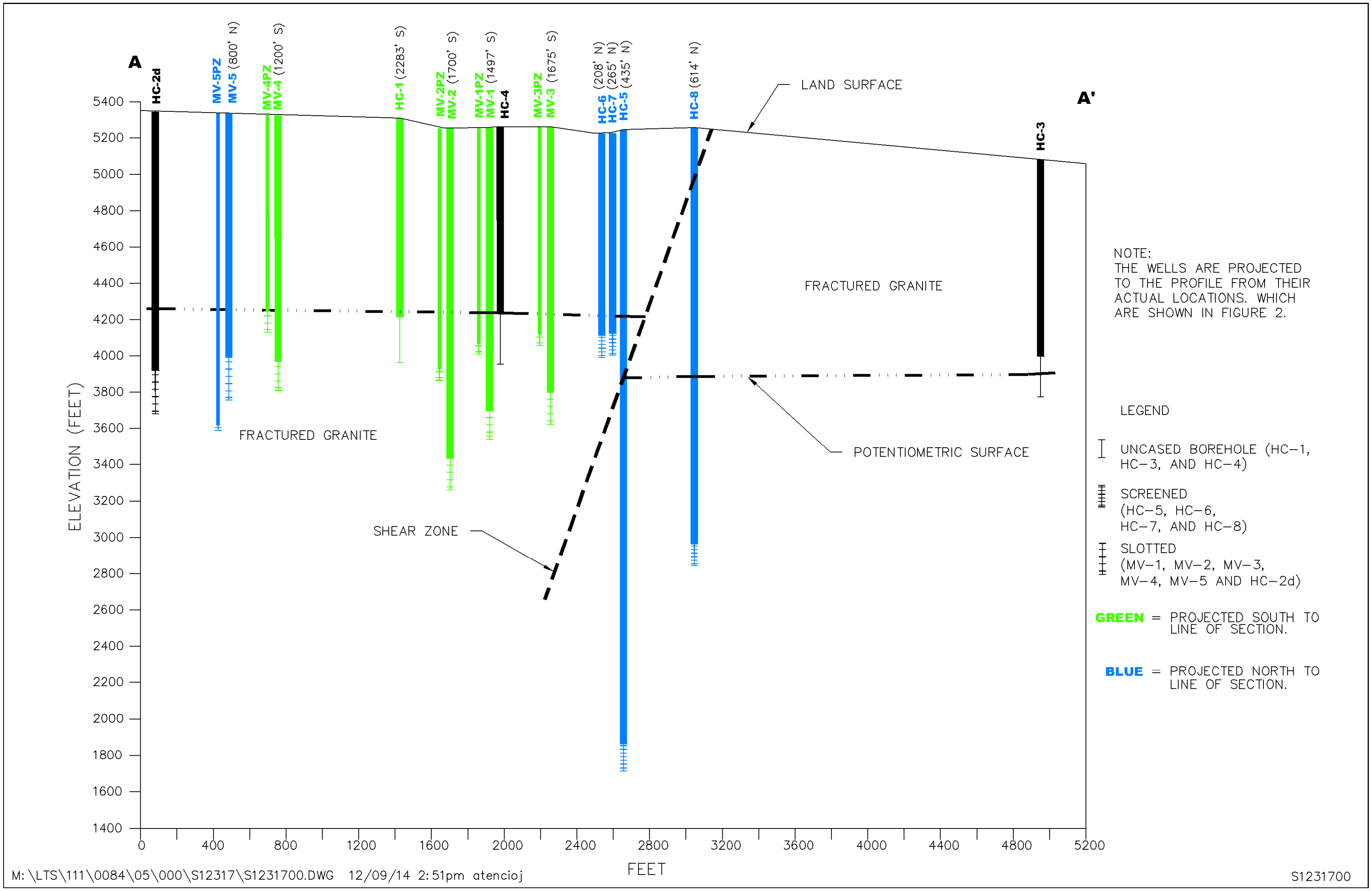

Figure 3. Cross Section A–A' Depicting Monitoring Well and Shear Zone Location, Project Shoal Area, Nevada

4.0 Monitoring Program and Objectives

The primary objectives of the monitoring program are (1) “detection monitoring” to identify any migration of radiologic contamination from the test cavity and (2) “system monitoring” to obtain hydraulic head data for monitoring the overall stability (quasi-steady state) of the hydrogeologic system. The monitoring program and objectives were established in the CADD/CAP, and the program was initiated after NDEP approved the CADD/CAP and wells MV-1, MV-2, and MV-3 were installed in 2006. Enhancements were made to the monitoring program after the numerical model could not be verified against data obtained from the MV wells (MV-1, MV-2, and MV-3). The enhancements are documented in short-term Data Acquisition Plans that were completed in 2009, 2011, and 2014 to support the CADD/CAP and provide interim guidance documents until an addendum to the CADD/CAP can be completed. The 2014 Data Acquisition Plan included the installation of two new monitoring wells (MV-4 and MV-5) and deepening of the existing well HC-2 (HC-2d) (DOE 2014b). The drilling program was completed in October 2014, and only limited data were available for this report. The *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351) is used to guide the quality assurance/quality control of the annual sampling and monitoring program.

The corrective action strategy is focused on revising the SCM and evaluating the adequacy of the current monitoring well network. Aspects of the SCM are currently known; however, two major concerns are the uncertainty in the groundwater flow direction and the cause of the rising water levels in site wells that are west of the shear zone. Water levels have been rising in the site wells west of the shear zone since the first wells were installed in 1996. LM continues to evaluate site data to enhance the SCM and monitor water levels as part of the ongoing groundwater monitoring program, which includes collecting samples for laboratory analysis, measuring depth to groundwater and downloading transducers in site monitoring wells, and downloading the rain gage data (the rain gage was installed in August 2012. The 2014 monitoring program was enhanced to include supplemental activities that were specified in the 2014 Sampling Plan (DOE 2014a). Results from the monitoring program are provided below, and results from the supplemental activities are provided in Section 5.0.

4.1 Radioisotopic Monitoring

Groundwater samples were collected from wells MV-1, MV-2, MV-3, HC-1, HC-2, HC-3, HC-4, HC-5, HC-6, HC-7, and HC-8 during the May 2014 sampling event. The new monitoring wells MV-4 and MV-5 and deepened well HC-2d were not sampled as part of this annual monitoring event because the drilling program was not completed until October 2014. Monitoring wells MV-1, MV-2, MV-3, HC-4, HC-5, HC-7, and HC-8 were purged prior to sampling using dedicated submersible pumps. At least one well casing volume was removed, and field parameters (temperature, pH, and specific conductance) were allowed to stabilize before samples were collected (Appendix A, Table A-1). Samples were collected from wells HC-1, HC-2, HC-3, and HC-6 using a depth-specific bailer because these wells are not completed with dedicated submersible pumps. The analytical results obtained from the annual sampling were validated in accordance with the *Environmental Procedures Catalog* (LMS/POL/S04325), “Standard Practice for Validation of Environmental Data.” A copy of the Data Validation Package is maintained in the LM records and is available on request. Table A-1 in Appendix A presents the final measurements of field parameters and well purge volumes.

Groundwater samples collected as part of the annual monitoring event were analyzed for tritium, uranium isotopes, gross alpha, and mass concentrations of uranium as specified in the Short-Term Data Acquisition Plans (DOE 2009, 2011a, 2014b), which enhanced the monitoring network defined in the CADD/CAP (DOE/NNSA 2006). The Short-Term Data Acquisition Plan completed in 2009 (DOE 2009) reduced the frequency for analyzing samples for carbon-14 (^{14}C) and iodine-129 (^{129}I) to every 5 years beginning after the 2010 sampling event. Tritium is the analyte selected as an indicator of contaminant migration from the cavity due to its mobility and abundance in the first 100 years of the post-shot monitoring period. However, because of tritium's short half-life, ^{14}C and ^{129}I are also monitored in support of long-term post-closure monitoring. Gross alpha is included in the analytical suite because elevated concentrations of gross alpha have been detected in the past at the PSA. The U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) for gross alpha is exclusive of uranium and radon. Including uranium mass and uranium isotope analyses as part of the analytical suite provides data to demonstrate that the elevated concentrations of gross alpha are from natural sources. Radon is not included in the analytical suite because it volatilizes during analysis and is an insignificant contributor to gross alpha.

The CADD/CAP established regulatory levels for site groundwater of 20,000 picocuries per liter (pCi/L) tritium, 2,000 pCi/L ^{14}C, and 1 pCi/L ^{129}I (DOE/NNSA 2006). These levels are not to be exceeded outside the compliance boundary, which is the modeled contaminant boundary (Figure 2). The EPA MCLs for gross alpha and uranium are 15 pCi/L and 30 micrograms per liter (µg/L), respectively. These constituents are believed to be naturally elevated in groundwater in the region. The LM required detection limit (RDL) for tritium is 400 pCi/L, which is slightly higher than the limit of 300 pCi/L established in the CADD/CAP. A record of technical change was submitted to NDEP and approved in March 2012 to change the RDL to 400 pCi/L in the CADD/CAP. The laboratory radiochemical minimum detectable concentration (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.

4.2 Radioisotopic Results

Table 1 presents a summary of analytical results for ^{14}C, ^{129}I, tritium, uranium, and gross alpha from the samples collected in 2012 through 2014. Tables B-1 and B-2 in Appendix B present analytical results from when the CADD/CAP monitoring program began in 2007 through the present. A time-concentration plot for well HC-4 (Figure 4) presents tritium results from the CADD/CAP monitoring program and sampling events performed by EPA and Desert Research Institute before the CADD/CAP monitoring program began in 2007. Well HC-4 was installed in 1996 and is the only well that has had detections of tritium above the laboratory's MDC using conventional laboratory methods. The presence of tritium in this well is attributed to its proximity to the nuclear detonation (Figure 2). This interpretation of the tritium source is supported by the elevated levels of ^{14}C detected in samples collected from well HC-4 compared to levels in samples from the other monitoring wells (Table 1 and Appendix B, Table B-1). The elevated concentration of ^{14}C in this well is likely the result of its migration in the gas phase near the water table, as part of the carbon dioxide (CO_2) molecule, where it dissolved into groundwater in the upper saturated zone near the detonation. It should be noted that concentrations of ^{14}C are below the RDL in all samples and that conclusions based on a comparison of the results are not useable for regulatory decisions.

Table 1. Radioisotope and Chemical Sampling Results 2012 through 2014

Monitoring Location	Date	Carbon-14 (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)	Gross Alpha (pCi/L)
MV-1	5/25/2012	NA	NA	<300	22	14.3
	5/22/2013	NA	NA	<370	21	13.6
	5/27/2014	NA	NA	<320	21	10.7
MV-2	5/24/2012	NA	NA	<300	22	10.6
	5/22/2013	NA	NA	<320	22	9.79
	5/27/2014	NA	NA	<320	22	11.6
	5/27/2014[a]	NA	NA	<320	21	10.8
MV-3	5/25/2012	<RDL (0.0106)	NA	<300	7	2.72
	5/21/2013	NA	NA	<340	8	5.08
	5/21/2013[a]	NA	NA	<380	8	5.84
	5/27/2014	NA	NA	<320	8.3	4.98
MV-4*	NA	NA	NA	NA	NA	NA
MV-5*	NA	NA	NA	NA	NA	NA
HC-1	5/23/2012	<RDL (0.0123)	NA	<300	1.1	<0.75
	5/22/2013	NA	NA	<340	0.9	3.19
	5/27/2014	NA	NA	<320	0.8	<1.2
HC-2	5/22/2012	NA	NA	<300	110	64.5
	5/22/2013	NA	NA	<330	100	61.1
	5/27/2014	NA	NA	<320	100	46.8
HC-2d*	NA	NA	NA	NA	NA	NA
HC-3	5/23/2012	<RDL (0.0145)	NA	<300	2	0.283
	5/22/2013	NA	NA	<350	2.7	0.724
	5/28/2014	NA	NA	<320	0.32	<1.9
HC-4	5/24/2012[a]	NA	NA	774	46	16.7
	5/24/2012	<RDL (2.50)	NA	803	46	22.9
	5/21/2013	NA	NA	964	60	35.1
	5/28/2014	NA	NA	700	62	27.8
HC-5	5/23/2012	<RDL (0.00370)	NA	<300	0.49	0.349
	5/22/2013	NA	NA	<340	0.40	0.957
	5/28/2014	NA	NA	<320	0.33	<2.2
HC-6	5/23/2012	<RDL (0.0116)	NA	<300	38	14.1
	5/22/2013	NA	NA	<360	36	19.1
	5/27/2014	NA	NA	<320	39	16.9
HC-7	5/23/2012	NA	NA	<300	41	23.9
	5/21/2013	NA	NA	<370	15	13.8
	5/28/2014	NA	NA	<320	11	6.76
HC-8	5/25/2012	NA	NA	<300	0.20	0.454
	5/23/2013	NA	NA	<380	0.14	1.24
	5/28/2014	NA	NA	<320	0.23	<1.9

[a] Indicates a duplicate sample.
* Indicates the well was added to the monitoring network in October 2014.
<RDL = below required detection limit with laboratory result in parentheses; RDL is 5 pCi/L for ^{14}C, 0.1 pCi/L for ^{129}I, 400 pCi/L for tritium, 50 µg/L for uranium, and 4 pCi/L for gross alpha (DOE/NNSA 2006).
NA = not applicable (samples not collected or samples not analyzed).
NR = not run, because sample bottle was broken during shipment to the laboratory.

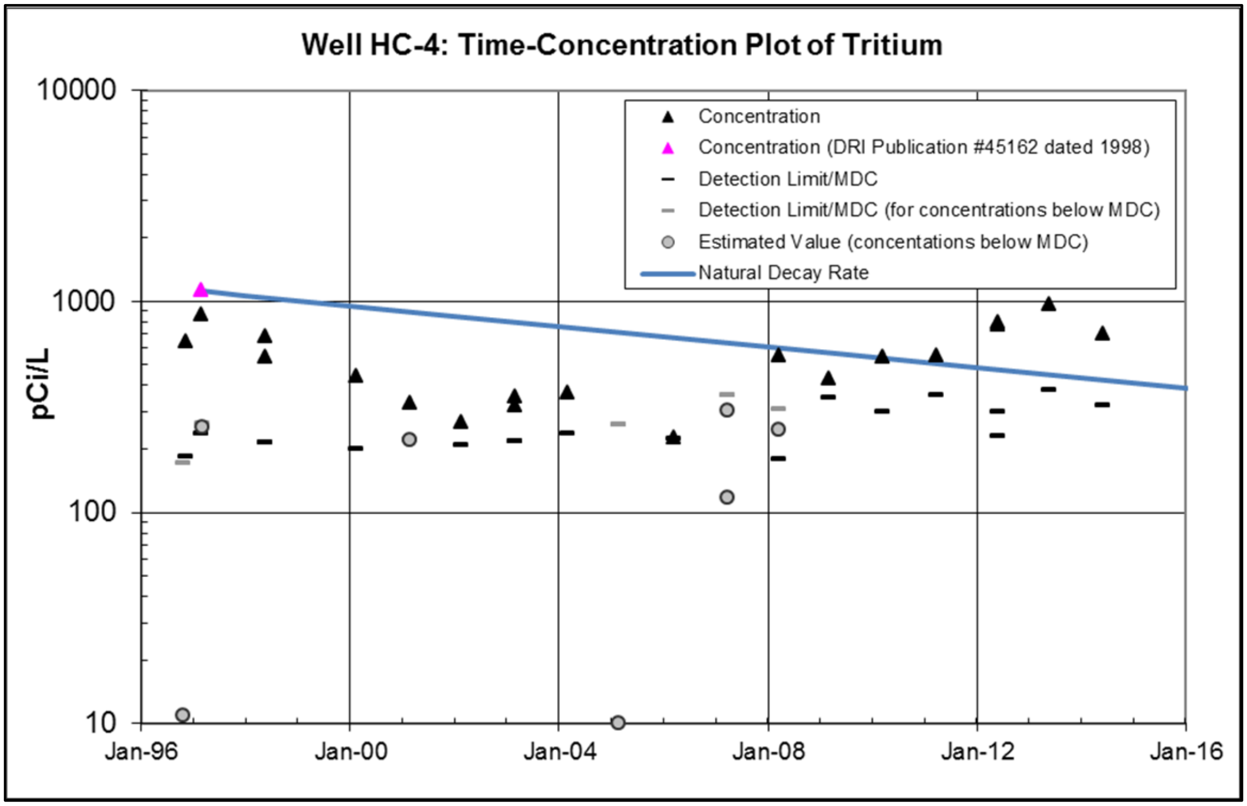

Figure 4. Time-Concentration Plot of Tritium at Well HC-4

Samples collected from well HC-4 during the May 2014 sampling event were the only samples where tritium was detected above the laboratory's MDC. Tritium levels in well HC-4 (Figure 4) were typically above laboratory MDCs from the mid-1990s until 2006, though some duplicate analyses were below MDCs. Tritium levels had been trending lower and were below the laboratory MDC for the 2005 and 2007 sampling events (Figure 4). Of the two samples analyzed in 2008 (one by EPA and one by Paragon), results were above the MDC for one sample and below the MDC for the other. Since 2008, tritium results have increased from a concentration that was below the laboratory MDC in 2007 to concentrations above the MDC, ranging from 434 pCi/L in 2009 to 964 pCi/L in 2013. The variation in tritium concentrations in this well is likely related to the different volumes of groundwater removed during the sampling events. The highest tritium concentration of 1,130 pCi/L was from a sample collected in 1997 by Desert Research Institute after approximately 1,100 gallons of groundwater were removed during an aquifer test. From 2007 through 2011 the well purge volumes for this well ranged from 200 to 420 gallons. These volumes were less than one well volume because of a misunderstanding in the well configuration (DOE 2013). The volume of groundwater removed from well HC-4 was increased after the 2011 sampling event to a minimum volume of 700 gallons (1 well volume). The well purge volumes are not available for samples collected prior to 2007, with the exception of the sample collected by Desert Research Institute in 1997.

Samples collected from wells MV-1 and MV-2 in 2007 and well HC-7 in 2012 (Appendix B, Table B-1) had detectable gross alpha activity and uranium mass concentrations above the EPA MCLs of 15 pCi/L and 30 µg/L, respectively. Concentrations in samples collected from wells MV-1 and MV-2 in 2008 declined below the EPA MCLs and have remained below the MCLs with the exception of the sample collected from well MV-1 in 2011, in which the gross alpha concentration (16.6 pCi/L) exceeded the MCL of 15 pCi/L. The concentrations in the sample collected from well HC-7 in 2012 are not consistent with historical results and were attributed to an increase in the volume of groundwater removed prior to sampling the well (DOE 2013). Analytical results obtained from the 2014 sampling event (Table 1) indicate that gross alpha activity and uranium mass concentrations were detected above the EPA MCLs in the samples from wells HC-2, HC-4, and HC-6. Historically, samples from wells HC-2 and HC-6 have had concentrations of gross alpha and uranium above the MCLs, and this trend continued in 2014. Analytical results for samples from well HC-4 indicate an increase in gross alpha and uranium concentrations above the EPA MCLs starting in 2012. These increases may be attributed to an increase in the volume of groundwater removed from the well during sampling. The remaining analytical results for gross alpha and uranium from the 2014 sampling event are consistent with previous results and below the MCLs.

Bevans et al. (1998) demonstrated that concentrations of uranium are elevated in ambient groundwater in the region surrounding the site. The elevated uranium concentrations are attributed to leaching from granitic bedrock and associated sediments. If the gross alpha values for samples from wells HC-2, HC-4, and HC-6 (Table 1) are adjusted by subtracting activities of uranium-234 (^{234}U) and uranium-238 (^{238}U) shown in Table 2, values are less than zero, indicating that uranium accounts for all or nearly all gross alpha activity in these samples (see example calculation below for adjusted results). Isotope ratios of uranium further support the interpretation of a natural source of uranium in groundwater rather than a nuclear-test-related source. Natural uranium-bearing systems typically have ^{234}U:^{238}U activity ratios near 1 (Cowart and Osmond 1977), which is indicative of secular equilibrium between the two isotopes. Table 2 indicates that most ratios observed in the samples range from 0.91 to 2.77—consistent with a natural uranium source. In contrast, average estimates of radionuclides resulting from nuclear tests at the Nevada National Security Site suggest a residual source term with a ^{234}U:^{238}U activity ratio of 56.25 (Smith 2001).

Example calculation (pCi/L): Gross alpha – ^{234}U – ^{238}U = Adjusted result

HC-2: 46.8 – 33.4 – 32.5 = −19.1

HC-4: 27.8 – 21.4 – 21.5 = −15.1

HC-6: 16.9 – 15.6 – 13.6 = −12.3

Note: Adjusted gross alpha results can be less than 0 due to laboratory measurement uncertainty.

Table 2. Uranium Isotope Sampling Results, 2012 Through 2014

Monitoring Location	Date	Uranium-234 (pCi/L)	Uranium-238 (pCi/L)	Uranium-234:Uranium-238
MV-1	5/25/2012	8.14	6.81	1.20
	5/22/2013	8.72	7.35	1.19
	5/27/2014	7.69	6.42	1.20
MV-2	5/24/2012	7.9	7.01	1.13
	5/22/2013	8.83	7.85	1.12
	5/27/2014	8.38	7.0	1.20
	5/27/2014[a]	8.15	7.16	1.14
MV-3	5/25/2012	2.49	2.3	1.08
	5/21/2013	3.6	2.73	1.32
	5/21/2013[a]	3.58	2.84	1.26
	5/27/2014	2.95	2.52	1.17
MV-4*	NA	NA	NA	NA
MV-5*	NA	NA	NA	NA
HC-1	5/23/2012	0.401	0.35	1.15
	5/22/2013	0.425	0.291	1.46
	5/27/2014	0.373	0.25	1.49
HC-2	5/22/2012	38.1	36.2	1.05
	5/22/2013	37.2	37.2	1.00
	5/27/2014	33.4	32.5	1.03
HC-2d*	NA	NA	NA	NA
HC-3	5/23/2012	0.678	0.668	1.01
	5/22/2013	0.932	0.966	0.96
	5/28/2014	0.102	0.106	0.96
HC-4	5/24/2012[a]	14.4	15.1	0.95
	5/24/2012	14.2	14.8	0.96
	5/21/2013	22	20.8	1.06
	5/28/2014	21.4	21.5	1.00
HC-5	5/23/2012	0.227	0.126	1.80
	5/22/2013	0.240	0.122	1.97
	5/28/2014	0.255	0.149	1.71
HC-6	5/23/2012	14.4	12.2	1.18
	5/22/2013	15.7	12.6	1.25
	5/27/2014	15.6	13.6	1.15
HC-7	5/23/2012	16.1	13.9	1.16
	5/21/2013	6.31	5.56	1.13
	5/28/2014	4.1	3.76	1.09
HC-8	5/25/2012	0.153	0.0553	2.77
	5/23/2013	0.107	0.041	2.61
	5/28/2014	0.102	0.094	1.09

[a] Indicates a duplicate sample.
* Indicates the well was added to the monitoring network in October 2014.
NA = not applicable (samples not collected or samples not analyzed).

4.3 Hydraulic Head Monitoring

The groundwater flow system was monitored by measurements of hydraulic head in the onsite wells/piezometers (MV-1 through MV-3 and HC-1 through HC-8) and offsite wells (H-2 and H-3) (Figure 2). Heads were recorded every 2 hours by transducers installed in these wells/piezometers. Water levels were measured manually, and transducers were downloaded in May as part of the annual sampling and in November as part of a site inspection. Installation of the new monitoring wells MV-4 and MV-5 and deepened well HC-2d was completed in October 2014. Water levels were measured manually from the new wells in November, but transducer data from these locations are not available for this reporting period. The manual water level measurements were collected prior to the occurrence of activities that would disturb ambient water level conditions. The manual water level measurements were used to convert the transducer data to groundwater elevations. Water levels measured in the new wells and piezometers may not be indicative of static conditions due to their recent installation and development activities.

The battery in the transducer that monitors water levels in well HC-2 failed, causing a loss of data for a period of time in 2014. The battery in the barometric transducer (used to monitor atmospheric pressure at the site) failed, causing a loss of atmospheric pressure data during a period in 2014. The transducers in the wells are non-vented, meaning that they “feel” the weight of overlying water plus the weight of the atmosphere. The average atmospheric pressure at the site, a single number, was used to correct the transducer data during the period with no atmospheric pressure readings. This results in an apparent increase in variability in water elevations during this time period. The effect is most obvious on the MV-2 piezometer hydrograph (Figure 5). The MV-2 piezometer has a poor connection to the formation and “feels” the entire weight of the atmosphere. The time periods when atmospheric pressure data are available to correct the MV-2 piezometer data result in a smooth line. For the time period when a single average value is used, the MV-2 piezometer data show the variability in atmospheric pressure superposed on the water level results.

4.4 Hydraulic Head Results

Table 3 presents well construction information and the hydraulic head data collected in November 2014. Hydrographs of hydraulic head data from site wells and piezometers from when the CADD/CAP monitoring program was initiated in 2007 are shown in Figure 5, Figure 6, and Figure 7. Hydrographs of hydraulic head data obtained from when the first wells were installed at the site in1996 to the present are shown in Figures C-1, C-2, and C-3 of Appendix C. Head data collected using a water level tape appear as individual symbols, and data collected with transducers appear as lines due to the recording frequency of every few hours. The hydrographs are grouped according to the location of the open interval of each well relative to the north-northeast-trending shear zone that transects the site.

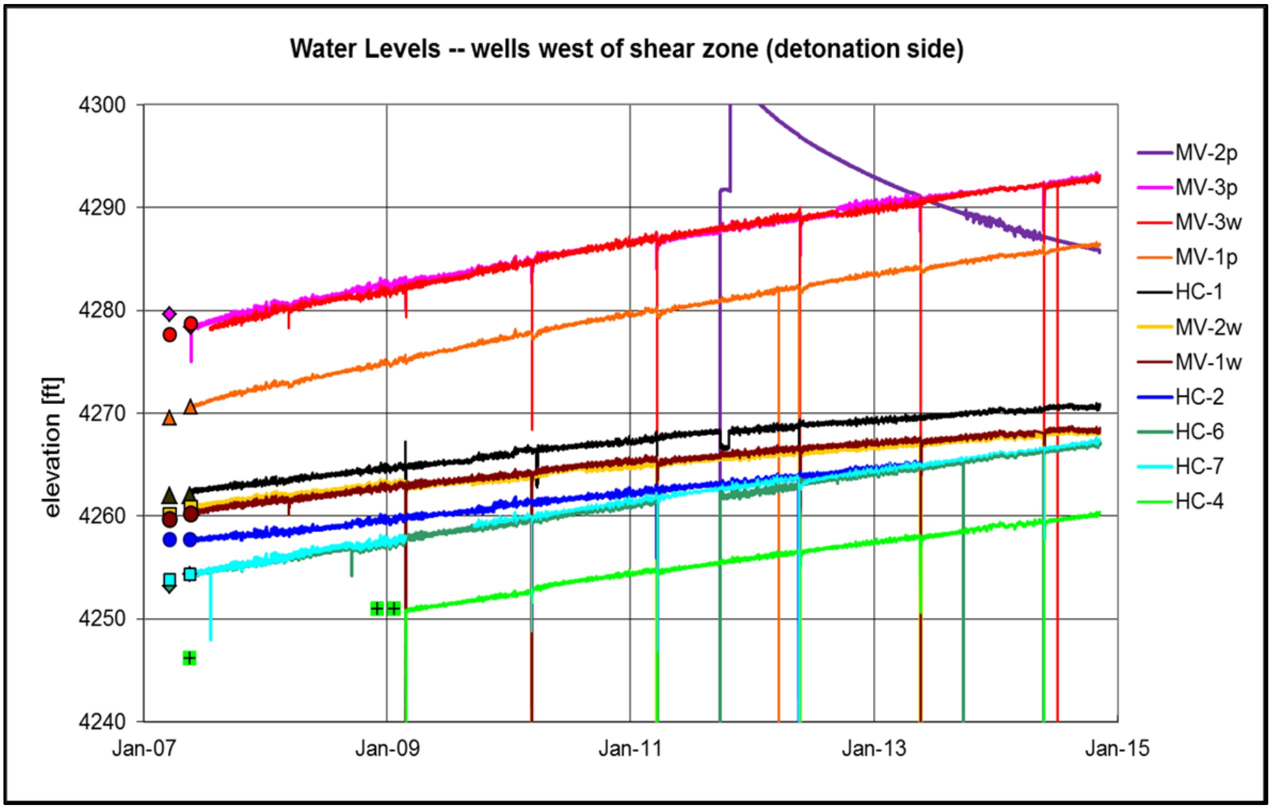

Figure 5. Hydrographs for Wells West of the Shear Zone

Monitoring locations west of the shear zone include the MV-1, MV-2, MV-3, MV-4, and MV-5 wells and piezometers and wells HC-1, HC-2, HC-2d, HC-4, HC-6, and HC-7 (Figure 5). Transducer data are being collected at new locations MV-4, MV-5, and HC-2d and will be available for the next monitoring report. Water levels in onsite wells west of the shear zone (detonation side) continued to rise from 0.82 ft in MV-2 to 1.64 ft in HC-6 (July 2013 to July 2014). The overall increase was similar to that of the previous year for most wells and still too high to conclude that water levels are beginning to stabilize. However, since drilling activity began in mid-August, water levels at the well locations (MV-1, MV-2, and HC-1) have stopped increasing. The short 2- to 3-month period is insufficient to conclude that water levels in these wells have stabilized. Table D-1 in Appendix D shows the annual water level changes in wells west of the shear zone from July 2007 through July 2014.

The hydrograph for the MV-2 piezometer was added to Figure 5 in 2012. The water level in this piezometer was recovering very slowly after its installation, and water was added in several stages until it began to take water, resulting in the current slowly declining water level that is not indicative of the head level in the formation at its screened interval. The MV-2 piezometer is not well-connected to the formation, either due to the few fractures within the screened interval having a limited extent or consolidation of drilling mud within those fractures. There is some connection because the water level is slowly falling after water was added to the piezometer. The water elevation in the MV-2 piezometer will always be suspect due to the lack of fractures and low permeability of the MV-2 piezometer open interval. It is recommended that this piezometer be transitioned to manual water level readings only when the battery in the installed transducer fails.

Table 3. Well Construction Details and November 2014 Head Data for Wells at the PSA

Well/Piezometer	TOC Elevation (ft amsl)	Water Depth (ft)[a]	Date	Elevation Water (ft amsl)[b]	Elevation TSZ (ft amsl)	Elevation BSZ (ft amsl)	Screen Length (ft)
MV-1	5,257.54	989.17	11/11/2014	4,268.37	3,684.81	3,531.00	153.81
MV-1 PZ	5,257.30	970.93	11/11/2014	4,286.37	3,919.80	3,859.80	60.00
MV-2	5,266.62	998.35	11/11/2014	4,268.27	3,446.75	3,275.98	170.77
MV-2 PZ	5,266.51	980.88[c]	11/11/2014	4,285.63[c]	4,078.82	4,019.32	59.50
MV-3	5,261.50	968.50	11/10/2014	4,293.00	3,797.91	3,626.75	171.16
MV-3 PZ	5,261.17	968.11	11/10/2014	4,293.06	4,120.75	4,060.72	60.03
MV-4	NM	1,083.80	11/10/2014	NM	NM	NM	160
MV-4PZ	NM	1,080.68	11/10/2014	NM	NM	NM	120
MV-5	NM	1,053.95	11/10/2014	NM	NM	NM	240
MV-5PZ	NM	1,053.08	11/10/2014	NM	NM	NM	30
HC-1	5,309.21	1,060.05	11/12/2014	4,270.37	4,236.01	3,997.12	238.89
HC-2d	NM	1,102.75	11/10/2014	NM	NM	NM	200
HC-3	5,081.52	1,180.48	11/11/2014	3,921.04	3,918.52	3,898.02	20.50
HC-4	5,260.90	1,004.45	11/11/2014	4,260.25	4,247.90	3,957.90	281.00
HC-5	5,247.37	1,369.02	11/11/2014	3,878.35	1,862.37	1,716.77	145.60
HC-6	5,228.68	962.48	11/11/2014	4,267.09	4,112.70	3,996.38	116.32
HC-7	5,229.72	962.55	11/11/2014	4,267.40	4,123.25	4,006.12	117.13
HC-8	5,259.91	1,371.75	11/11/2014	3,888.72	2,965.51	2,848.99	116.52
H-2	4,017.06[d]	110.21	11/11/2014	3,906.85	3,377.06	3,237.06	140.00
H-3	4,232.30[d]	325.58	11/11/2014	3,906.72	3,919.30	3,762.30	157.00

[a] Depth-to-water measurements not corrected for borehole deviation. Depth-to-water measurements were collected prior to performing activities that disturb ambient water level conditions.
[b] Corrected for borehole deviation.
[c] Indicates the water level/groundwater elevation have not recovered from bailing.
[d] Indicates land surface elevation because TOC elevations are not available.
BSZ = (bottom of open interval; screened, perforated, or open hole).
NM = Not measured.
TOC = top of casing (well/piezometer).
TSZ = (top of open interval; screened, perforated, or open hole).
Elevation Water (true vertical depth [TVD] corrected), Water Depth (not TVD corrected).

Water levels in wells east of the shear zone at the site are 300 to 400 ft lower than those in wells west of the shear zone at the site. Wells HC-3, HC-5, and HC-8 (Figure 6) monitor water levels east of the shear zone. Water levels in these wells have been interpreted as being stable, not increasing or decreasing, except for times when they are sampled. As more data have become available, it is apparent that the water levels in wells HC-5 and HC-8 are declining at the rate of approximately 1 to 2 ft every 10 years (Figure 6). This decline may be the cumulative result of purge water being removed during the sampling events. These wells have submersible pumps, and thousands of gallons are removed each sampling event. Well HC-3 is sampled with a bailer, and only a few gallons of water are removed during sampling.

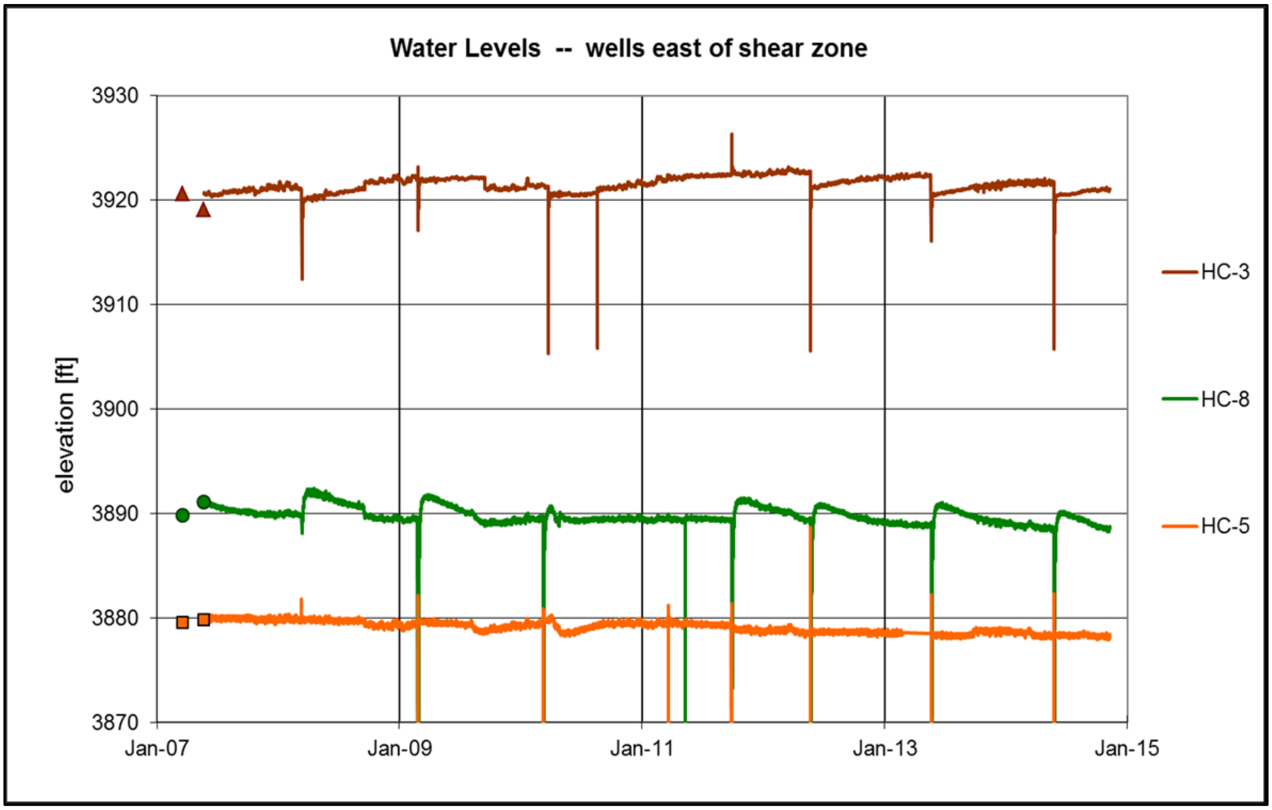

Figure 6. Hydrographs for Wells East of the Shear Zone

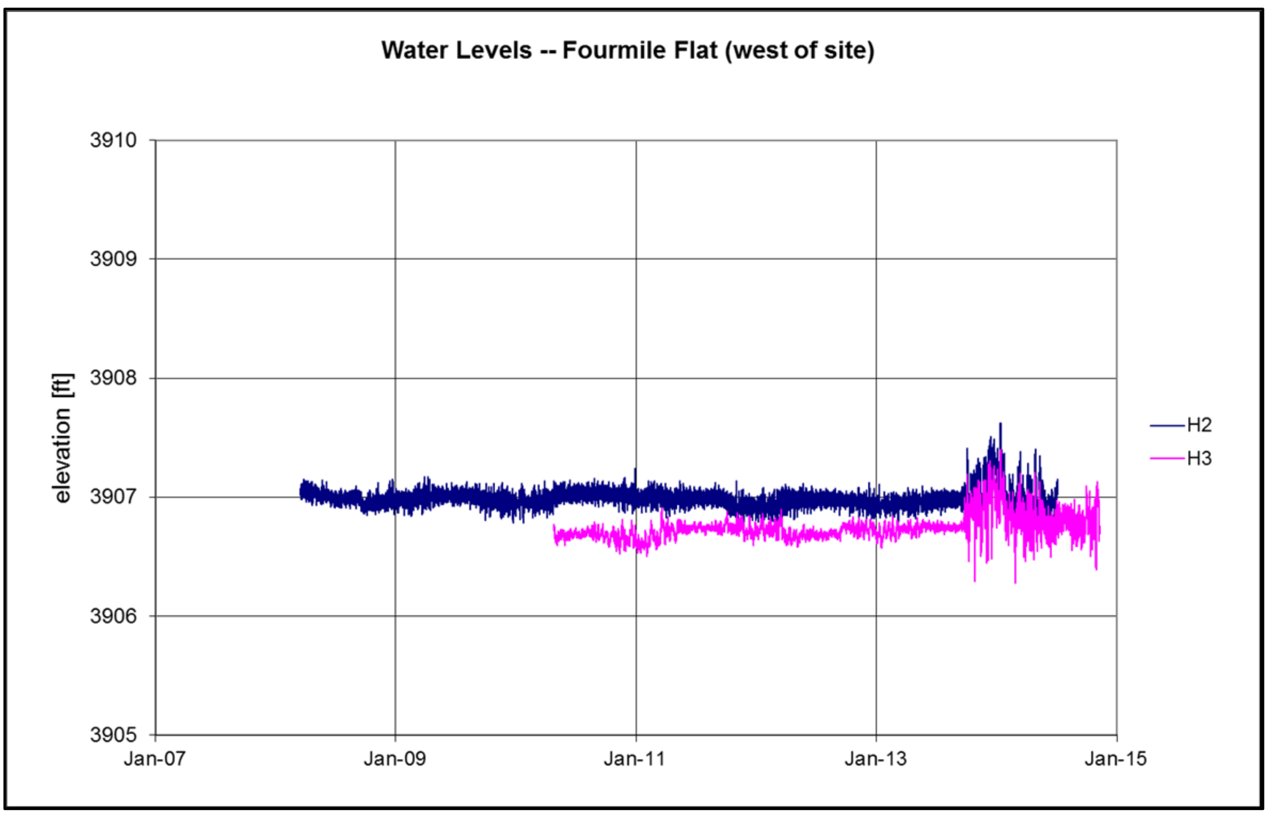

Figure 7. Hydrographs for Wells in Fourmile Flat

Water levels in wells west of the site in Fourmile Flat are 300 to 400 ft lower than those in wells west of the shear zone at the site and have been stable since they were installed in 1962. The hydrographs in wells H-2 and H-3 are shown in Figure 7. As mentioned in Section 4.3, the transducer recording barometric pressure near these wells failed, requiring a static atmospheric pressure correction to the water level data (this is apparent by the increase in variability during 2014). Given the long-term stability of water levels in these wells, it is recommended that they no longer be monitored by transducers. Water levels will continue to be taken at times when transducers in the other site wells are downloaded.

4.5 Rain Gage Monitoring Results

A Campbell Scientific tipping bucket rain gage with HOBO data logger was installed on August 8, 2012, to collect precipitation data at the site (Figure 2). The rain gage data logger was downloaded during the May 2014 sampling event but could not be downloaded during the November 2014 monitoring event. The rain gage was inspected and winterized, and a new battery was installed during the November monitoring event, but several attempts to connect to the data logger were unsuccessful. Communication with the data logger was reestablished by starting a new data collection test, but data from May through November 2014 could not be recovered. The data obtained for this monitoring period (September 2013 through May 2014) are presented with the historical data (August through September 2013) as Figure 8. The total precipitation measured from September 27, 2013, through May 28, 2014, was 6.23 inches. Precipitation data will continue to be included in future monitoring reports.

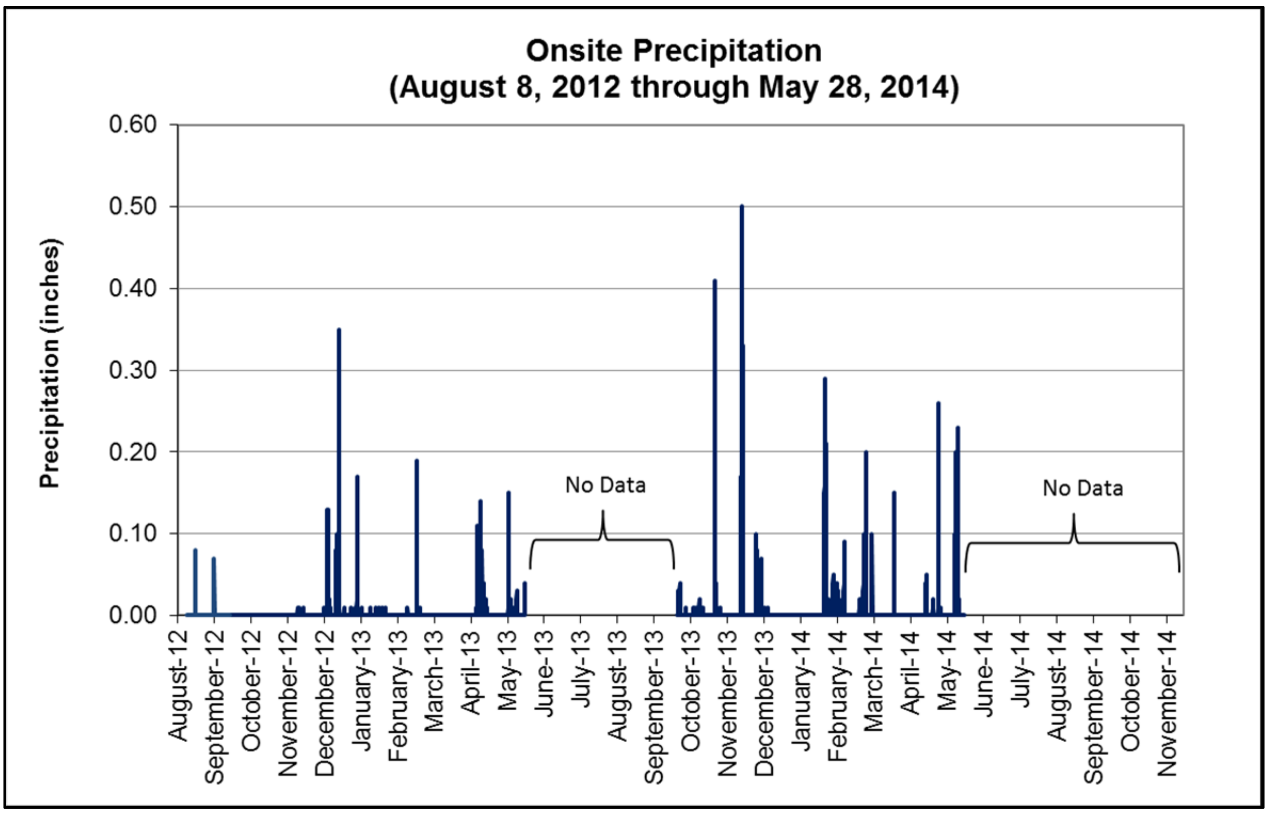

Figure 8. Precipitation Data, August 8, 2012, Through May 28, 2014

5.0 Site Inspection and Supplemental Site Activities

A site inspection was conducted as part of the monitoring events in May and November 2014. This included inspecting the site roads, rain gage, wellheads, and monument at surface ground zero for signs of damage. The rain gage, roads, wellheads, and monument were all in good condition at the time of the inspections. Supplemental activities conducted during the annual sampling event in May included collecting samples from the monitoring network wells to be analyzed for bromide. Results from the supplemental activities are provided in the following section.

5.1 Bromide Analysis

The May sampling event was enhanced by collecting samples from monitoring network wells to be analyzed for bromide. Bromide was an additive used during recent and previous drilling programs at the site to evaluate well development. It was also used during a tracer test between wells HC-6 and HC-7 in 1999. The highest concentrations of bromide were in the samples collected from well HC-6, which is where it was originally injected during the tracer test. The bromide results will be used as additional background data for the drilling program completed in October 2014. Table A-2 in Appendix A presents a summary of the bromide results from the 2014 annual sampling event.

6.0 Summary and Recommendations

The 2014 drilling program enhanced the monitoring network with five new monitoring locations (wells and piezometers) at the site. The drilling program was completed in October 2014, and only limited data were available from the new locations for this reporting period. The rain gage, roads, wellheads, and monument were all in good condition at the time of the inspections. The total precipitation measured at the site from September 27, 2013, through May 28, 2014, was 6.23 inches. No data were available from May 28 through November 11, 2014, because of a problem connecting to the rain gage data logger.

Analytical results from the 2014 monitoring event are consistent with those of the previous year. The sample collected from well HC-4 was the only sample with tritium detected above the laboratory's MDC. The tritium concentration was below EPA's tritium MCL of 20,000 pCi/L and below the well's highest concentration of 1,130 pCi/L reported in 1998 (Pohll et al. 1998). Samples collected from wells HC-2, HC-4, and HC-6 had detectable gross alpha activity and uranium mass concentrations above the EPA MCLs of 15 pCi/L and 30 µg/L, respectively. The gross alpha activity and uranium mass concentrations observed in samples collected from wells HC-2 and HC-6 are consistent with historical trends. The concentrations of gross alpha and uranium mass detected in samples from well HC-4 increased to concentrations above the EPA MCLs starting in 2012. These increases may be attributed to an increase in the volume of groundwater removed from the well during sampling. If the gross alpha values in samples collected from wells HC-2, HC-4, and HC-6 are adjusted by subtracting activities of ^{234}U and ^{238}U, the values are less than zero, indicating that uranium accounts for all or nearly all gross alpha activity in these samples. Isotope ratios of uranium obtained during this monitoring event continue to support the interpretation of a natural source of uranium in groundwater rather than a nuclear-test-related source.

Water level trends obtained from the 2014 water level data are consistent with those of previous years. Water levels in onsite wells west of the shear zone (detonation side) continued to rise from 0.82 ft in MV-2 to 1.64 ft in HC-6 (July 2013 to July 2014). The overall increase was similar to the previous year's increase for most wells and is still too high to conclude that water levels are beginning to stabilize. However, since drilling activity began in mid-August, water levels at the well locations (MV-1, MV-2, and HC-1) have stopped increasing. The short 2- to 3-month period is insufficient to conclude that water levels in these wells have stabilized. The water levels in wells HC-5 and HC-8 are declining at the rate of approximately 1 to 2 ft every 10 years.

LM recommends the following:

- Transition to manual water levels only in the MV-2 piezometer, and wells H-2 and H-3 after the batteries in the transducers fail.

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Appendix A

Well Purge Data, Bromide Sample Results from 2014 Sampling Event

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Table A-1. Monitoring Well Purge Data

Well	Date Sampled	Purged Volume (gallons)	Temperature (°C)	pH (s.u.)	Specific Conductance (µmhos/cm)
MV-1	5/27/2014	950	22.70	8.17	670
			22.80	8.14	671
			23.10	8.12	662
MV-2	5/27/2014	1255	23.70	8.24	458
			23.80	8.22	458
			24.00	8.19	458
MV-3	5/27/2014	860	22.70	8.29	689
			22.70	8.27	696
			22.70	8.24	696
HC-1	5/27/2014	5	21.99	7.03	401
HC-2	5/27/2014	5	20.83	7.69	674
HC-3	5/28/2014	4	24.60	8.33	579
HC-4	5/28/2014	725	22.40	7.44	685
			22.30	7.51	665
			22.40	7.52	655
HC-5	5/27/2014	2785	27.20	8.48	960
			27.20	8.48	958
			27.30	8.45	954
HC-6	5/27/2014	6	23.60	7.19	1095
HC-7	5/28/2014	320	22.10	7.75	1305
			22.20	7.84	1320
			22.00	7.87	1310
HC-8	5/28/2014	1405	27.90	8.22	814
			27.50	8.21	784
			27.60	8.21	786

µmhos/cm = micromhos per centimeter
NA = not analyzed
s.u. = Standard Unit

Table A-2. Bromide Sample Results from 2014 Sampling Event

Well Identification	Sample Date	Bromide (mg/L)
MV-1	5/27/2014	0.60
MV-2	5/27/2014	0.25
	5/27/2014[a]	0.26
MV-3	5/27/2014	0.89
HC-1	5/27/2014	0.40
HC-2	5/27/2014	0.42
HC-3	5/28/2014	2.50
HC-4	5/28/2014	0.67
HC-5	5/28/2014	0.27
HC-6	5/27/2014	7.00
HC-7	5/28/2014	0.96
HC-8	5/28/2014	0.43

[a] Indicates a duplicate sample
mg/L = milligrams per liter

Appendix B

Analytical Data: 2007 through Present

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Table B-1. Radioisotope and Chemical Sampling Results

Monitoring Location	Date	Carbon-14[a] (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)	Gross alpha (pCi/L)
MV-1	3/21/2007	<RDL (5.83E-03)[a]	<RDL (7.3E-11)	<359	42	25.6
	3/21/2007	NA	NA	NA	41[b]	21.5[b]
	3/11/2008	<RDL (2.49E-02)	<RDL (19.0E-11)	<180	21	14.0
	2/26/2009	<RDL (1.95E-02)	<RDL (10.5E-11)	<350	21	12.6
	3/11/2010	<RDL (1.93E-02)	<RDL (7.8E-11)	<300	21	11.3
	3/22/2011	NA	NA	<350	25	16.6
	3/22/2011[c]	NA	NA	<360	25	14.3
	5/25/2012	NA	NA	<300	22	14.3
	5/22/2013	NA	NA	<370	21	13.6
	5/27/2014	NA	NA	<320	21	10.7
MV-2	3/21/2007	<RDL (1.77E-02)[a]	<RDL (8.3E-11)	<361	34	16.3
	3/21/2007	NA	NA	NA	34[b]	17.3[b]
	3/11/2008	<RDL (2.44E-02)	<RDL (29.5E-11)	<180	23	11.1
	2/26/2009	<RDL (2.13E-02)	NR	<360	24	12
	3/11/2010	<RDL (3.31E-02)	<RDL16.5 (E-11)	<300	21	13.8
	3/22/2011	NA	NA	<350	23	9.92
	5/24/2012	NA	NA	<300	22	10.6
	5/22/2013	NA	NA	<320	22	9.79
	5/27/2014	NA	NA	<320	22	11.6
	5/27/2014[c]	NA	NA	<320	21	10.8
MV-3	3/21/2007	<RDL (5.90E-03)[a]	<RDL (13.5E-11)	<357	14	10.2
	3/21/2007	NA	NA	NA	14[b]	9.57[b]
	3/11/2008	<RDL (1.37E-02)	<RDL (18.0E-11)	<320	3.8	2.11
	2/26/2009	<RDL (8.37E-03)	<RDL (10.7E-11)	<360	3.8	<1.5
	3/12/2010	<RDL (1.29E-02)	<RDL (6.5E-11)	<300	4.2	2.63
	3/22/2011	NA	NA	<350	5.8	4.98
	5/25/2012	<RDL (1.06E-02)	NA	<300	7	2.72
	5/21/2013	NA	NA	<340	8	5.08
	5/21/2013[c]	NA	NA	<380	8	5.84
	5/27/2014	NA	NA	<320	8.3	4.98
HC-1	3/21/2007	<RDL (1.52E-02)[a]	<RDL (9.6E-11)	<355	3.3	3.9
	3/21/2007	NA	NA	NA	3.4[b]	4.46[b]
	3/11/2008	<RDL (2.35E-02)	<RDL (4.9E-11)	<320	4.8	12.5
	2/26/2009	<RDL (2.01E-02)	NR	<360	1.4	<1.4
	3/24/2010	<RDL (3.18E-02)	<RDL (11.9E-11)	<310	3.3	4.93
	3/22/2011	NA	NA	<360	1.6	2.19
	5/23/2012	<RDL (1.23E-02)	NA	<300	1.1	<0.75
	5/22/2013	NA	NA	<340	0.9	3.19
	5/27/2014	NA	NA	<320	0.8	<1.2
HC-2	3/24/2010	<RDL(1.90E-02)	<RDL (2.5E-11)	<300	140	63.8
	3/22/2011	NA	NA	<360	120	197
	5/22/2012	NA	NA	<300	110	64.5
	5/22/2013	NA	NA	<330	100	61.1
	5/27/2014	NA	NA	<320	100	46.8

Table B-1 (continued). Radioisotope and Chemical Sampling Results

Monitoring Location	Date	Carbon-14[a] (pCi/L)	Iodine-129 (pCi/L)	Tritium (pCi/L)	Uranium (µg/L)	Gross alpha (pCi/L)
HC-3	3/24/2010	<RDL (2.37E-02)	<RDL (541E-11)	<300	4.3	2.57
	3/22/2011	NA	NA	NA	NA	NA
	5/23/2012	<RDL (1.45E-02)	NA	<300	2	0.283
	5/22/2013	NA	NA	<350	2.7	0.724
	5/28/2014	NA	NA	<320	0.32	<1.9
HC-4	3/21/2007	<RDL (0.565)[a]	<RDL (32.4E-11)	<359	0.75	1.41
	3/21/2007	NA	NA	NA	0.85[b]	1.93[b]
	3/21/2007[c]	<RDL (0.436)[a]	<RDL (34.2E-11)	<359	0.69	1.75
	3/21/2007[c]	NA	NA	NA	0.81[b]	<0.876[b]
	3/11/2008	<RDL (2.06)	<RDL (21.5E-11)	555	4.5	2.88
	2/26/2009	<RDL (3.20)	<RDL (0.6E-11)	434	2.0	<1.4
	3/11/2010	<RDL (2.93)	<RDL (38.7E-11)	544	6.4	1.79[b]
	3/23/2011	NA	NA	554	8.9	3.82
	5/24/2012[c]	NA	NA	774	46	16.7
	5/24/2012	<RDL (2.50)	NA	803	46	22.9
	5/21/2013	NA	NA	964	60	35.1
	5/28/2014	NA	NA	700	62	27.8
HC-5	3/11/2010	<RDL (5.11E-03)	<RDL (1.1E-11)	<300	0.48	<1.5
	3/23/2011	NA	NA	<360	0.45	<2.1
	5/23/2012	<RDL (3.70E-03)	NA	<300	0.49	0.349
	5/22/2013	NA	NA	<340	0.40	0.957
	5/28/2014	NA	NA	<320	0.33	<2.2
HC-6	3/24/2010	<RDL (1.14E-02)	<RDL (5.6E-11)	<300	35	25.7
	3/23/2011	NA	NA	<360	37	20.4
	5/23/2012	<RDL (1.16E-02)	NA	<300	38	14.1
	5/22/2013	NA	NA	<360	36	19.1
	5/27/2014	NA	NA	<320	39	16.9
HC-7	3/11/2010	<RDL (5.31E-03)	<RDL (3.0E-11)	<300	7.4	5.77
	3/23/2011	NA	NA	<360	13	10.6
	5/23/2012	NA	NA	<300	41	23.9
	5/21/2013	NA	NA	<370	15	13.8
	5/28/2014	NA	NA	<320	11	6.76
HC-8	3/10/2010	<RDL (9.63E-03)	<RDL (1.3E-11)	<300	0.25	<1.3
	3/23/2011	NA	NA	NA	NA	NA
	5/25/2012	NA	NA	<300	0.2	0.454
	5/23/2013	NA	NA	<380	0.14	1.24
	5/28/2014	NA	NA	<320	0.23	<1.9

[a] Estimated based on sample volume of 200 milliliters for 2007 samples.
[b] Indicates the sample was filtered.
[c] Indicates a duplicate sample.
NA = not applicable (samples not collected or samples not analyzed).
NR = not run, because sample bottle was broken during shipment to the laboratory.
<RDL = below required detection limit with laboratory result in parentheses; RDL is 5 pCi/L for ^{14}C, 0.1 pCi/L for ^{129}I, 400 pCi/L for tritium, 50 µg/L for uranium, and 4 pCi/L for gross alpha (DOE/NNSA 2006).

Table B-2. Uranium Isotope Sampling Results

Monitoring Location	Date	Uranium-234 (pCi/L)	Uranium-238 (pCi/L)	Uranium-234:Uranium-238
MV-1	3/21/2007	16.8[a]	14.2[a]	1.18[a]
	3/21/2007	15.4	12.6	1.22
	3/11/2008	7.35	6.2	1.19
	2/26/2009	8.75	6.98	1.25
	3/11/2010	9.06	7.64	1.19
	3/22/2011	10.8	8.89	1.21
	3/22/2011[b]	10.4	8.77	1.19
	5/25/2012	8.14	6.81	1.20
	5/22/2013	8.72	7.35	1.19
	5/27/2014	7.69	6.42	1.20
MV-2	3/21/2007	13.6[a]	11.4[a]	1.19[a]
	3/21/2007	13.2	11.7	1.13
	3/11/2008	8.95	7.89	1.13
	2/26/2009	8.64	6.7	1.29
	3/11/2010	9.66	8.32	1.16
	3/22/2011	10.1	8.65	1.17
	5/24/2012	7.9	7.01	1.13
	5/22/2013	8.83	7.85	1.12
	5/27/2014	8.38	7.0	1.20
	5/27/2014[b]	8.15	7.16	1.14
MV-3	3/21/2007	4.64[a]	4.37[a]	1.06[a]
	3/21/2007	5.47	4.68	1.17
	3/11/2008	1.47	1.17	1.25
	2/26/2009	1.33	0.998	1.33
	3/12/2010	1.7	1.42	1.20
	3/22/2011	2.55	2.2	1.16
	5/25/2012	2.49	2.3	1.08
	5/21/2013	3.6	2.73	1.32
	5/21/2013[b]	3.58	2.84	1.26
	5/27/2014	2.95	2.52	1.17
HC-1	3/21/2007	1.28[a]	1.19[a]	1.08[a]
	3/21/2007	1.4	1.19	1.18
	3/11/2008	1.84	1.51	1.21
	2/26/2009	0.572	0.385	1.49
	3/24/2010	1.24	1.05	1.18
	3/22/2011	0.9	0.609	1.48
	5/23/2012	0.401	0.35	1.15
	5/22/2013	0.425	0.291	1.46
	5/27/2014	0.373	0.25	1.49
HC-2	3/24/2010	45.1	45.3	0.996
	3/22/2011	45.2	45.3	0.998
	5/22/2012	38.1	36.2	1.05
	5/22/2013	37.2	37.2	1.00
	5/27/2014	33.4	32.5	1.03

Table B-2 (continued). Uranium Isotope Sampling Results

Monitoring Location	Date	Uranium-234 (pCi/L)	Uranium-238 (pCi/L)	Uranium-234:Uranium-238
HC-3	3/24/2010	1.16	1.21	0.96
	3/22/2011	NA	NA	NA
	5/23/2012	0.678	0.668	1.01
	5/22/2013	0.932	0.966	0.96
	5/28/2014	0.102	0.106	0.96
HC-4	3/21/2007	0.349[a]	0.308[a]	1.12[a]
	3/21/2007[b]	0.313[a]	0.33[a]	0.95[a]
	3/21/2007	0.293	0.305	0.96
	3/21/2007[b]	0.31	0.336	0.92
	3/11/2008	1.53	1.63	0.94
	2/26/2009	0.654	0.722	0.91
	3/11/2010	2.27[a]	1.95[a]	1.16[a]
	3/23/2011	2.69	2.86	0.941
	5/24/2012[b]	14.4	15.1	0.95
	5/24/2012	14.2	14.8	0.96
	5/21/2013	22	20.8	1.06
	5/28/2014	21.4	21.5	1.00
HC-5	3/11/2010	0.295	0.173	1.71
	3/23/2011	0.264	0.117	2.26
	5/23/2012	0.227	0.126	1.80
	5/22/2013	0.240	0.122	1.97
	5/28/2014	0.255	0.149	1.71
HC-6	3/24/2010	14.4	12.2	1.18
	3/23/2011	15.4	13.5	1.14
	5/23/2012	14.4	12.2	1.18
	5/22/2013	15.7	12.6	1.25
	5/27/2014	15.6	13.6	1.15
HC-7	3/11/2010	3.43	3.08	1.11
	3/23/2011	5.9	4.78	1.23
	5/23/2012	16.1	13.9	1.16
	5/21/2013	6.31	5.56	1.13
	5/28/2014	4.1	3.76	1.09
HC-8	3/10/2010	0.187	0.101	1.85
	3/23/2011	NA	NA	NA
	5/25/2012	0.153	0.0553	2.77
	5/23/2013	0.107	0.041	2.61
	5/28/2014	0.102	0.094	1.09

[a] Indicates the sample was filtered.
[b] Indicates a duplicate sample.
NA = not applicable (samples not collected or samples not analyzed).

Appendix C

Hydraulic Head Data: 1996 through Present

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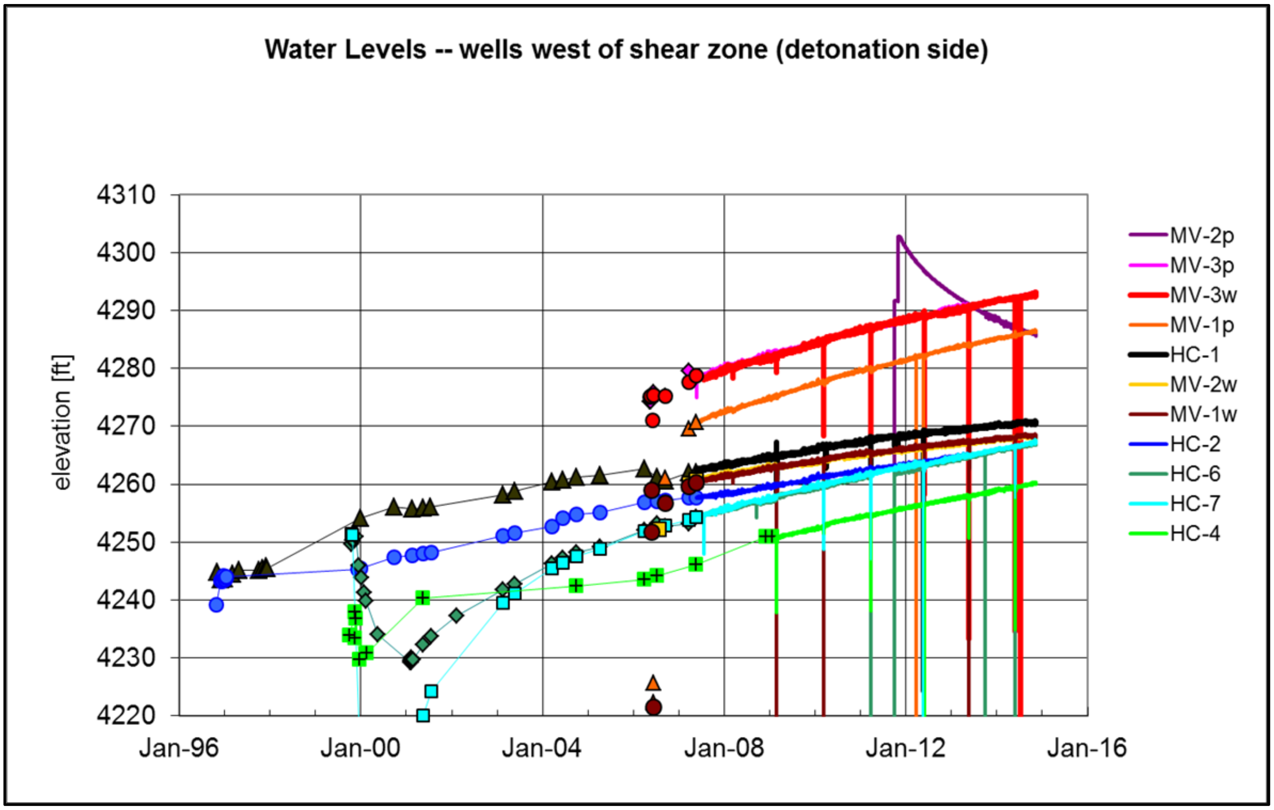

Figure C-1. Hydrographs for Wells West of the Shear Zone (expanded scale on Y axis)

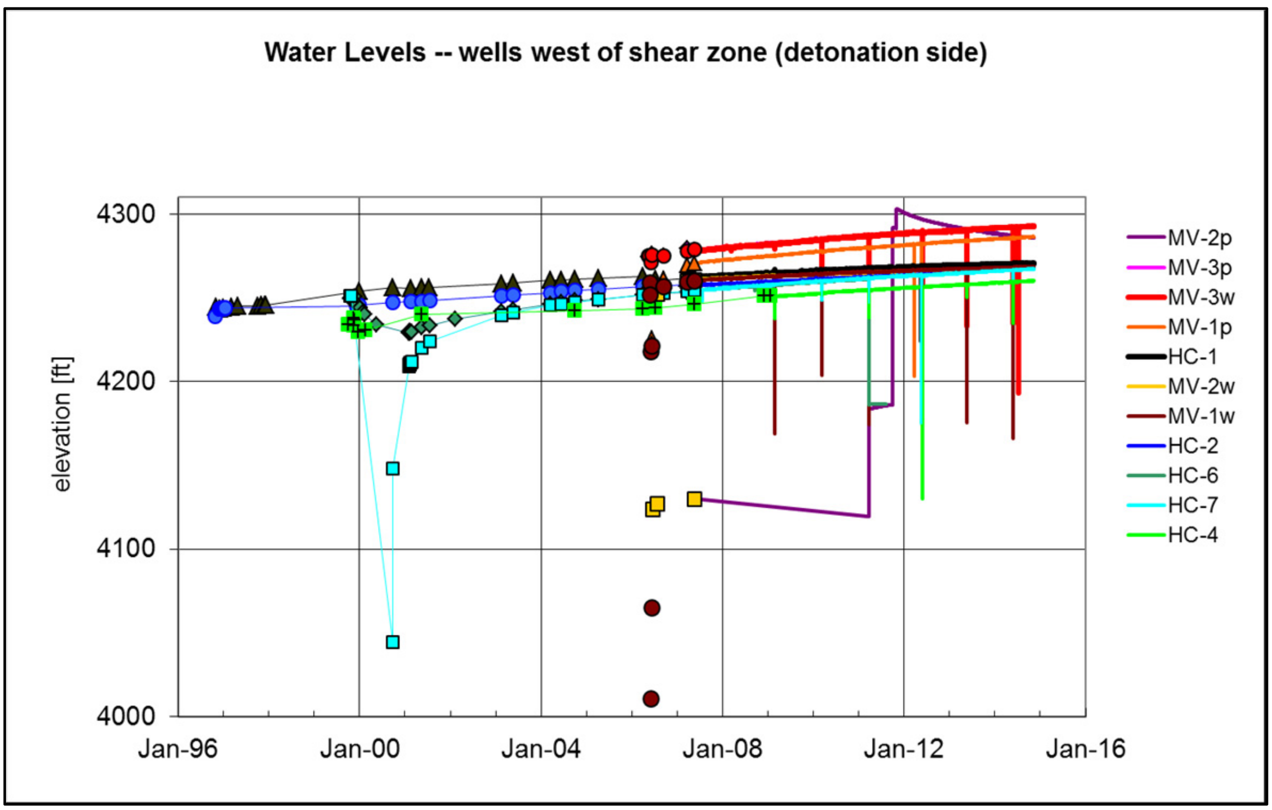

Figure C-2. Hydrographs for Wells West of the Shear Zone

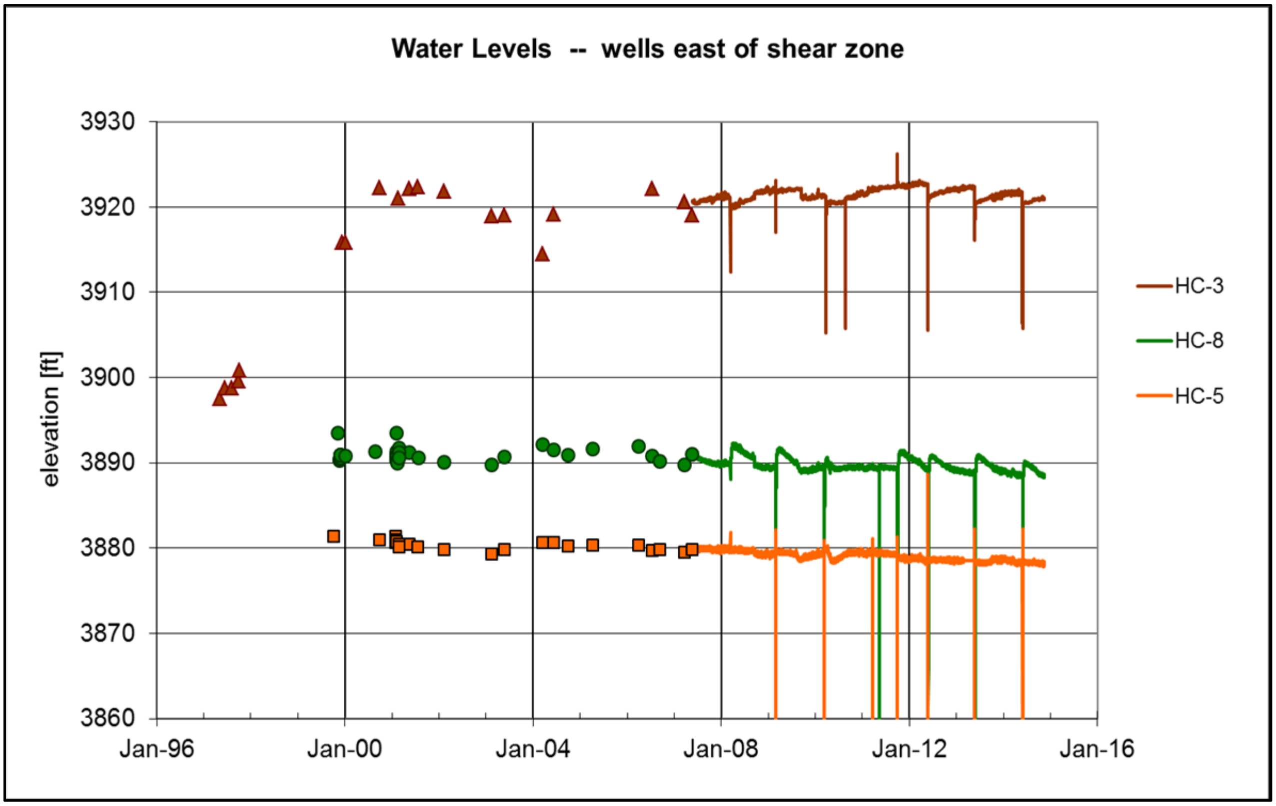

Figure C-3. Hydrographs for Wells East of the Shear Zone

Appendix D

Annual Water Level Changes in Wells West of Shear Zone: July 2007 through July 2014

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Table D-1. Annual Water Level Changes in Wells West of the Shear Zone

Date Range (month/year)	Wells/Piezometers West of Shear Zone (water level change in feet/year)										
	MV-1	**MV-1PZ**	**MV-2**	**MV-2PZ**	**MV-3**	**MV-3PZ**	**HC-1**	**HC-2**	**HC-4**	**HC-6**	**HC-7**
7/2007–7/2008	1.52	2.67	1.37	NM	2.71	2.57	1.40	1.09	NM	2.00	2.28
7/2008–7/2009	1.40	2.48	0.95	NM	2.16	2.20	1.32	1.40	NM	1.96	NM
7/2009–7/2010	1.38	2.48	1.36	NM	2.54	2.23	1.49	1.49	2.12	1.79	NM
7/2010–7/2011	0.79	1.80	0.76	NM	1.82	1.67	1.21	1.02	1.46	NM	1.64
7/2011–7/2012	1.23	2.10	0.94	NM	1.78	1.91	1.08	1.24	1.72	NM	1.35
7/2012–7/2013	0.67	1.71	0.85	NM	1.65	1.84	0.72	1.34	1.35	1.44	1.59
7/2013–7/2014	1.03	1.63	0.82	NM	1.43	1.41	0.94	NM	1.52	1.64	1.57

NM = Not measured, because transducer data were not available.

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Appendix E

NDEP Correspondence with Record of Review and Response to Comments

ndep
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
protecting the future for generations

STATE OF NEVADA
Department of Conservation & Natural Resources
DIVISION OF ENVIRONMENTAL PROTECTION

Brian Sandoval, Governor
Leo M. Drozdoff, P.E., Director
Colleen Cripps, Ph.D., Administrator

February 9, 2015

RECEIVE DOE
FEB 13 2015
GRAND JUNCTION OFFICE

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

RE: Draft 2014 Groundwater Monitoring Report for Corrective Action Unit (CAU) 447: Project Shoal Area – Subsurface
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 *Draft 2014 Groundwater Monitoring Report for Corrective Action Unit (CAU) 447: Project Shoal Area - Subsurface,* (Report) received on January 15, 2015. While this letter serves as a Notice of Completion for the January 16, 2015 Milestone Deadline for the "Draft 2015 Monitoring Report," the NDEP has the following comments on the Report which should be addressed in the Final version of the Report:

1. Page 4, Section 2.1, first full sentence on page: please add "a future" between "…will be provided to NDEP in" and "addendum to the CADD/CAP…"

2. Page 8, Section 4.1, first paragraph, second sentence: please specify which Short-term Data Acquisition Plan reduced the frequency for analyzing samples for carbon-14 and iodine-129.

3. Page 8, Section 4.2, first paragraph, sixth sentence: "…elevated levels of 14C detected in samples collected from well HC-4 compared to levels in other samples… (Table 1 and Appendix B, Table B-1)". The values listed in the referenced tables for HC-4 are all below RDL. Please add a clarifying sentence explaining that the comparison and conclusion are using lab results that are below the RDL and are not useable for regulatory decisions.

4. Page 10, Section 4.2, first paragraph, third sentence: please change "have" to "had" to reflect the trending being referenced in this sentence is in the past.

5. Page 10, Section 4.2, first paragraph, eighth, ninth and tenth sentences: please consider moving the eighth sentence to after the tenth sentence to have the information in these sentences in chronological order.

If you would like to discuss these comments, please contact me at 702-486-2850, ext. 232, or Mark McLane at ext. 226.

Sincerely,

Mark McLane
For

Christine D. Andres
Chief
Bureau of Federal Facilities

CDA/MM

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R. Hutton, Stoller, Grand Junction, CO

Record of Review

Due Date	Review No.	Project	Type of Review
3/20/15	1	Shoal	Draft Report - Technical Review

Document Title and\or Number and Revision
Draft 2014 Groundwater Monitoring Report, Project Shoal Area, Subsurface Corrective Action Unit 447

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Reviewers' Recommendation

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

Comments provided in NDEP letter dated February 9, 2015

Signature of Reviewer and Date

- ☒ Comments Have Been Addressed

Digitally signed by Mark Kautsky
Date: 2015.03.02 13:39:30 -07'00'

Signature of Author and Date

- ☒ Comment Resolution Satisfactory
- ☐ Comment Resolution Unsatisfactory

Mark McLane

Signature of Reviewer and Date

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
1	Page 4, Section 2.1, first full sentence on page: please add "a future" between "...will be provided to NDEP in" and "addendum to the CADD/CAP ..."	Y	1	The sentence was revised to include "a future".
2	Page 8, Section 4.1, first paragraph, second sentence: please specify which Short-term Data Acquisition Plan reduced the frequency for analyzing samples for carbon-14 and iodine-129.	Y	2	The sentence was modified to include reference to the Short-term Data Acquisition Plan completed in 2009 (DOE 2009) that reduced the frequency for analyzing samples for carbon-14 and iodine-129.
3	Page 8, Section 4.2, first paragraph, sixth sentence:"... elevated levels of 14C detected in samples collected from well HC-4 compared to levels in other samples... (Table 1 and Appendix B, Table B-1)". The values listed in the referenced tables for HC4 are all below RDL. Please add a clarifying sentence explaining that the comparison and conclusion are using lab results that are below the 'RDL and are not useable for regulatory decisions.	Y	3	The following sentence was added to the first paragraph in Section 4.2. "It should be noted that concentrations of 14C are below the RDL in all samples and that conclusions based on a comparison of the results are not useable for regulatory decisions."

Record of Review (continuation)

Review No.	Project

Item No.	Reviewer's Comments and Recommendation	Reqd. (Y/N)	Item No.	Author's Response (if required)
4	Page 10, Section 4.2, first paragraph, third sentence: please change "have" to "had" to reflect the trending being referenced in this sentence is in the past.	Y	4	The sentence was revised to replace "have" with "had".
5	Page 10, Section 4.2, first paragraph, eighth, ninth and tenth sentences: please consider moving the eighth sentence to after the tenth sentence to have the information in these sentences in chronological order.	Y	5	The sentences were reorganized to be in chronological order.

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