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Closure Report for the Project Shoal Area: Subsurface Corrective Action Unit 447 Shoal, Nevada, Site

October 2020

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

AEC	U.S. Atomic Energy Commission
amsl	above mean sea level
BLM	U.S. Bureau of Land Management
^{14}C	carbon-14
CADD/CAP	Corrective Action Decision Document/Corrective Action Plan
CAIP	Corrective Action Investigation Plan
CAS	Corrective Action Site
CAU	Corrective Action Unit
CFR	*Code of Federal Regulations*
DDA	Data Decision Analysis
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
FFACO	Federal Facility Agreement and Consent Order
FMP	Fluid Management Plan
FR	*Federal Register*
ft	feet
GIS	geographic information system
HC	hydrologic characterization
^{129}I	iodine-129
IC	institutional control
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
LM	Office of Legacy Management
m/d	meters per day
MDC	minimum detectable concentration
MV	monitoring/validation
NDEP	Nevada Division of Environmental Protection
NDWR	Nevada Division of Water Resources
PLO	Public Land Order
QSM	*Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*
ROTC	Record of Technical Change
SAP	Sampling and Analysis Plan

SCM	site conceptual model
SDWA	Safe Drinking Water Act
SGZ	surface ground zero
USC	*United States Code*

Executive Summary

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) prepared this Closure Report for the subsurface Corrective Action Unit (CAU) 447 at the Shoal, Nevada, Site, which was formerly called the Project Shoal Area. The Shoal site was the location of an underground nuclear test in 1963 that resulted in residual radionuclide contamination at the detonation depth of 1211 feet. Responsibility for the site's environmental restoration was transferred from the DOE, National Nuclear Security Administration, Nevada Field Office, to LM on October 1, 2006. The environmental restoration process and Corrective Action strategy for the site are conducted in accordance with the Federal Facility Agreement and Consent Order (FFACO) (FFACO 1996, as amended) and all applicable Nevada Division of Environmental Protection (NDEP) statutes and regulations. This Closure Report provides justification for closure and provides a summary of completed investigation and closure activities; describes the selected Corrective Action Alternative; provides an implementation plan for long-term monitoring with well network maintenance and approaches for implementing institutional controls (ICs); and presents the contaminant, compliance, and use-restriction boundaries for the site.

The subsurface contamination at the site, which is the focus of this report, is identified as CAU 447. This CAU is composed of two Corrective Action Sites (CASs): test cavity CAS 57-57-001 and emplacement shaft CAS 57-49-01. The former test cavity is the source of contamination at the site. The Corrective Action strategy for CAU 447 followed the original Nevada National Security Site (formerly Nevada Test Site) Underground Test Area strategy, with modifications to accommodate site conditions. The approach included developing a site conceptual model (SCM) and a numerical flow and transport model to calculate contaminant boundaries, negotiating compliance boundaries with NDEP, performing model validation, and monitoring groundwater. This strategy was executed through the Corrective Action Decision Document/Corrective Action Plan phase, which selected the Corrective Action Alternative "Proof-of-Concept and Monitoring with Institutional Controls" for implementation at the site. During the 5-year proof-of-concept monitoring and model validation process, LM determined that the groundwater flow and transport model developed for the site could not be validated because (1) the steady-state assumption used for the model was not valid and (2) groundwater elevations observed at wells MV-1, MV-2, and MV-3 did not validate the predominant horizontal flow direction predicted by the modeled realizations. Despite these results, hydraulic conductivity values and fracture geometry from the MV-1, MV-2, and MV-3 well data agreed with those used as model input. These conclusions prompted the recommendation that additional data be collected and alternative approaches be evaluated for determining the contaminant boundary at the site. This led to a revised Corrective Action strategy designed to validate the compliance boundary through monitoring and ICs, rather than relying predominantly on the numerical flow and transport model.

LM implemented the revised Corrective Action strategy (Section 5.0) it developed with NDEP by revising the FFACO, Appendix VI, completed in May 2011. The new approach was implemented through three separate short-term data acquisition plans completed in 2009, 2011, and 2014. These plans facilitated enhancements to the monitoring well network and data collections designed to improve the SCM. This included the conceptualization of three potential groundwater flow models and changes to the contaminant and compliance boundaries for the site. The new strategy included a new 5-year evaluation period, which began after the last data

acquisition plan was completed in 2014. Data collected during the current evaluation period (2014–2019) was used with data collected during the original proof-of-concept monitoring period that began in 2006, to demonstrate that the interpreted potential transport pathways identified through the SCMs are adequately monitored.

Implementation of the Corrective Action strategy for CAU 447 includes postclosure monitoring with ICs as part of the long-term stewardship of the site. Unrestricted public access to the Shoal site increases the importance of having ICs around areas of potential contamination. For this reason, the Corrective Action strategy includes a use-restriction area that mimics the compliance boundary that was negotiated with NDEP. The use-restriction is designed to control public access to groundwater through restrictions applied to drilling and to the use of groundwater. Long-term stewardship is designed to prevent exposure to radionuclides that remain in the former detonation cavity and ensure protection of human health and the environment. The long-term monitoring program is designed to (1) assess the effectiveness of the compliance boundary by monitoring for the radionuclides of interest and (2) evaluate the effectiveness of monitoring locations within the groundwater flow system by monitoring groundwater elevations and radionuclides of interest to ensure that monitoring wells are located along potential migration pathways. The monitoring program will provide time-series data (radionuclide concentrations and groundwater elevations) from a network of monitoring wells and piezometers at the site. The configuration of the monitoring network and frequency of data collection is based on available data regarding current and expected future site conditions. The long-term monitoring program will be reviewed periodically and revised as necessary to track changes in radionuclide concentrations and stability of the flow system over time.

LM will provide groundwater monitoring reports to NDEP during the long-term monitoring program. These reports will summarize the annual site inspection results, provide recommendations for any corrective maintenance actions, provide a status on the ICs, and document the contaminant detection and groundwater elevation monitoring results. The reports will include hydrographs for the wells and piezometers in the monitoring network. These data will be used to evaluate if the compliance and use-restriction boundaries are protective of human health and the environment.

1.0 Introduction

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) has prepared this Closure Report for subsurface Corrective Action Unit (CAU) 447 at the Shoal, Nevada, Site, which was formerly called the Project Shoal Area. The Shoal site was the location of an underground nuclear test in 1963 that resulted in residual radionuclide contamination at the detonation depth of 1211 feet (ft) (DOE 2015a). The environmental restoration process and Corrective Action strategy are conducted in accordance with the Federal Facility Agreement and Consent Order (FFACO) (FFACO 1996, as amended) and all applicable Nevada Division of Environmental Protection (NDEP) statues and regulations. Responsibility for the environmental site restoration was transferred from the DOE, National Nuclear Security Administration, Nevada Field Office, to LM on October 1, 2006.

The Shoal site is south of U.S. Highway 50, approximately 30 miles southeast of Fallon, in Churchill County, Nevada (Figure 1). The site was selected for underground nuclear testing in 1961, as part of the Vela Uniform Program. Vela was a research and development program directed toward locating, detecting, and identifying underground and high-altitude nuclear detonations. The Vela Uniform program was specific to underground detonations (AEC 1964). The objective of Project Shoal was to detonate a nuclear device underground in an active seismic area to improve the United States' ability to detect, identify, and locate underground nuclear detonations. The underground nuclear test at Shoal was a joint effort between the U.S. Department of Defense (DOD) and the U.S. Atomic Energy Commission (AEC), which was the predecessor agency to DOE. Figure 1 is a map showing the site location.

1.1 Purpose

The Closure Report provides justification for the closure of subsurface CAU 447 and describes the Corrective Action that was selected in the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) (DOE 2006b) and the Addendum to the CADD/CAP (DOE 2019b) for implementation at the site. The CADD/CAP evaluated potential Corrective Action Alternatives, provides the rationale for the selection of the recommended Corrective Action, presented the Corrective Action scope of work, and details the postclosure plan. The Addendum to the CADD/CAP incorporated findings from the Corrective Action scope of work, provided results of enhancements to the Corrective Action scope of work that were implemented through three separate data acquisition plans, and implements recommendations for changes to the Corrective Action plan. This Closure Report provides a summary of completed corrective actions, describes the selected Corrective Action Alternative, provides an implementation plan for long-term monitoring with well network maintenance and approaches for implementing institutional controls (ICs), and presents the contaminant, compliance, and use-restriction boundaries for the site.

1.2 Site Background and Regulatory Process

Preparation for the Shoal underground nuclear test began in 1959 with the evaluation of several sites as possible locations for the test. In 1961, the four-square mile site (2560 acres) situated in the Sand Springs Range was selected for the underground nuclear test (AEC 1964). The site was selected because of its location within an active seismic area with shallow focus earthquakes and

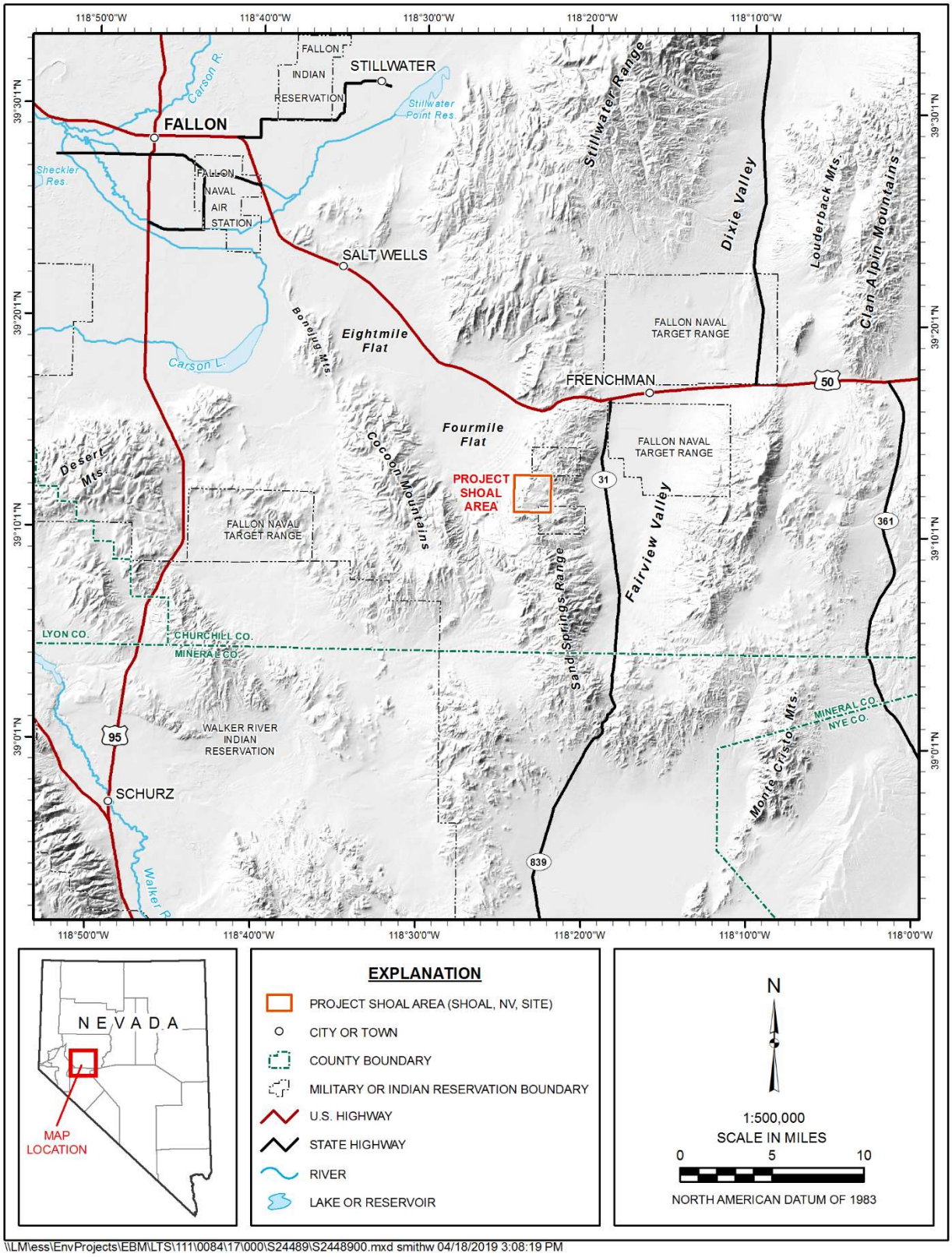


Figure 1. Shoal Site Location Map

for its granitic environment at the planned detonation depth (Figure 1). To secure the site, a total of 2560 acres were withdrawn from the U.S. Bureau of Land Management (BLM) under Public Land Order (PLO) 2771 on September 6, 1962 (Volume 27 *Federal Register* page 9062 [27 FR 9062]), and later amended by PLO 2834 on December 4, 1962 (27 FR 12219), to be used by AEC (predecessor agency to DOE) for experimental purposes. In Title XXX of the National Defense Authorization Act of 2000 (Public Law 106-65, Sections 3011–3023 [PL 106-65 Sections 3011-3023]) "the lands are hereby withdrawn from all forms of appropriation under the public land laws, including the mining laws and the mineral leasing and geothermal leasing laws". The surface of the Shoal site, along with the surrounding area, was reserved to the U.S. Navy for tactical maneuvering and air support testing and training. Under this same act, DOE retained responsibility and liability for subsurface interests and DOD is responsible for the management and use of the surface at the Shoal site.

Several agencies were involved in the site evaluation phase leading up to the 1963 detonation, including the assistance of the U.S. Bureau of Mines, the University of Nevada, and the U.S. Geological Survey in conducting geologic and hydrogeologic investigations at the site. Once it was determined that the site was suitable for the experiment, a 12 × 6 ft vertical shaft was mined to a depth of approximately 1300 ft (Figure 2). A horizontal drift/tunnel was then mined from the bottom of the shaft, extending approximately 300 ft to the west and approximately 1050 ft to the east and ending in a 30-foot vertical "buttonhook" that was designed for placement of the nuclear device. The underground nuclear test was conducted in granite rock at a depth of 1211 ft on October 26, 1963. The nuclear device had a reported yield of 12 kilotons (DOE 2015a). The detonation created a cavity that collapsed shortly after the test, forming a rubble chimney (Hazleton 1965). The former cavity, now the lower part of the collapse chimney, and fractured rock surrounding the former cavity are together referred to as the detonation zone. Site deactivation and postshot drilling activities began on October 28, 1963. 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 shaft (now referred to as the emplacement shaft) was covered with a concrete slab, and the particle motion boreholes, 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). Figure 3 is a cross section showing the well screen zones, potentiometric surface, emplacement shaft and drift/tunnel, and shear zone that crosses the site.

Surface and subsurface contamination resulted from the test. To address these areas of contamination, surface and subsurface CAUs were identified, and the areas of contamination were addressed through separate Corrective Action processes. These Corrective Action processes were conducted in accordance with the FFACO (FFACO 1996, as amended) and all applicable NDEP statutes and regulations. The surface was identified as CAU 416 and consisted of three Corrective Action Sites (CASs): mud pit CAS 57-01-09 with drilling mud impacted by petroleum hydrocarbons, muckpile CAS 57-06-01 composed of granite remaining from the excavation of the emplacement shaft, and housekeeping area CAS 57-98-01 containing approximately 20 rusted and empty oil cans. Remediation of the surface CAU 416 was completed in 1998 and summarized in the *Closure Report for Corrective Action Unit 416: Project Shoal Area* (DOE 1998b), also called the Surface Closure Report. NDEP approved the Surface Closure Report on February 13, 1998, stating that no postclosure monitoring is required, and that no land use restrictions apply at CAU 416 (NDEP 1998).

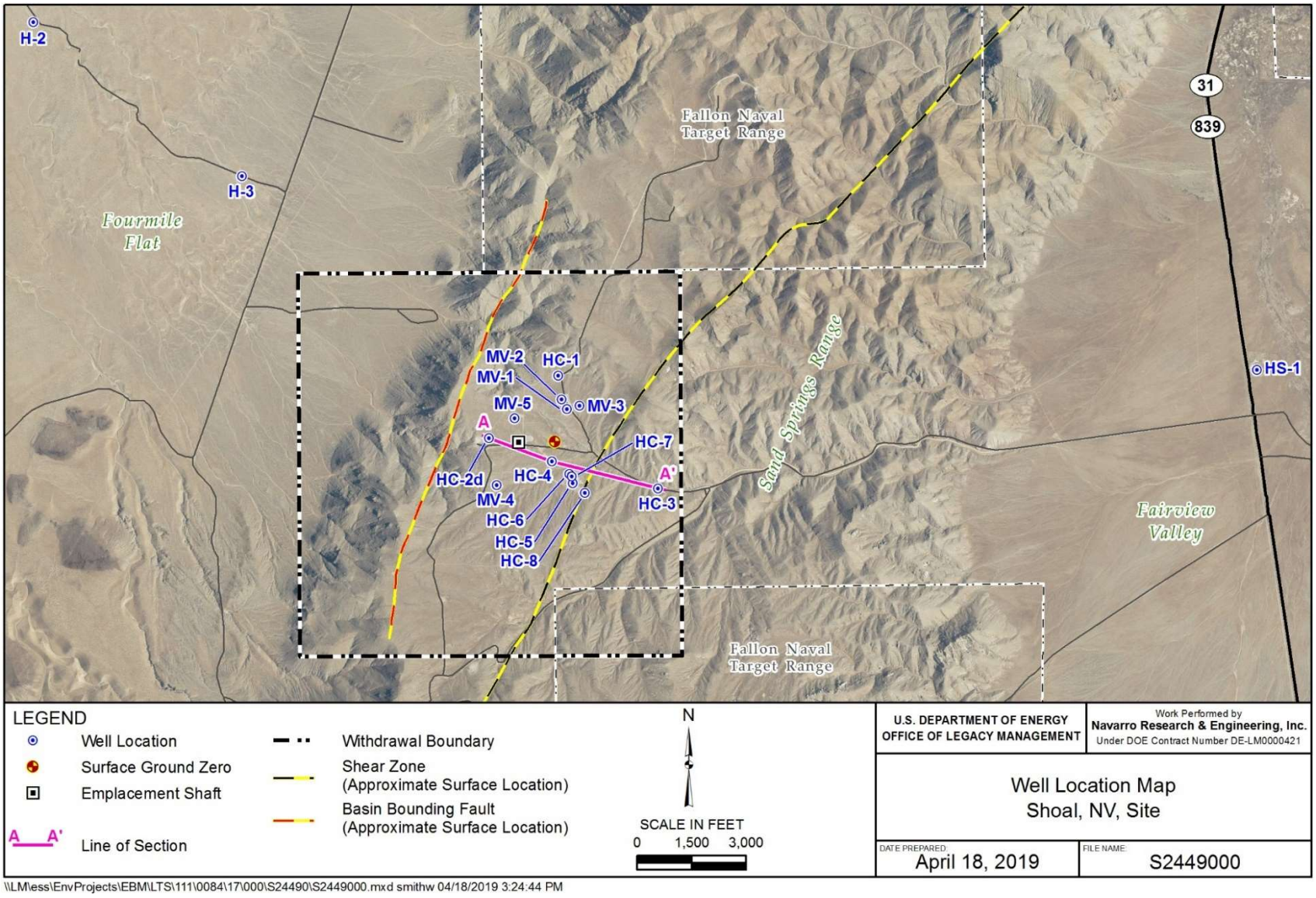


Figure 2. Well Location Map, Shoal, Nevada, Site

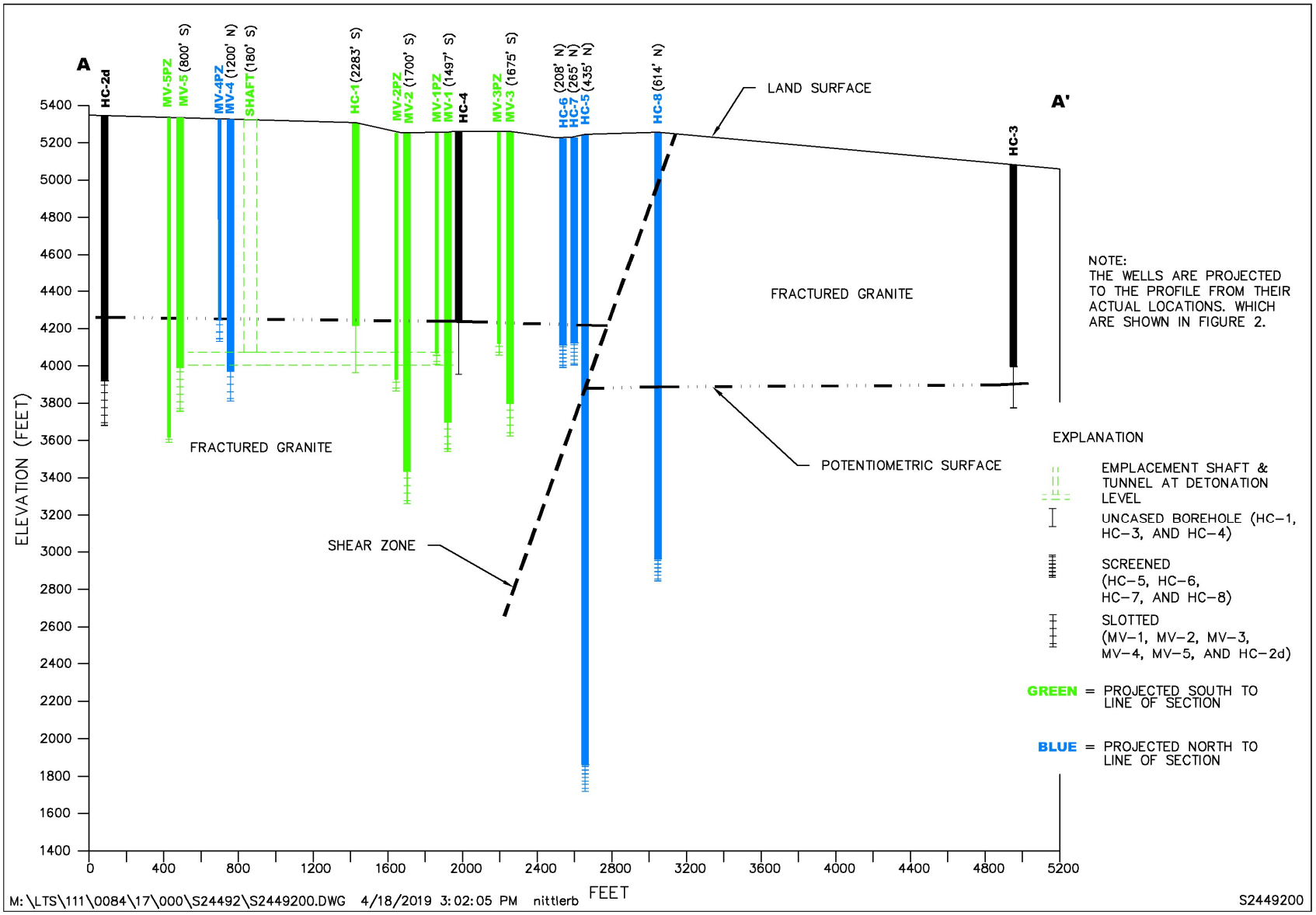


Figure 3. Cross-Sectional View of A–A' Shown in Figure 2

The subsurface contamination at the site, which is the focus of this report, is identified as CAU 447. This CAU consists of two CASs: test cavity CAS 57-57-001 and emplacement shaft CAS 57-49-01. The former test cavity, which is part of the detonation zone, is the source of contamination at the site. The former cavity 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 former cavity is contaminated by lower concentrations of mobile radionuclides, such as tritium. The mobile radionuclides in the former cavity are a source of contamination that could potentially migrate with groundwater.

The Corrective Action strategy for CAU 447 followed the original Underground Test Area strategy (FFACO 1996, as amended), with modifications to accommodate site conditions. This included a planning phase with the development of Corrective Action Investigation Plans, a Corrective Action Investigation phase that executed these plans, and a CADD/CAP phase. The approach included multiple field investigations, developing a site conceptual model (SCM), and a numerical flow and transport model to calculate contaminant boundaries, negotiating compliance boundaries with NDEP, performing model validation, and monitoring groundwater. This strategy was executed through the CADD/CAP phase, which selected the Corrective Action Alternative "Proof-of-Concept and Monitoring with Institutional Controls" for implementation at the site. LM determined during the 5-year proof-of-concept monitoring and model validation process that the groundwater flow and transport model developed for the site could not be validated because the steady-state assumption used for the model was not valid and that groundwater elevations observed at wells MV-1, MV 2, and MV-3 did not validate the predominant horizontal flow direction predicted by the modeled realizations. Despite these results, hydraulic conductivity values and fracture geometry from the MV-1, MV-2, and MV-3 well data agreed with those used as model input. These conclusions prompted the recommendation that additional data be collected, and that alternative approaches be evaluated for determining the contaminant boundary at the site (Stoller 2008). This led to a revised Corrective Action strategy designed to validate the compliance boundary through monitoring and ICs, rather than relying predominantly on the numerical flow and transport model (FFACO 1996, as amended). The revised approach was implemented through three separate short-term data acquisition plans completed in 2009, 2011, and 2014. These plans facilitated enhancements to the monitoring well network and data collections designed to improve the SCMs.

An addendum to the CADD/CAP provides summaries of the Corrective Action activities, numerical model validation results, enhancements made to the monitoring program and monitoring network as implemented through the three short-term data acquisition plans, and updates made to the SCMs since the original CADD/CAP was approved in 2006 (DOE 2019b). The addendum also proposed new compliance and contaminant boundaries for the site. NDEP approved the revised contaminant and compliance boundaries in an August 12, 2019 letter to LM (Andres 2019a).

1.3 Geologic and Hydrologic Setting

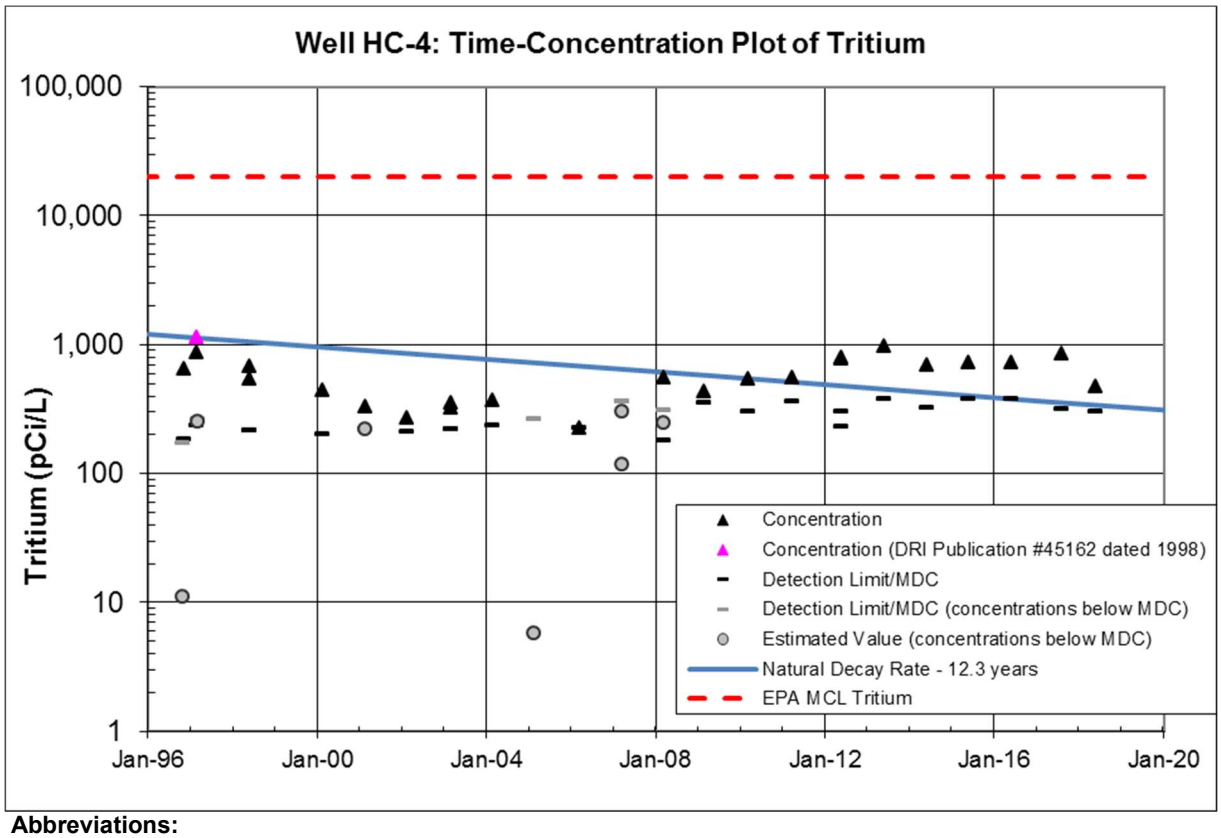
The Shoal site is in the northern portion of the Sand Springs Range in west-central Nevada's Churchill County. The Sand Springs Range is the southern extension of the Stillwater Range, a north-northeast–trending fault block range that traverses Churchill County. The Sand Springs Range rises to an elevation of approximately 6751 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 5250 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° W and N 30° E and are vertical to steeply dipping. The most dominant of these structural features are a shear zone that strikes N 30° E and transects the eastern portion of the site and a basin bounding fault that has a similar strike and is approximately 3000 ft west of the detonation (Figure 2). Several dikes visible at the surface west-northwest of the detonation occur along the same two orientations and intrude along 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 (Nevada Bureau of Mines and Geology 1964).

Groundwater is encountered in Fourmile Flat at about 3900 ft amsl and in Fairview Valley at about 3960 ft amsl (Figure 1). Groundwater beneath the site (near surface ground zero [SGZ] and west of the shear zone) ranges in depth from 950 to 1110 ft (4250 to 4300 ft amsl). Groundwater elevations in wells east of the shear zone ranges in depth from 1180 to 1370 ft (3920 ft amsl in shallow well HC-3 that is screened in the upper part of the saturated zone, and 3880 ft amsl in deeper wells HC-5 and HC-8). The shear zone dips steeply to the northwest from a surface location approximately 1500 ft east of SGZ (Figure 2 and Figure 3) and is interpreted as a barrier to groundwater flow on the basis of disparate water levels in wells separated by the shear zone (DRI 2001). Water levels measured in wells west of the shear zone (Figure 3) are increasing about 1 to 3 ft per year during the time they have been monitored, beginning with the installation of the hydrologic characterization (HC) wells in the late 1990s. Water levels measured in site wells east of the shear zone have not increased but have decreased in wells HC-5 and HC-8 (Figure 3) at a rate of approximately 1 to 2 ft every 10 years (DOE 2019a). The primary source of groundwater beneath the site is from infiltration during a wetter period about 12,500 years ago when the former Lake Lahontan filled Fourmile Flat to an elevation of nearly 4400 ft amsl (Nevada Bureau of Mines and Geology 1964). Strand lines from the former lake remain on the ranges surrounding Fourmile Flat, which is now a playa with evaporites and salt deposits. Carbon-14 (^{14}C) age dates of water samples from wells indicate that groundwater beneath the site ranges from 8000 to 22,000 years before present, which supports the interpretation that groundwater beneath the site is remnant water from the former Lake Lahontan (DOE 2013).

Groundwater flows through fractures in the low-permeability granite at the site, with hydraulic conductivity values ranging from about 0.0003 to 0.2 meter per day (m/d) (0.001 to 0.6 foot per day) based on aquifer tests of site wells. The permeability of the granite is assumed to increase near the detonation zone, which was subjected to fracturing from the underground nuclear test and is the source of contamination at the site. The extent of contamination at the site is believed

to be limited in that only well HC-4 has had detections of tritium (Figure 4) and ^{14}C (Figure 5) above laboratory detection limits using conventional laboratory methods (DOE 2019a). The presence of tritium and ^{14}C in well HC-4 are attributed to its proximity (the bottom-hole location is about 475 ft south of the detonation cavity) to the detonation zone (Figure 2 and Figure 3). The emplacement tunnel that extends approximately 1350 ft west of the detonation is also assumed to be a relatively higher permeability feature. Recharge occurs by infiltration of precipitation on the mountain range, and regional discharge occurs in the adjacent valleys (Nevada Bureau of Mines and Geology 1964).



Abbreviations:
DRI = Desert Research Institute
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
MDC = minimum detectable concentration
pCi/L = picocuries per liter

Figure 4. Tritium Activity in Well HC-4

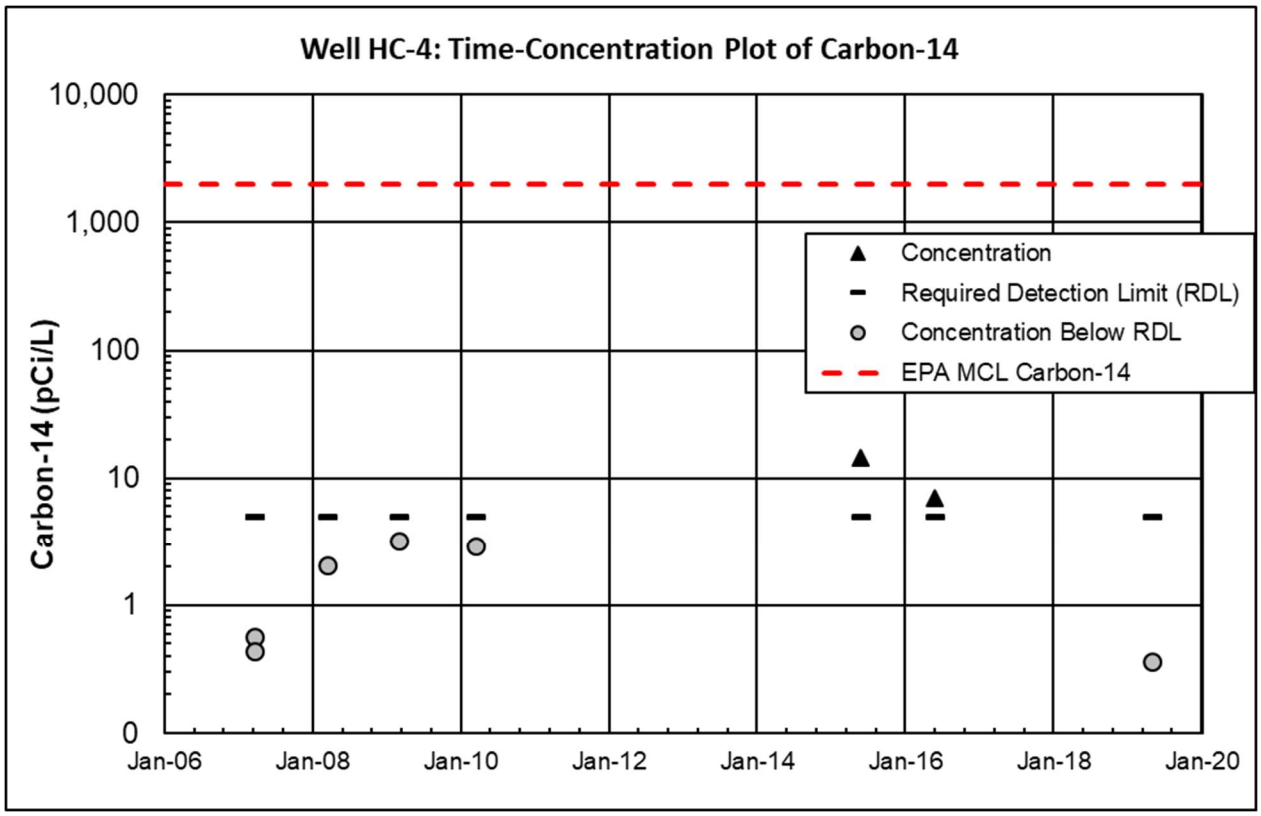


Figure 5. Carbon-14 Activity in Well HC-4

1.4 Selected Corrective Action Alternative

The Corrective Action Alternative selected for implementation at CAU 447 was "Proof-of-Concept and Monitoring with Institutional Controls" (DOE 2006b). The selected Corrective Action included establishing a monitoring program, use restrictions, and other ICs to protect human health and the environment. This alternative was selected based on results from the Corrective Action investigations completed before the CADD/CAP phase (summarized in Section 2.1) and the detailed comparative analysis of the potential Corrective Action Alternatives presented in the CADD/CAP (summarized in Section 2.2). The detailed comparative analysis of the potential alternatives is given in the Evaluation of Alternatives Section 3.0 of the CADD/CAP (DOE 2006b). It was also determined that this alternative was superior in implementability and cost, and it met the requirement for protection of human health and the environment. The rationale for selecting this alternative was provided in the CADD/CAP (DOE 2006b) and included the following:

- Health risks would be minimized by use of administrative controls (administrative controls can be interchanged with ICs) to prevent worker exposure and public access to the contaminated groundwater.
- Only minimal waste from drilling and sampling would be generated. If groundwater in the monitoring wells was not contaminated, these wastes would not be hazardous or radioactive.

- It was easily implemented, although coordination of all entities was necessary to ensure compliance with administrative controls (administrative controls can be interchanged with ICs). The required services and materials were readily available.
- It provided a cost-effective method to protect human health and the environment and to meet closure requirements.

1.5 Closure Report Contents

This Closure Report presents a summary of the Corrective Action investigations and CADD/CAP activities (Section 2.0); final contaminant, compliance, and use-restriction boundaries (Section 3.0); a description of the Corrective Action and how it will be implemented (Section 4.0); reporting requirements (Section 5.0), records and data management (Section 6.0); quality assurance (Section 7.0); recommendation to issue notices of completion and move CAU 447 from Appendix III to Appendix IV of the FFACO (Section 8.0); and a list of the references cited in this document (Section 9.0).

2.0 Summary of Site Corrective Action Investigations and CADD/CAP Activities

This section summarizes the site Corrective Action investigations and CADD/CAP activities associated with CAU 447.

2.1 Corrective Action Investigations

The Corrective Action investigations were performed in several stages from 1996 to 2003, as set forth in two separate Corrective Action Investigation Plans (CAIPs) prepared for the site. The initial CAIP was prepared for the surface but included a Hydrologic Investigation Plan that focused on the installation of HC wells, collection of groundwater data, and development of a numerical model to simulate the potential contaminant transport from the detonation cavity (DOE 1996). This included (1) collecting data to estimate groundwater velocity and direction and (2) collecting data to constrain boundary conditions regarding recharge from infiltrating precipitation. It also included backfilling and plugging the emplacement shaft. The Hydrologic Investigation Plan included a well drilling program having the following data objectives:

- Determine the groundwater gradient in the test area under undisturbed conditions
- Obtain information on the permeability and porosity of the Sand Springs granite
- Obtain information on recharge conditions
- Obtain information on migration of contaminants from the nuclear test

Four wells (HC-1 through HC-4) were installed as part of the initial drilling program that was completed in 1996 (DOE 1998c). Data collected from these wells accomplished the objectives outlined in the drilling program and were used to develop a numerical model that was completed in 1998. An evaluation of the groundwater model results indicated that more information was needed to reduce uncertainties in the model input parameters, so a second CAIP was developed (DOE 1998a). It called for a Data Decision Analysis (DDA) to determine which investigation and data collection methods would minimize model uncertainty (Pohll et al. 1999). Specific objectives for the investigation were outlined in the CAIP and DDA, which was included later as an Addendum to the CAIP (DOE 1999). The objectives were as follows:

- Combine historic and newly acquired data to map aquifer properties and provide a framework for flow simulations to determine mean velocity, direction, and spatial characteristics of the flow field
- Predict solute migration to determine the boundary of specified contaminant concentrations in the aquifer
- Reduce uncertainty in groundwater recharge through vadose zone modeling
- Reduce uncertainty in effective porosity by performing a two-well tracer test
- Reduce uncertainty in the hydraulic properties of the saturated zone at depths greater than previously investigated at the site

The second Corrective Action investigation included the installation and testing of four monitoring wells (HC-5, HC-6, HC-7, and HC-8) in 1999 and a groundwater tracer test study that was conducted from 1999 through 2000. This was followed by a second period of data

analysis and modeling that culminated in the final flow and transport model that was approved by NDEP in February 2004 (DRI 2003). The approved model was used to simulate the potential long-term migration of contaminants away from the detonation cavity. This was part of the regulatory process that included the calculation of a contaminant boundary and negotiation of a compliance boundary for the site (Section 3.1). The model-predicted contaminant boundary was approved by NDEP in January 2005 (NDEP 2005). In that January 2005 letter, NDEP also agreed that the compliance boundary should match the outer perimeter of the model-predicted contaminant boundary (NDEP 2005).

2.2 CADD/CAP and Recommendations

The CADD/CAP was developed and approved in 2006 (NDEP 2006). It provided the Corrective Action investigation results, the Corrective Action evaluation, and the approved boundaries (model-predicted contaminant and compliance boundaries) for the site (DOE 2006b). It was concluded in the CADD/CAP that the emplacement shaft (CAS 57-49-01) required no further action and that the Corrective Action evaluation would be specific to the test cavity (CAS 57-57-001). The Corrective Action Alternative selected for the site was "Proof-of-Concept and Monitoring with Institutional Controls" (DOE 2006b).

Implementation of the CADD/CAP included the installation of three monitoring/validation (MV) wells (MV-1, MV-2, and MV-3) in 2006 to monitor radionuclide concentrations, to monitor groundwater elevations, and to validate the flow and transport model developed for the site (DOE 2006a). LM concluded during the model validation process that the steady-state assumption used for the groundwater flow and transport model was not valid for the site (Stoller 2008). This was evident because groundwater elevations on the detonation-side of the shear zone had been increasing since the first HC wells were installed in 1996. Initially, water levels in the HC wells were within the uncertainty bounds of the numerical model and the increase was attributed to recovery from drilling and well development. But the trend of increasing water levels continued, and water levels at the MV-1, MV-2, and MV-3 wells (installed in 2006) were outside the middle 95% predictions of the numerical model. The model validation process also concluded that the horizontal component of groundwater flow predicted by the numerical model was primarily toward the north–northeast, whereas horizontal gradients inferred from water levels measured in site wells did not support this flow direction. Other aspects, such as hydraulic conductivity values and fracture geometry from the MV-1, MV-2, and MV-3 well data, agreed with those used as model input. The net result was that many model realizations performed well against the validation tests, but the increasing groundwater elevations raised a significant question about the steady-state assumption and the inferred groundwater flow directions at the site (DRI 2006). Results of the model validation are summarized in the groundwater model validation report dated May 19, 2008 (Stoller 2008).

These conclusions prompted the recommendation that additional data be collected and alternative approaches be evaluated for determining the contaminant boundary at the site (Stoller 2008). LM and NDEP used these conclusions and recommendations to develop a new strategy for the site, as allowed in Appendix VI of the FFACO (FFACO 1996, as amended). LM's discussions with NDEP led to the use of a stepped approach to collect new data at the site, which was outlined in a letter from NDEP in August 2009 (NDEP 2009). Another recommendation in this letter was to update Section 5.0, "Corrective Action Strategy," in Appendix VI of the FFACO to reflect current activities at the Central Nevada Test Area, Nevada, Site and the Shoal site (NDEP 2009). This process began, and further negotiations resulted in a

new strategy that focuses on evaluating the SCM and adequacy of the monitoring well network and collecting data designed to validate each site's compliance boundary through monitoring and ICs rather than relying predominantly on numerical modeling. LM implemented the new Corrective Action strategy it developed with NDEP by revising the FFACO, Appendix VI, which was completed in May 2011 (FFACO 1996, as amended).

The new strategy applied at the Shoal site led to the development of three potential SCMs, each with its own associated flow scenario with the objective strategy of developing a well network that monitors all likely flow paths from the detonation zone for each SCM. The new strategy did not include a revised flow and transport model but did include additions to the well network to monitor each flow scenario. The new strategy was implemented through three separate short-term data acquisition plans completed in 2009, 2011, and 2014. A new 5-year proof-of-concept monitoring period to validate the compliance boundary began after the new wells were installed.

2.3 Implementation of the Short-Term Data Acquisition Plans

The first data acquisition plan, completed in 2009, outlined plans to enhance the groundwater monitoring program and implement a surface geophysical program (i.e., seismic reflection and electromagnetic surveys), which included a survey of dikes visible at the surface of the site (DOE 2009). The groundwater monitoring program approved in the CADD/CAP included only five wells (HC-1, HC-4, MV-1, MV-2, and MV-3), but this monitoring network was expanded in 2009 to include the collection of radiochemistry data and water level data from all wells onsite and collection of water level data from wells H-2 and H-3 offsite in Fourmile Flat (Figure 2) (DOE 2009). The electromagnetic survey results identified areas of contrasting resistivity that generally trend with the fractured dikes along the western boundary of the survey area. An area west-northwest of the detonation zone (detonation cavity, chimney, and fractured area surrounding the detonation cavity) was identified as an area of relatively high electrical resistivity at the detonation depth, like that observed near the detonation zone and tunnel that connects the emplacement shaft with the detonation location (Figure 2 and Figure 3) (DOE 2011a). Seismic reflection survey results identified the shear zone east of SGZ (DOE 2011a). The surface geophysical results were used to develop potential SCMs.

In March 2009, LM organized a technical exchange meeting with the geophysicists who performed the geophysical surveys (Lee Liberty from Boise State University and Jim Hasbrouck from Hasbrouck Geophysics Inc.), Desert Research Institute, and NDEP to discuss survey results and potential SCMs. Meeting participants 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 completed in April 2011 recommended that geophysical data be evaluated further and compared with existing data to assess and enhance the potential SCMs (DOE 2011a). This was executed through the second data acquisition plan completed in October 2011, which included further review of the geophysical data with laboratory, hydrologic, and geologic data obtained from historical reports to help identify geologic structures that might influence groundwater flow at the site (DOE 2011b). These data were assembled for three-dimensional visualization and helped identify faults and fractures that might influence groundwater flow at the site; the data also helped identify locations for new monitoring wells and helped advance the SCMs.

The final data acquisition plan was completed in 2014 with the addition of monitoring wells MV-4 and MV-5 and the deepening of well HC-2, now identified as HC-2d (DOE 2014). These wells were installed to monitor potential groundwater flow paths identified for each of the SCMs. Monitoring wells MV-4 and MV-5 were dually completed with a well and piezometer to evaluate vertical and horizontal gradients. The well casing in existing well HC-2 was removed and the borehole deepened to allow installation of well HC-2d. The well completion report dated November 2015 (DOE 2015b) summarized these well installation activities. The new wells were completed with dedicated electric submersible pumps to facilitate groundwater sample collection and conduct aquifer tests. Analysis of aquifer test data from these wells (MV-4, MV-5, and HC-2d) obtained hydraulic conductivities that ranged from about 0.09 m/d in MV-5 to about 0.0003 m/d in HC-2d. A hydrologic testing report (DOE 2019c) summarizes aquifer test results.

2.4 CADD/CAP Addendum

The CADD/CAP Addendum summarizes the Corrective Action activities that were completed after the original CADD/CAP was approved in 2006 (DOE 2019b). It documents the numerical model validation results, enhancements made to the monitoring program and monitoring network as implemented through three short-term data acquisition plans, updates made to the SCMs, and proposed changes to the contaminant and compliance boundaries for the site. Many enhancements have been made to the monitoring program since 2006, and they have increased LM and NDEP understanding of the groundwater flow system at the site. The three SCMs and associated groundwater flow scenarios described in the CADD/CAP Addendum are somewhat simplistic in summary and are intended to provide a generalized conceptualization of the flow system as it relates to the potential fate and transport of radionuclides from the detonation zone. Enhancements made to the monitoring network after 2006 were designed to monitor the interpreted potential transport pathways of the three conceptual groundwater flow scenarios for the site with a focus on the following:

- **The groundwater flow mimics the surface topography:** The water table is a subdued reflection of the surface topography, with groundwater flowing from the higher elevation range tops toward the detonation zone/Gote Flat and out through the lower elevation canyons to Fourmile Flat. The shear zone limits groundwater flow to the east.
- **The groundwater flows preferentially through fractured dikes:** Dikes observed at the surface of the site west-northwest of the detonation zone are fractured more than the surrounding host rock and, if the fracturing persists at depth, may provide higher permeability pathways for groundwater flow to the west. The electromagnetic survey, completed in 2010, identified an area west-northwest of the detonation zone as an area of relatively high electrical resistivity, similar to that observed near the tunnel and detonation zone (DOE 2011a). LM interpreted that this area might be more fractured than the surrounding host rock since the detonation zone was highly fractured as a result of the detonation.
- **The groundwater flows parallel to shear zone and basin bounding fault:** The groundwater flow direction is parallel to the strike of the shear zone and basin bounding fault, both of which are low-permeability barriers that limit flow to the adjacent valleys.

Identifying all geologic features that might potentially influence groundwater flow is not possible, and the flow scenarios presented above might underestimate the impact some of these features may have on the groundwater flow system. It is also possible that groundwater flow at

the site is a combination of one or more of these flow scenarios or as yet unrecognized features or processes. The long-term monitoring program will continue to provide time-series data (groundwater elevation and radionuclide) from the network of monitoring wells and piezometers that will be reviewed to evaluate changes in the flow system. The results will be provided to NDEP in groundwater monitoring reports (Section 5.0).

To account for flow direction uncertainty, a simplified yet conservative approach that assumes groundwater flow could occur in any direction from the detonation zone was agreed upon by LM and NDEP. This approach treats the contaminant boundary as a cylindrical surface that encompasses the contaminant volume. The lateral extent of the cylinder is based on the distance that encompasses 95% of the contaminant transport model realizations, the same distance as the original modeled contaminant boundary except extended in all directions. This is reasonable in that hydraulic conductivity data from aquifer tests on the MW-1, MV-2, and MV-3 wells are within the 95% of the hydraulic conductivity distribution used in the numerical model. Aquifer test data from the wells (MV-4, MV-5, and HC-2d), installed in 2014, also fall within the hydraulic conductivity distribution used in the numerical model. Figure 4-30 in the CADD/CAP addendum presents the probability density function of hydraulic conductivity values used for the numerical model with hydraulic conductivities from wells installed in 2006 (MV-1, MV-2, and MV-3) and wells installed in 2014 (MV-4, MV-5, and HC-2d). The contaminant-boundary cylinder is truncated to the east at depth by the low-permeability shear zone, which is a barrier to groundwater flow (Figure 6).

2.5 Conceptual Model Evaluation

The monitoring well network was enhanced in 2014 with five new monitoring locations (wells and piezometers) to increase monitoring along the western portion of the site. Data from the monitoring network have been collected and evaluated since the first MV wells (MV-1, MV-2, and MV-3) were installed in 2006. These data have been evaluated as part of the Conceptual Model Evaluation phase to ensure that the monitoring network is adequate for surveillance of the site, in accordance with the CADD/CAP (DOE 2006b). LM specified further in the CADD/CAP Addendum (DOE 2019b) that this would be demonstrated by verifying that the potential transport pathways identified through the SCMs are adequately monitored. At the end of the 5-year monitoring period, the validity of the compliance boundary will be demonstrated by monitoring results that indicate radionuclides of interest (tritium, ^{14}C, and iodine-129 [^{129}I]) do not exceed the required detection limits[1] or are at or below local background concentrations in wells outside the impacts of the detonation zone. Results of the monitoring and evaluation have been provided to NDEP annually in groundwater monitoring reports since 2006.

Detection monitoring results indicate that tritium, ^{14}C, and ^{129}I concentrations have remained below their laboratory-required minimum detectable concentrations (MDCs) at all sampled locations outside the impacts of the detonation zone. One well (HC-4) is inside the contaminant boundary and within the area impacted by the detonation (area of increased fracturing near the former detonation cavity). HC-4 is the only well with tritium (Figure 4) and carbon-14 (Figure 5) concentrations above required detection limits using conventional laboratory methods. These results have been decreasing and are well below their U.S. Environmental Protection Agency maximum contaminant levels (Figure 4 and Figure 5).

[1] Required detection limits: tritium (400 picocuries per liter [pCi/L]), ^{14}C (5 pCi/L), ^{129}I (0.1 pCi/L).

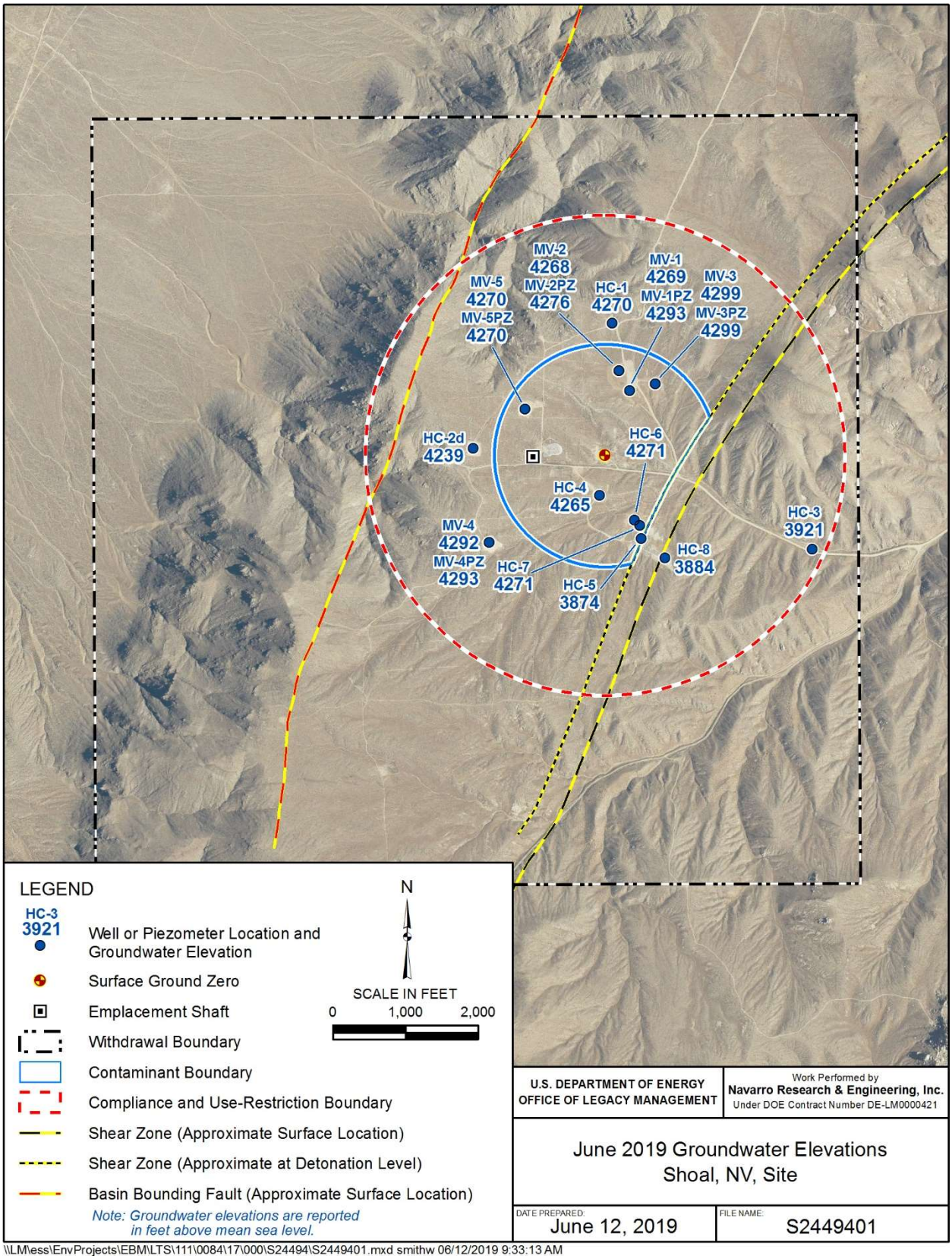
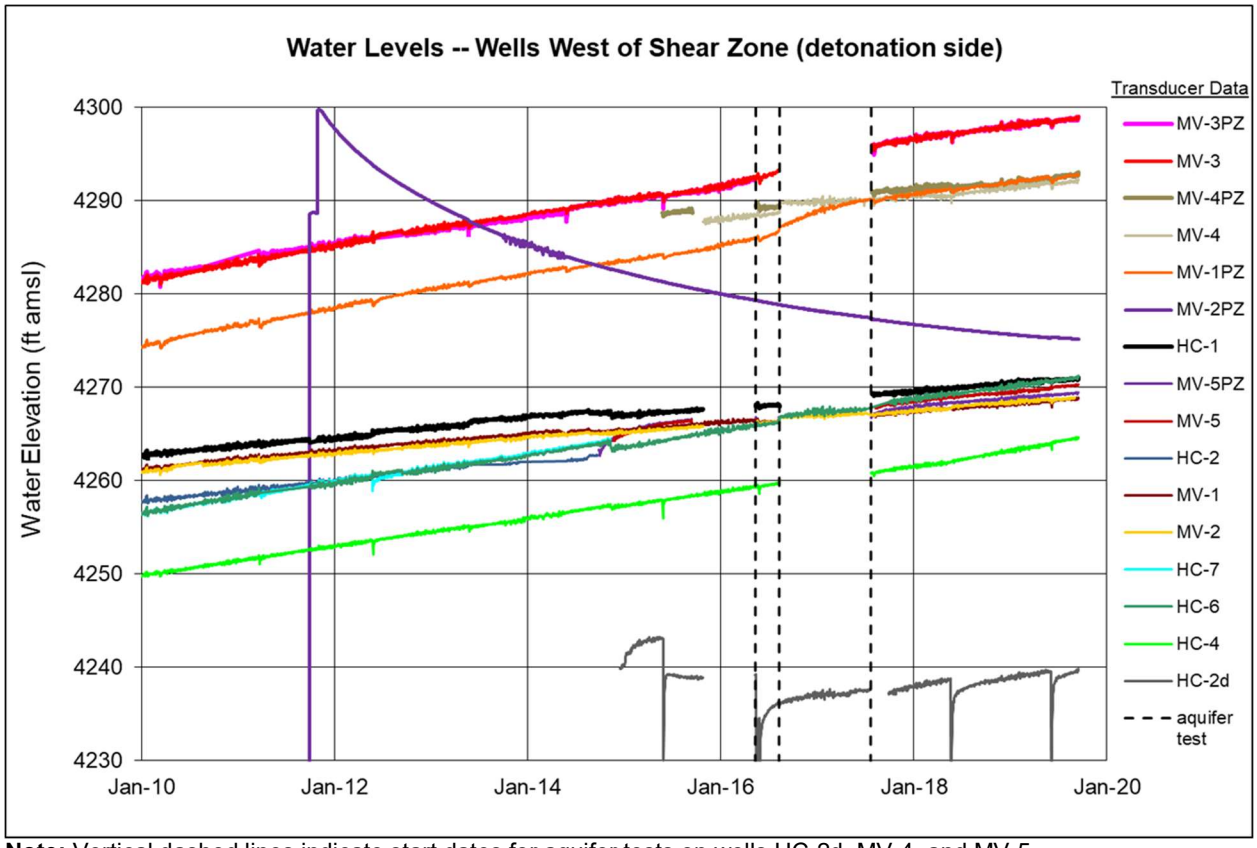


Figure 6. Shoal Site Water Elevations

The effectiveness of the monitoring well network has been evaluated to ensure that potential flow directions from the detonation zone for each possible SCM are monitored. Water levels in wells west of the shear zone are continuing to rise (as of summer 2019) with no indication of stabilizing, with the exception of the recompleted well HC-2d and piezometer MV-2PZ (Figure 6 and Figure 7). HC-2d is completed differently than the other wells at the site. The casing in well HC-2d is not cemented (as was the case with HC-2), allowing water to flow freely along the annulus of the borehole. The declining water level in piezometer MV-2PZ is attributed to water being added after a development event in 2012 to remove remnant drilling mud. This water level is not indicative of the static water level in the formation at its screened interval. The highest groundwater elevations at the site are nearing 4300 ft amsl north-northeast of SGZ in well MV-3 and in piezometers MV-1PZ and MV-3PZ. Groundwater elevations in the recently installed MV-4 well and piezometer southwest of SGZ are also above 4290 ft amsl and increasing, but at a slower rate than the wells north-northeast of SGZ.



Note: Vertical dashed lines indicate start dates for aquifer tests on wells HC-2d, MV-4, and MV-5.

Figure 7. Water Elevations West of the Shear Zone

The groundwater elevation at HC-2d is the lowest west of the shear zone at the site. It is more than 20 ft lower than the groundwater elevation in HC-4 (nearest well to SGZ), which was the previous lowest groundwater elevation well. Water elevations in HC-2d are also apparently not rising, indicating that when it was deepened it became connected to a previously unidentified separate fault block. Aquifer testing of recompleted HC-2d indicates that the hydraulic conductivity of this area is low relative to other areas at the site. The hydraulic conductivities

from aquifer test results along with the hydraulic conductivity distributions used for the modeling are presented in Figure 8.

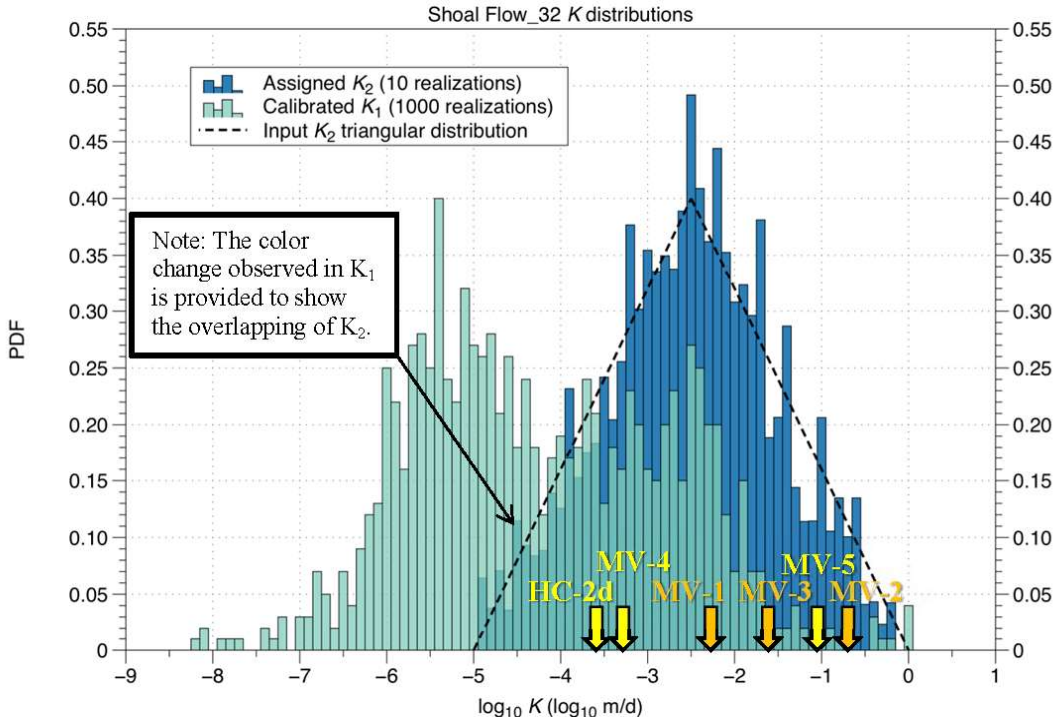


Figure 8. Hydraulic Conductivity Distributions Used in the Shoal Models with Aquifer Test Results

A downward vertical gradient is expected at the site, which is located on a mountain range (a recharge area) with adjacent valleys to the west and east (discharge areas). All model simulations indicated a downward vertical gradient that exceeded the horizontal gradient in many realizations (DRI 2006). This was the motivation in 2006 and 2014 to install dually completed wells (a piezometer to monitor water levels in the upper saturated zone and a deeper well to monitor both water levels and the most likely contaminant pathways). Well HC-2, which had a bottom depth above the detonation level, was deepened to account for the downward component of potential contaminant migration to the west. The lower water elevations in HC-2d relative to the shallower HC-2 support a downward gradient at this location. The increasing water elevations in site wells make interpreting the long-term horizontal gradient and attendant lateral flow direction uncertain at this time. Current water elevations do not rule out any of the SCMs.

2.6 Move to Closure Phase

LM recommended that a Closure Report be prepared for subsurface CAU 447 in the letter dated September 30, 2019 (Kautsky 2019). This recommendation is based on groundwater elevations and radionuclide data that continue to demonstrate that the interpreted potential transport pathways identified through the SCMs are adequately monitored. NDEP approved moving to the closure phase for CAU 447 in the letter dated October 15, 2019 (Andres 2019b). Appendix A provides a copy of the letter from NDEP approving the move to the Closure Report phase.

3.0 Boundaries and Objectives

The original contaminant and compliance boundaries were developed and negotiated with NDEP during the Corrective Action process and documented in the CADD/CAP completed in 2006. In 2008, LM determined that the groundwater flow and transport model used to develop the contaminant boundary could not be validated, so LM decided with NDEP that alternative approaches to revise the contaminant boundary should be evaluated (Stoller 2008). This was completed in 2018 and the revised contaminant and compliance boundaries were presented in the CADD/CAP Addendum (DOE 2019b), which was approved by NDEP in August 2019 (Andres 2019a). The boundaries and their objectives are presented in the following sections.

3.1 Contaminant Boundary

The original model-predicted contaminant boundary for the site was revised because the groundwater flow and transport model used to calculate the contaminant boundary could not be validated. The model could not be validated because groundwater elevations observed at wells MV-1, MV-2, and MV-3 did not validate the predominant horizontal flow direction predicted by the modeled realizations; however, hydraulic conductivity values from aquifer tests on these wells fell within the inner 95% of the hydraulic conductivity distribution used in the numerical model (Stoller 2008). This led to conclusions that the overall range of the hydraulic conductivity values used in the numerical model was reasonable, and the field observations at the three wells support the range of hydraulic conductivity values available to be selected for each of the model realizations. Aquifer test data from the wells (MV-4, MV-5, and HC-2d) installed in 2014 also fall within the hydraulic conductivity distribution used in the numerical model (DOE 2019b). These data, reviewed with historical aquifer test data from other wells onsite, support the extent, though not the direction, of the numerical model-predicted contaminant boundary. Given that water levels in site wells on the detonation side of the shear zone continue to rise and at differing rates, a prevailing horizontal flow direction could not be identified. It is also possible that the horizontal gradient will continue to vary over time and a stable flow direction will never be obtained.

To account for these uncertainties, the revised contaminant boundary assumes groundwater flow is equally probable in any direction from the detonation zone. This approach treats the contaminant boundary as a cylindrical surface that encompasses the contaminant volume. The lateral extent of the cylinder is based on the distance that encompasses 95% of the model realizations of radionuclide-contaminated groundwater from the underground nuclear test could migrate over a 1000-year time period, which is the same as the original modeled contaminant boundary except extended in all directions. However, the cylinder is truncated to the east at depth by the low-permeability shear zone that is interpreted as a barrier to groundwater flow (Figure 9). The delineated extent is a volume and is projected upward to the ground surface to define the contaminant boundary perimeter in two dimensions. Contaminated groundwater is defined as water with radionuclide concentrations that exceed the SDWA standards (FFACO 1996, as amended 2011). Appendix B provides the NDEP approval of the contaminant boundary for the site. Figure 9 shows the contaminant boundary and compliance boundary for the site.

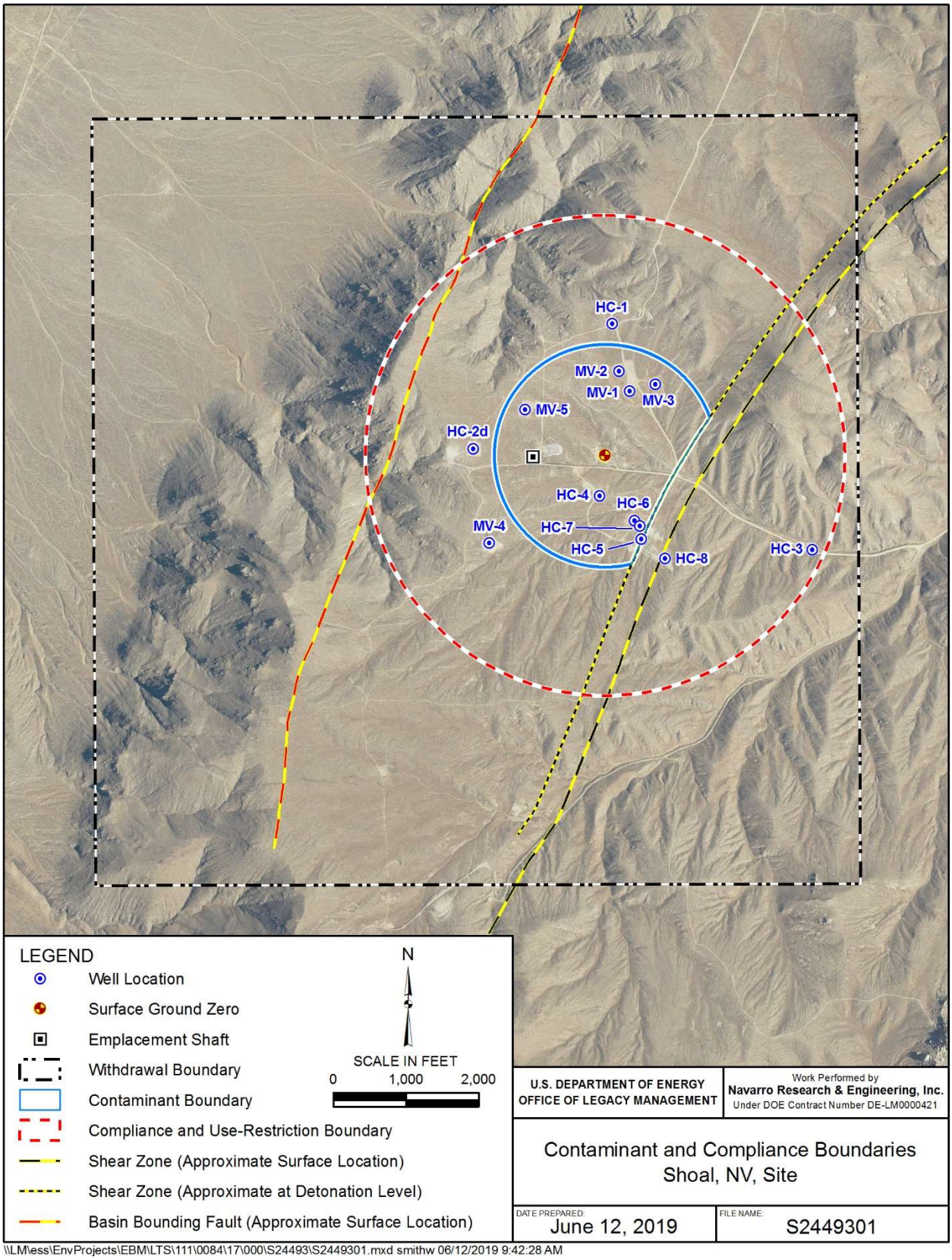


Figure 9. Contaminant and Compliance Boundaries, Shoal, Nevada, Site

3.2 Compliance Boundary

The objective of the compliance boundary is to protect the public and environment from exposure to groundwater contaminated by the underground nuclear test. It is the area within which the radionuclides with concentrations above the SDWA standards are expected to remain. The compliance boundary presented in the CADD/CAP completed in 2006 matched the outer perimeter of the numerical model-predicted contaminant boundary. LM recently separated these boundaries with concurrence from NDEP and expanded the compliance boundary so it coincides with the subsurface use-restriction boundary (DOE 2019b). The compliance boundary now extends a horizontal distance of 3300 ft from SGZ (Figure 9) to accommodate uncertainties associated with the transient nature of the groundwater flow system and to account for any potentially varying lateral flow directions. Appendix B provides the NDEP approval of the compliance boundary.

3.3 Use-Restriction Boundary

The Shoal site is accessible to the public and is used for livestock grazing and ranching, with recreational use for the public. The site is part of a larger area that was withdrawn by DOD in 1999 for U.S. Navy military training. Under this land withdrawal, DOE remains responsible and liable for the subsurface and DOD is responsible for the management and use of the surface. In Title XXX of the National Defense Authorization Act of 2000 (Public Law 106-65, Sections 3011–3023 [PL 106-65 Sections 3011-3023]), "the lands are hereby withdrawn from all forms of appropriation under the public land laws, including the mining laws and the mineral leasing and geothermal leasing laws". A total of 13 groundwater monitoring wells are in the withdrawn area to monitor groundwater near the detonation zone. There are no wells at the site that supply water for livestock or human consumption, and no water rights are filed with the Nevada Division of Water Resources (NDWR). The closest water use is well HS-1, which is approximately 4 miles east of the site and used for livestock watering (Figure 2). No residences or other habitable structures exist on the Shoal site.

The use-restriction boundary coincides with the compliance boundary and is intended to restrict subsurface intrusion actions while maintaining public access for surface activities. The use-restriction boundary extends 3300 ft from SGZ. The boundary encompasses the contaminant boundary (Figure 9). The objective of this boundary is to restrict access to subsurface materials, including groundwater. The actions currently restricted are defined on a monument at SGZ as follows:

> No excavation, drilling, and/or removal of material is permitted between a level of plus 5050 feet (1539 meters) and plus 3530 feet (1076 meters) above mean sea level out a horizontal distance of 3300 feet (1006 meters) from the surface ground zero location. Any reentry into drill holes or the shaft within this horizontal restricted area is prohibited.

LM is working with BLM, U.S. Navy, and the Nevada State Engineer's Office to establish a process for implementing the necessary restrictions within the boundary. LM will include NDEP in the decision-making process to help establish effective restrictions for the site. Appendix D provides the use-restriction information and map for the site. Appendix E provides the use-restriction notification requirements.

3.4 Land Withdrawal Boundary

The land withdrawal for Shoal is 2560 acres (Figure 9). The total acreage is withdrawn from all forms of appropriation associated with mining laws and leasing. LM is working with BLM to establish a process for implementing the necessary restrictions within the withdrawal boundary. LM will include NDEP in the decision-making process for these changes to help establish effective restrictions for the site.

4.0 Corrective Action Implementation

Implementation of the Corrective Action for subsurface CAU 447 includes postclosure monitoring with ICs as part of the long-term stewardship of the site. Long-term stewardship is designed to prevent exposure to radionuclides that remain in the detonation zone and ensure protection of human health and the environment. This section establishes the long-term monitoring requirements, provides technical and administrative contingency plans for actions to be taken if monitoring results are not acceptable, and defines the ICs.

4.1 Long-Term Monitoring

The long-term monitoring program is designed to (1) assess the effectiveness of the compliance boundary by monitoring for the radionuclides of interest and (2) evaluate the effectiveness of monitoring locations within the groundwater flow system by monitoring groundwater elevations to ensure that monitoring wells are located along potential migration pathways. The monitoring program will provide time-series data (radionuclide and groundwater elevations) from a network of monitoring wells and piezometers at the site (Table 1). The configuration of the monitoring network and frequency of data collection is based on available data regarding current and expected future site conditions. The long-term monitoring program will be reviewed periodically (Section 4.3) and will be revised as necessary to adequately track changes in radionuclide concentrations and stability of the flow system over time. Table 1 shows the zone of completion (top and bottom) with elevations and lithologic unit monitored by each of the wells and piezometers in the monitoring network.

4.1.1 Monitoring Network

The monitoring network for assessing the presence of the radionuclides of interest includes wells and piezometers installed at the site (Table 2). The network is designed to monitor for any potential migration from the detonation cavity, which is the source of contamination at the site. Table 2 provides the monitoring network with sampling frequency for the radionuclides of interest. Appendix C, Table C1, provides the well descriptions with well completion information.

The monitoring network is designed to monitor the three potential flow scenarios established for the site (Section 2.4). The monitoring wells west of the shear zone (MV-1 through MV-5, HC-1, HC-2d, HC-4, HC-6, and HC-7) are most likely to encounter the radionuclides of interest because they are on the detonation side of the shear zone, which is interpreted as a barrier to flow (Figure 2 and Figure 3). The contaminant boundary reflects this interpretation and is truncated to the east at depth by the low-permeability shear zone (Figure 8). Well HC-4 is inside the contaminant boundary and is completed near the detonation cavity within the area of increased fracturing (Figure 3). It is the only well that has had detections of tritium and ^{14}C above laboratory detection limits using conventional laboratory methods. Wells HC-1, MV-1, MV-2, and MV-3 provide monitoring if groundwater flow is toward the north-northeast; wells MV-4 and HC-4 provide monitoring if groundwater flow is toward the south-southwest; and wells HC-6 and HC-7 provide monitoring if groundwater flow is toward the south-southeast. Wells HC-1 and HC-6 are not completed with submersible electric pumps and will be sampled less frequently because of their proximity to wells MV-2 and HC-7, respectively.

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

Monitoring Wells/Piezometer	TOC Elevation (ft amsl)[a]	TSZ Elevation (ft amsl)	BSZ Elevation (ft amsl)	Screen Length (ft)	Lithologic Unit Monitored
MV-1	5254.64	3680.24	3526.43	154	Fractured Granite (West of the Shear Zone)
MV-1PZ	5254.38	3915.47	3855.47	60	
MV-2	5263.72	3442.63	3271.86	171	
MV-2PZ	5263.60	4074.80	4015.30	60	
MV-3	5258.60	3793.61	3622.45	171	
MV-3PZ	5258.24	4116.78	4056.75	60	
MV-4	5370.78	3969.08	3809.08	160	
MV-4PZ	5370.41	4249.08	4129.08	120	
MV-5	5318.16	3991.01	3751.01	240	
MV-5PZ	5317.50	3616.01	3586.01	30	
HC-1	5306.32	4210.44	3979.64	231	
HC-2d	5343.93	3925.15	3685.15	240[b]	
HC-4	5257.88	4242.63	3961.63	281	
HC-6	5225.73	4109.00	3992.68	116	
HC-7	5226.74	4119.23	4002.10	117	
HC-3	5078.57	3893.20	3872.70	21	Fractured Granite (East of the Shear Zone)
HC-5	5244.33	1857.34	1711.74	146	
HC-8	5256.89	2960.85	2844.37	116	
H-2	4018.22	3377.06	3237.06	340[b]	Alluvium/Fractured Granite (Fourmile Flat)
H-3	4233.95	3919.30	3762.30	157	

Notes:

[a] The TOC elevations obtained after the drilling program in 2014 are provided in the U.S. State Plane, Zone Nevada West 2703, coordinate system, with vertical data based on the National Geodetic Vertical Datum of 1929 (DOE 2015c).

[b] Indicates the well is screened across multiple intervals and the total effective screen length is provided.

Abbreviations:

BSZ = bottom of open interval; screened, perforated, or open hole
TOC = top of casing (well or piezometer)
TSZ = top of open interval; screened, perforated, or open hole

Wells MV-5 and HC-2d are completed northwest and west of the detonation zone (Figure 2) and provide monitoring if groundwater flow occurs through the fractured dikes observed at the surface of the site west-northwest of the detonation zone. The electromagnetic survey, completed in 2010, identified the area where well MV-5 was installed as an area of relatively high electrical resistivity, similar to that observed near the tunnel and detonation zone (DOE 2011a). LM interpreted that this area might be more fractured than the surrounding host rock because the detonation zone was highly fractured as a result of the detonation. Aquifer test results indicate that well MV-5 is in an area of relatively high hydraulic conductivity for the site (Figure 8). Wells MV-4, MV-5, and HC-2d also provide monitoring if groundwater flows from the higher elevation range tops toward the detonation zone/Gote Flat and out through the lower elevation canyons to Fourmile Flat.

Table 2. Monitoring Network with Sampling Frequency for Radionuclides of Interest

Monitoring Wells/Piezometers	Monitoring Network and Sampling Frequency for Radionuclides of Interest													Lithologic Unit Monitored
	2021	2024	2027	2030	2033	2036	2039	2042	2045	2048	2051	2054	2057	
MV-1	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	Fractured Granite (West of the Shear Zone)
MV-1PZ														
MV-2	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
MV-2PZ														
MV-3	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
MV-3PZ														
MV-4	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
MV-4PZ														
MV-5	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
MV-5PZ														
HC-1		T		TCI		T		TCI		T		TCI		
HC-2d	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
HC-4	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
HC-6		T		TCI		T		TCI		T		TCI		
HC-7	T	T	T	TCI	T	T	T	TCI	T	T	T	TCI	T	
HC-3		T		TCI		T		TCI		T		TCI		Fractured Granite (East of the Shear Zone)
HC-5		T		TCI		T		TCI		T		TCI		
HC-8		T		TCI		T		TCI		T		TCI		
H-2														Alluvium/Fractured Granite (Fourmile Flat)
H-3														

Abbreviations:
C = Analyze sample for ^{14}C
I = Analyze sample for ^{129}I
T = Analyze sample for tritium

The monitoring wells east of the shear zone (HC-3, HC-5, and HC-8) are less likely to encounter the radionuclides from the detonation zone because the shear zone acts as a barrier to flow, reducing the potential for migration from the detonation zone. Wells HC-3, HC-5, and HC-8 will be monitored less frequently because of the limited potential for encountering the radionuclides of interest. The piezometers and well HC-3 are not designed for efficient sampling because of their small diameter (1.9-inch inside diameter); consequently, they will be sampled less frequently.

Samples will be analyzed for tritium, ^{14}C, and ^{129}I during the long-term monitoring program. Tritium is the primary radionuclide of interest because of its initial abundance after the detonation and its mobility in groundwater. The half-life of tritium is 12.3 years, and after 200 years it is estimated that the source of tritium will have decayed by 5 orders of magnitude. As the monitoring program progresses, the longer-lived radionuclides, ^{14}C (5730-year half-life) and ^{129}I (1.57×10^7-year half-life), will become the primary focus of the long-term monitoring program.

4.1.2 Sampling Frequency

The sampling frequency for wells in the monitoring network (Table 2) is based on available data regarding the current and expected future site conditions and is consistent with the postclosure sampling frequency implemented at the Central Nevada Test Area. This sampling frequency was based on several factors. The factors included a well's location within the interpreted flow path from the source of contamination, proximity to another monitoring location, depth of completion, and difficulty in collecting a sample. Since the wells completed in the fractured granite west of the shear zone (MV-1 through MV-5, HC-2d, HC-4, and HC-7) are in locations most likely to encounter detonation-related contamination, they are sampled at an increased frequency relative to the wells completed east of the shear zone (HC-3, HC-5, and HC-8) or in Fourmile Flat (H-2 and H-3). The sampling planned for years 2030, 2042, and 2054 include the full suite of radionuclides (tritium, ^{14}C, and ^{129}I), and data from these sampling events may be used to recommend changes to the monitoring network and sampling frequencies. Any changes or recommendations to the sampling frequency will be provided to NDEP for concurrence prior to implementation. Table 2 provides the monitoring network with the recommended sampling schedule and monitoring requirements through 2057.

4.1.3 Laboratory Analyses/Methods

The analytical laboratory will use accepted procedures that are based on the specified methods to analyze the radionuclides of interest (tritium, ^{14}C, and ^{129}I) in the long-term monitoring program (Table 3). The required MDCs for these radionuclides were established in the CADD/CAP (DOE 2006b), were maintained in the CADD/CAP Addendum (DOE 2019b), and will continue during the postclosure monitoring. Table 3 provides the required MDCs for tritium, ^{14}C, and ^{129}I. The required MDCs for ^{14}C and ^{129}I are low because these analyses will be used to provide a baseline of background conditions for comparison during postclosure monitoring and may be increased when the monitoring network and sampling frequencies are reevaluated in years 2030, 2042, and/or 2054.

Table 3. Radionuclides of Interest, Required MDCs, and Compliance Levels

Radionuclide of Interest	Measurement Method	Required MDC (pCi/L)	Compliance Levels (pCi/L)
Tritium	Liquid Scintillation Counting	400	20,000
Carbon-14	Accelerator Mass Spectrometry	5	2,000
Iodine-129	Accelerator Mass Spectrometry	0.1	1

Abbreviation:
pCi/L = picocuries per liter

Commercial laboratories provide analytical services in accordance with the *Department of Defense (DoD) Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories* (QSM) to ensure that data are of known, documented quality (DOD and DOE 2017). The QSM is based on International Organization for Standardization/ International Electrotechnical Commission (ISO/IEC) 17025:2005(E), ISO/IEC 17025:2017(E), and The NELAC Institute Standards, Volume 1, (September 2009); and incorporates the requirements in DOE Order 414.1D Admin Chg 1, *Quality Assurance*. The QSM provides a framework for performing, controlling, documenting, and reporting laboratory analyses (DOD and DOE 2017). Analytical data will be validated according to the *Environmental Data Validation Procedure* (LMS/PRO/S15870).

4.1.4 Water Levels

Water levels will be measured at all wells and piezometers in the monitoring network (Table 1) during scheduled sampling events and site inspections, using an electric water level tool and according to procedures specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351). The water level data will be used to assess groundwater flow directions and monitor gradients at the site. Past and future water level measurements will provide a historical record from which temporal changes in groundwater flow directions can be interpreted and provide further understanding of the SCMs.

Transducers are installed in select wells and piezometers in the monitoring network to frequently monitor groundwater elevations (Table 1). The transducer data is calibrated to manual water level measurements taken during sampling events and site inspections. The water level data will be used to determine groundwater elevations, which will be used to evaluate the quasi-steady state of the groundwater system. Hydrographs of the groundwater elevation data will be maintained and evaluated for wells completed in the same geologic unit, having similar depths, and/or having similar locations (east or west of the shear zone). Transducers will be maintained only in wells and piezometers determined to be key to the monitoring program as agreed to with NDEP. The wells and piezometers that are not considered key to the groundwater monitoring network at this time are well HC-7 (due to its proximity to well HC-6), wells H-2 and H-3 (due to their location in Fourmile Flat and the stability of water levels at their location), and wells HC-3, HC-5, and HC-8 (due to their location east of the shear zone, which acts as a barrier to flow). Any changes to the water level monitoring program will be discussed with NDEP and approved prior to implementation. These changes may be communicated verbally or provided as recommendations in the groundwater monitoring reports (Section 5.0).

4.1.5 Well-Field Maintenance

Well-field maintenance will be conducted to maintain the integrity of the wells and piezometers in the monitoring network (Table 1). The condition of the wells and piezometers will be documented during annual site inspections (Section 4.1.6) and scheduled sampling events. Inspection of the wells and piezometers may include video logging to assess the condition of the casing and the screened or perforated intervals. Maintenance may include redevelopment of the well or piezometer to increase the flow or efficiency within the screened interval. If corrective maintenance is required (e.g., pump failure or other damage to the well or piezometer that prevents the well's/piezometer's use as a monitoring location), LM will notify NDEP and develop a plan to implement any necessary corrective maintenance actions. Performance of corrective maintenance actions will depend on the well's or piezometer's location within the interpreted flow paths from the detonation cavity. This may require an analysis of the monitoring data from the location. Plans for any corrective maintenance actions will be provided in the groundwater monitoring report (Section 5.0) for NDEP review and approval. Well or piezometer replacement may be included as a corrective maintenance action.

4.1.6 Annual Inspections of Monitoring Network and Use Restrictions

Annual site inspections will be conducted to assess the condition of the concrete cap that covers the emplacement shaft, inspect the condition of the monitoring network well boxes and other site features, and confirm that use restrictions remain in place and effective. The site inspectors will inspect for any evidence of land use changes or significant land disturbances. They will measure water levels in wells and piezometers in the monitoring network (Table 1) and photo-document any unauthorized land use and any damage to the monitoring network, the site roads, and the monument at SGZ. Site inspections will also be conducted during scheduled sampling events. Site inspection and sampling schedules will be provided to NDEP through the FFACO Field Activity Reporting process. Site inspection results will be summarized in the groundwater monitoring report (Section 5.0). If unauthorized land use is observed, LM will notify BLM and/or the U.S. Navy and send a letter to initiate any necessary Corrective Actions. NDEP will be included in any correspondence and Corrective Actions associated with the Shoal site.

4.1.7 Corrective Action Levels

Table 4 provides the Corrective Action levels and NDEP notification requirements. The CADD/CAP (DOE 2006b) established groundwater compliance levels and laboratory-required MDCs for the radionuclides of interest at the site. The compliance levels are consistent with the SDWA maximum contaminant levels. The compliance levels and laboratory-required MDCs were maintained in the CADD/CAP Addendum and will be maintained during the postclosure monitoring program (Table 3). The compliance levels and laboratory-required MDCs were used to establish the action levels for the site (Table 4). If an action level is exceeded, LM will provide the required notifications to NDEP within 90 days of receiving the laboratory analytical results.

Table 4. Monitoring Network with Action Levels for Radionuclides of Interest

Monitoring Wells/Piezometers	Action Levels for Radionuclides of Interest						Lithologic Unit Monitored
	Inside Contaminant Boundary			Outside Contaminant Boundary, but Inside Compliance Boundary			
	>5x MDC	>0.5 MCL	>MCL	>3x MDC	>0.5 MCL	>MCL	
MV-1	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				Fractured Granite (West of the Shear Zone)
MV-1PZ							
MV-2	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				
MV-2PZ							
MV-3	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				
MV-3PZ							
MV-4				Notify NDEP 1	Notify NDEP 2	Notify NDEP 3	
MV-4PZ							
MV-5	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				
MV-5PZ							
HC-1				Notify NDEP 1	Notify NDEP 2	Notify NDEP 3	
HC-2d				Notify NDEP 1	Notify NDEP 2	Notify NDEP 3	
HC-4	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				
HC-6	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				
HC-7	Notify NDEP 1	Notify NDEP 2	Notify NDEP 3				
HC-3				Notify NDEP 1	Notify NDEP 2	Notify NDEP 3	Fractured Granite (East of the Shear Zone)
HC-5				Notify NDEP 1	Notify NDEP 2	Notify NDEP 3	
HC-8				Notify NDEP 1	Notify NDEP 2	Notify NDEP 3	
H-2							Alluvium/Fractured Granite (Fourmile Flat)
H-3							

Note:
All notifications (email or telephone call) shall be within 90 calendar days of receiving analytical data from laboratory.

Abbreviations and definitions:
Radionuclides of Interest = Tritium, ^{14}C, and ^{129}I
MCL = SDWA maximum contaminant levels: 20,000 picocuries per liter (pCi/L) for tritium, 2000 pCi/L for ^{14}C, and 1 pCi/L for ^{129}I.
>0.5 MCL = Concentrations greater than 10,000 pCi/L for tritium, 1000 pCi/L for ^{14}C, and 0.5 pCi/L for ^{129}I.
MDC = Minimum detectable concentration required by laboratory: 400 pCi/L for tritium, 5 pCi/L for ^{14}C, and 0.1 pCi/L for ^{129}I.
>5x MDC = Concentrations greater than 2000 pCi/L for tritium, 25 pCi/L for ^{14}C, and 0.5 pCi/L for ^{129}I.
>3x MDC = Concentrations greater than 1200 pCi/L for tritium, 10 pCi/L for ^{14}C, and 0.2 pCi/L for ^{129}I.
Notify NDEP 1 = Notification only, no action required.
Notify NDEP 2 = Modify the sampling plan (sampling locations and/or frequency) in consultation with NDEP.
Notify NDEP 3 = Develop a new strategy/path forward report (e.g., new monitoring wells may be required) in consultation with NDEP.

4.1.8 Waste Disposition

Waste generated during the long-term monitoring program will be managed in accordance with the Fluid Management Plan (FMP) for CAU 447 (DOE 2011c). The FMP provides guidance for managing fluids and associated materials generated during subsurface investigations, and it provides standards that govern their final disposal. NDEP is not a signatory to the FMP but was involved in negotiating the plan contents and approves the general conditions contained within the plan. All fluids produced during drilling, construction, development, testing, experimentation, or sampling of wells that support activities at CAU 447 shall be managed in accordance with the FMP.

4.2 Institutional Controls

The Corrective Action Alternative selected for the site is "Proof-of-Concept and Monitoring with Institutional Controls" (DOE 2006b). The term "institutional controls" broadly defines the instruments (documents) and mechanisms (physical features) that are maintained to ensure long-term protectiveness of the site (DOE 2015c). The ICs should be visible to all future users of the site and resources, durable to last as long as restrictions are needed, and enforceable to ensure compliance. Existing ICs will be maintained at the Shoal site. This includes the monument at SGZ and the amended land withdrawal executed through PLO 2834 that is within a much larger area withdrawn by the U.S. Navy. DOE will continue to work with the U.S. Navy and other federal and state agencies to improve the effectiveness of these ICs and implement the subsurface use-restriction, which is designed to limit access to the area of potentially contaminated material (including groundwater) at the site.

Any restrictions provided as ICs that are required as part of the remedy will be used to meet the objectives of the subsurface use restriction described in Section 3.3 and will be needed in perpetuity. DOE will establish ICs, in conjunction with BLM and U.S. Navy, to limit access to areas of potentially contaminated material (including groundwater) and establish a procedure of notifications when activities around the site have the potential to impact site-closure activities. ICs can either be active (such as land-use control) or passive (such as markers, public records, or other methods of preserving site history and knowledge of site conditions). All ICs will be routinely monitored to verify performance.

Future use within the Shoal use-restriction zone is restricted from any activity that might alter or modify the site closure conditions as approved by NDEP, unless appropriate concurrence is obtained in advance. ICs in effect or being established for Shoal include:

- **Federal ownership:** The Secretary of Energy shall remain responsible and liable for the subsurface estate and all its activities at the "Shoal Site" withdrawn and reserved by Public Land Order Number 2771 on September 6, 1962 (27 FR 9062), as amended by Public Land Order Number 2834 on December 4, 1962 (27 FR 12219). In Title XXX of the National Defense Authorization Act of 2000 (Public Law 106-65, Sections 3011–3023 [PL 106-65 Sections 3011-3023]), "the lands are hereby withdrawn from all forms of appropriation under the public land laws, including the mining laws and the mineral leasing and geothermal leasing laws". The surface of the Shoal site, along with the surrounding area, was reserved to the U.S. Navy for tactical maneuvering and air support testing and training. Under this same act, DOE retained responsibility and liability for subsurface interests and DOD is responsible for the management and use of the surface at the Shoal site.

- **Use-restriction zone:** LM is working with BLM and the U.S. Navy to incorporate the use-restricted zone into their geographic information system (GIS). DOE will not deny any reasonable request for access to the use-restricted area but will retain the right of first refusal to any activities that have the potential to create an exposure pathway to subsurface contamination (such as digging/excavation, drilling, and/or groundwater use), while allowing as many beneficial uses of the land and resources as are safe. LM will include NDEP in the decision-making process to ensure that all parties are aware of any potential future activities at the site.
- **Five-mile notification zone:** LM is pursuing agreements with BLM and the U.S. Navy for them to notify LM of any ground-disturbing activities within 5 miles from SGZ. This is intended as a courtesy notification only and will provide LM with notice of any wells (oil, gas, or mining) that may have the potential to impact site contamination. No restrictions are included between the 3300 ft use-restriction zone and the 5-mile notification zone.
- **Water use applications:** The State of Nevada Division of Water Resources is responsible for managing water use through appropriation of public waters. LM will consult with NDWR annually to verify that no well permit applications or driller's logs have been submitted or received within the use-restriction zone and to obtain information about any well permits granted within the 5-mile notification zone.
- **Federal oversight:** DOE maintains an active long-term surveillance and maintenance program for the Shoal site to maintain the remedy and ensure protectiveness of human health and the environment. This program includes the ICs, inspections, monitoring, and maintenance of DOE assets. Routine visits to the site for these activities provide a measure of oversight for ICs effectiveness.

4.3 Periodic Evaluation

LM will conduct periodic evaluations as new data become available following each sampling event to ensure that the Corrective Action (postclosure monitoring with ICs) is effective. These data (detection monitoring and groundwater elevations) should continue to demonstrate the effectiveness of the monitoring system with respect to monitoring well locations within the flow field being monitored at the site. Sample results and water level data will be compared with past results for trend analysis. Any significant changes will be evaluated in light of the SCMs that considers transient shot effects and the shear zone acting as groundwater flow barrier.

Data from the monitoring network will continually add to knowledge about the groundwater system at the site. New data and information that is added to the knowledge base will be reviewed to determine whether it continues to support the SCMs and the decision for closure, thus reducing the uncertainties associated with the closure decision. Groundwater elevation data will be used to develop hydrographs for comparable monitored units. These data and interpretations, along with the detection monitoring results, will be evaluated to determine whether they demonstrate that the compliance, withdrawal, and use-restriction boundaries are protective of human health and the environment. Results from the periodic evaluations will be included in the groundwater monitoring reports (Section 5.0).

4.4 Performance Assessment

If data do not support the SCMs, or indicate conditions that call into question the ongoing validity of the closure decision, NDEP will be consulted and it may be necessary to develop a new strategy. Any new strategy would be presented as a new strategy/path forward report for NDEP approval. A new strategy/path forward report would likely require a change or addendum to the Closure Report, which would be submitted to NDEP for approval. Changes in resource use near the Shoal site (e.g., groundwater development) would also trigger a reevaluation of the closure conditions, even in advance of discernible impacts on groundwater elevations, in order for management options to be considered in a proactive, rather than reactive, time frame. The availability of new science or technologies for the remediation of the detonation cavity could also trigger a reevaluation of the closure conditions and would be presented as a new strategy/path forward report for NDEP approval (Section 5.0).

5.0 Postclosure Reporting

LM will conduct postclosure monitoring and reporting as part of the long-term stewardship of the site. Postclosure reports (where applicable), will include the items described below.

Groundwater monitoring reports: Groundwater monitoring reports will be provided to NDEP within one year of a scheduled sampling event (Table 2). These reports will include a summary of the annual site inspection results, provide recommendations for any corrective maintenance actions (Section 4.1.5), provide a status on the ICs, describe any change in resource use, and document the detection and groundwater level monitoring results. The report will include hydrographs of groundwater elevations for the wells and piezometers included in the monitoring network. These data will be evaluated with the detection monitoring results to determine if the data continue to support the SCMs and demonstrate that the compliance and use-restriction boundaries are protective of human health and the environment. If an action level is exceeded (Table 4), LM will notify NDEP within 90 days of receiving the laboratory results.

New strategy/path forward reports: A new strategy/path forward report will be provided to NDEP if an action level is exceeded (as specified in Table 4), new data become available that do not support the SCMs, a change in resource use (water, oil, or gas development) occurs that could impact the flow system near the site, or new science or technology becomes available for remediation of the detonation cavity. The new strategy/path forward report will be provided to NDEP for review and approval. Any new document will have to be finalized. The type of document can be discussed prior to its finalization.

Record of Technical Change: A Record of Technical Change (ROTC) will be used to make minor changes or updates to the Closure Report. This may include updating the sampling network or sampling frequency (Table 2). NDEP will review and approve all ROTCs before they are incorporated into the Closure Report.

The cleanup at DOE sites and plans for long-term management of the sites have benefited and are expected to continue to benefit from dialogue among state and federal regulators, stakeholder organizations, elected officials, and members of the general public. The groundwater monitoring reports, new strategy/path forward reports, and Closure Report with ROTCs will be provided to NDEP and made available to the public. These reports, along with other reports developed for the site, will be maintained and made available as follows:

- Reports (mentioned in this section) will be posted to the LM public website at https://www.lm.doe.gov/shoal/Sites.aspx; where there are webpages with public information specific to the Shoal site, including site records, the fact sheet, and a link to the Geospatial Environmental Mapping System for the site.
- Reports will be maintained on the Office of Science and Technical Information webpage, which is accessible to the public at http://www.osti.gov/scitech/.
- Limited information about the site will be maintained on the NDEP webpage, which is accessible to the public at https://ndep.nv.gov/land/department-of-energy-oversight.
- Information about the Shoal site is also available by contacting Public Affairs at (970) 248-6363 or (970) 248-6000, or by sending an email request to public.affairs@lm.doe.gov.

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6.0 Records/Data Management

To support postremediation maintenance of the site, LM will maintain records at their office in Grand Junction, Colorado, and at the LM Business Center in Morgantown, West Virginia. These records contain critical information required to protect human health and the environment, manage land and assets, protect the legal interests of DOE and the public, and mitigate community impacts resulting from the cleanup of legacy waste. Site historical records about the environmental remediation and stewardship are included in the collection. All LM records will be managed in accordance with the following requirements:

- 44 USC 2901 et seq., "Records Management by the Archivist of the United States," *United States Code,* available online at https://www.archives.gov/about/laws/records-management.html
- 44 USC 3101 et seq., "Records Management by Federal Agencies," *United States Code,* available online at https://www.archives.gov/about/laws/fed-agencies.html
- 44 USC 3301–3314, "Disposal of Records," *United States Code,* available online at http://www.archives.gov/about/laws/disposal-of-records.html
- Title 36 *Code of Federal Regulations* Sections 1220–1239 (36 CFR 1220–1239), Chapter 12, Subchapter B, "Records Management," available online at https://www.archives.gov/about/regulations/regulations.html

  DOE Order 243.1, *Records Management Program,* U.S. Department of Energy, Washington, D.C., available online at https://www.directives.doe.gov/directives-documents/200-series/0243.1-BOrder-b-admchg1
- Governing requirements of LM's Records Management program

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7.0 Quality Assurance

Quality assurance measures for implementing the long-term monitoring program include using trained and qualified personnel and following established procedures. Water quality data will be collected in accordance with procedures specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (SAP). The SAP specifies requirements for sample collection, quality control samples, analytical methods and reporting limits, and field instrument calibration. The long-term care of the site and all activities related to the annual surveillance, monitoring, and maintenance of the site comply with DOE Order 414.1D Admin Chg 1, *Quality Assurance*; applicable requirements of 10 CFR 830, "Quality Assurance Requirements"; and American National Standards Institute/American Society for Quality (ANSI/ASQ) E4-2004, *Quality Systems for Environmental Data and Technology Programs: Requirements with Guidance for Use*.

The quality of the monitoring data depends on the use of effective sampling and analysis procedures. LM environmental procedures incorporate ASTM International, DOE, and U.S. Environmental Protection Agency guidance. Field quality assurance includes the collection and analysis of quality control samples as specified in the SAP. Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. Equipment blanks may be collected after sampling equipment has been decontaminated and before environmental samples have been collected. These blanks are useful in documenting the adequate decontamination of sampling equipment.

Data validation is performed as specified in *Environmental Data Validation Procedure* to determine if data meet the specific technical and quality criteria, and to establish the usability and extent of bias of any data not meeting those criteria. Validation includes evaluating sample collection and field measurement activities against the requirements in the SAP and evaluating laboratory analyses against the requirements in the reference analytical procedures and the QSM (DOD and DOE 2017), when applicable. Items associated with field activities that are evaluated include completeness (all data were collected as planned), calibration and operational checks of field instruments, compliance with sampling protocols, and field quality control sample results. Validation of laboratory analyses includes assessment of chain of custody and receipt documentation, completeness of the analytical data, compliance with holding times and sample preservation requirements, quality control check performance, instrument calibration, and an assessment of potential outliers. Qualifiers are applied to the data based on the results of the validation.

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8.0 Recommendations

NDEP approval of this Closure Report will initiate implementation of the Corrective Action (Postclosure Monitoring with ICs) for CAU 447 at Shoal. This includes groundwater monitoring (CAS 57-57-001) and maintaining the concrete cap that covers the emplacement shaft (CAS 57-49-01). NDEP approval will also signify that the closure process has been completed in accordance with the CADD/CAP (DOE 2006b) and CADD/CAP Addendum (DOE 2019b). On the basis of this approval, LM provides the following recommendations to NDEP:

- A Notice of Milestone Completion should be issued by NDEP to LM for CAU 447 at the Shoal site if the use-restriction is not yet recorded in BLM's and the Navy's GIS systems.
- A Notice of CAU Completion should be issued by NDEP to LM for CAU 447 at the Shoal site when the use-restriction is recorded in BLM's and the Navy's GIS systems.
- The CAU 447 at the Shoal site should be moved from Appendix III to Appendix IV of the FFACO, after the use-restriction is implemented by BLM and the Navy (in accordance with the DOE notification to BLM and Navy in Appendix E).

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Appendix A

NDEP Approval for Moving to the Closure Report

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NEVADA DIVISION OF
ENVIRONMENTAL
PROTECTION

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

October 15, 2019

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

RE: REQUEST FOR APPROVAL TO PROCEED TO THE CLOSURE REPORT FOR PROJECT SHOAL AREA: SUBSURFACE CORRECTIVE ACTION UNIT (CAU) 447, SHOAL, NEVADA, SITE
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 (DOE-LM) request for approval to proceed to the Closure Report (CR) for CAU 447, received in a letter dated September 30, 2019 (Letter). This request is being made pursuant to Step 5a of Section 5, Appendix VI of the FFACO (Offsites Corrective Action Strategy). At this time, the NDEP agrees that the monitoring results presented in annual groundwater monitoring reports for the Project Shoal Area and summarized in the Letter are adequate to prepare a CR with a long-term monitoring plan and institutional controls.

If you have any comments or questions on the above, please contact me at 702-486-2850, ext. 232, or Mark McLane at ext. 226.

Sincerely,

Chris Andres

Christine D. Andres
Chief
Bureau of Federal Facilities

CDA/MM

ec: EM Records, Las Vegas, NV
Navarro Central Files
FFACO Group, Las Vegas, NV
MSTS Correspondence Management, Las Vegas, NV
R. F. Boehlecke, Las Vegas, NV

cc: EM Records, Las Vegas, NV
Jeffrey Fraher, DTRA/CXTS, Kirtland AFB, NM
J. B. Chapman, DRI, Las Vegas, NV
J. Elmer, Navarro, Grand Junction, CO
K. Kreie, OLM, Grand Junction, CO
R. Findlay, Navarro, Grand Junction, CO

Appendix B

NDEP Approval: CADD/CAP Contaminant Boundary and Compliance Boundary

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NEVADA DIVISION OF
ENVIRONMENTAL
PROTECTION

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

August 12, 2019

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

RE: Addendum to: Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for the Shoal, Nevada, Site
Federal Facility Agreement and Consent Order (FFACO)

Dear Mr. Kautsky:

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) has received and reviewed the above referenced document from the U. S. Department of Energy, Office of Legacy Management (DOE-LM). In sections 5.6.3 and 5.6.4, of the document, changes to the Contaminant Boundary and Compliance Boundary, respectively, have been explained. The NDEP agrees with the placement of these boundaries and approves them as the final Contaminant Boundary and Compliance Boundary for Corrective Action Unit (CAU) 447, the Shoal, Nevada, Site.

As required by the FFACO, Appendix VI, Section 5.0, the revised strategy for the Shoal Site was included in this CADD/CAP Addendum. This revised strategy was implemented as a stepped approach, through three separate short-term data acquisition plans completed in 2009, 2011, and 2014. NDEP was involved in the development of these plans and approved the strategy outlined in each plan prior to the short-term data acquisition work being performed. As such, DOE-LM has completed steps 4(b) and 5 in Section 5.0 of Appendix VI of the FFACO.

All of the NDEP's comments on the Draft document, from the November 2018 meeting and transmitted by e-mail April 9, 2019, have been satisfactorily addressed. The NDEP therefore, accepts the Addendum to the CADD/CAP for the Subsurface CAU 447, Shoal, Nevada, Site, as final and approves DOE-LM to move to step 5(a) in Section 5.0 of Appendix VI of the FFACO and petition NDEP to move through Step 6 of the strategy shown in Figure 5-28 of the CADD/CAP Addendum.

If you have any comments or questions on the above, please contact me at 702-486-2850, ext. 232, or Mark McLane at ext. 226.

2030 E. Flamingo Road, Suite 230 • Las Vegas, Nevada 89119 • p: 702.486.2850 • f: 702.486.2863 • ndep.nv.gov

Sincerely,

Christine D. Andres
Chief
Bureau of Federal Facilities

CDA/MM

ec: EM Records, Las Vegas, NV
Navarro Central Files
R. Findlay, Navarro, Grand Junction, CO
FFACO Group, Las Vegas, NV
MSTS Correspondence Management, Las Vegas, NV
R. F. Boehlecke, Las Vegas, NV
K. Karp, Navarro, Grand Junction, CO

cc: EM Records, Las Vegas, NV
J. B. Chapman, DRI, Las Vegas, NV
Jeffrey Fraher, DTRA/CXTS, Kirtland AFB, NM

Appendix C

Well Descriptions with Well Completion Information

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Table C1. Well Descriptions with Well Completion Information

Well/Piezometer ID	Northing (ft)	Easting (ft)	Construction Material	Material Type	Material Use	Interval (ft)	Stemming Material	Volume (ft^3)	Interval (ft)
MV-1	1621056.50	557878.03	Surface Casing	24-inch Carbon Steel Casing	Blank	0–99	Cement Seal	219	0–100
			Piezometer Casing	2.375-inch Carbon Steel Flush-Joint Tubing	Blank	+1.08–1338	Cement Seal	1026	0–1242
					Screen	1338–1398	6 × 12 Sand Pack	105	1242–1308
					Blank with End Cap	1398–1407	1/8–1/4-inch Gravel Pack	149	1308–1425
							Cement Seal	59	1425–1481
			Monitoring Well Casing	5.5-inch Carbon Steel Casing (Internal Epoxy Coated)	Blank	+1.31–1573			
					Screen	1573–1727	6 × 12 Sand Pack	59	1481–1545
					Blank with End Cap	1727–1750	1/8–1/4-inch Gravel Pack	211	1545–1788
MV-2	1621327.59	557731.38	Surface Casing	24-inch Carbon Steel Casing	Blank	0–99	Cement Seal	200	0–99
			Piezometer Casing	2.375-inch Carbon Steel Flush-Joint Tubing	Blank	+0.79–1188	Cement Seal	888	0–1076
					Screen	1188–1247	6 × 12 Sand Pack	50	1076–1166
					Blank with End Cap	1247–1258	1/8–1/4-inch Gravel Pack	62	1166–1280
							Cement Seal	284	1280–1739
			Monitoring Well Casing	5.5-inch Carbon Steel Casing (Internal Epoxy Coated)	Blank	+0.90–1820			
					Screen	1820–1991	6 × 12 Sand Pack	30	1739–1780
					Blank with End Cap	1991–2011	1/8–1/4-inch Gravel Pack	150	1780–2018
MV-3	1621150.26	558232.20	Surface Casing	24-inch Carbon Steel Casing	Blank	0–97	Cement Seal	214	0–97
			Intermediate Casing	13.375-inch Carbon Steel Casing	Blank	0–1225	Cement Seal	1901	0–1049
			Piezometer Casing	2.375-inch Carbon Steel Flush-Joint Tubing	Blank	+0.65–1140	20 × 24 Sand Pack	69	1049–1080
					Screen	1140–1200	6 × 12 Sand Pack	60	1080–1110
					Blank with End Cap	1200–1210	1/8–1/4-inch Gravel Pack	180	1110–1203
							Cement Seal	32	1203–1225
			Monitoring Well Casing	5.5-inch Carbon Steel Casing (Internal Epoxy Coated)	Blank	+1.0–1464	Cement Seal	968	0–1363
							20 × 40 Sand Pack	25	1363–1391
					Screen	1464–1635	6 × 12 Sand Pack	23	1391–1429
					Blank with End Cap	1635–1658	1/8–1/4-inch Gravel Pack	180	1429–1669
MV-4	1618968.08	555950.40	Surface Casing	14-inch Carbon Steel Casing	Blank	0–60	Cement Seal	167	0–60
			Piezometer Casing	2.375-inch Carbon Steel Flush-Joint Casing	Blank	0–1120	Cement Seal	1280	0–1090
							3/8-inch Bentonite Chips	3.3	1090–1095
							No. 6 Sand Pack	6.7	1095–1105
					Screen with End Cap	1120–1240	1/8–1/4-inch Gravel Pack	216	1105–1275
							3/8-inch Bentonite Chips	6.7	1275–1329
							Cement Seal	63	1329–1374
			Monitor Well Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–1400	3/8-inch Bentonite Chips	3.3	1374–1380
							No. 6 Sand Pack	3.3	1380–1385
					Screen with End Cap	1400–1560	1/8–1/4-inch Gravel Pack	128	1385–1570
MV-5	1620801.32	556441.09	Surface Casing	14-inch Carbon Steel Casing	Blank	0–60	Cement Seal	167	0–60
			Bubble Tube	0.25-inch Stainless Steel Tubing Strapped to Well	Blank	0–1100	1/8–1/4-inch Gravel Pack	20	1010–1130
			Monitor Well Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–1325	Cement Seal	137	1152–1310
							3/8-inch Bentonite Chips	3.3	1310–1315
							No. 6 Sand Pack	5.3	1315–1320

Well/Piezometer ID	Northing (ft)	Easting (ft)	Construction Material	Material Type	Material Use	Interval (ft)	Stemming Material	Volume (ft^3)	Interval (ft)
					Screen with End Cap	1325–1565	1/8–1/4-inch Gravel Pack	137	1324–1593
			Piezometer Casing	2.375-inch Carbon Steel Flush-Joint Casing	Blank	0–1700	3/8-inch Bentonite Chips	5	1593–1602
							Cement Seal	38	1640–1675
							3/8-inch Bentonite chips	7	1675–1640
							Cement Seal	35	1640–1677
							3/8-inch Bentonite Chips	4.7	1677–1680
					Screen with End cap	1700–1730	1/8–1/4-inch Gravel Pack	63	1680–1730
							Natural Formation Fill Material	NA	1730–1751
HC-1	1621982.53	557638.31	Surface Casing	8.625-inch Carbon Steel Casing	Blank	0–102	Cement Seal	NA	0–102
			Intermediate Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–1094	NA	NA	0–1094
			Borehole (8.0-inch)	Open to Formation	Open Hole	0–1343	NA	NA	0–1343
HC-2d	1620263.52	555725.90	Monitor Well Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–1417	NA	NA	0–1417
					Screen	1417–1517	NA	NA	1417–1517
					Blank	1517–1557	NA	NA	1517–1557
					Screen with End Cap	1557–1657	NA	NA	1557–1657
			Borehole (12.25-inch)	Open to Formation	Open Hole	0–1836	NA	NA	0–1836
HC-3	1627471.94	548930.97	Surface Casing	8.625-inch Carbon Steel Casing	Blank	0–103	Cement Seal	NA	0–103
			Intermediate Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–1094	NA	NA	0–1094
			Well Casing	2.375-inch Carbon Steel Flush-Joint Casing	Blank	0–1184	NA	NA	0–1184
					Perforated with Tricone Bit	1184–1204	NA	NA	1184–1204
			Borehole (8.0-inch)	Open to Formation	Open Hole	0–1303	NA	NA	0–1303
HC-4	1619615.99	557465.96	Surface Casing	8.625-inch Carbon Steel Casing	Blank	0–103	Cement Seal	NA	0–103
			Intermediate Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–1013	NA	NA	0–1013
			Borehole (8.0-inch)	Open to Formation	Open Hole	0–1303	NA	NA	0–1303
HC-5	1619022.26	558042.18	Surface Casing	20-inch Carbon Steel Casing	Blank	0–100	Cement Seal	NA	0–100
			Intermediate Casing	13.375-inch Carbon Steel Casing	Blank	0–1200	Cement Seal	NA	0–1200
			Well Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–879	Cement Seal	NA	0–3296
				5.5-inch Fiberglass Flush-Joint Casing	Blank	879–3385	20/40 Sand Pack	NA	3296–3310
							6/9 Sand Pack	NA	3310–3335
					Screen	3385–3531	3/8-inch Gravel Pack	NA	3335–3565
					Blank with End Cap	3531–3561		NA	
HC-6	1619278.73	557949.55	Surface Casing	20-inch Carbon Steel Casing	Blank	0–100	Cement Seal	NA	0–100
			Well Casing	5.5-inch Fiberglass Flush-Joint Casing	Blank	0–1116	Cement Seal (Cement Basket)	NA	0–70
							Open Borehole	NA	70–970
							3/8-inch Gravel Pack	NA	970–975
					Screen	1116–1232	6/9 Sand Pack	NA	975–1105
					Blank with End Cap	1232–1234	3/8-inch Gravel Pack	NA	1105–1240
HC-7	1619203.43	558018.70	Surface Casing	20-inch Carbon Steel Casing	Blank	0–100	Cement Seal	NA	0–100
			Well Casing	5.5-inch Fiberglass Flush-Joint Casing	Blank	0–1116	Cement Seal (Cement Basket)	NA	0–67
							Open Borehole	NA	67–980
					Screen	1106–1224	6/9 Sand Pack	NA	980–1100
					Blank with End Cap	1224–1225	3/8-inch Gravel Pack	NA	1100–1240

Well/Piezometer ID	Northing (ft)	Easting (ft)	Construction Material	Material Type	Material Use	Interval (ft)	Stemming Material	Volume (ft^3)	Interval (ft)
HC-8	1618755.26	558369.59	Surface Casing	20-inch Carbon Steel Casing	Blank	0–100	Cement Seal	NA	0–100
			Well Casing	5.5-inch Carbon Steel Flush-Joint Casing	Blank	0–811	Cement Seal	NA	0–2200
				5.5-inch Fiberglass Flush-Joint Casing	Blank	811–2294	20/40 Sand Pack	NA	2200–2220
							6/9 Sand Pack	NA	2220–2247
					Screen	2294–2411	3/8-inch Gravel Pack	NA	2247–2448
					Blank with End Cap	2411–2441		NA	
							Natural Fill Material	NA	2448–2530

Notes:
Volumes for stemming material is calculated from the recorded quantities of materials used, not from the calculated size of the annulus (the well bore contains numerous out-of-gage intervals that make such calculations misleading).
The coordinate system is: U.S. State Plane, Zone Nevada West 2703, with horizontal datum: North American Datum of 1927.

Abbreviation:
NA = not applicable

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Appendix D

Use Restriction Forms and Map

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U.S. Department of Energy, Legacy Management
Use Restriction Information

General Information

Use Restriction (UR) Type(s):	Administrative Only
Corrective Action Unit (CAU) Number & Description:	447 - Project Shoal Area - Subsurface
Corrective Action Site (CAS) Number & Description:	57-57-001 - Cavity
CAU/CAS Owner:	Offsites - OLM
Note:	N/A

Section I. *Federal Facility Agreement and Consent Order* (FFACO) UR

An FFACO UR is not identified for this site.

Section II. Administrative UR

Basis for Administrative UR

Summary Statement: This Administrative UR is established to protect workers should future land use result in increased exposure to site contaminants. Radiological contaminants are assumed to be present that exceed action levels under the Industrial Area (2,000 hours per year) exposure scenario.

It is also established to limit activities that may impact the groundwater flow system at the site.

U.S. Department of Energy, Environmental Management Nevada Program
Use Restriction Information

Administrative UR Physical Description

Surveyed Area (UTM, Zone 11, NAD 83, meters):

UR Boundary	UR Point[1]	Easting[2]	Northing[2]
Admin Boundary	1	380,715	4,338,886
	2	380,009	4,339,191
	3	379,725	4,339,906
	4	380,030	4,340,613
	5	380,746	4,340,897
	6	381,453	4,340,591
	7	381,736	4,339,876
	8	381,431	4,339,169
	9	380,715	4,338,886

[1]UR Points are listed clockwise beginning at the southernmost point. If multiple points share the southernmost Northing coordinate, the easternmost point is listed as Point 1.

[2]UR Coordinate values presented herein were captured in North American Datum of 1983, and rounded to the nearest meter when necessary; due to that rounding, coordinates may not reflect the original precision of values contained within the source GIS data set.

Boundary Applies to: Subsurface

Starting Depth: 7 **Ending Depth:**

Depth Unit: Meters

Survey Source: GPS

Administrative UR Requirements

Administrative URs do not require onsite postings or other physical barriers, and they do not require periodic inspections or maintenance.

Site Controls:

This Administrative UR is recorded as described in **Section IV. Recordation Requirements** to restrict activities within the area defined by the coordinates listed above and depicted in the attached figure without prior notification of NDEP unless the activities are conducted under the provisions of 10 CFR, Part 835, Occupational Radiation Protection and 10 CFR, Part 851, Worker Safety and Health Program.

CAU 447 / CAS 57-57-001

UR is effective upon acceptance by NDEP.

U.S. Department of Energy, Environmental Management Nevada Program
Use Restriction Information

Section III. Supporting Documentation

UR Source Document(s)

U.S. Department of Energy Legacy Management. 2020. Closure Report for Corrective Action Unit 447: Project Shoal Area - Subsurface, Shoal Nevada, Rev. 0, LMS/SHL/S24488.

Attachments

- FFACO UR Boundary Map (UTM, Zone 11, NAD 83 meters)

Section IV. Recordation Requirements

Recordation:

The above UR(s) are recorded in the:

- FFACO Database
- NNSA M&O Contractor GIS
- EM Nevada Program CAU/CAS Files
- U.S. Bureau of Land Management
- U.S. Navy GIS

Section V. LM Approval

Digitally signed by MARK KAUTSKY
Date: 2020.07.16 10:35:51 -06'00'

Date: _____

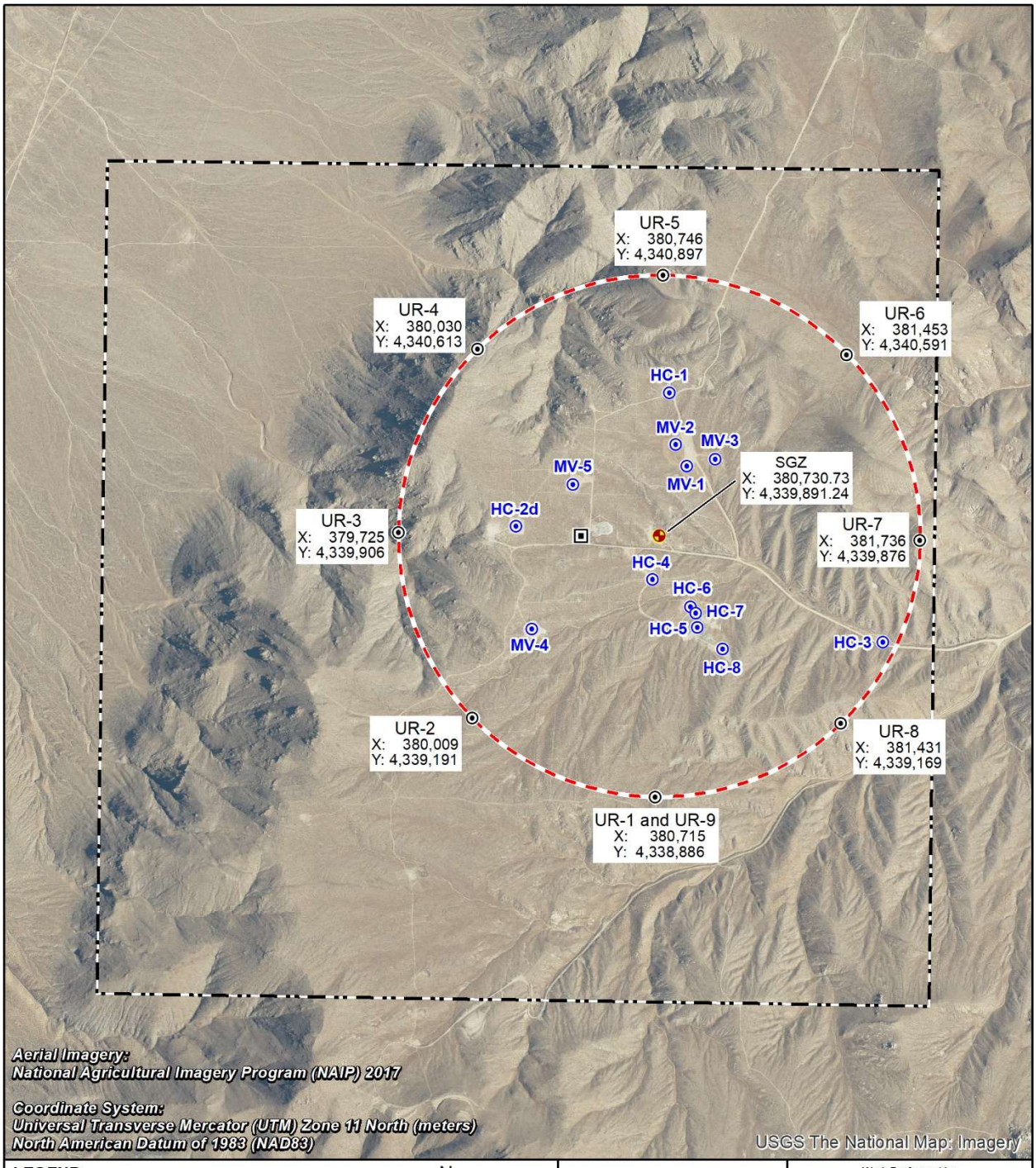
Mark Kautsky

Activity Lead

Legacy Management

CAU 447 / CAS 57-57-001

UR is effective upon acceptance by NDEP.


UR-5
X: 380,746
Y: 4,340,897
UR-4
X: 380,030
Y: 4,340,613
UR-6
X: 381,453
Y: 4,340,591
HC-1
MV-2
MV-3
MV-5
MV-1
SGZ
X: 380,730.73
Y: 4,339,891.24
HC-2d
UR-3
X: 379,725
Y: 4,339,906
UR-7
X: 381,736
Y: 4,339,876
HC-4
HC-6
HC-7
HC-5
MV-4
HC-3
HC-8
UR-2
X: 380,009
Y: 4,339,191
UR-8
X: 381,431
Y: 4,339,169
UR-1 and UR-9
X: 380,715
Y: 4,338,886
Aerial Imagery:
National Agricultural Imagery Program (NAIP) 2017
Coordinate System:
Universal Transverse Mercator (UTM) Zone 11 North (meters)
North American Datum of 1983 (NAD83)
USGS The National Map: Imagery
LEGEND
Use Restriction (UR) Boundary Point
Well Location
Surface Ground Zero (SGZ)
Emplacement Shaft
Withdrawal Boundary
Compliance Boundary
(Use Restriction Boundary)
N
SCALE IN FEET
0
1,000
2,000
U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT
Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421
Boundary Location Map
Shoal, NV, Site
DATE PREPARED:
March 19, 2020
FILE NAME:
S2449602
\\LM\ess\EnvProjects\EBM\LTS\111\0084\17\000\S24496\S2449602.mxd smithw 03/19/2020 1:55:46 PM

Appendix E

DOE Notification to BLM and U.S. Navy

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DOE Notification to BLM and U.S. Navy

A letter or email from the agency that maintains the surface (U.S. Bureau of Land Management and/or U.S. Navy) must be submitted to NDEP stating that the use-restriction information has been recorded in their GIS. If DOE is unable to include this letter with the Closure Report due to agency response times, DOE must provide documentation that use-restriction information has been sent to the appropriate agency with a request to record the use restrictions. NDEP will then issue a notice of milestone completion if this is the only unresolved issue. Once the appropriate agency acknowledges recordation, NDEP will issue the CAU Notice of Completion for the CAU.

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Document Management

From: Findlay, Rick (CONTR)
Sent: Friday, July 10, 2020 11:31 AM
To: Rule, Robert M CIV NAVFAC SW
Cc: 'Ligon, Teri D CIV USN NAWDC (USA)'; 'Murphy, Melissa L CIV USN NAVFAC SW SAN CA (USA)'; Kautsky, Mark; Smith, Wyatt (CONTR)
Subject: Shoal Site - GIS Files
Attachments: Memo between Navy & BLM 2007.pdf; GCS_NAD83.pdf; Groundwater_Monitoring_Wells.cpg; Groundwater_Monitoring_Wells.dbf; Groundwater_Monitoring_Wells.prj; Groundwater_Monitoring_Wells.sbn; Groundwater_Monitoring_Wells.sbx; Groundwater_Monitoring_Wells.shp; Groundwater_Monitoring_Wells.shx; Surface_Ground_Zero_Monument.cpg; Surface_Ground_Zero_Monument.dbf; Surface_Ground_Zero_Monument.prj; Surface_Ground_Zero_Monument.sbn; Surface_Ground_Zero_Monument.sbx; Surface_Ground_Zero_Monument.shp; Surface_Ground_Zero_Monument.shx; Emplacement_Shaft.cpg; Emplacement_Shaft.dbf; Emplacement_Shaft.prj; Emplacement_Shaft.sbn; Emplacement_Shaft.sbx; Emplacement_Shaft.shp; Emplacement_Shaft.shx; Site_Withdrawal_Boundary.cpg; Site_Withdrawal_Boundary.dbf; Site_Withdrawal_Boundary.prj; Site_Withdrawal_Boundary.sbn; Site_Withdrawal_Boundary.sbx; Site_Withdrawal_Boundary.shp; Site_Withdrawal_Boundary.shx; Use_Restriction_Compliance_Boundary.cpg; Use_Restriction_Compliance_Boundary.dbf; Use_Restriction_Compliance_Boundary.prj; Use_Restriction_Compliance_Boundary.sbn; Use_Restriction_Compliance_Boundary.sbx; Use_Restriction_Compliance_Boundary.shp; Use_Restriction_Compliance_Boundary.shx

Rob –

As discussed, LM is working with the Nevada Division of Environmental Protection (NDEP) to close the Shoal site and move it to our long-term monitoring and surveillance program. As part of this process, we need to provide assurance to NDEP that our site boundary information (withdrawal boundary and subsurface use-restriction boundary) and site features (wells, emplacement shaft, and monument at surface ground zero) are in your GIS database. LM provided this information to you in the past, so the attached files should replace/update what you currently have in your GIS database. The attached .pdf file (GCS_NAD83) is a map showing the site features and coordinate system they are provided in. The attached .dbf files are the shapefiles for the site features mentioned above (35 files in total). I've also include a copy of the agreement between the Navy and BLM, which outlines LM's withdrawal restrictions for the site (highlighted text on page 8). LM will be referencing this agreement in our correspondence with NDEP to provide additional assurances that LM's restrictions are maintained with the Navy and BLM. I've copied Wyatt Smith on this email, because he is our GIS specialist for the project. If Teri or Melissa have any trouble loading the files they can contact Wyatt by email. I've also copied Mark Kautsky because he is the LM Site Manager for the Shoal site.

To satisfy NDEPs request, please respond with an email stating that you have incorporated the shapefiles into the Navy's GIS database and provide a map showing the features.

Thanks again for the help with this. LM appreciates your efforts in helping us complete this task. Feel free to email or call if you have any questions.

Richard C. Findlay
Navarro Research and Engineering, Inc.
Contractor to the U.S. Department of Energy
Office of Legacy Management

1

2597 Legacy Way, Grand Junction, CO 81503
Office: (970) 248-6419
rick.findlay@lm.doe.gov

Document Management

From: Findlay, Rick (CONTR)
Sent: Friday, July 10, 2020 11:34 AM
To: 'Ken Collum (KCollum@blm.gov)'
Cc: Smith, Wyatt (CONTR); Kautsky, Mark
Subject: Shoal Site - GIS Files
Attachments: Memo between Navy & BLM 2007.pdf; GCS_NAD83.pdf; Groundwater_Monitoring_Wells.cpg; Groundwater_Monitoring_Wells.dbf; Groundwater_Monitoring_Wells.prj; Groundwater_Monitoring_Wells.sbn; Groundwater_Monitoring_Wells.sbx; Groundwater_Monitoring_Wells.shp; Groundwater_Monitoring_Wells.shx; Surface_Ground_Zero_Monument.cpg; Surface_Ground_Zero_Monument.dbf; Surface_Ground_Zero_Monument.prj; Surface_Ground_Zero_Monument.sbn; Surface_Ground_Zero_Monument.sbx; Surface_Ground_Zero_Monument.shp; Surface_Ground_Zero_Monument.shx; Emplacement_Shaft.cpg; Emplacement_Shaft.dbf; Emplacement_Shaft.prj; Emplacement_Shaft.sbn; Emplacement_Shaft.sbx; Emplacement_Shaft.shp; Emplacement_Shaft.shx; Site_Withdrawal_Boundary.cpg; Site_Withdrawal_Boundary.dbf; Site_Withdrawal_Boundary.prj; Site_Withdrawal_Boundary.sbn; Site_Withdrawal_Boundary.sbx; Site_Withdrawal_Boundary.shp; Site_Withdrawal_Boundary.shx; Use_Restriction_Compliance_Boundary.cpg; Use_Restriction_Compliance_Boundary.dbf; Use_Restriction_Compliance_Boundary.prj; Use_Restriction_Compliance_Boundary.sbn; Use_Restriction_Compliance_Boundary.sbx; Use_Restriction_Compliance_Boundary.shp; Use_Restriction_Compliance_Boundary.shx

Contacts: Ken Collum

Ken –

As discussed, LM is working with the Nevada Division of Environmental Protection (NDEP) to close the Shoal site and move it to our long-term monitoring and surveillance program. As part of this process, we need to provide assurance to NDEP that our site boundary information (withdrawal boundary and subsurface use-restriction boundary) and site features (wells, emplacement shaft, and monument at surface ground zero) are in your GIS database. The attached .pdf file (GCS_NAD83) is a map showing the site features and coordinate system they are provided in. The attached .dbf files are shapefiles for the site features mentioned above (35 files in total). I've also include a copy of the agreement between the BLM and Navy, which outlines LM's withdrawal restrictions for the site (highlighted text on page 8). LM will be referencing this agreement in our correspondence with NDEP to provide additional assurances that LM's restrictions are maintained with the BLM and Navy. I've copied Wyatt Smith on this email, because he is our GIS specialist for the project. If you have any trouble loading the files you can contact Wyatt by email. I've also copied Mark Kautsky because he is the LM Site Manager for the Shoal site.

To satisfy NDEPs request, please respond with an email stating that you have incorporated the shapefiles into BLM's GIS database and provide a map showing the features. LM appreciates your efforts in helping us complete this task. Feel free to email or call if you have any questions.

Thanks again for your help with this.

Richard C. Findlay
Navarro Research and Engineering, Inc.
Contractor to the U.S. Department of Energy
Office of Legacy Management

1

2597 Legacy Way, Grand Junction, CO 81503
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Appendix F

NDEP Comments 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
Steve Sisolak, Governor
Bradley Crowell, Director
Greg Lovato, Administrator

February 13, 2020

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

RE: Submittal of Draft Closure Report for the Project Shoal Area: Subsurface Corrective Action Unit 447 Shoal, Nevada, Site
Federal Facility Agreement and Consent Order (FFACO)

Dear Mr. Kautsky,

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) has received and reviewed the above referenced report, received on January 30, 2020. While this letter serves as the Notice of Completion for the January 30, 2020 milestone for the Shoal Draft Closure Report, the NDEP has the following comments which should be addressed in Final document.

1. Page 9, Section 1.4, Selected Corrective Action Alternative, First Paragraph, Third Sentence: This sentence refers to "the Corrective Action investigations." It is not clear what investigations (plural) are being referred to as it appears this paragraph is referencing work up to the CADD/CAP. Is more than one investigation being referenced? It would aid the reader if all the investigations being referenced were identified in the early portion of this document. Are these actual investigations of some type or activities under a certain phase of FFACO work? If applicable, it may be helpful to add a phrase such as, "…and together with all the activities through the CADD/CAP phase, constitute the corrective action investigations." at the end of the second paragraph on Page 6, Section 1.2 if this indeed is a true statement.

2. Page 10, Section 1.5, Closure Report Contents, First Sentence and Page 11, Sections 2.0, First Sentence and 2.1, Summary of Site Corrective Action Investigations and CADD/CAP Activities and Corrective Action Investigation, First Sentence: See Comment No.1, above, regarding "investigation" vs "investigations."

3. Page 11, Section 2.1, Second Paragraph, Third Sentence and Third Paragraph, First Sentence: If the "second CAIP" and/or "second Corrective Action Investigation" referenced in these sentences is the reason for "investigations" being used in the above-cited comments, then this should be explained or "defined" earlier in this report.

4. Page 11, Section 2.1, Corrective Action Investigation, Second Paragraph, Fifth Sentence: Please add the reference for the Addendum to the CAIP in the text and in the reference section.

5. Page 12, Section 2.1, Corrective Action Investigation, First Partial Paragraph on page, First Partial Sentence: Please include a reference in the text for "the final flow and transport model."

6. Page 14, Section 2.3, Implementation of the Short-Term Data Acquisition Plans, First Paragraph, Last Sentence: Reference DOE 2018a should be DOE 2018. Please correct.

7. Page 14, Section 2.4, CADD/CAP Addendum, First Paragraph, First Sentence: Please add the reference DOE, 2019b after "The CADD/CAP Addendum."

8. Page 17, Figure 7: This Figure is confusing. Please remove the "Manual Water Level (WL) Data" legend and explain in a note below the figure why the data for MV-2PZ is so irregular.

9. Page 32, Section 4.4, Performance Assessment: The use of "might" in this paragraph is misleading as the use of it in the sentences implies that any of the scenarios are up to the discretion of the contractor. NDEP will need to be approve any new strategy, changes in resource use near the site or any reevaluation of the closure conditions. Please reword the sentences accordingly.

10. Page 33, Section 5.0, Postclosure Reporting, First Paragraph, Second Sentence: Please change "results may include" to "where applicable, results will include."

11. Page 33, Section 5.0, New Strategy/path forward reports, Last Sentence: Any new document will have to be finalized. The type of document can be discussed prior to its finalization.

12. Appendix D: Are the forms used for the UR information the most current version? If a requirement is not applicable, please mark as such.

Please address any questions regarding this matter to Chris Andres at (702) 486-2850 ext. 232 or Mark McLane at ext. 226.

Sincerely,

Chris Andres

Christine D. Andres
Chief
Bureau of Federal Facilities

ec: EM Records, Las Vegas, NV
Navarro Central Files
R. Findlay, Navarro, Grand Junction, CO
FFACO Group, EM Nevada, Las Vegas, NV
W. R. Wilborn, EM Nevada, Las Vegas, NV
R. F. Boehlecke, EM Nevada, Las Vegas, NV
Jeffrey Fraher, DTRA/CXTS, Kirtland AFB, NM
MSTS Correspondence Management, Las Vegas, NV
K. Kreie, DOE-LM, Grand Junction, CO

cc: EM Records, Las Vegas, NV
J. B. Chapman, DRI, Las Vegas, NV

NAVARRO

Contractor to the U.S. Department of Energy Office of Legacy Management

Record of Review

The Record of Review process is described in the *Quality Assurance Manual*, Section 5.0.

Document Information

Due date: 05/16/2020 Review number: 1 Project: Nevada Offsites - CNTA Charge code: LMCP.LMCP.2. JJW

Document title, number, and revision: Draft "Closure Report for the Project Shoal Area: Subsurface Corrective Action Unit 447, Shoal, Nevada, Site"

Author: Mark Kautsky Author's phone: (970) 248-6018 Author's organization: DOE-LM

Reviewer: Christine D. Andres Reviewer's phone: (702) 486-2850 Reviewer's organization: NDEP

Reviewer's recommendation: ☐ Release without comment ☐ Consider comments ☒ Resolve comments and reroute for review

Reviewer signature: Refer to the NDEP letter dated February 13, 2020 Date: Date

Author's response: ☒ Comments have been addressed

Author's signature: Mark Kautsky Digitally signed by MARK KAUTSKY Date: 2020.04.28 16:33:03 -06'00' Date: Date

Comment resolution: ☐ Satisfactory ☐ Unsatisfactory

Reviewer's signature: Christine Andres Date: Date 4/29/2020

Item Number	Reviewer's Comments and Recommendations	Required	Author's Response (if required)
1	Page 9, Section 1.4, Selected Corrective Action Alternative, First Paragraph, Third Sentence: This sentence refers to "the Corrective Action investigations." It is not clear what investigations (plural) are being referred to as it appears this paragraph is referencing work up to the CADD/CAP. Is more than one investigation being referenced? It would aid the reader if all the investigations being referenced were identified in the early portion of this document. Are these actual investigations of some type or activities under a certain phase of FFACO work? If applicable, it may be helpful to add a phrase such as, " ... and together with all the activities through the CADD/CAP phase, constitute the corrective action investigations." at the end of the second paragraph on Page 6, Section 1.2 if this indeed is a true statement.	Yes	In this section (Section 1.4) more than one investigation is being referenced. Its referencing the investigations completed before the CADD/CAP phase as outlined in Section 2.1. As a result, the suggested phrase was not added, but the sentence in Section 1.4 was revised (as follows) to provide more clarity. This alternative was selected based on results from the Corrective Action investigations completed before the CADD/CAP phase (Section 2.1) and the detailed comparative analysis of the potential Corrective Action Alternatives presented in the CADD/CAP (Section 2.2).
2	Page 10, Section 1.5, Closure Report Contents, First Sentence and Page 11, Sections 2.0, First Sentence and 2.1, Summary of Site Corrective Action Investigations and CADD/CAP Activities and Corrective Action Investigation, First Sentence: See Comment No. 1, above, regarding "investigation" vs "investigations."	Yes	The Section 2.1 heading was changed to Corrective Action Investigations and the first sentence of Section 2.1 was changed from "The Corrective Action investigation was" to "The Corrective Action investigations were" to be clear that more than one investigation was conducted before the CADD/CAP phase (Section 2.2).

Record of Review (continued)

Item Number	Reviewer's Comments and Recommendations	Required	Author's Response (if required)
3	Page 11, Section 2.1, Second Paragraph, Third Sentence and Third Paragraph, Fifth Sentence: If the "second CAIP" and/or "second Corrective Action Investigation" referenced in these sentences is the reason for "investigations" being used in the above-cited comments, then this should be explained or "defined" earlier in this report.	Yes	Section 1.2, Page 6, Second Paragraph: To provide more clarity on the investigations conducted before the CADD/CAP phase a sentence was added after the first sentence of this paragraph and the second sentence (now the third sentence) was revised as follows. This included a planning phase with the development of Corrective Action Investigation Plans, a Corrective Action Investigation phase that executed these plans, and a CADD/CAP phase. The approach included multiple field investigations, developing a site conceptual model (SCM), and a numerical flow and transport model to calculate contaminant boundaries, negotiating compliance boundaries with NDEP, performing model validation, and monitoring groundwater.
4	Page 11, Section 2.1, Corrective Action Investigation, Second Paragraph, Fifth Sentence: Please add the reference for the Addendum to the CAIP in the text and in the reference section.	Yes	The reference was added to the text and reference section as requested.
5	Page 12, Section 2.1, Corrective Action Investigation, First Partial Paragraph on page, First Partial Sentence: Please include a reference in the text for "the final flow and transport model."	Yes	The reference was added to the text and reference section as requested.
6	Page 14, Section 2.3, Implementation of the Short-Term Data Acquisition Plans, First Paragraph, Last Sentence: Reference DOE 2018a should be DOE 2018. Please correct.	Yes	The reference was revised to 2019c, because the referenced Hydrologic Testing Report was finalized in 2019 not 2018. The reference section was also revised to reflect this change.
7	Page 14, Section 2.4, CADD/CAP Addendum, First Paragraph, First Sentence: Please add the reference DOE, 2019b after "The CADD/CAP Addendum."	Yes	The reference was added as requested.
8	Page 17, Figure 7: This Figure is confusing. Please remove the "Manual Water Level (WL) Data" legend and explain in a note below the figure why the data for MV-2PZ is so irregular.	Yes	Figure 7 was revised as requested and the third paragraph of Section 2.5 was revised to include the following explanation for the water level in piezometer MV-2PZ. A note was added below the figure to provide an explanation for the dashed vertical lines. The declining water level in piezometer MV-2PZ is attributed to water being added after a development event in 2012 to remove remnant drilling mud. This water level is not indicative of the static water level in the formation at its screened interval.

Record of Review (continued)

Item Number	Reviewer's Comments and Recommendations	Required	Author's Response (if required)
9	Page 32, Section 4.4, Performance Assessment: The use of "might" in this paragraph is misleading as the use of it in the sentences implies that any of the scenarios are up to the discretion of the contractor. NDEP will need to be approve any new strategy, changes in resource use near the site or any reevaluation of the closure conditions. Please reword the sentences accordingly.	Yes	It has always been LMs intent that NDEP would be the approver of any new strategy, change in resource use near the site, or any reevaluation of the closure conditions. The term "might" was changed to "would" or "could" to make sure this is clear.
10	Page 33, Section 5.0, Postclosure Reporting, First Paragraph, Second Sentence: Please change "results may include" to "where applicable, results will include."	Yes	The sentence was changed to read as follows: Postclosure reports (where applicable), will include the items described below.
11	Page 33, Section 5.0, New Strategy/path forward reports, Last Sentence: Any new document will have to be finalized. The type of document can be discussed prior to its finalization.	Yes	The two sentences were added as requested.
12	Appendix D: Are the forms used for the UR information the most current version? If a requirement is not applicable, please mark as such.	Yes	The Use Restriction forms provided in Appendix D were replaced with the most current version of the form as requested.

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NEVADA DIVISION OF
ENVIRONMENTAL
PROTECTION

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

October 12, 2020

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

RE: Submittal of Final Closure Report For The Project Shoal Area: Subsurface Corrective Action Unit 447 Shoal, Nevada, Site
Federal Facility Agreement and Consent Order

Dear Mr. Kautsky:

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) has reviewed the *Final Closure Report for the Project Shoal Area: Subsurface Corrective Action Unit 447 Shoal, Nevada, Site,* received on September 1, 2020, with cover letter dated August 20, 2020. The NDEP has the following two comments on this Final document:

1. As documented in a September 28, 2020, email from Rick Findlay to Mark Kautsky, following discussion with NDEP staff, the third sentence of the first paragraph on Page 9, Section 1.4, will be revised and a new fourth sentence will be added as follows: "This alternative was selected based on results from the Corrective Action investigations completed before the CADD/CAP phase (summarized in Section 2.1) and the detailed comparative analysis of the potential Corrective Action Alternatives presented in the CADD/CAP (summarized in Section 2.2). The detailed comparative analysis of the potential alternatives is given in the Evaluation of Alternatives Section 3.0 of the CADD/CAP (DOE 2006b)."

2. Appendix F, Record of Review, Item Number 9: In the "Reviewer's Comments and Recommendations," the page number should 32, not 33. Please correct this.

It is the NDEP's understanding that once these requested changes are made, the Final Closure Report will be re-issued. Upon receipt and review, the re-issued document will be approved. Should you have any questions regarding this matter, please contact either Britt Jacobson or me via email.

Sincerely,

Christine D. Andres
Chief
Bureau of Federal Facilities

375 East Warm Springs Rd, Suite 200 • Las Vegas, NV 89119 • p: 702.668.3900 • f: 702.486.2863 • ndep.nv.gov

CDA/EJ

ec: FFACO Group, EM
EM Records, AMEM
Navarro Central Files
Robert Boehlecke, EM
Jenny Chapman, DRI
Jeffrey Fraher, DTRA/CXTS
MSTS Correspondence Management
NNSA/NFO Read File
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R. Findlay, Navarro
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