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Completion Report for Model Evaluation Well ER-11-2

Corrective Action Unit 98: Frenchman Flat

January 2013

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

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Completion Report for Model Evaluation Well ER-11-2

Corrective Action Unit 98: Frenchman Flat

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January 2013

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**Completion Report for
Model Evaluation Well ER-11-2**

**Corrective Action Unit 98:
Frenchman Flat**

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Abstract

Model Evaluation Well ER-11-2 was drilled for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office in support of Nevada Environmental Management Operations at the Nevada National Security Site (formerly known as the Nevada Test Site). The well was drilled in August 2012 as part of a model evaluation program in the Frenchman Flat area of Nye County, Nevada. The primary purpose of the well was to provide detailed geologic, hydrogeologic, chemical, and radionuclide data that can be used to test and build confidence in the applicability of the Frenchman Flat Corrective Action Unit flow and transport models for their intended purpose. In particular, this well was designed to provide data to evaluate the uncertainty in model forecasts of contaminant migration from the upgradient underground nuclear test PIN STRIPE, conducted in borehole U-11b in 1966. Well ER-11-2 will provide information that can be used to refine the Phase II Frenchman Flat hydrostratigraphic framework model if necessary, as well as to support future groundwater flow and transport modeling.

The main 31.1-centimeter (cm) hole was drilled to a total depth of 399.6 meters (m). A completion casing string was not set in Well ER-11-2. However, a piezometer string was installed in the 31.1-cm open hole. The piezometer is composed of 7.3-cm stainless-steel tubing hung on 6.0-cm carbon-steel tubing via a crossover sub. The piezometer string was landed at 394.5 m, for monitoring the lower tuff confining unit.

Data collected during and shortly after hole construction include composite drill cuttings samples collected every 3.0 m, various geophysical logs, water quality (including tritium and other test-related radionuclides) measurements, and water level measurements. The well penetrated 42.7 m of Quaternary and Tertiary alluvium and 356.9 m of Tertiary volcanic rock.

The water-level measured in the piezometer string on September 25, 2012, was 353.8 m below ground surface. No tritium above levels detectable by field methods were encountered in this hole. No well development or hydrologic testing was conducted in this well immediately after completion, and future well development, sampling, and hydrologic testing planned for this well will be limited due to the diameter of the piezometer string.

The stratigraphy, general lithology, and the water level are as expected, but the section of geology encountered is higher than expected due to faulting. No tritium above the minimum detection limit of the field equipment was detected because the target aquifer (the Topopah Spring aquifer) at Well ER-11-2 is structurally higher than expected and thus unsaturated.

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Nevada National Security Site

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List of Acronyms and Abbreviations

BN	Bechtel Nevada
CADD/CAP	Corrective Action Decision Document/Corrective Action Plan
CAU	Corrective Action Unit
cm	centimeter(s)
CFR	Code of Federal Regulations
DOE/NV	U.S. Department of Energy, Nevada Operations Office
EPA	Environmental Protection Agency
FAWP	Field Activity Work Package
FMP	Fluid Management Plan
ft	foot (feet)
gal	gallon(s)
gpm	gallon(s) per minute
HFM	hydrostratigraphic framework model
HSU	hydrostratigraphic unit
id	inside diameter
in.	inch(es)
km	kilometer(s)
Lpm	liter(s) per minute
LSC	liquid scintillation counter
LTCU	lower tuff confining unit
m	meter(s)
m ³	cubic meter(s)
Ma	million years ago
MDA	minimum detectable activity
mi	mile(s)
NAD	North American Datum
NARA	National Archives and Records Administration
NDEP	Nevada Division of Environmental Protection
N-I	Navarro-Intera, LLC
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSS	Nevada National Security Site

List of Acronyms and Abbreviations (continued)

NSTec	National Security Technologies, LLC
OAA	older alluvial aquifer
od	outside diameter
pCi/L	picocurie(s) per liter
Rc	cavity radius (radii)
SNJV	Stoller-Navarro Joint Venture
TD	total depth
TMLVTA	Timber Mountain lower vitric-tuff aquifer
TSA	Topopah Spring aquifer
UDI	United Drilling, Inc.
UGT	underground nuclear test
UGTA	Underground Test Area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
yd ³	cubic yard(s)

1.0 Introduction

1.1 Project Description

Model Evaluation Well ER-11-2 was constructed for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) in support of the Nevada Environmental Management Operations Underground Test Area (UGTA) Activity at the Nevada National Security Site (NNSS) (formerly known as the Nevada Test Site), Nye County, Nevada. Well ER-11-2 was the second of two UGTA model evaluation wells constructed in Frenchman Flat during the summer of 2012.

The Frenchman Flat model evaluation well-drilling program is part of the Corrective Action Decision Document/Corrective Action Plan (CADD/CAP) for the Frenchman Flat Corrective Action Unit (CAU) 98 (NNSA/NSO, 2011). The CADD/CAP is a requirement of the Federal Facility Agreement and Consent Order (1996, as amended), agreed to by the U.S. Department of Energy, Nevada Operations Office (DOE/NV), the Nevada Division of Environmental Protection (NDEP), and the U.S. Department of Defense. The Frenchman Flat CAU is one of five UGTA CAUs at the NNSS, and the first to progress to the model-evaluation stage.

Two of the goals of the UGTA Activity are to evaluate the nature and extent of contamination in groundwater due to underground nuclear testing, and to establish a long-term groundwater monitoring network. UGTA scientists have developed computer models of groundwater flow and contaminant migration within and near the Frenchman Flat CAU to forecast contaminant boundaries that enclose areas that may potentially exceed the radiological standards of the Safe Drinking Water Act (Code of Federal Regulations [CFR], 2012a) over 1,000 years. The primary purpose of the model evaluation wells is to collect data that can be used to test and build confidence in the applicability of the Frenchman Flat Corrective Action Unit flow and transport models for their intended purpose, including development of contaminant boundary forecasts.

The specific purpose of Well ER-11-2 was to obtain data that can be used to reduce the uncertainty of contaminant boundary forecasts associated with the upgradient underground nuclear test (UGT) PIN STRIPE, which was conducted in Emplacement Hole U-11b in 1966. This well also provided detailed hydrogeologic information for certain volcanic aquifers near the water table in northern Frenchman Flat, which will help reduce uncertainties in the Frenchman Flat hydrostratigraphic framework model (HFM). A later document on the results of the Model Evaluation Well drilling project will include a discussion of how this new information may be used if it is deemed necessary to update the Frenchman Flat flow and transport models.

Well ER-11-2 is located in northern Frenchman Flat on the NNSS, approximately 975 meters (m) (3,200 feet [ft]) west of the eastern boundary of the NNSS (Figure 1-1).

1.2 Project Organization

The construction of Well ER-11-2 was intended to help fulfill the goals of the Environmental Management Operations UGTA Activity. Several advisory groups function within the UGTA Activity, whose responsibilities include ensuring that UGTA goals are properly planned and achieved. The roles of these groups with regard to successful construction of Well ER-11-2 are described in this section.

A model evaluation committee was organized to advise NNSA/NSO during the model evaluation phase for the Frenchman Flat CAU (Navarro-Intera, LLC [N-I], 2010a). A drilling advisory team was convened specifically to oversee the drilling and completion of Well ER-11-2. These two groups comprise subject matter experts with significant knowledge of the geology and hydrogeology of the Frenchman Flat CAU, and include scientists and engineers from the following organizations:

▪ NNSA/NSO	▪ N-I (environmental contractor)
▪ Lawrence Livermore National Laboratory	▪ Golder Associates (subcontractor to N-I)
▪ Los Alamos National Laboratory	▪ National Security Technologies, LLC (NSTec; NNSS management and operating contractor)
▪ Desert Research Institute	
▪ NDEP	

See *Frenchman Flat Model Evaluation Wells Drilling and Completion Criteria* (N-I, 2012a) for descriptions of the general plan and goals of the Frenchman Flat evaluation phase as well as specific goals for each well.

Site supervision, engineering, construction, inspection, and geologic support were provided by NSTec. The drilling company was United Drilling, Inc. (UDI), a subcontractor to NSTec. The roles and responsibilities of these and other contractors involved in the project are described in NSTec subcontract number 107553 and in Field Activity Work Package (FAWP) numbers D-011-001.12 and D-007-001.12 (NSTec, 2011; NSTec, 2012).

N-I was the principal environmental contractor for the project and was responsible for general environmental compliance and waste management at the drill site. N-I was responsible for collecting and analyzing fluid samples for water quality and chemistry, and for monitoring and

Figure 1-1
Reference Map Showing Location of Well ER-11-2 on the Nevada National Security Site

documenting disposition of fluids and drill cuttings produced from the borehole. N-I personnel also collected geologic, hydrologic, and drilling parameter data during drilling.

General guidelines for managing fluids used and generated during drilling, completion, and testing of UGTA wells are provided in the UGTA Fluid Management Plan (FMP) (NNSA/NSO, 2009). Well-specific operation strategies for fluid management are further identified in the well-specific fluid management strategy letter (N-I, 2012b; reproduced in Appendix B-2 of this report) as required by the FMP and approved by NDEP before fluid-generating activities are initiated. Estimates of expected production of fluid and drill cuttings for the Frenchman Flat holes are given in Appendix C of the drilling and completion criteria document for the drilling project (N-I, 2012a), along with sampling requirements and contingency plans for management of any hazardous waste produced. All activities were conducted according to specific FAWPs (e.g., NSTec, 2011; 2012; N-I, 2012c) and the UGTA Project Health and Safety Plan, Revision 2 (NSTec, 2008).

This report presents well-construction, environmental compliance, and waste management data, and summarizes model evaluation data gathered during the drilling of Well ER-11-2. Some of the information in this report is preliminary and unprocessed but is being released with the drilling and completion data for convenient reference. Some of these data were obtained from N-I's preliminary Well ER-11-2 data package (N-I, 2012d), which is now superseded by this document. Hydrogeologic information for this area is presented in the data documentation package for the Frenchman Flat HFM prepared by Bechtel Nevada ([BN], 2005).

Documentation for Phase II flow and transport modeling, which guided this Evaluation Phase data collection activity, can be found in N-I (2010a; 2010b). Pre-drilling geologic information for this area (including any changes in the geologic interpretation since completion of the Frenchman Flat HFM [BN, 2005]) is compiled in the Model Evaluation Wells drilling criteria document (N-I, 2012a). Information on well development, aquifer testing, and groundwater analytical sampling (which are outside the scope of this report) are typically compiled and distributed separately.

1.3 Location and Significant Nearby Features

The Well ER-11-2 location is in northern Frenchman Flat, in the southeastern corner of Operational Area 11 of the NNSS, at an elevation of 1,089.1 m (3,573.0 ft) (Figure 1-1). It is located just west of the eastern boundary of the NNSS on a southward sloping alluvial surface. The well is located approximately 7.6 kilometers (km) (4.7 miles [mi]) north of the Frenchman Lake playa and 3.4 km (2.1 mi) northeast of the Area 5 Radioactive Waste Management Site (Figure 1-2). Surface drainage is generally to the south into the playa. The well is located approximately 1,585 m (5,200 ft) north of existing UGTA Well Cluster ER-5-3 (NNSA/NSO,

2005). Well ER-11-2 is located approximately 2,042 m (6,700 ft) northwest from Model Evaluation Well ER-5-5 (NNSA/NSO, 2013), which was the first well drilled as part of the CADD/CAP model evaluation drilling program. The locations of these wells in relation to Well ER-11-2 are shown in Figure 1-2. Additional information about Well ER-11-2 is provided in Table 1-1.

The UGTs closest to Well ER-11-2 are PIN STRIPE (U-11b), DIAGONAL LINE (U-11g), and NEW POINT (U-11c) (Figure 1-2). All three of these tests were conducted above the water table. Table 1-2 provides information pertaining to these tests and other tests in the area. The Well ER-11-2 site is approximately 190.5 m (625 ft) east of the PIN STRIPE UGT, which was conducted 46 years before Well ER-11-2 was drilled. The well site was expected to be within the contaminant plume from the test, based on model forecasts of the 50-, 100-, and 1,000-year contaminant boundaries (Figure 1-3).

1.4 Objectives

The primary purpose for drilling Well ER-11-2 was to obtain data to evaluate uncertainty in the conceptual models of groundwater flow and contaminant transport and contaminant boundary forecasts (N-I, 2012a). In particular, the well was intended to produce data that will help characterize the hydrogeology and possible radiological contamination immediately downgradient from the PIN STRIPE UGT, which was conducted in the U-11b borehole in 1966. Well ER-11-2 is sited along the centerline of the contaminant boundaries forecasted by the model, approximately five cavity radii from PIN STRIPE. The cavity radius was calculated using the maximum yield of the announced range in DOE/NV (2000) and equations in Pawloski (1999). Well ER-11-2 was also expected to provide information that can be used to evaluate flow paths in northern Frenchman Flat and reduce uncertainty in the location and character of volcanic units near the water table. Well ER-11-2 was planned to be constructed in such a manner that, if desired, it could be used as a long-term monitoring well.

The objectives for Well ER-11-2 are listed in Appendix B of the drilling and completion criteria document for the Frenchman Flat Model Evaluation Wells (N-I, 2012a). The objectives are described below, along with well-specific activities necessary to accomplish the objectives:

- Obtain hydrogeologic information that will be used to evaluate the various parameters, assumptions, and models (HFM, flow and transport models, hydrologic source-term models).
- Use the data collected (listed below) to help reduce uncertainties within the northern Frenchman Flat area during any future model runs deemed necessary.

Figure 1-2
Topographic Map of the Well ER-11-2 Area Showing the Locations of Roads
and Nearby Drill Holes

**Table 1-1
Site Data Summary for Well ER-11-2**

Site Coordinates^a	<p>Nevada State Plane – Central Zone, NAD 27 N 778,755.2 ft E 712,898.9 ft</p> <p>Nevada State Plane – Central Zone, NAD 83 N 6,237,365.5 m E 564,813.2 m</p> <p>UTM – Zone 11, NAD 83 N 4,082,892.0 m E 594,497.2 m</p> <p>UTM – Zone 11, NAD 27 N 4,082,695.1 m E 594,576.4 m</p> <p>Geographic – NAD 83 (degrees, minutes, seconds) Latitude: 36° 53' 14.2" Longitude: 115° 56' 22.3"</p> <p>Township and Range^c Southeast ¼ of Southeast ¼ of Section 15 Township 12 south, Range 54 east</p>
Surface Elevation^{a, b}	1,089.1 m (3,573.0 ft)
Drilled Depth	399.6 m (1,311 ft)
Preliminary Fluid Level Depth^d	353.8 m (1,160.6 ft)
Fluid Level Elevation	735.3 m (2,412.4 ft)
Surface Geology	Alluvium (old alluvial deposits [QTa])

- a Measurements made by NSTec Survey on August 29, 2012, using NAD 27 Nevada State Plane coordinates in feet. All other coordinates listed were calculated from NAD 27 feet using Corpscon (U.S. Army Corps of Engineers, 2004). NAD = North American Datum (National Archives and Records Administration [NARA], 1989; U.S. Coast and Geodetic Survey, 1927). UTM = Universal Transverse Mercator.
- b Measurement of elevation of ground at wellhead made by NSTec Survey on August 29, 2012. National Geodetic Vertical Datum 1929 (NARA, 1973). Elevations are relative to mean sea level.
- c Quarter and quarter/quarter section values were visually estimated using data from Public Land Survey System (Bureau of Land Management Cadastral Survey, 2006).
- d Measured in the piezometer string by N-I on September 25, 2012.

Table 1-2
Information for Underground Nuclear Tests Conducted in the Frenchman Flat Northern Test Area

Emplacement Hole Designation	Test Name ^a	Test Date ^a	Surface Elevation ^b meters (feet)	Announced Yield ^a (kilotons)	Depth of Burial ^b meters (feet)	Estimated Depth to Static Water Level ^c meters (feet)	Working Point Geology ^c	Estimated Alluvium Thickness ^c meters (feet)	Working Point HSU ^{c, d}	Lateral Distance to Well ER-11-2 Location meters (feet)
U-5i	DERRINGER	09/12/1966	1,034.8 (3,395)	7.8	255.1 (837)	335 (1,100)	Alluvium	305 (1,000)	OAA	1,660.3 (5,447.3)
U-5k	MILK SHAKE	03/25/1968	1,020.8 (3,349)	<20	264.6 (868)	286 (939)	Alluvium	500 (1,640)	OAA	1,856.1 (6,089.4)
U-11b	PIN STRIPE	04/25/1966	1,093.0 (3,586)	<20	295.7 (970)	358 (1,176) ^e	Bedded tuff, vitric	58 (190)	TMLVTA	190.5 (625.0)
U-11c	NEW POINT	12/13/1966	1,030.5 (3,381)	<20	239.3 (785)	299 (980)	Alluvium	479 (1,570)	OAA	1,118.2 (3,668.6)
U-11e	DIANA MOON	08/27/1968	1,031.7 (3,385)	<20	242.0 (794)	305 (1,000)	Alluvium	366 (1,200)	OAA	1,309.2 (4,295.4)
U-11f	MINUTE STEAK	09/12/1969	1,034.2 (3,393)	<20	264.6 (868)	302 (990)	Alluvium	427 (1,400)	OAA	1,441.2 (4,728.4)
U-11g	DIAGONAL LINE	11/24/1971	1,037.8 (3,405)	<20	264.6 (868)	301 (988)	Alluvium	341 (1,120)	OAA	964.3 (3,163.7)

a DOE/NV (2000)

b N-I (2011)

c BN (2005)

d Hydrostratigraphic nomenclature: OAA = older alluvial aquifer; TMLVTA = Timber Mountain lower vitric-tuff aquifer

e N-I (2010b), based on UE-11b

Figure 1-3
Forecast Contaminant Boundaries for the U-11b PIN STRIPE Underground Nuclear Test

- Detailed hydrogeologic information for the shallow-depth volcanic aquifers, including the Topopah Spring aquifer (TSA)
- Detailed geologic data, including fracture information for the TSA in the upper portion of the saturated section where contaminant transport is most likely
- Obtain water level data and investigate potential local groundwater flow downgradient from the PIN STRIPE UGT.
- Obtain aqueous geochemistry samples to better define possible groundwater flow paths based on water chemistry.
 - Sample for tritium and other radionuclide byproducts from the upgradient PIN STRIPE UGT.

Additional data that will help characterize the hydrology in the vicinity of the PIN STRIPE UGT will be obtained during later sampling and hydraulic testing at this well. Specific criteria for these later tests will be provided elsewhere (e.g., FAWPs and specific hydraulic testing plans), but, ultimately, Well ER-11-2 is expected to provide the following, as listed in Appendix B of N-I (2012a):

- Data for determination of horizontal and vertical conductivity
- Hydraulic properties of the saturated hydrostratigraphic units (HSUs) penetrated
- Groundwater chemistry

The well was expected to accommodate single-well hydraulic testing.

1.5 Project Summary

This section summarizes construction operations for Well ER-11-2; the details are provided in Sections 2.0 through 8.0 of this report.

A 91.4-centimeter (cm) (36-inch [in.]) diameter surface conductor hole was constructed by drilling to a depth of 33.5 m (110 ft) and installing a string of 20-in. conductor casing to the depth of 33.0 m (108.3 ft). Drilling of the main hole with a 17½-in. chisel tooth tricone bit, using an air-foam drilling fluid in conventional circulation, began on August 18, 2012. The 44.5-cm (17.5-in.) diameter surface hole was drilled to a depth of 52.1 m (171 ft), and cement was then placed in the hole to stabilize the alluvium section. The hole diameter was decreased to 31.1 cm (12.25 in.) at the depth of 52.1 m (171 ft), and the well was drilled to a total depth (TD) of 399.6 m (1,311 ft), reached on August 21, 2012. The top of the TSA was reached at 213.4 m (700 ft). The last open-hole fluid-level depth measured prior to installation of the piezometer string was 386.8 m (1,269 ft) on August 22, 2012, during geophysical logging. On September 25, 2012, about a month after the well was completed, a fluid level of 353.8 m

(1,160.6 ft) was measured in the piezometer string, which accesses the lower tuff confining unit (LTCU). No tritium above levels detectable by field methods was detected in this hole during drilling.

One piezometer string was installed in Well ER-11-2. The piezometer string is composed of 2 $\frac{7}{8}$ -in. stainless-steel tubing that hangs from 2 $\frac{3}{8}$ -in. carbon-steel tubing via a crossover sub. The string was landed at 394.5 m (1,294.2 ft). The piezometer string is slotted from 355.9 to 393.8 m (1,167.6 to 1,292.0 ft) for monitoring within the LTCU. The bottom 0.7 m (2.2 ft) of the string is blank and bullnosed. The completion zone is gravel-packed from the top of fill in the bottom of the hole at the depth of 397.5 m (1,304 ft) to 345.0 m (1,132 ft), a total thickness of 52.5 m (172 ft).

Composite drill cuttings were collected every 3.0 m (10 ft) from the depth of 33.5 m (110 ft) to TD. Open-hole geophysical logging of the well was conducted to help verify the geology and characterize the hydrologic properties of the rocks; some logs also aided in the construction of the well by indicating borehole volume and condition. The well was drilled mostly within Tertiary volcanic rocks with a small section of alluvium at the surface.

No well development or hydrologic testing was conducted in this well immediately after completion. Future well development, sampling, and hydrologic testing planned for this well will be limited due to the diameter of the piezometer string.

1.6 Contact Information

Inquiries concerning Well ER-11-2 should be directed to the Federal UGTA Activity Lead at:

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Environmental Management Operations
Post Office Box 98518
Las Vegas, Nevada 89193-8518

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2.0 Drilling Summary

2.1 Introduction

This section contains a detailed description of Well ER-11-2 drilling operations. The general drilling requirements for all the Frenchman Flat model evaluation wells were provided in *Frenchman Flat Model Evaluation Wells Drilling and Completion Criteria* (N-I, 2012a). Specific requirements for Well ER-11-2 were outlined in FAWP numbers D-011-001.12 and D-007-001.12 (NSTec, 2011; 2012).

The layout of the drill site is shown in Figure 2-1. Figure 2-2 is a chart of the drilling and completion history for Well ER-11-2. A summary of drilling statistics for the well is given in Table 2-1. The following information was compiled primarily from NSTec daily drilling reports.

2.2 Drilling History

Field operations at Well ER-11-2 began on February 1, 2012, when an NSTec crew set up the Auger II drill rig to auger a 91.4-cm (36-in.) diameter conductor hole to the depth of 33.5 m (110 ft). A string of 20-in. conductor casing was set at the depth of 33.0 m (108.3 ft). The conductor casing was cemented in place on February 7, 2012, using 39.5 cubic meters (m³) (51.7 cubic yards [yd³]) of Redi-Mix Formula 400 (see cement composition in Appendix A-3). The cement was pumped into the annulus between the casing and the formation to seal the annulus from the depth of 33.5 m (110 ft) to ground level. The crew finished preparations for drilling of the main hole by drilling the “rat” and “mouse” holes, and moved off the location on February 9, 2012.

The site remained idle until the UDI crew began mobilization from Well ER-5-5 to Well ER-11-2 on August 13, 2012, and started rigging up the Wilson Mogul 42B drill rig. They finished rigging up on August 18, 2012, and began drilling from the top of cement inside the 20-in. casing at 31.4 m (103 ft). The drill crew worked through the cement to the bottom of the 20-in. casing with a 17½-in. chisel tooth tricone bit. The drilling fluid was an air/water/soap mix in conventional circulation. Drilling of the 44.5-cm (17.5-in.) hole continued to the depth of 52.1 m (171 ft). The top of the volcanic rocks was encountered at the depth of 42.7 m (140 ft), indicating that the alluvium was somewhat thinner than expected. So rather than set a short section of surface casing to seal off the unstable alluvial section, it was decided to cement the upper portion of the hole. Drilling was stopped at the depth of 52.1 m (171 ft), and NSTec cementers placed 6.2 m³ (8.1 yd³) of Type II neat cement (Appendix A-3), filling the hole to the depth of 28.3 m (93 ft) on August 19, 2012.

Figure 2-1
Drill Site Configuration for Well ER-11-2

LEGEND	
BA	Baker Atlas
BHA	bottom hole assembly
cm	centimeter(s)
ft	foot (feet)
HO	hole opener
HWDP	heavy-weight drill pipe
in.	inch(es)
m	meter(s)
NSTec	National Security Technologies, LLC
RIH	run in hole
TD	total depth
TIH	trip into hole
TOC	top of cement
TOH	trip out of hole
UDI	United Drilling, Inc.
WOC	wait on cement

WELL ER-11-2 SUMMARY	
Activity	Date
Begin drilling conductor hole:	02/01/2012
Conductor hole completed and 20-in. casing set at 33.0 m (108.3 ft):	02/06/2012
Begin drilling 44.5-cm (17.5-in.) hole:	08/18/2012
Begin drilling 31.1-cm (12.25-in.) hole:	08/19/2012
Reach total drilled depth of 399.6 m (1,311 ft):	08/21/2012
Well completed:	08/23/2012

FIGURE 2-3
WELL ER-11-2
DRILLING AND
COMPLETION HISTORY
SHEET 1 OF 1

Table 2-1
Abridged Drill Hole Statistics for Well ER-11-2

LOCATION DATA:	
Coordinates:	Nevada State Plane (Central Zone) (NAD 27): N 778,755.2 ft E 712,898.9 ft Nevada State Plane (Central Zone) (NAD 83): N 6,237,365.5 m E 564,813.2 m Universal Transverse Mercator (Zone 11) (NAD 83): N 4,082,892.0 m E 594,497.2 m Universal Transverse Mercator (Zone 11) (NAD 27): N 4,082,695.1 m E 594,576.4 m
Surface Elevation ^a :	1,089.1 m (3,573.0 ft)
DRILLING DATA:	
Spud Date:	08/18/2012 (main hole drilling with Wilson Mogul 42B rig)
Total Depth (TD):	399.6 m (1,311 ft)
Date TD Reached:	08/21/2012
Date Well Completed:	08/23/2012 (date completion string was cemented in place)
Hole Diameter:	91.4 cm (36 in.) from surface to 33.5 m (110 ft); 44.5 cm (17.5 in.) from 33.5 to 52.1 m (110 to 171 ft); 31.1 cm (12.25 in.) from 52.1 m (171 ft) to TD of 399.6 m (1,311 ft).
Drilling Techniques:	Drill 91.4 cm (36 in.) hole from surface to 33.5 m (110 ft) with dry-hole auger; rotary drill with 17½-in. tricone bit, using air-foam in direct circulation from 33.5 to 52.1 m (110 to 171 ft). Center-punch with 12¼-in. tricone bit mounted below a 18½ -in. hole opener to 37.2 m (122 ft); rotary drill with 12¼-in. tricone bit, using air-foam in direct circulation to the TD of 399.6 m (1,311 ft).
CASING DATA:	20-in. conductor casing 0 to 33.0 m (0 to 108.3 ft)
WELL COMPLETION DATA:	
One bullnosed 2⅞-in. piezometer string (inside diameter [id] of 5.900 cm [2.323 in.]) was installed. The stainless-steel tubing string hangs from a string of 2⅞-in. carbon-steel tubing (id of 5.067 cm [1.995 in.]) connected via a crossover sub. The piezometer string was landed at 394.5 m (1,294.2 ft). The bottom 0.7 m (2.2 ft) of the string is blank and bullnosed. Detailed data for the completion interval are provided in Section 8.0 of this report.	
Depth of Slotted Section:	2⅞-in. piezometer string: 355.9 to 393.8 m (1,167.6 to 1,292.0 ft)
Depth of Gravel Pack:	345.0 to 397.5 m (1,132 to 1,304 ft)
Depth of Pump:	Not installed at the time of completion
Water Depth:	Fluid-level depth in piezometer string of 353.8 m (1,160.6 ft) measured by N-I on September 25, 2012
DRILLING CONTRACTOR: United Drilling, Inc.	
GEOPHYSICAL LOGS BY: Baker Atlas	
SURVEYING CONTRACTOR: National Security Technologies, LLC	

^a Elevation of ground level at wellhead. National Geodetic Vertical Datum, 1929 (NARA, 1973).

The drill crew put together a center-punch assembly consisting of a 12¼-in. chisel tooth tricone bit mounted 4.1 m (13.5 ft) below an 18½-in. hole opener. Cement was tagged at 32.3 m (106 ft), indicating that the cement had settled and/or that some had been lost to the porous alluvium formation. The hole opener was removed when the hole reached the depth of 37.2 m (122 ft).

Drilling of the surface hole with a 12¼-in. chisel tooth tricone bit continued on August 19, 2012. The drilling fluid was an air/water/soap mix in conventional circulation. The 31.1-cm (12.25-in.) hole was drilled through cement from 37.2 to 52.1 m (122 to 171 ft) and then through tuff, uneventfully, with little (about 0.9 m [3 ft]) or no fill reported after stopping to make pipe connections. At 91.1 m (299 ft), the crew pulled up the drill string to change out the rotating head rubber and encountered 4.6 m (15 ft) of fill when they lowered the string to resume drilling. At 128.0 m (420 ft), the crew pulled the drill string from the hole to replace heavy-weight drill pipe with drill collars and jars. When they lowered the new bottom-hole assembly into the borehole, there was 2.1 m (7 ft) of fill in the hole. The UDI crew cleaned out the fill material, then continued drilling to the TD of 399.6 (1,311 ft), reached on August 21, 2012, with only one minor delay for a rig repair. The drillers pulled the drill pipe up a short distance to clean and condition the hole, and after waiting 30 minutes, lowered the drill string and tagged fill at 397.2 m (1,303 ft).

Tritium analyses conducted at the rig site on samples of drilling effluent indicated that all samples were below levels detectable by field methods (see Section 3.1.2 and Appendix B-1). The tracer analyses gave an estimated water production rate of 7.6 to 11.4 liters per minute (Lpm) (2 to 3 gallons per minute [gpm]) starting at the depth of approximately 387.1 m (1,270 ft) to TD. See Section 6.2 and Appendix F for more information on groundwater production.

Geophysical logging operations were conducted by Baker Atlas on August 22, 2012. On the final log run, the logging crew tagged the top of fluid at 386.8 m (1,269 ft) and the top of fill at 397.5 m (1,304 ft), indicating a total accumulation of 2.1 m (7 ft) of fill during logging. Baker Atlas rigged down and departed the location on August 23, 2012.

On August 23, 2012, the drill crew installed a 2⅞-in. stainless-steel piezometer string at a depth of 394.5 m (1,294.2 ft). The piezometer string has one slotted interval and hangs from 2⅝-in. carbon-steel tubing via a crossover sub. The piezometer string was gravel-packed. Stemming operations were completed on August 23, 2012. See Section 8.0 for more details about completion activities.

The drillers started demobilizing the rig and drilling equipment on August 23, 2012, and crews worked one shift per day after that, until demobilization to the Well ER-20-11 site was completed on August 29, 2012.

The inclination of the borehole was determined from borehole orientation logs run by Baker Atlas during logging operations on August 22, 2012. At a depth of about 152.4 m (500 ft), the borehole path begins to gradually change, and then at about 304.8 m (1,000 ft) dramatically changes from a generally westerly direction to a northerly direction. This depth roughly corresponds to the top of zeolitization and the top of the bedded Wahmonie Formation. The average borehole inclination is 0.8 degrees, with the greatest deviations of 1.5 degrees at 387.1 and 394.4 m (1,270 and 1,294 ft) and 1.3 degrees at 371.9 m (1,220 ft). The borehole drifted a total of approximately 3.6 m (11.9 ft) to the northwest on an azimuth of 319.1 degrees from the collar. At the lowest logged depth of 394.4 m (1,294 ft), the true vertical depth is calculated to be 394.4 m (1,293.9 ft), a difference of 0.03 m (0.1 ft). Figure 2-3 is a three-dimensional view of the borehole showing deviation, borehole profile from the caliper log, and stratigraphy.

A graphical depiction of drilling parameters, including penetration rate, rotary revolutions per minute, pump pressure, and weight on the bit, is presented in Appendix A-1. See Appendix A-2 for a listing of tubing and casing materials. Drilling fluids and cements used in Well ER-11-2 are listed in Appendix A-3.

2.3 *Drilling Problems*

Drilling proceeded smoothly with only very minor difficulties, which caused delays of up to only about 30 minutes. Borehole sloughing was not a major problem during drilling of the main hole. However, the cement that was installed to stabilize the alluvial section also mitigated any potential hole instability issues. The well site was on standby for a total of about 10 hours over the course of well construction due to lightning and heavy rain.

Modified from N-I, 2012d

Figure 2-3
Well ER-11-2 Directional Survey Showing Caliper Profile and Stratigraphy
 (See Table 5-1 for key to stratigraphic nomenclature)

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3.0 Management of Fluids, Drill Cuttings, and Waste

This section describes how fluids and drill cuttings produced from the Well ER-11-2 borehole and hydrocarbon and sanitary waste generated during well construction were managed. The information in this section was obtained from N-I (2012d).

3.1 Fluid and Drill Cuttings Management

3.1.1 Fluid Management Strategy

The management of drilling fluids and solid waste (i.e., cuttings) is addressed in the *Underground Test Area Project Waste Management Plan; Attachment 1 Fluid Management Plan for the Underground Test Area Project* (NNSA/NSO, 2009). The *Final Well Specific Fluid Management Strategy for UGTA Well ER-11-2, Area 11, Nevada National Security Site* (reproduced in Appendix B-2), as required by the UGTA FMP, addresses specific fluid management strategies to be employed at Well ER-11-2 for fluid-generating activities relating to well drilling, well construction, and well development and testing activities. The drilling fluid discharge was monitored routinely during drilling in accordance with these plans to guide operational decisions for proper fluid containment and, ultimately, proper fluid disposal.

Radionuclides were expected at Well ER-11-2, based on Phase II flow and transport modeling (Stoller-Navarro Joint Venture, 2006 and 2007; Navarro Nevada Environmental Services, 2010). To manage the anticipated water production, two sumps were constructed (Sump #1 [lined] and Sump #2 [unlined]) to contain fluids and drill cuttings during operations at Well ER-11-2 (Figure 2-1). The air-foam drilling fluid was circulated down the inside of the drill string and back up the hole through the annulus (conventional, or direct circulation). The drilling effluent was discharged into the lined Sump #1 in case elevated levels of tritium were encountered in the groundwater. Sump #2 was not used.

Water used to prepare the drilling fluids came from a water storage pond supplied by Water Well C-1 in Area 6. Water Well C-1 was pumped and sampled on October 19, 2010. These sample data were reviewed, and all analytes detected were below National Primary Drinking Water Regulations (CFR, 2010) limits.

3.1.2 Fluid Management Sampling Results

An important element of the FMP strategy (NNSA/NSO, 2009) is the onsite monitoring program. This program is intended to provide the timely detection of indicator contaminants, and determines onsite fluid management requirements.

Discharged drilling fluids were collected hourly during periods of borehole advancement by N-I site personnel. The fluid samples were analyzed on site for tritium by NSTec radiological control personnel using NSTec-supplied liquid scintillation counters (LSCs) for the purpose of fluid management and worker protection. A minimum detectable activity (MDA) is associated with the analysis of each sample. The average MDA for the onsite LSCs at Well ER-11-2 was approximately 1,500 picocuries per liter (pCi/L). Samples collected and analyzed for tritium were for screening purposes, and the reported results are not intended to accurately represent lower concentrations of tritium (i.e., less than approximately 1,500 pCi/L) due to errors in counting statistics or issues relating to the nature of fluids analyzed (e.g., drilling fluids).

The onsite monitoring results for the drilling effluent (listed in Appendix B-1) indicated that tritium levels were well below the drinking water standards limit of 20,000 pCi/L (CFR, 2012a), as measured by field instruments. In accordance with NNSS radiological control guidelines (Radiological Control Managers' Council, 2012), many of the onsite fluid samples with initial tritium results greater than the MDA were re-analyzed until the results stabilized. False high tritium levels measured on several samples were attributed to a chemical interaction between solids (cement and rock) in the effluent and the scintillation cocktail used in the analysis (chemoluminescence). After the samples were re-analyzed, the tritium levels were found to be below the MDA. Some of the samples for which onsite tritium analysis exceeded the MDA were not re-analyzed due to the low levels measured. Tritium analyses for discharge samples from both the unsaturated and saturated zones in Well ER-11-2 ranged from 0 to 952 pCi/L.

Following the completion of drilling activities, N-I personnel collected an FMP (NNSA/NSO, 2009) confirmatory sample and a duplicate sample from Sump #1 on August 27, 2012. The samples were analyzed by an offsite laboratory for total and dissolved metals, gross alpha and beta, and tritium. The analytical results for the FMP confirmatory samples from Sump #1 are presented in Appendix B-1.

3.1.3 Disposition of Fluids and Drill Cuttings

The FMP (NNSA/NSO, 2009) and the ER-11-2 FMP strategy letter (Appendix B-2) established concentrations for specified parameters below which drilling fluids may be discharged to a lined sump, an unlined containment basin infiltration area, or directly to the ground surface. The results of Well ER-11-2 monitoring samples and FMP confirmatory samples indicated that fluids generated from drilling the unsaturated and saturated zones at Well ER-11-2 met the FMP criteria for discharge to a designated infiltration area, although the fluids were retained in the lined sump and not discharged to the ground surface.

The fluid volumes produced during unsaturated and saturated zone drilling are presented on the Well ER-11-2 Fluid Disposition Reporting Form, which is reproduced in Appendix B-1. At the completion of drilling on August 21, 2012, an estimated combined total of 380 m³ (100,385 gallons [gal]) of drilling fluid and solids remained in lined Sump #1.

3.2 *Environmental Compliance and Waste Management*

N-I was responsible for environmental compliance and waste management at the Well ER-11-2 site. Periodic site evaluations were conducted during site operations to ensure compliance with the Occupational Safety and Health Act (CFR, 2012b), the Resource Conservation and Recovery Act (CFR, 2012c), the UGTA Waste Management Plan (NNSA/NSO, 2009), and internal contractor procedures.

Waste generated during drilling operations at the Well ER-11-2 site consisted of hydrocarbon and sanitary wastes. A summary of waste type, volume, and disposition of waste streams generated during drilling is provided in Appendix C. Sanitary waste generated at the well site during drilling operations was routinely collected by NSTec and disposed at the Area 23 solid waste landfill. The hydrocarbon waste was removed from the Well ER-11-2 drill site and transported by N-I personnel to Building 6-909 for interim storage until disposed of by NSTec. The 7,571-liter (2,000-gal) condensate tank with contents was transferred to Well ER-20-11 by NSTec. All waste was characterized using process knowledge and onsite monitoring results for tritium.

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4.0 Geologic Data Collection

4.1 Introduction

This section describes the sources of geologic data obtained from Well ER-11-2 and the methods of data collection. Confirming and characterizing the subsurface structure, stratigraphy, and hydrogeology along the predicted local groundwater flow path were among the primary objectives of Well ER-11-2, so the proper collection of geologic and hydrogeologic data from the borehole was considered fundamental to successful completion of the well-construction project.

Geologic data collected at Well ER-11-2 consist of drill cuttings and geophysical logs. Data collection, sampling, transfer, and documentation activities were performed according to applicable contractor procedures, as listed in the N-I FAWP (N-I, 2012c).

4.2 Drill Cuttings

Because the simple near-surface alluvial geology is well known, no samples were collected during augering of the shallow conductor hole. During drilling of the main hole, N-I personnel collected composite drill cuttings at 3.0-m (10-ft) intervals. Triplicate samples, each consisting of approximately 550 cubic centimeters of material, were collected from 120 intervals from 33.5 m (110 ft) to TD. The quality of the cuttings samples is generally fair. However, the samples collected in the depth interval 128.0 to 176.8 m (420 to 580 ft) are poor because they are very fine-grained and limited in volume due to intermittent and temporary poor drilling fluid returns; some are contaminated with up-hole material. The cuttings are also fine-grained from 323.1 to 341.4 m (1,060 to 1,120 ft).

These samples are stored under environmentally controlled, secure conditions at the U.S. Geological Survey (USGS) Geologic Data Center and Core Library in Mercury, Nevada. One of each triplicate sample set was sealed with custody tape at the rig site and remains sealed as an archive sample; one set was left unsealed in the original sample containers; and the third set was processed and stored according to standard USGS Core Library procedures. The third set was used by NSTec geologists to construct the detailed lithologic log presented in Appendix D. The N-I field representative collected an additional set of reference drill cuttings samples from each of the cuttings intervals. This set was examined at the drill site for use in preparing field lithologic descriptions and remains in the custody of N-I. All samples were washed by N-I at the well site.

4.3 Sidewall Core Samples

No sidewall core samples were collected from Well ER-11-2.

4.4 Sample Analysis

No sample analyses were planned or conducted because the geologic units in this area are considered to be well characterized.

4.5 Geophysical Log Data

Geophysical logs were run in the borehole to further characterize the lithology, structure, and hydrologic properties of the rocks encountered, and to evaluate borehole conditions.

Geophysical logging was conducted in one stage after the TD was reached at 399.6 m (1,311 ft). The overall quality of the geophysical log data collected was very good.

A complete listing of the logs, date run, and depths is provided in Table 4-1. Note that a gamma-ray log is typically included with each logging run for depth control. Electronic and paper versions of the logs are stored at NSTec offices in Mercury, Nevada, and copies are on file at the N-I office in Las Vegas, Nevada, and at the USGS Geologic Data Center and Core Library in Mercury, Nevada. Plots of selected geophysical log data are provided in Appendix E.

Table 4-1
Well ER-11-2 Geophysical Log Summary

Geophysical Log Type ^a	Log Purpose	Run Number	Bottom of Logged Interval ^b meters (feet)	Top of Logged Interval ^b meters (feet)
*Temperature / Gamma Ray	Saturated zone: groundwater temperature / stratigraphic and depth correlation	TL-1 / GR-1	394.9 (1,295.5)	15.2 (50)
Aligned Borehole Profile (i.e., Oriented *6-Arm Caliper) / Gamma Ray	Borehole conditions, cement volume calculation, lithologic features, borehole orientation / stratigraphic and depth correlation	CA6-1 / ORIT-1 / GR-2	394.6 (1,294.5)	32.9 (108)
*Gamma Ray / *Digital Spectralog	Stratigraphy, mineralogy, and natural and man-made radiation determination	GR-2 / SGR-1	388.3 (1,274)	0 (0)
*High Definition Induction / Gamma Ray / 6-Arm Caliper	Lithologic determination; saturation of formations / stratigraphic and depth correlation	HDIL-1 / GR-3 / CA6-1	394.7 (1,295)	32.9 (108)
*Compensated Z-Densilog / *Compensated Neutron / Gamma Ray / Caliper	Stratigraphic and lithologic determination, identification of welding, alteration, rock porosity, and water content	ZDL-1 / CN-1 / GR-4 / CAL-1	396.8 (1,302)	32.9 (108)

All logs provided by Baker Atlas, a division of Baker Hughes, Inc.

All logs were run on August 22, 2012.

a Logs presented in geophysical log summary, Appendix E, are indicated by *. A gamma-ray log is included on each logging run to aid in depth control.

b Drilled depth

5.0 Geology and Hydrogeology

5.1 Introduction

This section describes the geology and hydrogeology of Well ER-11-2. The basis for the discussions here is the detailed geologic characterization of Well ER-11-2 presented as a detailed lithologic log in Appendix D. The detailed lithologic log was developed using drill cuttings, geophysical logs, and drilling parameters.

5.2 Geology

This section is divided into three discussions relating to the geology of Well ER-11-2. Section 5.2.1 briefly describes the geologic setting of the Frenchman Flat area and the Well ER-11-2 site. The stratigraphic and lithologic units penetrated at the well are discussed in Section 5.2.2. Because of the significant influence some alteration products have on the hydraulic properties of certain rocks, alteration of the rocks encountered at the well is discussed separately in Section 5.2.3. Detailed descriptions of the stratigraphy, lithology, and alteration of the geologic units encountered are provided in the detailed lithologic log presented in Appendix D. Tables 5-1 and 5-2 provide the definitions of symbols used to represent stratigraphic units and HSUs in various figures in this report. See Figure 5-1 for a surface geologic map of the area surrounding the Well ER-11-2 site.

5.2.1 Geologic Setting

Well ER-11-2 lies on a southward sloping alluvial surface (Figure 5-1) in the northern portion of Frenchman Flat (Figure 1-1). Frenchman Flat is a hydrologically closed, Cenozoic-age basin formed in response to basin-and-range extension. Topographically, the basin is roughly oval-shaped, elongated in a northeast direction, and contains the Frenchman Lake playa, which marks the topographic low point of the basin.

The geology of the Frenchman Flat area is presented in detail in BN (2005) and summarized here. Geophysical data suggest that in its deepest portions, the basin probably contains 2,438 to 3,018 m (8,000 to 9,900 ft) of mostly Tertiary-age alluvium, volcanic rocks, and tuffaceous sedimentary rocks that overlie Paleozoic-age sedimentary rocks that form the “basement” of the basin. No major horst or graben structures appear to disrupt the floor of the basin in its central portion (BN, 2005). Rocks exposed in the highlands around the margins of Frenchman Flat consist of Tertiary-age volcanic and tuffaceous sedimentary rocks that overlie complexly folded and faulted Paleozoic sedimentary rocks. In the center of the basin the volcanic and sedimentary rocks are buried by thick aprons of alluvial debris shed from the exposed highlands. Alluvial deposits reach a thickness of 1,676 m (5,500 ft) in the central portion of Frenchman Flat.

Table 5-1
Key to Stratigraphic Units and Symbols of the Well ER-11-2 Area

Stratigraphic Unit	Map Symbol
Quaternary and Tertiary deposits young alluvial deposits intermediate alluvial deposits old alluvial deposits	QT Qay Qai QTa
Timber Mountain Group Ammonia Tanks Tuff Rainier Mesa Tuff mafic-poor Rainier Mesa Tuff tuff of Holmes Road	Tm Tma Tmr Tmrp Tmrh
Paintbrush Group Topopah Spring Tuff	Tp Tpt
Calico Hills Formation mafic-poor Calico Hills Formation	Th Thp
Wahmonie Formation	Tw

Table 5-2
Key to Hydrostratigraphic Units and Symbols of the Well ER-11-2 Area

Hydrostratigraphic Unit	Symbol
alluvial aquifer	AA
basalt lava-flow aquifer	BLFA
older altered alluvial aquifer	OAA and OAA1
Timber Mountain welded-tuff aquifer	TMWTA
Timber Mountain lower vitric-tuff aquifer	TMLVTA
upper tuff confining unit	UTCU
Topopah Spring aquifer	TSA
lower vitric-tuff aquifer	LVTA
lower tuff confining unit	LTCU and LTCU1
Wahmonie confining unit	WCU
lower carbonate aquifer	LCA

Figure 5-1
Surface Geologic Map of the Well ER-11-2 Area

5.2.2 Stratigraphy and Lithology

The stratigraphic and lithologic units penetrated at Well ER-11-2 are illustrated in Figure 5-2, and an interpretation of the distribution of stratigraphic units in the vicinity of the well is shown in the geologic cross section presented in Figure 5-3.

Drilling at Well ER-11-2 began in Quaternary and Tertiary alluvium, which forms the ground surface in the immediate vicinity of the well (Hinrichs and McKay, 1965; Slate et al., 1999; Figure 5-1). The alluvium was encountered from the surface to a depth of 42.7 m (140 ft). The alluvium consists mostly of sandy gravel composed of a mixture of bedded tuffs, nonwelded tuffs, and welded ash-flow tuffs predominantly of Rainier Mesa Tuff derived from the nearby highlands.

The Rainier Mesa Tuff was encountered directly beneath the alluvium at a depth of 42.7 m (140 ft). The Rainier Mesa Tuff consists of 73.2 m (240 ft) of vitric and devitrified nonwelded to densely welded ash-flow tuff. The mafic-poor member of the formation was encountered. The stratigraphic assignment of Rainier Mesa Tuff is based on the ash-flow tuff lithology, stratigraphic position at the top of the volcanic section, similar to exposures in the foothills just north of the well's location (Slate et al., 1999), and the primary mineralogy, which consists of moderate amounts of quartz, feldspar, and biotite, and the absence of sphene. The Rainier Mesa Tuff was erupted 11.6 million years ago (Ma) (Sawyer et al., 1994) from the Timber Mountain caldera complex approximately 32.2 km (20 mi) to the northwest (Figure 1-1).

Below the Rainier Mesa Tuff, 97.5 m (320 ft) of vitric to weakly zeolitic bedded tuff assigned to the tuff of Holmes Road was penetrated. The stratigraphic assignment is based mainly on lithologic character, the presence of quartz, the abundance and variety of mafic minerals, and the unit's intervening position between welded ash-flow tuffs of Rainier Mesa Tuff (discussed above) and Topopah Spring Tuff.

Another ash-flow tuff was encountered below the tuff of Holmes Road in the interval 213.4 to 288.0 m (700 to 945 ft). This ash-flow tuff unit is assigned to the Topopah Spring Tuff based mainly on its stratigraphic position and ash-flow tuff lithology, especially the presence of a vitrophyre at the top of the unit, which is characteristic of the Topopah Spring Tuff in this area and is observed in nearby outcrops (Hinrichs and McKay, 1965). The observation of moderate amounts of felsic phenocrysts, the general absence of quartz, and rare biotite, are also characteristic of the Topopah Spring Tuff. At Well ER-11-2, the Topopah Spring Tuff consists of devitrified moderately to densely welded and vitrophyric ash-flow tuff. The Topopah Spring

Figure 5-2
Graphical Presentation Showing Geology and Hydrogeology for Well ER-11-2

Figure 5-3
West-East Geologic Cross Section A-A' through Emplacement Hole U-111b and Well ER-11-2

Tuff was erupted 12.8 Ma (Sawyer et al., 1994) from a caldera probably located in the vicinity of the southern portion of the Timber Mountain caldera complex approximately 48 km (30 mi) west of Frenchman Flat.

A relatively thin (22.9 m [75 ft]) interval of mostly vitric bedded tuff was penetrated below the Topopah Spring Tuff. This bedded tuff unit is identified as the mafic-poor Calico Hills Formation, based mainly on its stratigraphic position directly below the Topopah Spring Tuff and the presence of quartz phenocrysts and rare biotite.

The borehole then penetrated 88.7 m (291 ft) of mostly zeolitic bedded and nonwelded ash-flow tuff and tuffaceous sandstone from 310.9 m (1,020 ft) to the TD at 399.6 m (1,311 ft). This interval is assigned to the Wahmonie Formation mainly on the basis of its conspicuously mafic-rich character, including the presence of orthopyroxene, and the very rare occurrence of quartz phenocrysts. Rocks of the Wahmonie Formation were erupted 13.0 Ma from the Wahmonie volcanic center (Sawyer et al., 1994), the remnants of which form the highlands that border Frenchman Flat on the west.

5.2.3 Alteration

The alluvium encountered in Well ER-11-2 is generally calcareous. The volcanic rocks penetrated at Well ER-11-2 are generally vitric or devitrified above 310.9 m (1,020 ft). The unaltered rocks include nonwelded and bedded tuffs that have retained their original (i.e., glassy) character. The welded portions of ash-flow tuffs above 310.9 m (1,020 ft) are mostly devitrified as a result of recrystallization of the original glass matrix to microcrystalline quartz and feldspar during cooling and degassing. Below 310.9 m (1,020 ft) the rocks are generally zeolitic.

5.3 Predicted and Actual Geology

The geology encountered at Well ER-11-2 is generally similar to what was predicted prior to drilling. However, when compared with nearby holes U-11b and UE-11b, the stratigraphic units in Well ER-11-2 are structurally higher, suggesting there is a fault present between the holes, as shown on Figure 5-3. The abrupt contact between the welded and nonwelded Rainier Mesa Tuff, as seen on the bulk density log from Well ER-11-2, indicates that the borehole may intersect this fault at the depth of 86.9 m (285 ft). Such a fault would also explain the anomalously thin occurrence of Rainier Mesa Tuff in Well ER-11-2 relative to nearby holes U-11b and UE-11b and to the pre-drill predicted thickness. Because the stratigraphic section at Well ER-11-2 is structurally higher than predicted, the target aquifer for the well (the TSA) is unsaturated.

Figure 5-4 provides a comparison of the geology predicted for Well ER-11-2 prior to drilling and the geology actually encountered in the borehole. The geologic prediction for Well ER-11-2 was

Figure 5-4
Predicted and Actual Stratigraphy at Well ER-11-2

based on the geology at nearby Exploratory Hole UE-11b and model profiles from the UGTA Frenchman Flat HFM (BN, 2005).

A discussion of how this new information may be used if it is deemed necessary to update the Frenchman Flat flow and transport model will be included in a later document on the results of Model Evaluation Well drilling.

Pairs of west-east and south-north model profiles are presented in Figures 5-5 and 5-6, respectively. In each pair, the upper profile is a model profile from the original Frenchman Flat HFM, and the lower one is the same profile that has been manually modified to include information from Well ER-11-2. The modified profiles provide a visualization of what a revised HFM may look like, and illustrate that the hydrostratigraphy in the vicinity of Well ER-11-2 is generally the same as shown in the original HFM (upper profiles); the elevations of the HSUs at the well location are modified to reflect the previously unknown faulting. Note, however, that the original model profiles are modified only within the immediate vicinity of Well ER-11-2.

5.4 Hydrogeology

Most of the unsaturated portion of Well ER-11-2 consists of an alternating sequence of welded-tuff aquifers and vitric-tuff aquifers (Figure 5-2). The saturated portion of the well consists of a tuff confining unit. An interpretation of the possible distribution of the HSUs in the vicinity of Well ER-11-2 is shown in the model profiles in Figures 5-5 and 5-6.

Prior to drilling, it was predicted that the water table would be encountered within the welded-tuff aquifer of the Topopah Spring Tuff at a depth of 354.5 m (1,163 ft). The actual water table depth, measured on September 25, 2012, in the piezometer string, was 353.8 m (1,160.6 ft) and was within tuff confining unit rocks of the Wahmonie Formation.

Figure 5-5
West–East Profiles from the Frenchman Flat Phase II HFM

Profiles compare the original model (top) with the same profile manually modified to include information from Well ER-11-2 (bottom).

(Note: Red lines are original model faults)

Figure 5-6
South-North Profiles from the Frenchman Flat Phase II HFM

Profiles compare the original model (top) with the same profile manually modified to include information from Well ER-11-2 (bottom)

(Note: Red lines are original model faults; T = fault movement toward reader;
 A = fault movement away from reader)

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6.0 Hydrology

Hydrologic data collected at the well site included water-level measurements, groundwater production values during drilling, and borehole water quality measurements from discharged drilling fluids. The following sections summarize the well hydrology observed during drilling and well completion operations, as modified from N-I (2012d). Well ER-11-2 is open to a zeolitic tuff unit that is part of the LTCU in the Frenchman Flat HFM. An interpretation of the possible distribution of the HSUs in the vicinity of Well ER-11-2 is shown in Figures 5-5 and 5-6.

6.1 Water Levels

Prior to drilling, the water level at Well ER-11-2 was estimated to be within the TSA at a depth of 354.5 m (1,163 ft) below ground surface (N-I, 2012a). The last open-hole fluid level measured by Baker Atlas prior to the installation of the piezometer string was 386.8 m (1,269 ft) on August 22, 2012, during geophysical logging. Approximately one month later, on September 25, 2012, a fluid level was measured by N-I in the piezometer string (accessing the LTCU) at 353.8 m (1,160.6 ft) before installation of the pressure transducer. The gradual increase in water levels is due to the low conductivity of the Wahmonie Formation, a zeolitic tuff confining unit in this area. The low hydraulic conductivity of this confining unit increases the amount of time needed for water levels to recover from drilling effects. Fluid level measurements made in the borehole are summarized in Table 6-1.

The fluid levels presented here should be considered preliminary, and may not represent natural groundwater levels. Well development and hydrologic testing at Well ER-11-2, which will provide more accurate water level data, is planned to take place in February 2013.

6.2 Water Production

Water production was estimated during drilling of Well ER-11-2 on the basis of dilution of a lithium bromide tracer, as measured at the rig site by N-I field personnel. The tracer was added to drilling fluids before being injected down-hole. Concentrations of bromide in mixing tanks and in discharged fluids were monitored regularly as drilling progressed. Differences between injected and discharged bromide concentrations were used to calculate groundwater production rates. When appropriate, visual estimates of water production were used to support calculated fluid production rates from the flow line. Appendix F presents the bromide tracer results and calculated water production rates from Well ER-11-2.

Table 6-1
Well ER-11-2 Water Level Measurements

Date Time	Fluid Depth ^a		Fluid Elevation ^b		Notes
	meters	feet	meters	feet	
08/22/2012 12:15	389.5	1,278	699.5	2,295	Estimated fluid level reported by Baker Atlas on the differential temperature log.
08/22/2012 18:00	388.3	1,274	700.7	2,299	Estimated fluid level reported by Baker Atlas on the high definition induction log.
08/22/2012 20:00	387.1	1,270	702.0	2,303	Estimated fluid level reported by Baker Atlas on the compensated z-densilog and compensated neutron log.
08/22/2012 23:18	386.8	1,269	702.3	2,304	Estimated fluid level reported by Baker Atlas on the temperature log.
08/25/2012 08:50	367.0	1,204.0	722.1	2,369.0	Fluid level measured by N-I within the 2.875-in. piezometer tubing using a calibrated Solinst e-tape.
08/30/2012 11:35	362.8	1,190.3	726.2	2,382.7	Fluid level measured by N-I within the 2.875-in. piezometer tubing using a calibrated Solinst e-tape.
09/25/2012 12:30	353.8	1,160.6	735.3	2,412.4	Fluid level measured by N-I within the 2.875-in. piezometer tubing using a calibrated Solinst e-tape.

Data from N-I (2012d)

- a Depths are below ground surface elevation.
- b Ground surface used as reference datum. Ground surface elevation was surveyed by NSTec on August 29, 2012, at 1,089.1 m (3,573.0 ft) above mean sea level.

The first observation of water in returns was reported on August 21, 2012, at the approximate depth of 387.1 m (1,270 ft). Based on bromide dilution calculations, estimated water production ranged from 7.6 to 11.4 Lpm (2 to 3 gpm) while drilling the LTCU. See Appendix F for a list of bromide tracer injection concentrations and corresponding estimated water production rates. A plot of estimated water production rates is shown with drilling parameters and borehole stratigraphy in Appendix A-1. More accurate water production information may become available after limited hydraulic testing (i.e., bailing and monitoring recovery) is conducted.

6.3 Flow Meter Data

Thermal flow and chemistry logs were not obtained for Well ER-11-2. Because of the simple hydrologic setting and because a single completion zone was planned, the drilling advisory team decided that these logs would contribute little to the scientific objectives of the well.

6.4 *Groundwater Chemistry*

N-I monitored discharged drilling fluids on site for pH, temperature, and electrical conductivity throughout the drilling operations, and used these data to evaluate changes in groundwater conditions during drilling. Water quality measurements were affected by cement and the use of drilling foam and polymer during drilling operations, and do not accurately reflect natural groundwater quality; however, they may be reflective of changed conditions within the borehole during drilling.

No preliminary groundwater characterization samples were collected that could provide initial groundwater chemistry data from the well. Sampling is planned to take place after well development. Development for this well will be limited to a series of bailing and recovery cycles.

6.5 *Radionuclides Encountered*

N-I site personnel collected discharged drilling fluid samples hourly during borehole advancement. The samples were analyzed on site for tritium by NSTec radiological control personnel for purposes of fluid management and worker protection screening purposes, as described in Section 3.1.2.

Field monitoring did not indicate the presence of tritium in samples of drilling effluent. Onsite tritium analyses of drilling fluid returns from both the unsaturated and saturated zones ranged from 0 to 952 pCi/L (see Section 3.1.2 and Appendix B-1), less than the average MDA of the field analytical equipment and well below the limit of 20,000 pCi/L established in the National Primary Drinking Water Regulations (CFR, 2012a).

These field monitoring data should not be considered representative of the groundwater at Well ER-11-2. More sensitive laboratory methods will be used on samples to be collected later during well development and sampling activities.

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7.0 Precompletion and Open-Hole Development

Initial well development conducted in Well ER-11-2 consisted of using the drill string to air-lift groundwater to remove residual cuttings and drilling fluids from the borehole immediately after the TD was reached.

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8.0 Well Completion

8.1 Introduction

Well completion refers to the installation in a borehole of a string of tubing or casing that is slotted or screened at one or more locations along its length. The completion process also typically includes emplacement of backfill materials around the string, with coarse fill such as gravel adjacent to the open intervals and impervious materials such as cement placed between or above the open intervals to isolate them. The string serves as a conduit for inserting a pump in the well, for inserting devices for measuring fluid level, and for sampling, so that accurate potentiometric and water chemistry data can be collected from known portions of the borehole.

The proposed design for Well ER-11-2 was presented in the drilling and completion criteria document (N-I, 2012a). The proposed completion plans are summarized in Section 8.2.1 of this report, and the actual well completion design, based on the hydrogeology encountered in the borehole, is presented in Section 8.2.2. The rationale for differences between the planned and actual design is discussed in Section 8.2.3, and the completion methods are presented in Section 8.3. Figure 8-1 is a schematic diagram of the well completion design. Figure 8-2 shows a plan view and profile of the final wellhead surface completion. Figure 8-3 is a photograph showing the ER-11-2 wellhead. Table 8-1 is a construction summary for the piezometer string.

8.2 Well Completion Design

The following sections describe the well completion design and methods. The final completion design differs from the proposed design, as described in the following sections.

8.2.1 Proposed Completion Design

The original proposed well completion design (presented in N-I [2012a]) for Well ER-11-2 was based on the possibility that man-made radionuclides would be present, that the borehole would penetrate the water table within the TSA, and that the borehole would reach TD below the TSA within the lower vitric-tuff aquifer. On the basis of these expectations, Well ER-11-2 was planned to be completed with a string of 6 $\frac{5}{8}$ -in. completion casing extending through the TSA in the 31.1-cm (12.25-in.) borehole. The completion casing was to be slotted and gravel-packed at the TSA. Because the TSA was the only saturated aquifer expected, no cemented isolation intervals were planned. The completion string was to consist of epoxy-coated carbon-steel casing to within 12.2 m (40 ft) above the water table and stainless-steel casing below the water table.

Figure 8-1
As-Built Completion Schematic for Well ER-11-2

Figure 8-2
Wellhead Diagram for Well ER-11-2

Photograph by NSTec, August 30, 2012

Figure 8-3
Photograph of the ER-11-2 Wellhead

Table 8-1
Well ER-11-2 Piezometer String Construction Summary

Tubing	Configuration meters (feet)		Cement meters (feet)	Sand/Gravel meters (feet)
2 $\frac{3}{8}$ -in. carbon-steel tubing with crossover sub	0 to 343.2 (0 to 1,126.0)	Blank	None	
2 $\frac{7}{8}$ -in. stainless-steel tubing	343.2 to 394.5 (1,126.0 to 1,294.2)	Blank 343.2 to 355.9 (1,126.0 to 1,167.6)	None	$\frac{3}{8}$-in. Washed Gravel 345.0 to 397.5 (1,132 to 1,304)
		Slotted^a 355.9 to 393.8 (1,167.6 to 1,292.0)		
		Blank and Bullnosed 393.8 to 394.5 (1,292.0 to 1,294.2)		

- a Vertical slots are 0.159 cm (0.0625 in.) wide and 5.400 cm (2.125 in.) long, arranged in 69 rows on 6.35-cm (2.5-in.) centers. The 8 slots per row are positioned radially around the tubing at 45 degrees. Each row is offset by 22.5 degrees from the next.

If deemed necessary, the proposed design included an option to open the hole to 47.0 cm (18.5 in.) in diameter and set 13 $\frac{3}{8}$ -in. surface casing down to the water table if sloughing became a major problem.

A 2 $\frac{7}{8}$ -in. piezometer string was to be placed within the open 31.1-cm (12.25-in.) surface hole or inside the optional 13 $\frac{3}{8}$ -in. surface casing next to the completion casing. The piezometer string was to be slotted and positioned within the gravel-packed interval at approximately the same depth as the slotted interval in the completion string.

The primary goal of the proposed completion design was to provide groundwater production data from the TSA and to provide access to groundwater for monitoring and sampling.

8.2.2 As-Built Completion Design

The final Well ER-11-2 completion design was determined by the UGTA Well ER-11-2 drilling advisory team on the basis of onsite evaluation of data such as lithology, water production, water level, borehole condition, drilling data, and data from geophysical logs. The completion design was based on the determination that the elevation of the target aquifer (the TSA) was higher than expected and that the TSA is unsaturated.

One piezometer string was installed in the 31.1-cm (12.25-in.) open hole. A main completion casing string was not installed at Well ER-11-2.

Photo by N-I, October 13, 2012

Figure 8-4
Photograph Showing an Example of
Slotted Casing

The piezometer string is composed of 2⁷/₈-in. stainless-steel tubing with a blank bullnosed termination that hangs from 2³/₈-in. carbon-steel tubing via a crossover sub. The string was landed at 394.5 m (1,294.2 ft). The piezometer string is slotted from 355.9 to 393.8 m (1,167.6 to 1,292.0 ft) for monitoring within the LTCU. The machine-cut openings in each of the 6 slotted joints are 0.159 cm (0.0625 in.) wide and 5.400 cm (2.125 in.) long. The vertical slots in each joint are arranged in 69 rows, on 6.35-cm (2.5-in.) centers. The 8 slots in each row are positioned radially around the tubing at 45 degrees. Each row is offset by 22.5 degrees from the next.

Figure 8-4 illustrates a typical arrangement of slots on casing joints as aid for visualizing slot configuration for the tubing in Well ER-11-2.

The slotted section is gravel packed from the top of the fill at the bottom of the borehole at 397.5 m (1,304 ft) to 345.0 m (1,132 ft).

8.2.3 Rationale for Differences between Planned and Actual Well Design

The original proposed well completion design for Well ER-11-2 (N-I, 2012a) was based on the expectation that the hole would penetrate the TSA and it would be saturated. Because the TSA was unsaturated, and the saturated units encountered were tuff confining units, the completion casing string was not installed and the slotted section of the piezometer string is within the saturated LTCU.

8.3 Well Completion Method

The piezometer string was installed after geophysical logging had been conducted. The UDI crew installed the 2⁷/₈-in. piezometer string (described in Section 8.2.2) on August 23, 2012, then inserted a 2⁷/₈-in. Hydril tremie line to be used as a conduit for stemming materials during their emplacement (the tremie line was pulled up as stemming progressed and was removed from the

borehole after gravel emplacement). The slotted section is gravel packed from the top of fill at 397.5 m (1,304 ft) to 345.0 m (1,132 ft). Stemming operations were completed on August 23, 2012.

The UDI drill rig was released after the piezometer was installed and stemming operations were complete. Planned hydrologic testing for this well is being reevaluated. Such activities will be a separate effort, so a pump was not installed in the well, and no well-development or pumping tests were conducted immediately after completion. All well construction materials used for the completion were inspected according to relevant procedures, as listed in N-I (2012a). Standard decontamination procedures were employed to prevent the introduction of contaminants into the well.

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9.0 Planned and Actual Costs and Scheduling

This section provides brief discussions of the planned and actual schedule and costs for constructing Well ER-11-2.

The original NSTec-approved baseline work package cost estimate for drilling and completing Well ER-11-2 was based on drilling to a planned TD of 457.2 m (1,500 ft) and installing one production casing string and one piezometer string. This estimate was submitted before the drilling criteria document (N-I, 2012a) was issued with an updated planned TD of 393.2 m (1,290 ft). In the baseline estimate, a 10-day schedule for constructing a 457.2-m (1,500-ft) deep well was used.

It took 8 days to construct Well ER-11-2, starting with setting up to drill the 44.5-cm (17.5-in.) surface hole. The final TD of the borehole is 399.6 m (1,311 ft), which is 6.4 m (21 ft) deeper than the planned depth, as specified in the drilling criteria document (N-I, 2012a). Due to favorable drilling conditions, the drilling operation remained 2 days ahead of schedule. The production casing string was not installed in the borehole, and only a piezometer string was set. A graphical comparison, by day, of planned and actual well-construction activities is presented in Figure 9-1.

The cost analysis for Well ER-11-2 begins with the mobilization of the UDI drill rig to the drill site, where the conductor hole had already been constructed. The total construction cost for Well ER-11-2 includes all drilling costs: charges by the drilling subcontractor, charges by other support subcontractors (including compressor services, drilling fluids, casing services, down-hole tools, and geophysical logging), and charges by NSTec for mobilization and demobilization of equipment, cementing services, radiological control technician services, inspection services, site supervision, and geotechnical consultation. The cost of building the roads, drill pad, sumps, and conductor hole is not included, nor is the cost of well-site support by N-I personnel.

The total planned cost for constructing Well ER-11-2 with a planned TD of 457.2 m (1,500 ft) was \$2,087,198. The actual cost for constructing the well with the TD of 399.6 m (1,311 ft) was \$1,704,760, or 18.3 percent less than the estimated cost. Figure 9-2 presents a comparison of the planned and actual costs, by day, for construction of Well ER-11-2.

Figure 9-1
Planned and Actual Construction Progress for Well ER-11-2

Note that the planned TD is based on a preliminary plan developed prior to issue of the drilling criteria document (N-I, 2012a)

Figure 9-2
Planned and Actual Cost of Constructing Well ER-11-2

Note that the planned cost is based on a preliminary plan developed prior to issue of the drilling criteria document (N-I, 2012a)

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10.0 Summary, Recommendations, and Lessons Learned

10.1 Summary

Main hole drilling at Well ER-11-2 commenced on August 18, 2012, and concluded on August 21, 2012, at a total drilled depth of 399.6 m (1,311 ft). The borehole reached TD within altered, nonwelded tuffs of the Wahmonie Formation. Minor issues caused only brief delays.

The 44.5-cm (17.5-in.) diameter surface hole was drilled to a depth of 52.1 m (171 ft), and cement was then placed in the hole to stabilize the alluvium section. The hole diameter was decreased to 31.1 cm (12.25 in.) at the depth of 52.1 m (171 ft), and the well was drilled to a TD of 399.6 m (1,311 ft). The top of the TSA, the proposed target aquifer, was reached at 213.4 m (700 ft). The TSA is unsaturated in Well ER-11-2 because it is structurally higher than expected and is above the water table. The units in which fluid was encountered (below approximately 353.8 m [1,160.6 ft]) are zeolitic tuffs of the LTCU, which have a very low hydraulic conductivity. Based on the hydrogeology, a completion casing string was not set in the well.

One piezometer string was installed in Well ER-11-2 in the 31.1-cm (12.25-in.) open hole. The piezometer string is composed of 2⁷/₈ in. stainless-steel tubing that hangs on 2³/₈ in. carbon-steel tubing via a crossover sub. The string was landed at 394.5 m (1,294.2 ft). The piezometer string is slotted from 355.9 to 393.8 m (1,167.6 to 1,292.0 ft) for monitoring within the LTCU. The bottom 0.7 m (2.2 ft) of the tubing is blank and bullnosed. The slotted section is gravel-packed from the top of fill at 397.5 m (1,304 ft) to 345.0 m (1,132 ft). Future well development, sampling, and hydrologic testing planned for this well will be limited due to the diameter of the piezometer string.

Data collected during drilling of Well ER-11-2 include composite drill cuttings samples collected every 3.0 m (10 ft) from 33.5 m (110 ft) to TD. Open-hole geophysical logging was conducted in the open borehole after the TD of the well was reached. Some of these logs were used to aid in construction of the well, while others helped to verify the geology and determine the hydrologic characteristics of the rocks.

Well ER-11-2 is collared in older alluvial deposits and penetrated 356.9 m (1,171 ft) of Tertiary volcanic rocks. These rocks consisted of bedded tuffs, nonwelded to vitrophyric ash-flow tuffs, and tuffaceous sandstones/siltstones. On September 25, 2012, a water level of 353.8 m (1,160.6 ft) was measured in the piezometer string (accessing the LTCU). The elevation of the water level is 735.3 m (2,412.4 ft). This should be considered a preliminary value until well development (i.e., bailing) is conducted.

The stratigraphy, general lithology, and the water level were generally as expected at Well ER-11-2, though the stratigraphic section is structurally higher than expected due to faulting. Tritium levels in the drilling fluid were below the MDA of the field instruments used during drilling of Well ER-11-2. The flow and transport models forecast that tritium would be encountered; lack of tritium transport is due to the local volcanic aquifer (the TSA) being structurally higher than expected, and unsaturated. The low conductivity tuff confining units in the saturated zone further restrict tritium transport in the direction of Well ER-11-2. Data for samples of drilling effluent may not be representative of the groundwater. Representative groundwater data will not be available until the well is developed and sampled.

10.2 Recommendations

It is important that appropriate planned well development, sampling, and hydrologic testing be conducted at Well ER-11-2 to assure that the goals of the CADD/CAP model evaluation project can be completed.

10.3 Lessons Learned

The efficiency of drilling and constructing wells to obtain hydrogeologic data in support of the UGTA Activity continues to improve as experience is gained with each new well. Lessons learned during the construction of Well ER-11-2 confirmed some of the lessons learned during recent drilling at nearby Well ER-5-5 (NNSA/NSO, 2013):

- Preemptive cementing of the upper thin alluvial section was proven to be an efficient way to stabilize the thin alluvial section, rather than setting a casing in this short section of the borehole.
- Bachman F-485 foaming agent was used throughout drilling of Well ER-11-2, based on the poor performance of the GeoFoam I foaming agent used at Well ER-5-5, and was found to perform well. Continued use of Bachman F-485 foaming agent at future wells is recommended for better cuttings quality and minimizing fill on connections.

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Appendix A

Drilling Data

- A-1 Drilling Parameter Log for Well ER-11-2**
- A-2 Tubing and Casing Data for Well ER-11-2**
- A-3 Well ER-11-2 Drilling Fluids and Cement Composition**

Appendix A-1
Drilling Parameter Log for Well ER-11-2

Well ER-11-2

Logging Company: Baker Atlas
Drilled Depth: 399.6 m (1,311 ft)
Date TD Reached: August 21, 2012
Drill Method: Rotary/Air foam

Surface Elevation: 1,089.1 m (3,573.0 ft)
Coordinates (UTM [NAD 83]): N 4,082,892.0 m
 E 594,497.2 m
Water Level: 353.8 m (1,160.6 ft) on September 25, 2012

See Table 5-1 for key to stratigraphic unit symbols.

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Appendix A-2
Tubing and Casing Data for Well ER-11-2

Table A-2-1
Tubing and Casing Data for Well ER-11-2

Casing and Tubing	Depth Interval meters (feet)	Type	Grade	Outside Diameter centimeters (inches)	Inside Diameter centimeters (inches)	Wall Thickness centimeters (inches)	Weight per foot (pounds)
Conductor Casing	0 to 33.0 (0 to 108.3)	Carbon Steel	K55	50.8 (20)	48.575 (19.124)	1.113 (0.438)	94
Piezometer (with crossover)	0 to 343.2 (0 to 1,126.0)	Carbon Steel	NR	6.033 (2.375)	5.067 (1.995)	0.483 (0.190)	4.7
Piezometer	343.2 to 394.5 (1,126.0 to 1,294.2)	Stainless Steel	NR	7.303 (2.875)	5.900 (2.323)	0.701 (0.276)	7.66

NR = not recorded

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Appendix A-3
Well ER-11-2 Drilling Fluids and Cement Composition

**Table A-3-1
Drilling Fluids Used in Well ER-11-2**

Typical Air-Foam Mix
37.9 liters (10 gallons) Bachman Foam ^{®a} per 7,949 liters (50 barrels) water

a Bachman Foam[®] foaming agent is a product of Bachman Services, Inc.

NOTES:

1. All water used to mix drilling fluids for Well ER-11-2 came from Water Well C-1.
2. A concentrated lithium bromide (LiBr) solution was added to all introduced fluids to make up a final concentration of approximately 20 to 40 parts per million LiBr. The concentration was increased in zones of higher water production to make up a solution of 40 to 90 parts per million LiBr.

**Table A-3-2
Well ER-11-2 Cement Composition**

Cement Composition	20-inch Conductor Casing	Open Hole
Redi-Mix Formula 400: 998 kilograms (2,200 pounds) sand, 326 kilograms (719 pounds) Portland cement, and 232 liters (61 gallons) water per cubic yard	0 to 33.5 m ^a (0 to 110 ft) ^b	None
Type II neat	None	28.3 to 52.1 m (93 to 171 ft)

a meter(s)

b foot (feet)

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Appendix B

Well ER-11-2 Fluid Management Data

B-1 Fluid Management Data for Well ER-11-2

**B-2 Final Well Specific Fluid Management Strategy for UGTA
Well ER-11-2, Area 11, Nevada National Security Site**

Appendix B-1
Fluid Management Data for Well ER-11-2

Table B-1-1
Tritium Activities Measured on Fluid Samples during Drilling of Well ER-11-2 (three pages)

Sample ID Number	Depth		NSTec Onsite Tritium Analysis Results					Sample Description
	meters	feet	Tritium Results (pCi/L)	MDA (pCi/L)	Recount #1 (pCi/L)	Recount #2 (pCi/L)	Recount #3 (pCi/L)	
ER-11-2-081912-01	N/A	N/A	1,037	1,198.87	–	–	–	Baker Tank
ER-11-2-081912-02	36.6	120	619	1,254.17	–	–	–	Discharge Line
ER-11-2-081912-03	41.1	135	0	1,415.23	–	–	–	Discharge Line
ER-11-2-081912-04	44.2	145	952	1,321.95	–	–	–	Discharge Line
ER-11-2-081912-05	47.9	157	0	1,453.48	–	–	–	Discharge Line
ER-11-2-081912-06	50.0	164	0	1,406.43	–	–	–	Discharge Line
ER-11-2-081912-07	51.8	170	436	1,288.05	–	–	–	Discharge Line
ER-11-2-081912-08	52.1	171	61	1,288.05	–	–	–	Discharge Line
ER-11-2-081912-09	N/A	N/A	0	1,272.68	–	–	–	Baker Tank
ER-11-2-082012-10	52.7	173	0	1,272.60	–	–	–	Discharge Line
ER-11-2-082012-11	54.3	178	0	1,498.98	–	–	–	Discharge Line
ER-11-2-082012-12	57.6	189	0	1,415.23	–	–	–	Discharge Line
ER-11-2-082012-13	63.1	207	0	1,255.85	–	–	–	Discharge Line
ER-11-2-082012-14	68.6	225	325	1,131.81	–	–	–	Discharge Line
ER-11-2-082012-15	72.2	237	268	1,208.97	–	–	–	Discharge Line
ER-11-2-082012-16	76.8	252	0	1,255.85	–	–	–	Discharge Line
ER-11-2-082012-17	85.0	279	0	1,311.68	–	–	–	Discharge Line
ER-11-2-082012-18	92.0	302	420	1,179.49	–	–	–	Discharge Line
ER-11-2-082012-19	93.0	305	707	1,255.85	–	–	–	Discharge Line
ER-11-2-082012-20	100.9	331	309	1,321.95	–	–	–	Discharge Line
ER-11-2-082012-21	115.2	378	97	1,288.05	–	–	–	Discharge Line
ER-11-2-082012-22	132.6	435	16,981	13,865.61	13,475	25,192	0	Discharge Line
ER-11-2-082012-23	137.5	451	69,924	1,378.94	13,784	0	–	Discharge Line
ER-11-2-082012-24	N/A	N/A	167,612	1,195.05	0	–	–	Baker Tank
ER-11-2-082012-25	142.3	467	200,531	1,369.42	99,192	68,505	0	Discharge Line
ER-11-2-082012-26	150.0	492	1,717	1,269.22	0	–	–	Discharge Line
ER-11-2-082012-27	157.9	518	190	1,540.62	–	–	–	Discharge Line
ER-11-2-082112-28	166.4	546	0	1,406.43	–	–	–	Discharge Line
ER-11-2-082112-29	178.3	585	0	1,502.48	–	–	–	Discharge Line
ER-11-2-082112-30	188.4	618	0	1,498.98	–	–	–	Discharge Line
ER-11-2-082112-31	N/A	N/A	155	1,369.42	–	–	–	Baker Tank
ER-11-2-082112-32	198.7	652	0	1,459.54	–	–	–	Discharge Line
ER-11-2-082112-33	208.5	684	110	1,734.80	–	–	–	Discharge Line

Table B-1-1
Tritium Activities Measured on Fluid Samples during Drilling of Well ER-11-2 (three pages)

Sample ID Number	Depth		NSTec Onsite Tritium Analysis Results					Sample Description
	meters	feet	Tritium Results (pCi/L)	MDA (pCi/L)	Recount #1 (pCi/L)	Recount #2 (pCi/L)	Recount #3 (pCi/L)	
ER-11-2-082112-34	217.6	714	0	1,453.48	–	–	–	Discharge Line
ER-11-2-082112-35	225.6	740	1,449	1,239.97	354	–	–	Discharge Line
ER-11-2-082112-36	236.8	777	565	1,208.97	–	–	–	Discharge Line
ER-11-2-082112-37	248.4	815	333	1,208.98	–	–	–	Discharge Line
ER-11-2-082112-38	261.5	858	636	1,239.97	–	–	–	Discharge Line
ER-11-2-082112-39	277.4	910	0	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-40	289.6	950	0	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-41	300.8	987	601	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-42	307.8	1,010	396	1,208.97	–	–	–	Discharge Line
ER-11-2-082112-43	315.5	1,035	0	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-44	323.7	1,062	677	1,221.16	–	–	–	Discharge Line
ER-11-2-082112-45	326.7	1,072	844	1,445.50	–	–	–	Discharge Line
ER-11-2-082112-46	330.7	1,085	866	1,445.50	–	–	–	Discharge Line
ER-11-2-082112-47	332.8	1,092	59	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-48	337.7	1,108	0	1,415.23	–	–	–	Discharge Line
ER-11-2-082112-49	340.8	1,118	27	1,344.47	–	–	–	Discharge Line
ER-11-2-082112-50	342.0	1,122	358	1,288.05	–	–	–	Discharge Line
ER-11-2-082112-51	344.7	1,131	0	1,369.42	–	–	–	Discharge Line
ER-11-2-082112-52	347.8	1,141	1,842	1,269.22	372	–	–	Discharge Line
ER-11-2-082112-53 ^a	350.8	1,151	–	–	–	–	–	Discharge Line
ER-11-2-082112-54	351.7	1,154	689	1,378.94	–	–	–	Discharge Line
ER-11-2-082112-55	353.6	1,160	470	1,288.05	–	–	–	Discharge Line
ER-11-2-082112-56	356.6	1,170	0	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-57	359.7	1,180	7,203	1,406.43	35,156	0	–	Discharge Line
ER-11-2-082112-58	362.7	1,190	662	1,300.95	–	–	–	Discharge Line
ER-11-2-082112-59	365.8	1,200	0	1,543.09	–	–	–	Discharge Line
ER-11-2-082112-60	368.8	1,210	9	1,378.94	–	–	–	Discharge Line
ER-11-2-082112-61	372.2	1,221	0	1,498.98	–	–	–	Discharge Line
ER-11-2-082112-62 ^a	374.9	1,230	–	–	–	–	–	Discharge Line
ER-11-2-082112-63	378.0	1,240	0	1,459.54	–	–	–	Discharge Line
ER-11-2-082112-64	381.0	1,250	373	1,288.05	–	–	–	Discharge Line
ER-11-2-082112-65	384.0	1,260	0	1,386.56	–	–	–	Discharge Line
ER-11-2-082112-66	387.1	1,270	600	1,208.97	–	–	–	Discharge Line

Table B-1-1
Tritium Activities Measured on Fluid Samples during Drilling of Well ER-11-2 (three pages)

Sample ID Number	Depth		NSTec Onsite Tritium Analysis Results					Sample Description
	meters	feet	Tritium Results (pCi/L)	MDA (pCi/L)	Recount #1 (pCi/L)	Recount #2 (pCi/L)	Recount #3 (pCi/L)	
ER-11-2-082112-67	390.1	1,280	332	1,378.94	–	–	–	Discharge Line
ER-11-2-082112-68 ^a	393.2	1,290	–	–	–	–	–	Discharge Line
ER-11-2-082112-69	396.2	1,300	0	1,459.54	–	–	–	Discharge Line
ER-11-2-082112-70	399.3	1,310	2,758	1,255.85	520	–	–	Discharge Line

Data from N-I (2012d)

Notes:

NSTec = National Security Technologies, LLC

N/A = not applicable

Baker tank is the holding tank from which water is obtained for mixing the down-hole drilling fluids

MDA = minimum detectable activity

pCi/L = picocuries per liter

– = no recorded data

a Sample lost during processing

Table B-1-2
Analytical Results for Fluid Management Plan Confirmatory Samples from
Sump #1 (Lined) at Well ER-11-2

Analyte	Analytical Method ^a	Detection Limit	08/27/2012 FMP Samples from Well ER-11-2 Sump #1			
			Sample No. 200-082712-1 Sump #1		Sample No. 200-082712-2 Sump #1 Duplicate	
			Total	Dissolved	Total	Dissolved
Metals (milligrams per liter)						
Arsenic	SW-846 6010 ^b	0.01	0.01 U	0.01 U	0.01 U	0.01 U
Barium		0.1	0.1 UJ	0.1 UJ	0.1 UJ	0.1 UJ
Cadmium		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Chromium		0.01	0.044	0.048	0.051	0.05
Lead		0.003	0.003 U	0.003 U	0.003 U	0.003 U
Selenium		0.005	0.0062	0.0056	0.005 U	0.005 U
Silver		0.01	0.01 U	0.01 U	0.01 U	0.01 U
Mercury	SW-846 7470 ^b	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Radiological Indicator Parameters (picocuries per liter)						
		MDC ^c	Result	Error	Result	Error
Tritium	EPA 906.0 ^d	360	-10 U	210	-190 U	210
Gross Alpha	EPA 900.0 ^d	1.33, 1.49	0.62 U	0.81	0 U	0.86
Gross Beta		1.8, 2.1	5.6	1.5	4.7	1.6

Source: N-I (2012d)

- a For commercial laboratory analysis, the most current EPA or equivalent accepted standard laboratory analytical methods may be used as appropriate to attain specified detection limits.
- b EPA (2012)
- c MDC varies by matrix, instrument, and count rates. Where two detection limits are given, the first corresponds with sample number 200-082712-1 and the second with 200-082712-2.
- d EPA (1980)

EPA = U.S. Environmental Protection Agency

FMP = Fluid Management Plan

MDC = Minimum detectable concentration

U = Compound was analyzed for but was not detected ("non-detect")

UJ = Compound was non-detect, but result is biased low

Note: Analyses were performed by ALS Laboratory Group

Table B-1-3
Well ER-11-2 Fluid Disposition Reporting Form

Site Identification: ER-11-2 Site Location: Nevada National Security Site Site Coordinates: (UTM AND 27, Zone 11) N 4,082,695.06 m; E 594,576.41m Well Classification: Model Evaluation Well N-I Project No: UG12-205	Report Date: 11/13/12 NNSA/NSO UGTA Activity Lead: Bill Wilborn N-I Project Manager: Sam Marutzky N-I Site Representative: Jeff Wurtz N-I Field Environmental Specialist: Mark Hesel
---	--

Well Construction Activity	Activity Duration		#Ops. Days ^a	Well Depth (m)	Import Fluid (m ³)	Sump #1 Volumes (m ³)		Sump #2 Volumes (m ³)		Infiltration Area ^e (m ²)		Other ^d (m ³)	Fluid Quality Objective Met?
	From	To				Solids ^b	Liquids	Solids ^b	Liquids	Solids ^b	Liquids		
Phase I: Vadose-Zone Drilling	8/18/2012	8/21/2012	2.75	353.75	289.38	52.48	287.52	N/A	NA	N/A	N/A	N/A	Yes
Phase I: Saturated-Zone Drilling	8/21/2012	8/21/2012	0.25	399.56	0.00	39.63	0.00	N/A	NA	N/A	N/A	N/A	Yes
Phase II: Initial Well Development	-	-	-	-	-	-	-	-	-	-	-	-	-
Phase II: Aquifer Testing	-	-	-	-	-	-	-	-	-	-	-	-	-
Phase II: Final Development	-	-	-	-	-	-	-	-	-	-	-	-	-
Cumulative Production Totals to Date:			3	399.56	289.38	92.11	287.52	N/A	NA	N/A	N/A	N/A	Yes

^a Operational days refer to the number of days that fluids were produced during at least part (>3 hours) of one shift.

^b Solids volume estimates include calculated added volume attributed to rock bulking factor.

^c Discharge to an NDEP approved infiltration area as defined in the Well-Specific Fluid Management Strategy Letter for ER-11-2.

^d Other refers to fluid conveyance to other fluid management devices or facilities; e.g., baker tank or transported to another well site for storage.

N/A = Not Applicable; m = meters; m³ = cubic meters

Total Facility Capacities (at 8 ft fluid level): Sump # 1 = 1,547 m³ Sump #2 = 1,547 m³ Infiltration Area (assuming very low/no infiltration) = N/A

Remaining Facility Capacity (Approximate) as of 08/28/2012: Sump #1 = 944 m³ (61%) Sump #2 = 1,547 m³ (100%)

Current Average Tritium, Sump #1 FMP samples = less than the minimum detectable concentration of 360 pCi/L.

Notes: None

N-I Authorizing Signature/Date:

11-13-12

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Appendix B-2
Final Well Specific Fluid Management Strategy for UGTA
Well ER-11-2, Area 11, Nevada National Security Site
(9 pages)

Department of Energy
National Nuclear Security Administration
Nevada Site Office
P.O. Box 98518
Las Vegas, NV 89193-8518

AUG 14 2012

Tim Murphy, Chief
Bureau of Federal Facilities
Division of Environmental Protection
2030 East Flamingo Road, Suite 230
Las Vegas, NV 89119-0818

**SUBMITTAL OF THE FINAL WELL SPECIFIC FLUID MANAGEMENT STRATEGY FOR
THE UNDERGROUND TEST AREA (UGTA) WELL ER-11-2, AREA 11, NEVADA
NATIONAL SECURITY SITE**

Enclosed are two copies of the Final Revision 0 of the subject report for your review and approval.

Please direct comments and questions to Bill Wilborn, of my staff, at (702) 295-3188.

Robert F. Boehlecke, Manager
Environmental Management Operations

EMO:8836.CD

Enclosures:
As stated

cc w/o encl.:
C. D. Andres, NDEP, Las Vegas, NV
J. T. Fraher, DTRA/CXTS, Kirtland AFB, NM
N-I Central Files, MS NSF 156
NSTec Correspondence Control, MS NLV008
W. R. Wilborn, EMO, NNSA/NSO, Las Vegas, NV
FFACO Group, EMOS, NNSA/NSO, Las Vegas, NV
NNSA/NSO Read File

FINAL
WELL SPECIFIC FLUID MANAGEMENT STRATEGY
FOR UGTA WELL ER-11-2, AREA 11, NEVADA NATIONAL SECURITY SITE

August 8, 2012

INTRODUCTION

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO), Underground Test Area Activity (UGTA) is proposing to drill and construct model evaluation Well ER-11-2. This well is part of the Frenchman Flat Model Evaluation Drilling Program as specified by the Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP) for the Frenchman Flat Corrective Action Unit (CAU) 98. (NNSA/NSO 2011). This well specific fluid management strategy letter describes the monitoring and management of fluids generated during the drilling, well development, testing and sampling of the well in accordance with the requirements of the Fluid Management Plan (FMP) for the Underground Test Area Project, Rev. 5., (NNSA/NSO 2009b).

The planned Well ER-11-2 is located in northern Frenchman Flat within Area 11 of the Nevada National Security Site (NNSS), approximately 995 meters (3,264 feet) west of the boundary between the NNSS and the Nevada Test and Training Range (NTTR). The drilling and construction of Well ER-11-2 will acquire geologic, hydrologic and groundwater chemistry data from an area located to the south of areas of historic underground nuclear testing. However, the primary purpose of the well is to collect data to specifically evaluate uncertainty in the flow and transport numeric model and its contamination boundary forecasts; and to detect radionuclides in groundwater from the nearby and upgradient PIN STRIPE underground test, conducted in emplacement hole U-11b as described in the CADD/CAP (NNSA/NSO 2011).

Well ER-11-2 is one of 2 proposed “model evaluation” wells to be drilled and constructed by the NNSA/NSO UGTA project as part of the Frenchman Flat Model Evaluation drilling initiative at this time. A second model evaluation well ER-5-5 is planned and located south of the ER-11-2 location near the MILK SHAKE (U-5k) underground test. Figure 1 shows the location of planned Well ER-11-2 relative to proposed and existing wells. Figure 2 provides an orthophoto view of the planned Well ER-11-2 location, showing the general physiographic character of the area and the proposed infiltration area. The planned completed depth of Well ER-11-2 is approximately 393.2 meters (1,290 ft), below ground surface (bgs) with the predicted water table located at an approximate depth of 354.5 m (1,163 ft) bgs.

The potential for encountering radionuclide contamination exceeding the SDWA for tritium (20,000 pCi/L) in groundwater resulting from fluid generating activities associated with well drilling, well construction, well pumping, hydraulic testing, monitoring and sampling activities is high. This is based on the results of the probabilistic groundwater flow and transport model forecast. Well ER-11-2 is located 189.9 m (623 ft) east of the PIN STRIPE (U-11b) test in a location believed to be downgradient from the test. The well is located within 5 cavity radii from the working point of the test (Figure 2). The PIN STRIPE (U-11b) test was conducted in Tertiary ash flow tuffs located above the water table with a depth of burial of 295.7 m (970 ft) bgs; however the cavity of the test is believed to have potentially intersected the water table

located at 354.5 m (1,163 ft) bgs. The PIN STRIPE (U-11b) test was detonated in 1966 and had an announce yield of < 20 kilotons (DOE/NV 2000).

Based on the present understanding of the groundwater flow and transport model, the radionuclide concentrations to be encountered within the groundwater at Well ER-11-2 are expected to exceed the SDWA limit for tritium (20,000 pCi/L) however it is not certain that tritium concentrations in groundwater will exceed 400,000 pCi/L. This knowledge supports the conductance of Well ER-11-2 well drilling, construction, pumping and monitoring under a FMP Far-field fluid management strategy. In the case that contaminated groundwater in excess of the FMP criteria for Far-field operations (tritium in excess of 400,000 pCi/L) on the NNSS were encountered the site operations would be transitioned to a FMP Near-field strategy for operations on the NNSS.

Figure 2
Orthophoto Map of Proposed Well ER-11-2 Showing Proposed Infiltration Area

BACKGROUND AND ANALYTICAL DATA FROM NEARBY WELLS

As shown in Figure 1, several existing wells are in the vicinity of the Well ER-11-2 location. The following provides a summary of these wells and their groundwater chemistry. These wells generally provide background analytical data for groundwater that is contained within alluvial volcanic aquifers near or at the water table. However, these data may not reflect the groundwater chemistry that may be encountered at Well ER-11-2 due to its close proximity to underground testing.

Well ER-5-3: The ER-5-3 well cluster was drilled in 2000 as part of the Frenchman Flat Drilling Program. Well ER-5-3 is one of 3 wells drilled at this site as a well cluster designed for multiple well aquifer testing and the well was drilled to a depth of 794.3 m (2,606 ft) and completed with two completion intervals, one within the alluvium near the water table and a deep completion interval within the saturated welded tuff aquifer. The ER-5-3 well cluster consists of Wells ER-5-3, ER-5-3 #2 and ER-5-3 #3 and is located in northeast Area 5 approximately 1.6 km (.99 mi) south and downgradient of the Well ER-11-2. Drilling at Well ER-5-3 well cluster was conducted under a Far-field FMP strategy. During drilling, on-site monitoring indicated no tritium in excess of the Minimum Detectable Activity (MDA). Subsequent well development and sampling did not detect tritium or other parameters in excess of the FMP criteria. The results of laboratory analysis of groundwater from ER-5-3 are shown in Exhibit 1.

Wells UE-5PW-1/2: Wells UE-5PW-1 and UE-5PW-2 were drilled in 1992 as part of several monitoring wells established for the Area Radioactive Waste Management Site (RWMS). These wells were drilled to depths 839 ft and 919 ft respectively within Quaternary and Tertiary deposits. Well UE-5PW-1 is located approximately 4.07 km (2.53 mi) from the Well ER-11-2 location and Well UE-PW-2 is located approximately 2.71 km (1.68 mi) from the Well ER-11-2 location. These wells are not sampled for all FMP parameters; however the radionuclides analyzed meet the FMP criteria for ground surface discharge (Exhibit 1).

WELL OPERATIONS STRATEGY

Based on the information presented above, it is proposed that fluid generating activities related to drilling, well construction, pumping and sampling at Well ER-11-2 will be conducted using the Far-field well site operations strategy for wells located on the NNSS as specified in the FMP. This strategy may be transitioned to a Near-field strategy based on results of on-site monitoring as specified in the FMP and detailed below.

Fluid Containment and Discharge Criteria - The NNSA/NSO proposes the following fluid containment and discharge strategy for Well ER-11-2:

- Fluids or groundwater generated from the well during drilling, well construction, well pumping and sampling will be routed from the well through a well head, well head manifold, through a flow line (drilling) or flexible piping (pumping operations) and discharged to an unlined or lined sump constructed on the Well ER-11-2 drill pad based on the FMP discharge criteria for wells located on the NNSS.

- In the event that on-site monitoring results do not exceed the FMP Far-field criteria for tritium (400,000 pCi/L) for wells located on the NNSS, operations will be conducted under a FMP Far-field operational strategy and both the unlined and lined sumps may be utilized to contain generated fluids.
- Fluids that do not exceed the FMP criteria for tritium (400,000 pCi/L) for wells located on the NNSS may also be discharged or conveyed from the existing lined or unlined sump to a designated posted (or fenced) infiltration area as shown in Figure 2. Fluids will be routed and discharged to this infiltration area in a manner that minimizes the degradation or erosion of the natural ground surface.
- In the event that on-site monitoring results exceed the FMP Far-field criteria for tritium (400,000 pCi/L) for wells located on the NNSS, operations are to be conducted under a FMP Near-field operational strategy. Fluids generated will be contained within an on-site lined sump.
- In the unlikely case that on-site fluid containment capacity (lined sump) may be exceeded under a Near-field operational strategy well site operations will be suspended until sufficient suitable fluid storage can be made available.

On-Site Monitoring – In accordance with the FMP, tritium monitoring samples will be collected from the discharge line during fluid generating activities. Tritium monitoring samples will be collected and analyzed hourly at a minimum during drilling operations, except during periods where the borehole is not being advanced (e.g. circulating, well construction etc.). The results of on-site tritium monitoring will be compared to the FMP discharge criteria as results are available. For other fluid or groundwater generating well activities, tritium monitoring samples will be collected from the discharge line and analyzed on a daily basis.

In accordance with the FMP, lead monitoring samples will be collected during drilling from the discharge and analyzed every eight hours if tritium monitoring results exceed 200,000 pCi/L. The results of on-site lead monitoring will be compared to the FMP discharge criteria as results are available.

Notifications – Nevada Division of Environmental Protection will be notified of on-site monitoring results that exceed action levels as specified in the FMP.

REFERENCES

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2011. *Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 98: Frenchman Flat Nevada National Security Site, Nevada*, DOE/NV--1455. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2009b. Attachment 1, Fluid Management Plan for the Underground Test Area Project. Rev. 5. DOE/NV-370

U.S. Department of Energy, Nevada Operations Office. 2000b. *United States Nuclear Tests, July 1945 through September 1992*, DOE/NV--209-REV 15. Las Vegas, NV.

Exhibit 1

Analytical Data for Wells ER-5-3, UE-5PW-1 and UE-5PW-2

Analysis Performed	ER-5-3 ^a	UE-5PW-1 ^{b, c}	UE-5PW-2 ^{c, d}
<i>(mg/l)</i>			
Aluminum	0.2 U	--	--
Arsenic	0.035	--	--
Barium	0.1 UJ	--	--
Cadmium	0.005 UJ	--	--
Calcium	1	16.8	16.4
Chloride	14	9.2 J	9.5 J
Chromium	0.0048	--	--
Fluoride	5.4	1 J	1 J
Iron	0.021 U	0.045 U	0.045 U
Lithium	0.0017	--	--
Lead	0.003 U	--	--
Magnesium	0.089 U	7.02	6.05
Manganese	0.0037	0.002	0.0009 U
Mercury	0.0002 UJ	--	--
Potassium	6	5.68 J	4.54 J
Selenium	0.005 U	--	--
Silicon	26	28.2	27.5
Silver	0.01 U	--	--
Sodium	130	52.7	56.4
Strontium	0.0032 U	--	--
Sulfate	36	28.7J	35.9 J
Total Organic Carbon	1 U	--	--
²³⁸ U	0.2 U	--	--
Alkalinity (as CaCO ₃)	210	--	--
Bicarbonate Alkalinity (as CaCO ₃)	110	125	135
Carbonate Alkalinity (as CaCO ₃)	100	0.5 U	0.5 U
Specific Conductance (μmhos/cm)	590	352	364
pH (SU)	9.6 J	8.27	8.31
Total Dissolved Solids	360	297	285
Radionuclides (pCi/L)			
Gross Alpha	3.1 U	3.87	3.13
Gross Beta	4.6	3.65 U	3.87
⁹⁹ Tc	1.2 U	6.35 U	6.33 U
Tritium	-70 U	21.9 U	21.8 U
⁹⁰ Sr	0.09 U	0.55 U	0.63 U
²³⁸ Pu	-0.016 U	0.062 U	0.046 U

Source: N-I, 2011a

^a Composite GWC sample collected by IT on 07/17/2001.

^b Samples collected on 04/19/2005, 10/11/2005, and 09/10/2008.

^c Specific conductance reported in S/cm.

^d Samples collected on 04/19/2005, 10/11/2005, and 09/10/2008.

J = Estimated value.

U = Compound was analyzed for, but was not detected ("Non-detect").

UJ = Compound was Non-detect, but result is biased low.

SU = Standard unit

μmhos/cm = Micromhos per centimeter

S/cm = Microsiemens per centimeter

CaCO₃ = Calcium carbonate

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Appendix C
Waste Disposition Data for Well ER-11-2

Table C-1
Final Waste Disposition for Well ER-11-2 Drilling Operations

Container ID Number	Contents	Container Type and Size liters (gallons)	Estimated Volume liters (gallons)	Disposition ^a	Status/Comments
ER-11-2-01	Hydrocarbon solids; absorbent pads; absorbent	Open-top drum; 208.2 (55)	189.3 (50)	Moved to UGTA Building 6-909	Pending disposal
ER-11-2-02 (ER-5-5-04) ^b	Used oil	Closed-top drum; 208.2 (55)	11.4 (3) ^c	Moved to UGTA Building 6-909	Pending disposal
ER-11-2-03	Hydrocarbon solids; absorbent pads; absorbent, filters	Open-top drum; 208.2 (55)	189.3 (50)	Moved to UGTA Building 6-909	Pending disposal
ER-11-2-04 (ER-5-5-02) ^b	Used oil	Closed-top drum; 208.2 (55)	45.4 (12)	Moved to UGTA Building 6-909	Pending disposal
ER-11-2-05 (ER-5-5-05) ^b	Used synthetic oil	Closed-top drum; 208.2 (55)	37.9 (10)	Moved to UGTA Building 6-909	Pending disposal
ER-11-2-06 (Condensate Tank)	Oily condensate from compressors	Tank; 7,570.8 (2000)	3,369.0 (890)	Moved to Well ER-20-11 drill site with contents	Container emptied after completion of Well ER-20-11 drilling
Total Waste Containers					
Pads/debris: 2					
Used oil (liquid): 3					
Total number of 208.2-liter (55-gallon) waste containers: 5					
Total number of 7,570.8-liter (2,000-gallon) waste containers: 1					

Data from N-I (2012d)

- a Waste to be transferred to NSTec for disposal.
- b Used the same waste containers at Well ER-11-2 that were started at Well ER-5-5 to efficiently use container capacity. Both old and new container ID numbers are on containers and in waste container logbook to maintain traceability.
- c The contents of container ER-11-2-02 (11.4 liters [3 gallons]) were consolidated into container ER-11-2-05. Container ER-11-2-02 is now empty.

ID = Identification

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Appendix D
Detailed Lithologic Log for Well ER-11-2

Table D-1

Detailed Lithologic Log for Well ER-11-2

Logged by Jennifer Mercadante and Sigmund Drellack, National Security Technologies, LLC, in November 2012

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Lithologic Description ^b	Stratigraphic Unit (map symbol)
0–42.7 (0–140)	42.7 (140)	No samples from 0 to 33.5 m (0 to 110 ft) DA below 33.5 m (110 ft)	<p>Tuffaceous Alluvium: Sandy gravel with gravel fraction consisting of a mixture of bedded tuffs, nonwelded tuffs, and welded ash-flow tuffs predominately of Rainier Mesa Tuff derived from the nearby highlands.</p> <p>Bedded Tuff: Grayish orange (10YR 7/4); calcareous; rare to minor pumice; rare to minor quartz; minor to common very small mafic minerals including bronze biotite; minor to common very small lithic fragments.</p> <p>Bedded Tuff: Grayish orange pink (5YR 7/2); calcareous; rare pumice; minor felsic phenocrysts of quartz and feldspar; rare mafic minerals, most biotite is bronze; rare lithic fragments.</p> <p>Nonwelded Tuff: Light brownish gray (5YR 6/1); vitric; trace to rare pumice; minor quartz; trace to rare mafic minerals; rare lithic fragments.</p> <p>Moderately Welded Ash-Flow Tuff: Moderate brown (5YR 4/4); mostly devitrified with vapor phase mineralization, lesser vitric; trace to rare pumice; minor quartz; trace to rare mafic minerals; rare lithic fragments.</p> <p>Bedded Tuff: Olive gray (5Y 4/1); calcareous; trace to rare pumice; rare quartz; trace to rare mafic minerals; common lithic fragments.</p>	Quaternary and Tertiary alluvium (QTa)
42.7–64.0 (140–210)	21.3 (70)	DA	Densely Welded Ash-Flow Tuff: Moderate brown (5YR 4/4); devitrified; rare white pumice; minor to common felsic phenocrysts of quartz and feldspar; rare biotite, about 25% is bronze; rare lithic fragments. Cement in boxes. Top is approximate and based on a change in the rate of penetration during drilling.	mafic-poor Rainier Mesa Tuff (Tmrp)

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Lithologic Description ^b	Stratigraphic Unit (map symbol)
64.0–93.0 (210–305)	29.0 (95)	DA	<p>Moderately Welded Ash-Flow Tuff: Pale brown (5YR 5/2); devitrified; trace to rare pumice; rare felsic phenocrysts of quartz and feldspar; rare biotite, mostly bronze; rare lithic fragments, most are very small. Cement in some boxes.</p> <p>Partially welded ash-flow tuff at the base of the interval from 86.9 to 93.0 m (285 to 305 ft) based on geophysical logs.</p> <p>Fault at 86.9 m (285 ft) based on geophysical logs, specifically the abrupt change from moderately welded to nonwelded ash-flow tuff, as observed on the bulk density log, and the thin occurrence of Rainier Mesa Tuff in Well ER-11-2 relative to nearby holes U-11b and UE-11b.</p>	mafic-poor Rainier Mesa Tuff (Tmrp)
93.0–115.8 (305–380)	22.9 (75)	DB4	<p>Nonwelded Ash-Flow Tuff: Pale brown (5YR 5/2); vitric; minor pumice; minor felsic phenocrysts of quartz and feldspar; rare biotite, most is bronze; rare lithic fragments, most are very small. Cement in some samples.</p>	
115.8–213.4 (380–700)	97.5 (320)	DA	<p>Bedded Tuff: Moderate yellowish brown (10YR 5/4); vitric to weakly zeolitic; rare to minor yellow and white pumice; rare felsic phenocrysts of quartz and feldspar, most are characteristically very small; minor to common mafic minerals of biotite, clinopyroxene, and hornblende; minor to abundant lithic fragments, increasing with depth, most very small. Samples badly contaminated with up-hole material 118.9 to 137.2 m (390 to 450 ft), and includes various lithologies and cement.</p>	tuff of Holmes Road (Tmrh)
213.4–227.1 (700–745)	13.7 (45)	DB4	<p>Vitrophyric Ash-Flow Tuff: Black (N1), some mottled with light brown (5YR 5/6); vitric; rare to minor felsic phenocrysts of feldspar; rare pumice; rare biotite; rare lithic fragments.</p> <p>Small 3.0 m (10 ft) interval of densely welded ash-flow tuff occurs at the top of the interval observed in cuttings.</p>	Topopah Spring Tuff (Tpt)

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Lithologic Description ^b	Stratigraphic Unit (map symbol)
227.1–265.2 (745–870)	38.1 (125)	DA	Densely Welded Ash-Flow Tuff: Moderate brown (5YR 4/4) to moderate brown (5YR 3/4); devitrified; rare to minor white pumice; rare to minor feldspar phenocrysts, increase at 250.0 m (820 ft); rare mafic minerals, including biotite, some of which is bronze; rare lithic fragments. Cement in several samples.	Topopah Spring Tuff (Tpt)
265.2–288.0 (870–945)	22.9 (75)	DA	Moderately Welded Ash-Flow Tuff: Moderate brown (5YR 4/4); devitrified; rare pumice; rare felsic phenocrysts of feldspar; rare mafic minerals of biotite; rare lithic fragments. A few glass shards, clear to dark yellowish orange (10YR 6/6) increasing to abundant toward the base. Cement in several samples. Partially welded to nonwelded and weakly zeolitic pumice at the base of the interval below 280.4 m (920 ft).	
288.0–310.9 (945–1,020)	22.9 (75)	DA	Bedded Tuff: Moderate yellowish brown (10YR 5/4); vitric, pumice may be becoming zeolitic in the lower half of the interval; rare to minor yellow to orange pumice becoming more distinct and common toward base; minor felsic phenocrysts of quartz and feldspar, yellow and orange; trace biotite; rare lithic fragments, which are more common in bottom portion of interval.	mafic-poor Calico Hills Formation (Thp)
310.9–332.2 (1,020–1,090)	21.3 (70)	DA	Bedded Tuff: Moderate reddish brown (10R 4/6), pale yellowish brown (10YR 6/2) to pale reddish brown (10R 5/4), and moderate yellowish brown (10YR 5/4); zeolitic to some possibly vitric remnants; minor to abundant white pumice; minor feldspar phenocrysts; common to abundant biotite and homblende, ranges in size from large to small, increasing in abundance toward the base of the interval; rare to minor lithic fragments. No cement, but some up-hole contamination.	Wahmonie Formation (Tw)

Depth Interval meters (feet)	Thickness meters (feet)	Sample Type ^a	Lithologic Description ^b	Stratigraphic Unit (map symbol)
332.2–349.0 (1,090–1,145)	16.8 (55)	DA	Tuffaceous Sandstone/Siltstone: Dark reddish brown (10R 3/4); non-calcareous; minerals are very small, barely visible; well sorted; fine to very fine sand; trace to rare zeolitic pumice; common felsic phenocrysts, white/milky and clear; minor to common mafic minerals; rare lithic fragments. Pumice and felsic phenocrysts are sub-rounded.	Wahmonie Formation (Tw)
349.0–359.7 (1,145–1,180)	10.7 (35)	DB4	Bedded Tuff: Moderate greenish yellow (10Y 7/4) to light olive (10Y 5/4) to pale greenish yellow (10Y 8/2); zeolitic; minor to common often indistinct pumice, grayish yellow (5Y 8/4) to moderate greenish yellow (10Y 7/4), some white to yellowish gray (5Y 8/1); rare to minor feldspar phenocrysts, some interbeds with common feldspar phenocrysts; minor to common mafic minerals of mostly large biotite, lesser hornblende and orthopyroxene; rare lithic fragments.	
359.7–365.8 (1,180–1,200)	6.1 (20)	DB4	Tuffaceous Sandstone/Siltstone: Moderate reddish brown (10R 4/6); noncalcareous; minerals are very small, barely visible; well sorted; fine to very fine sand; trace to rare zeolitic pumice; common felsic phenocrysts, white/milky and clear; minor to common mafic minerals; rare lithic fragments. Pumice and felsic phenocrysts are rounded. Some bedding evident in samples.	
365.8–399.6 (1,200–1,311) TD	33.8 (111)	DA	Nonwelded Ash-Flow Tuff: Pale reddish brown (10R 5/4); mostly zeolitic, though portions have a vitric appearance; minor white pumice; minor feldspar phenocrysts; conspicuously mafic-rich with very abundant brown and black biotite, large and small, and black hornblende; minor lithic fragments, variable in size, up to 1 cm. A fragment in the 396.2 to 399.3 m (1,300 to 1,310 ft) sample has slickensides.	

NOTES:

- a Lithologic samples collected from interval during drilling operations and utilized for lithological interpretation. **DA** = drill cuttings that represent lithologic character of interval. **DB4** = cuttings that are intimate mixtures of units; generally less than 50% of drill cuttings represent lithologic character of interval.
- b Descriptions are based mainly on visual examination of lithologic samples using a 10x- to 40x-zoom binocular microscope, and incorporating observations from geophysical logs. Colors describe wet sample color unless otherwise noted.
- Abundances for felsic phenocrysts, pumice fragments, and lithic fragments: **trace** = only one or two individuals observed; **rare** = $\leq 1\%$; **minor** = 5%; **common** = 10%; **abundant** = 15%; **very abundant** = $\geq 20\%$.
- Abundances for mafic minerals: **trace** = only one or two individuals observed; **rare** = $\leq 0.05\%$; **minor** = 0.2%; **common** = 0.5%; **abundant** = 1%; **very abundant** = $\geq 2\%$.

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Appendix E
Geophysical Logs Run in Well ER-11-2

Appendix E contains plots of selected geophysical logs run in Well ER-11-2. Table E-1 summarizes the logs presented. See Table 4-1 for more information.

Table E-1
Well ER-11-2 Geophysical Logs Presented

Log Type	Run Number	Date	Log Interval	
			meters	feet
Temperature	TL-1	8/22/2012	15.2–394.9	50–1,295.5
Caliper	CA6-1	8/22/2012	32.9–394.6	108–1,294.5
Gamma Ray	GR-2	8/22/2012	0–388.3	0–1,274
Spectral Gamma Ray (potassium, thorium, uranium)	SGR-1	8/22/2012	0–388.3	0–1,274
High Definition Induction (resistivity)	HDIL-1	8/22/2012	32.9–394.7	108–1,295
Density	ZDL-1	8/22/2012	32.9–396.8	108–1,302
Compensated Neutron	CN-1	8/22/2012	32.9–396.8	108–1,302

Well ER-11-2

Logging Company: Baker Atlas

Date Logged: August 22, 2012

Drilled Depth: 399.6 m (1,311 ft)

Date TD Reached: August 21, 2012

Drill Method: Rotary/Air foam

Surface Elevation: 1,089.1 m (3,573.0 ft)

Coordinates (UTM [NAD 83]): N 4,082,892.0 m

E 594,497.2 m

Water Level: 353.8 m (1,160.6 ft) on September 25, 2012

See Table 5-1 for key to stratigraphic symbols.

Well ER-11-2

Logging Company: Baker Atlas
Date Logged: August 22, 2012
Drilled Depth: 399.6 m (1,311 ft)
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See Table 5-1 for key to stratigraphic symbols.

Appendix F
Water Production Data for Well ER-11-2

Table F-1
Bromide Concentrations and Calculated Water Production during
Drilling at Well ER-11-2

Date	Time	Depth below Ground Surface		Bromide Concentration (milligrams/liter)		Injection Rate (barrels per hour)	Water Production ^a	
		meters	feet	Mixing Tank	Discharge Line		liters per minute	gallons per minute
08/18/2012	23:50	36.0	118	54.1	52.2	12	0	0
08/19/2012	03:50	49.4	162	27.6	31.6	15	-3.8	-1
08/20/2012	03:10	52.7	173	41.3	40.6	15	0	0
08/20/2012	06:00	63.1	207	38.6	40.0	15	0	0
08/20/2012	10:00	84.1	276	22.1	23.9	15	-3.8	-1
08/20/2012	14:05	112.5	369	25.2	29.1	15	-3.8	-1
08/20/2012	18:40	130.5	428	23.8	22.9	15	0	0
08/20/2012	22:30	153.3	503	26.1	25.0	15	0	0
08/21/2012	02:30	195.1	640	20.8	13.6	15	22.7	6
08/21/2012	06:05	225.6	740	20.5	23.8	15	-3.8	-1
08/21/2012	10:05	278.3	913	3.50	5.38	15	-15.1	-4
08/21/2012	11:45	295.7	970	5.73	6.90	15	-7.6	-2
08/21/2012	12:45	304.8	1,000	4.78	8.70	15	-18.9	-5
08/21/2012	14:25	318.5	1,045	46.4	35.4	15	11.4	3
08/21/2012	15:30	333.1	1,093	5.42	5.78	15	-3.8	-1
08/21/2012	16:20	342.9	1,125	5.08	5.16	15	0	0
08/21/2012	16:45	348.4	1,143	9.13	8.74	15	0	0
08/21/2012	17:25	353.3	1,159	7.42	7.53	15	0	0
08/21/2012	17:40	358.1	1,175	43.6	16.0	15	68.1	18
08/21/2012	18:25	365.8	1,200	51.5	56.3	15	-3.8	-1
08/21/2012	19:30	379.8	1,246	40.1	46.4	15	-3.8	-1
08/21/2012	20:33	389.5	1,278	81.4	65.7	15	11.4	3
08/21/2012	21:28	399.3	1,310	91.9	81.0	15	3.8	1

Data from N-I (2012d)

- a Calculated water production values above the water table are not indicative of water yield from the formation.

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