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UNDERGROUND TEST AREA CALENDAR YEAR 2016 ANNUAL SAMPLING ANALYSIS REPORT NEVADA NATIONAL SECURITY SITE, NEVADA

U.S. Department of Energy,
Environmental Management Nevada Program
Las Vegas, Nevada

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UNDERGROUND TEST AREA
CALENDAR YEAR 2016
ANNUAL SAMPLING ANALYSIS REPORT
NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: /s/ Bill R. Wilborn Date: 03/13/2018

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List of Acronyms and Abbreviations

General Acronyms and Abbreviations

AD	Absolute difference
ALS	ALS Laboratory Group
AMS	American Meteorological Society
amsl	Above mean sea level
ASTM	ASTM International
atoms/g	Atoms per gram
bgs	Below ground surface
BLM	U.S. Bureau of Land Management
CADD	Corrective action decision document
CAI	Corrective action investigation
CAIP	Corrective action investigation plan
CAP	Corrective action plan
CAS	Corrective action site
CAU	Corrective action unit
COC	Contaminant of concern
COPC	Contaminant of potential concern
CR	Closure report
CS	Carbon steel
CY	Calendar year
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DRI	Desert Research Institute
EERF	Eastern Environmental Radiation Facility
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ES	Electric submersible
FD	Field duplicate
FFACO	*Federal Facility Agreement and Consent Order*
FMP	Fluid Management Plan

List of Acronyms and Abbreviations (Continued)

ft	Foot
gal	Gallon
GEL	General Engineering Laboratories
gpm	Gallons per minute
HASL	Health and Safety Laboratory
HRMP	Hydrologic Radionuclide Monitoring Program
HSU	Hydrostratigraphic unit
in.	Inch
ISPID	Integrated Sampling Plan Identifier
IT	IT Corporation
LANL	Los Alamos National Laboratory
Lat	Latitude
LCS	Laboratory control sample
LLNL	Lawrence Livermore National Laboratory
Long	Longitude
m	Meter
MB	Method blank
MCL	Maximum contaminant level
MDC	Minimum detectable concentration
MDL	Minimum detection level
mg/L	Milligrams per liter
mi	Mile
M&O	Management and operating
mrem/yr	Millirem per year
MS	Matrix spike
N/A	Not applicable
NAD	North American Datum
NCR	Nonconformance report
ND	Normalized difference
NDEP	Nevada Division of Environmental Protection

List of Acronyms and Abbreviations (Continued)

N-I	Navarro-Intera, LLC
NIST	National Institute of Standards and Technology
NNSS	Nevada National Security Site
NSF	National Science Foundation
NSPC	Nevada State Plane Coordinates
NTTR	Nevada Test and Training Range
NTU	Nephelometric turbidity unit
pCi/L	Picocuries per liter
pmc	Percent modern carbon
QA	Quality assurance
QAP	Quality Assurance Plan
QC	Quality control
REECo	Reynolds Electrical & Engineering Co., Inc.
RL	Reporting limit
RM/SM	Rainier Mesa/Shoshone Mountain
RN	Radionuclide
RPD	Relative percent difference
RREMP	Routine Radiological Environmental Monitoring Program
SDWA	*Safe Drinking Water Act*
SEC	Specific electrical conductance
SNJV	Stoller-Navarro Joint Venture
SOP	Standard operating procedure
SS	Stainless steel
SU	Standard unit
TBD	To be determined
UDI	United Drilling, Inc.
UGT	Underground test
UGTA	Underground test area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

List of Acronyms and Abbreviations *(Continued)*

WPM-OV	Western Pahute Mesa-Oasis Valley
YF/CM	Yucca Flat/Climax Mine
°C	Degrees Celsius
%meq/L	Percent milliequivalents per liter
‰	Per mil
µg/L	Micrograms per liter
µmho	Micromho
µmhos/cm	Micromhos per centimeter
µS/cm	Microsiemens per centimeter

Stratigraphic, Hydrostratigraphic, Hydrogeologic, and Lithologic Unit Abbreviations and Symbols

Note: Some well completion diagrams in Appendix C include terminology that has been redefined or replaced since the well was initially drilled. In these instances, both acronyms and/or definitions have been included on the following list.

AA	Alluvial aquifer
AA3	Alluvial aquifer
ATCU	Argillic tuff confining unit
ATWTA	Ammonia Tanks welded-tuff aquifer
BA	Benham aquifer
BFCU	Bullfrog confining unit
BLFA	Basalt lava-flow aquifer
BRA	Belted Range aquifer
BRCU	Belted Range confining unit
BWCU	Buttonhook Wash confining unit
BWWTA	Buttonhook Wash welded-tuff aquifer
Cbk	Bonanza King Formation
CFCM	Crater Flat composite unit
CFCU	Crater Flat confining unit
CHCU	Calico Hills confining unit

List of Acronyms and Abbreviations (Continued)

CHZCM	Calico Hills zeolitic composite unit
CPA	Comb Peak aquifer
CZw	Wood Canyon Formation
FCCM	Fortymile Canyon composite unit
FCCU	Fluorspar Canyon confining unit
FCWTA	Fortymile Canyon welded-tuff aquifer
LCA	Lower carbonate aquifer
LCA3	Lower carbonate aquifer-upper plate
LCA3	Lower carbonate aquifer 3-Thrust plate
LCCU	Lower clastic confining unit
LCCU1	Lower clastic confining unit-thrust plate
LPCU	Lower Paintbrush confining unit
LTCU	Lower tuff confining unit
LVTA	Lower vitric-tuff aquifer
LVTA1	Lower vitric tuff aquifer 1
Mc	Chainman Formation
MPCU	Middle Paintbrush confining unit
OAA	Older altered alluvial aquifer
OAA	Older altered alluvium
OAA1	Older altered alluvial aquifer
OSBCU	Oak Spring Butte confining unit
OSBCU	Oak Springs Butte confining unit
PBPCU	Post-Benham Paintbrush confining unit
PBRCM	Pre-Belted Range composite unit
PLFA	Paintbrush lava-flow aquifer
Pre-Tmr	Pre-Rainier Mesa Tuff
Pz	Paleozoic Carbonate Rocks, undivided
Pz	Paleozoic rocks, undivided
Pz	Paleozoic (undivided)
QTa	Pliocene through Miocene alluvium

List of Acronyms and Abbreviations *(Continued)*

QTa	Quaternary and Tertiary alluvium
QTa	Quaternary or Tertiary alluvium
QTa	Quaternary-Tertiary alluvium
QTa	Quaternary/Tertiary alluvium
RMWTA	Rainier Mesa welded-tuff aquifer
RVA	Redrock Valley aquifer
SPA	Scrugham Peak aquifer
Ta	Pliocene through Miocene alluvium
Tbd	Dead Horse Flat Formation
Tbg	Grouse Canyon Tuff
Tbgb	Bedded Grouse Canyon Tuff
Tbgb	Grouse Canyon bedded tuff
Tbgb	Grouse Canyon Tuff, Bedded
Tbgp	Crystal Poor Grouse Canyon Tuff
Tbgp	Crystal-poor Grouse Canyon Tuff
Tbgr	Crystal-rich Grouse Canyon Tuff
Tbq	Comendite of Quartet Dome
Tc	Crater Flat Group, undivided
TCA	Tiva Canyon aquifer
Tcb	Bullfrog Tuff
Tcbs	Bullfrog Tuff, Stockade Wash Lobe
Tcg	Latite of Grimy Gulch
Tcj	Rhyolite of Jorum
TCVA	Thirsty Canyon volcanic aquifer
Tf	Volcanics of Fortymile Canyon
Tfb	Beatty Wash Formation
Tfbr	Rhyolite of Chukar Canyon
Tfbw	Rhyolite of Beatty Wash
Th	Calico Hills bedded/Nonwelded tuff
Th	Calico Hills Formation

List of Acronyms and Abbreviations *(Continued)*

THCM	Tannenbaum Hill composite unit
THCU	Tannenbaum Hill confining unit
THLFA	Tannenbaum Hill lava-flow aquifer
Thp	Calico Hills Formation, mafic-poor
Thp	Mafic-poor Calico Hills Formation
Thr	Calico Hills mafic-rich Tuff
Thr	Mafic-rich Calico Hills Formation
Thrl	Calico Hills - Rhyolitic Lava
Tlc/To	Paleocolluvium and older tuffs
Tlt	Tuffaceous paleocolluvium
Tma	Ammonia Tanks Tuff
Tmab	Ammonia Tanks bedded tuff
Tmab	Bedded Ammonia Tanks Tuff
Tmab	Timber Mountain Ammonia Tanks bedded tuff
Tmac	Tuff of Crooked Canyon
Tmap	Mafic-poor Ammonia Tanks Tuff
Tmar	Mafic-rich Ammonia Tanks Tuff
Tmar	Timber Mountain Ammonia Tanks mafic-rich Tuff
Tmat	Rhyolite of Tannenbaum Hill
Tmatx	Landslide deposits related to the rhyolite of Tannenbaum Hill
Tmaw	Tuff of Buttonhook Wash
TMCM	Timber Mountain composite unit
TMLVTA	Timber Mountain lower vitric tuff aquifer
TMLVTA	Timber Mountain lower vitric-tuff aquifer
Tmrb	Rainier Mesa bedded tuff
Tmrb	Timber Mountain Rainier Mesa bedded tuff
Tmrf	Rhyolite of Fluorspar Canyon
Tmrh	Tuff of Holmes Road
Tmrh/Ta	Pre-Rainier Mesa Tuff - Post Wahmonie Tuff
Tmrp	Mafic-poor Rainier Mesa Tuff

List of Acronyms and Abbreviations *(Continued)*

Tmrp	Rainier Mesa mafic-poor Tuff
Tmrp	Timber Mountain Rainier Mesa mafic-poor tuff
Tmrr	Mafic-rich Rainier Mesa Tuff
Tmrr	Rainier Mesa mafic-rich Tuff
Tmrr	Timber Mountain Rainier Mesa mafic-rich Tuff
Tmt	Basalts of Tierra
TMUVTA	Timber Mountain upper vitric-tuff aquifer
TMWTA	Timber Mountain welded tuff aquifer
TMWTA	Timber Mountain welded-tuff aquifer
Tn	Tunnel Formation
Tn3A	Beds 3A Tunnel Formation
Tn3BC	Beds 3BC Tunnel Formation
Tn3bcd	Beds 3B - D Tunnel Formation
Tn3D	Beds 3D Tunnel Formation
Tn4abcde	Beds 4A - E Tunnel Formation
Tn4AF	Beds 4A - F Tunnel Formation
Tn4f	Beds 4F Tunnel Formation
Tn4g	Beds 4G Tunnel Formation
Tn4G	Beds 4G Tunnel Formation
Tn4H	Beds 4H Tunnel Formation
Tn4J	Beds 4J Tunnel Formation
Tn4k	Beds 4K Tunnel Formation
Tn4K	Beds 4K Tunnel Formation
To	Volcanics of Oak Spring Butte
Toh	Rhyolite of the Hump
Ton	Older tunnel beds
Ton1	Tunnel bed 1
Ton2	Tunnel bed 2
Tor	Redrock Valley Tuff
Tot	Tuff of Twin Peaks

List of Acronyms and Abbreviations *(Continued)*

Toy	Yucca Flat Tuff
Tp	Paintbrush Group Non-welded tuff
Tp	Paintbrush Group, undivided
Tpcm	Pahute Mesa lobe of Tiva Canyon Tuff
Tpcp	Crystal-poor Tiva Canyon Tuff
Tpcx	Tiva Canyon, Landslide or Breccia
Tpcy	Tuff of Pinyon Pass
Tpd	Rhyolite of Delirium Canyon
Tpt	Topopah Spring Tuff
Tptm	Pahute Mesa lobe of Topopah Spring Tuff
Tptx	Topopah Spring, Landslide or Breccia
Tqh	Middle rhyolite of Quartz Mountain
Tqj	Rhyolite of Handley
TSA	Topopah Spring aquifer
TSA	Topopah Spring Tuff aquifer
Tt	Thirsty Canyon Group, undivided
Ttc	Comendite of Ribbon Cliff
Ttcl	Lower Comendite of Ribbon Cliff
Ttcm	Middle Comendite of Ribbon Cliff
Ttp	Pahute Mesa Tuff
Ttt	Trail Ridge Tuff
Tub	Tub Spring Tuff
Tw	Wahmonie Formation
Tybf	Basalt of Frenchman Flat
UCCU	Upper clastic confining unit
UPCU	Upper Paintbrush confining unit
UTCU	Upper tuff confining unit
UTCU1	Upper tuff confining unit 1

List of Acronyms and Abbreviations *(Continued)*

Symbols for Elements and Compounds

Ag	Silver
Al	Aluminum
Am	Americium
Ar	Argon
As	Arsenic
Ba	Barium
Br	Bromide
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
Cd	Cadmium
Cl	Chlorine
CO_3	Carbonate
Cr	Chromium
Cs	Cesium
DIC	Dissolved inorganic carbon
DO	Dissolved oxygen
DOC	Dissolved organic carbon
Eu	Europium
F	Fluorine
Fe	Iron
^2H	Deuterium
^3H	Tritium
H_2O	Water
HCO_3	Bicarbonate
He	Helium
Hg	Mercury
I	Iodine
K	Potassium

List of Acronyms and Abbreviations *(Continued)*

Kr	Krypton
Li	Lithium
Mg	Magnesium
Mn	Manganese
Na	Sodium
Nb	Niobium
Ne	Neon
Np	Neptunium
O	Oxygen
Pb	Lead
Pu	Plutonium
S	Sulfur
Se	Selenium
Si	Silicon
SO_4	Sulfate
Sr	Strontium
Tc	Technetium
TDIC	Total dissolved inorganic carbon
TDOC	Total dissolved organic carbon
Th	Thorium
U	Uranium
Xe	Xenon
δ^2H	Delta deuterium
$\delta^{13}C$	Delta carbon-13
$\delta^{18}O$	Delta oxygen-18

1.0 Introduction

The Nevada National Security Site (NNSS) Integrated Groundwater Sampling Plan (NNSA/NFO, 2014) was designed to provide a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet the objectives of the U.S. Department of Energy (DOE), Environmental Management (EM) Nevada Program's Underground Test Area (UGTA) Activity. The Sampling Plan ensures routine sampling that is critical to understanding contaminant transport near and downgradient of the underground nuclear testing areas and is designed to ensure compliance with the UGTA Activity Quality Assurance Plan (QAP) (NNSA/NFO, 2015a) and the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended). The primary regulatory agreement governing the UGTA Activity is the FFACO (1996, as amended). The FFACO calls for the consequences of radionuclide (RN) exposure to be based on the *Safe Drinking Water Act* (SDWA) radiological standards (CFR, 2016).

This report presents the analytical data for the 2016 calendar year (CY) (January 1 through December 31, 2016) and an evaluation of the data to ensure that the Sampling Plan's objectives are met. Special investigations that took place in 2016 that are relevant to the Sampling Plan are also presented.

1.1 Background

A total of 907 underground nuclear detonations were conducted on the NNSS (formerly the Nevada Test Site) between 1957 and 1992 that resulted in 878 corrective action sites (CASs) (FFACO, 1996 as amended). The CASs are grouped into five corrective action units (CAUs) based primarily on geographically distinct areas of underground testing: Yucca Flat/Climax Mine (YF/CM) (CAU 97), Frenchman Flat (CAU 98), Rainier Mesa/Shoshone Mountain (RM/SM) (CAU 99), Central Pahute Mesa (CAU 101), and Western Pahute Mesa (CAU 102). The CAU locations are shown in Figure 1-1. The anticipated corrective action for each CAU is closure in place with monitoring and institutional controls because there is no reasonable method to remove or stabilize the RNs remaining from the underground nuclear tests, and potential risks from these RNs are only realized with access to the groundwater (DOE, 2006). The corrective action strategy for all UGTA CAUs except RM/SM is fulfilled in four stages: the Corrective Action Investigation Plan (CAIP), Corrective Action

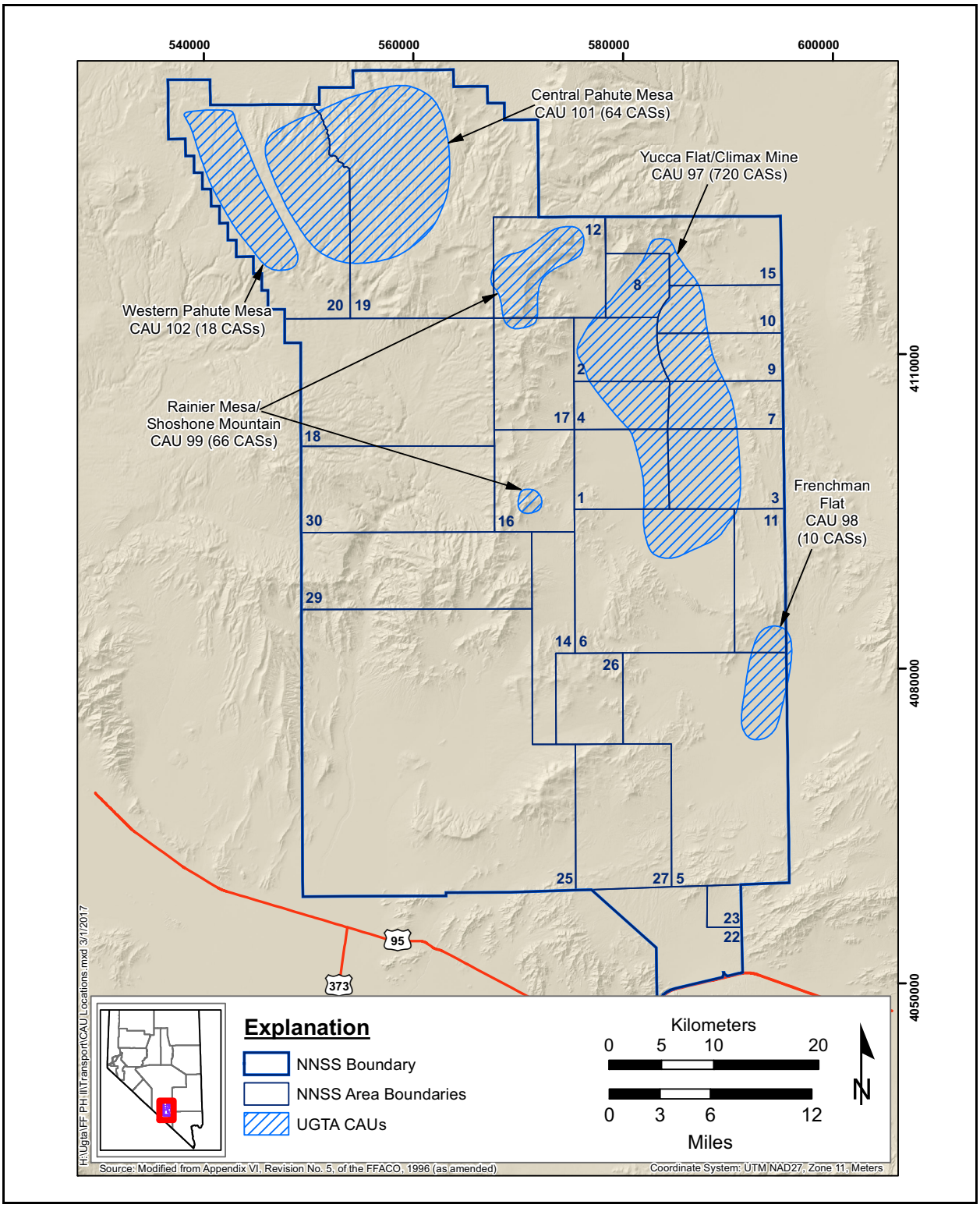


Figure 1-1
UGTA CAU Locations

Investigation (CAI), Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP), and Closure Report (CR) (FFACO, 1996 as amended). The RM/SM CAU strategy was revised because of the complex hydrogeologic setting, its geographical isolation within the north–central portion in the NNSS interior, the low associated inventory (0.7 percent of the UGTA radiological inventory), and the high cost and low benefit of additional characterization and modeling (NNSA/NFO, 2013). Following CAI stage completion, this CAU will advance directly to the CR stage and monitoring and institutional controls rather than modeling will be emphasized. During CY16, with the exception of the Frenchman Flat CAU, all CAUs were in the CAI stage. Frenchman Flat is in the CR stage.

1.2 Sampling Plan Implementation

Groundwater sampling is an integral part of the UGTA Activity, providing data to characterize the CAUs, and to develop and evaluate groundwater flow and contaminant transport conceptual and numerical models. The chemical and isotopic character of groundwater provides information on groundwater movement, and on the potential for and actual extent of contaminant transport. Locations sampled for the Sampling Plan (NNSA/NFO, 2014) are categorized into six types based on the sampling objectives: characterization, source/plume, early detection, distal, community, and inactive. The six types are defined and the objectives identified for each type in Table 1-1. The type dictates the analytical suite, associated detection limits, and sampling frequency (Table 1-1). The sampling locations and their types are shown in Figure 1-2.

An Integrated Sampling Plan Identifier (ISPID) has been developed to identify the specific well configuration at the time of sampling. The nomenclature is summarized as follows:

- Piezometers are identified with a "_p" extension.
- Main completions are identified with an "_m" extension.
- Open boreholes are identified with an "_o" extension.
- Access tubes are identified with an "_a" extension.
- Piezometer and main completion intervals are numbered with a "1" for the deepest, "2" for the next deepest, and so on.

Table 1-1
Type Definitions and Objectives for Water Sample Locations

Location Type	Definition	Objective	Analytes	Frequency
Characterization	Used for system characterization or model evaluation.	• Support flow and transport model development and/or evaluation. • Identify groundwater flow paths. • Establish the presence or absence of groundwater COCs and COPCs. • Estimate travel time of contaminants.	General chemistry, metals, age and migration parameters, gross alpha, gross beta, and select radioisotopes [a]	2–3 years, as needed [b]
Source/Plume	Located within the plume from an underground nuclear test (i.e., test-related contamination present).	• Support flow and transport model development and/or evaluation. • Identify COCs. • Monitor contaminant migration. • Monitor natural attenuation.	COCs and CAU-specific COPCs (see Table 1-3)	4 years
Early Detection	Located downgradient of a UGT, and no radioisotopes detected above the MDC for standard analysis.	• Support flow and transport model development and/or evaluation. • Detect and monitor plume edge.	^{3}H (low-level analysis) [c]	2–5 years [d]
Distal	Downgradient of the Early Detection area.	• Support flow and transport model development and/or evaluation. • Monitor COC (^{3}H) below SDWA 1,000-pCi/L detection limit. [e]	^{3}H (standard analysis) [c]	5 years
Community	Located on BLM or private land; used as a water supply source or is located near one.	• Monitor COC (i.e., ^{3}H) below SDWA 1,000-pCi/L detection limit. [e]	^{3}H (standard analysis) [c]	5 years
Inactive	Locations not routinely sampled but available for sampling.	• Defined as needed.	As necessary	As necessary

[a] Radioisotopes include ^{3}H (standard or low-level), ^{14}C, ^{26}Al, ^{36}Cl, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, $^{238/239/240}$Pu, ^{241}Am, and ^{243}Am.
[b] Characterization locations will transition to another type when a sufficient baseline (a minimum of three samples) is established to support recategorization.
[c] Standard ^{3}H analytical methods achieve a minimum detection limit of approximately 300 pCi/L; low-level ^{3}H analytical methods achieve detection limits as low as 1 pCi/L.
[d] Sampling frequency is every two years for Pahute Mesa CAUs and every five years for Frenchman Flat, RM/SM, and YF/CM CAUs (NNSA/NFO, 2014).
[e] CFR, 2016

BLM = U.S. Bureau of Land Management
COC = Contaminant of concern
COPC = Contaminant of potential concern
MDC = Minimum detectable concentration
pCi/L = Picocuries per liter
UGT = Underground test

Al = Aluminum
Am = Americium
C = Carbon
Cl =Chlorine
Cs = Cesium

Eu = Europium
^{3}H = Tritium
I = Iodine
Nb = Niobium

Pu = Plutonium
Sr = Strontium
Tc = Technetium
U = Uranium

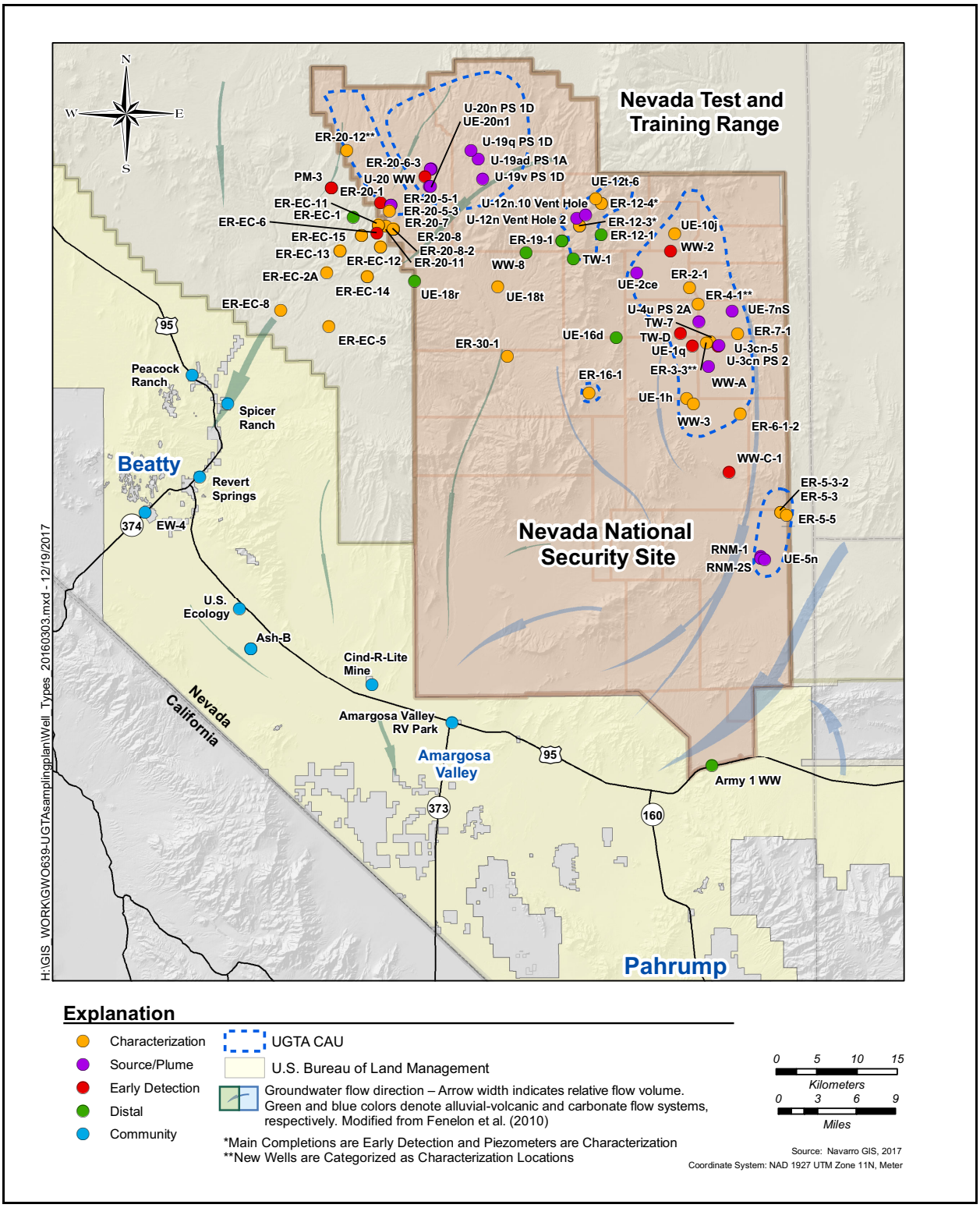


Figure 1-2
Sampling Plan Well Locations

- Open borehole intervals are numbered according to the time of sample collection as drilling progresses with a "1" for the first sample, "2" for the next greatest depth, and so on. Generally, this results in the lowest numbers associated with the most shallow depths.

For example, the ISPID associated with a sample collected from the deepest piezometer at ER-EC-11 is identified as ER-EC-11_p1 and from the deepest open interval within the main completion is identified as ER-EC-11_m1. The ISPID associated with the first sample collected from the ER-EC-11 open borehole (before it was completed) is identified as ER-EC-11_o1.

1.3 Contaminants of Concern and Contaminants of Potential Concern

The SDWA maximum contaminant levels (MCLs) for RNs included in the Sampling Plan are presented in Table 1-2. Neptunium-237 (^{237}Np), ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{242}Pu, ^{241}Am, and ^{243}Am are alpha-emitting RNs, and the MCL for these combined RNs is 15 pCi/L(CFR, 2016). The MCL for beta and photon emitters is based on a calculated dose of 4 millirem per year (mrem/yr) (CFR, 2016). This means that the combined dose from all beta and photon emitting RNs present in a particular water source must be less than 4 mrem/yr. Each single RN has a unique concentration of radioactivity (measured in pCi/L), which equates to a 4-mrem/yr dose (EPA, 2002). The corresponding U.S. Environmental Protection Agency (EPA)-derived MCLs in Table 1-2 indicate the concentration of each single RN that will result in a 4-mrem/yr dose.

Table 1-2
SDWA Maximum Contaminant Levels
(Page 1 of 2)

RN	MCL (pCi/L)
Alpha Particles	
^{237}Np	15
$^{238/239/240}$Pu	15
$^{241/243}$Am	15
Beta Particles and Photon Emitters	
^{3}H	20,000
^{14}C	2,000
^{36}Cl	700
^{90}Sr	8

Table 1-2
SDWA Maximum Contaminant Levels
(Page 2 of 2)

RN	MCL (pCi/L)
^{99}Tc	900
^{129}I	1
^{137}Cs	200
^{152}Eu	200
^{154}Eu	60
Uranium	
$^{234/235/236/238}U$	30 µg/L

Note: The MCL is 15 pCi/L (cumulative) for alpha-emitting RNs, 4 mrem/yr (cumulative) for beta and photon emitters, and 30 µg/L (cumulative) for uranium (CFR, 2016). EPA (2002) provides the conversion from dose (4 mrem/yr) to activity (pCi/L) for beta and photon emitters.

µg/L = Micrograms per liter

A COC is defined in the Sampling Plan as an RN that exceeds 10 percent of its MCL at sampling locations other than in or near the underground nuclear test cavity (i.e., in sampling locations other than wells drilled directly into the nuclear test cavity, near-field satellite wells, or Rainier Mesa tunnels). Tritium is the only radioisotope that meets this criterion (NNSA/NFO, 2014) and has been identified as the COC for all CAUs (Table 1-3).

Table 1-3
CAU-Specific COCs and COPCs

CAU	COC	COPC
Frenchman Flat	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Pahute Mesa (Central and Western)	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
RM/SM	^{3}H	^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, and $^{238/239/240}Pu$
YF/CM	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I (and ^{90}Sr and ^{137}Cs in LCA samples)

LCA = Lower carbonate aquifer

A COPC is defined as an RN that has not been detected above 10 percent of its MCL in sampling locations other than in or near the underground nuclear test cavity, but has some likelihood of

exceeding this criterion in the future. A COPC list, specific to each CAU, has been developed based on the NNSS RN inventory (Finnegan et al., 2016), an understanding of relative mobility of the inventory RNs, previous sampling and analysis data, and modeling results (Table 1-3).

The maximum ^{3}H concentrations for the most recent samples from each Sampling Plan location are presented in Table A.1-1 (see Appendix A). When ^{3}H was not detected, the value is reported as less than the sample's MDC (i.e., <MDC). A map of the maximum ^{3}H concentrations relative to the SDWA MCL (20,000 pCi/L) is presented in Figure 1-3. The greatest concentrations of ^{3}H for each sampling location is shown in Figure 1-3 (e.g., shallow interval for ER-EC-11 and ER-20-8), and detailed results (maximum ^{3}H concentrations for the different sampled depth intervals) are in Table A.1-1.

MCL exceedances for RNs other than ^{3}H are presented in Table 1-4 and Figure 1-4. Only locations where ^{3}H has been previously detected are shown on Figure 1-4. Test-related RNs are not present in NNSS groundwater without the simultaneous presence of ^{3}H, because ^{3}H is highly mobile and it is the RN produced at the greatest concentration by the nuclear tests (Finnegan et al., 2016). The maximum concentrations of the COPCs for the most current samples for characterization and source/plume locations are presented in Table A.1-2. As shown in Table A.1-2, the analytical detection capability was insufficient to determine whether the RN activity exceeded the MCL in some cases (i.e., the MDC is greater than the MCL). For instance, it is difficult for commercial laboratories to measure ^{129}I below the 1-pCi/L MCL. In fact, an MDC as high as 6.4 pCi/L is reported for this RN (Table A.1-2). Specialized analytical methods are sometimes needed to ensure the MCL has not been exceeded (see Section 2.2). These specialized analyses are currently used to measure ^{99}Tc, ^{129}I, and $^{239/240}Pu$ when the ^{3}H activity is greater than 5,000 pCi/L. These RNs have not been detected in NNSS groundwater when ^{3}H is below this level (Navarro, 2017b).

The MCLs for RNs other than ^{3}H have been exceeded at six locations (Figure 1-4). These locations are either (1) a post-shot well that samples within the test cavity or chimney area (RNM-1, U-4u PS 2A, U-19ad PS 1A, U-19v PS 1D, U-20n PS 1D) or (2) an access point that samples from a tunnel used for nuclear testing (U-12n.10 Vent Hole). Several RNs (^{90}Sr, ^{129}I, ^{137}Cs, and $^{239/240}Pu$) exceeded their MCLs in samples collected from U-19ad PS 1A (see Table A.1-2). Groundwater from this well contains some of the highest concentrations of these RNs observed in any NNSS test cavity; this is

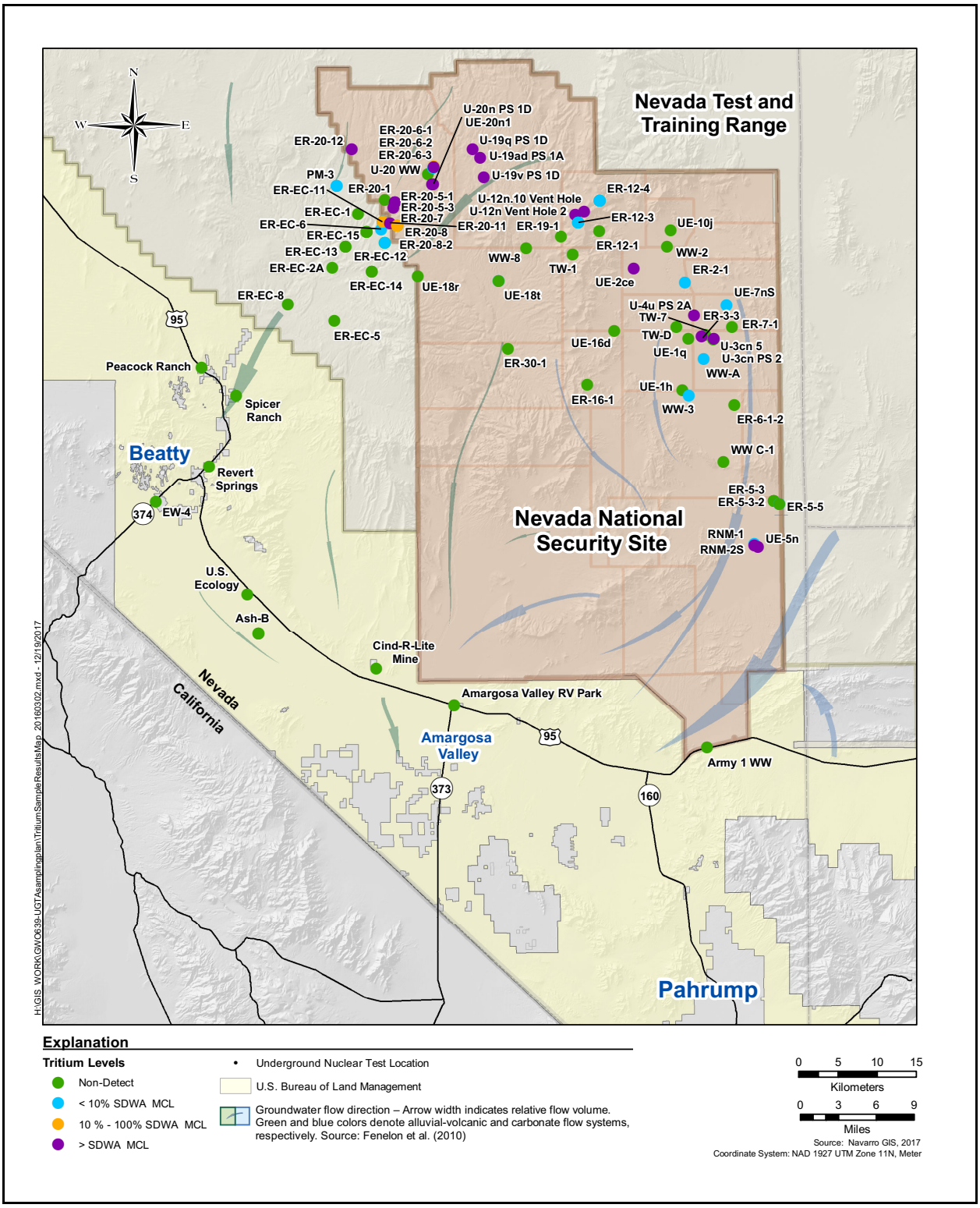


Figure 1-3
Maximum ^{3}H Concentrations

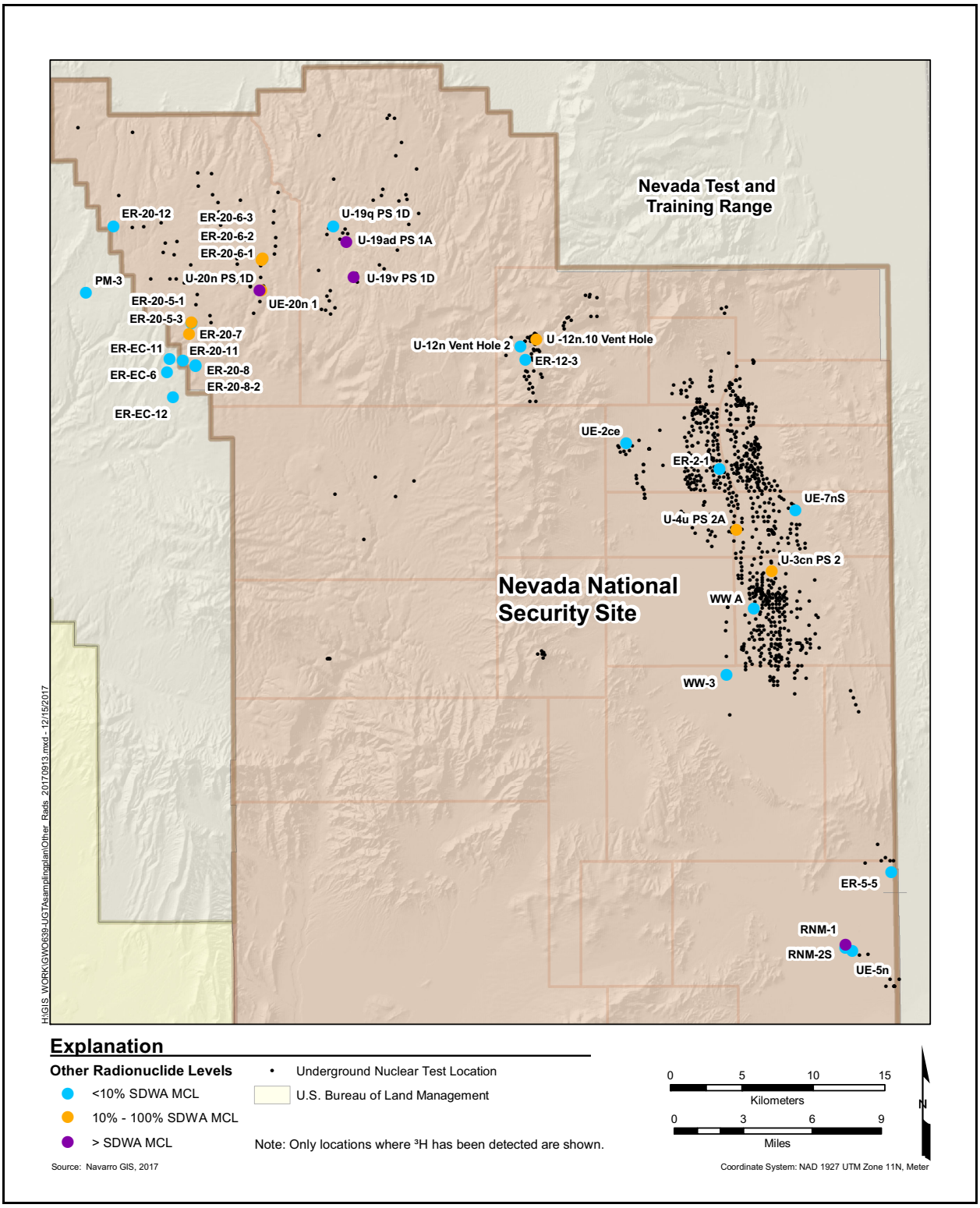


Figure 1-4
MCL Exceedances for RNs Other Than ^3H

Note: Although no single RN exceeded its MCL at U-4u PS 2A and U-12n.10 Vent Hole, the combined concentrations of multiple RNs exceeded the 4-mrem/yr MCL at these locations.

the only Sampling Plan well that exceeds the Pu MCL. This, along with the high temperature (around 75 degrees Celsius [°C]) and reducing conditions, are an indication that the residual radioactivity from the test is still largely contained within the cavity environment (Rose et al., 2011; Reimus and Boukhalfa, 2014). At locations other than U-19ad PS 1A, the RNs that contribute to the MCL exceedances are ^{90}Sr, ^{129}I, and ^{137}Cs (Table 1-4). Although no single RN exceeded its MCL at U-4u PS 2A and U-12n.10 Vent Hole, the combined concentrations of multiple RNs exceeded the 4-mrem/yr MCL at these locations. The fractional contribution for ^{129}I, ^{14}C, ^{90}Sr, and ^{137}Cs toward the 4-mrem/yr dose are 0.15, 0.16, 0.39, and 0.46, respectively, for U-4u PS 2A. The fractional contributions for ^{129}I, ^{36}Cl, and $^{239/240}$Pu toward the 4-mrem/yr dose in the 2008 U-12n.10 Vent Hole sample are 0.99, 0.14, and 0.11, respectively; no ^{90}Sr data are available for this location. Although four RNs (^{14}C, ^{36}Cl, ^{99}Tc, and ^{238}Pu) are identified as COPCs, they have not exceeded their MCL at any of the Sampling Plan locations.

Table 1-4
Locations and Specific COPC Exceedances

COPC	Sampling Locations
MCL Exceeded [a]	
^{90}Sr	RNM-1, U-19ad PS 1A, and U-20n PS 1D
^{129}I	U-19ad PS 1A and U-19v PS 1D
^{137}Cs	U-19ad PS 1A and U-20n PS 1D
$^{239/240}$Pu	U-19ad PS 1A
Less than MCL but Greater than 10% MCL	
^{14}C	UE-20n1, U-3cn PS 2, U-4u PS 2A, and U-19q PS 1D
^{36}Cl	U-12n.10 Vent Hole
^{90}Sr	ER-20-6-1, ER-20-6-3, U-3cn PS 2, and U-4u PS 2A
^{129}I	ER-20-5-1, ER-20-7, U-12n.10 Vent Hole, UE-20n1, U-20n PS 1D, U-3cn PS 2, and U-4u PS 2A
^{137}Cs	U-4u PS 2A
^{238}Pu	U-19ad PS 1A
$^{239/240}$Pu	U-12n.10 Vent Hole

[a] Although no single RN exceeded its MCL at U-4u PS 2A and U-12n.10 Vent Hole, the combined concentrations of multiple RNs exceeded the 4-mrem/yr MCL at these locations.

1.4 Special Investigations

Drilling of four wells was completed in 2016: one in Western Pahute Mesa (ER-20-12) and three in Yucca Flat (ER-2-2, ER-3-3, and ER-4-1). In addition, samples were collected from one post-shot hole on Pahute Mesa (U-20AA PS1D) and from E-Tunnel discharge on Rainier Mesa.

Drilling of the Phase II Pahute Mesa well (ER-20-12), was initiated in October 2015 and completed in January 2016. Well development and testing of the ER-20-12 main completion was also completed in 2016. ER-20-12 is located south–southwest of the HANDLEY UGT and north–northeast of PM-3, and was drilled to investigate the source of ^{3}H detected in PM-3 groundwater in 2010 (N-I, 2015a). This well is newly categorized as a characterization well. Sampling results are presented in Section 3.2.1.

Drilling of three model evaluation wells in Yucca Flat (ER-2-2, ER-3-3, and ER-4-1) was completed in 2016. These wells are located near detonations identified as likely to have impacted the regional carbonate aquifer within the Yucca Flat basin. Understanding RN transport to the regional carbonate aquifer was identified as the highest priority for siting the wells because it is the only pathway for RNs to migrate out of the basin (N-I, 2013). No ^{3}H was detected in the carbonate aquifer at ER-3-3 and ER-4-1. ER-2-2 was plugged and abandoned because of difficulties encountered during drilling. A sample was collected from the regional carbonate aquifer at ER-2-2 before it was plugged, and the ^{3}H was reported as 13.3 pCi/L. The value was reported as an estimate because laboratory quality control (QC) measurements exceeded the acceptable criteria. While the ^{3}H in the regional aquifer is very low or nonexistent, elevated ^{3}H was reported for samples collected from more shallow depths in volcanic rock units at ER-2-2 (up to 23,400,000 pCi/L) and ER-4-1 (up to 59,600 pCi/L). The lack of ^{3}H migration from the shallow volcanic rock units to the deeper carbonate aquifer demonstrates the effectiveness of the confining units overlaying the carbonate aquifer as barriers to contaminant migration. The lack of ^{3}H at ER-3-3 also indicates that contaminant migration within the Yucca Fault is limited. Both of these observations support the conceptual model that UGTs that do not intersect the carbonate aquifer have a negligible impact on migration within the regional carbonate aquifer and thus outside the basin. Two of these wells are newly categorized as characterization wells, and further sampling results are presented in Sections 3.4.1 and 3.4.2. ER-2-2 was not categorized for routine sampling in the future because the carbonate aquifer is no longer assessable at this well and therefore is not a recommended monitoring location.

E-Tunnel on Rainier Mesa and U-20AA PS1D on Pahute Mesa were evaluated as a potential new sampling point for the Sampling Plan (E-Tunnel) or to study the near-field environment of a nuclear test cavity. U-20AA PS1D is a slant hole drilled in 1976 to within 1,000 feet (ft) of the COLBY detonation cavity in bedded tuffs. On October 5, 2016, bailed samples were collected at 3,535 ft below ground surface (bgs) within the casing (Pohlmann et al., 2017). The mean ^{3}H concentration is 2.8E+07 pCi/L. Desert Research Institute (DRI) conducted chemistry, pressure, and temperature logging in 2017. Full analysis of the results will be provided in future reports.

E-Tunnel was used for nuclear weapons testing from 1960 to 1993 in Rainier Mesa. Water samples were collected from E-Tunnel at the request of Lawrence Livermore National Laboratory (LLNL) to establish a baseline of comparable analyses to the N-Tunnel discharge (source/plume sampling locations). The results of the tunnel evaluations will be provided in future reports. E-Tunnel discharge, currently sampled annually for ^{3}H, gross alpha, and gross beta under Water Pollution Control Permit NEV96021 (Navarro, 2016c), will be considered for source/plume monitoring in future updates to the Sampling Plan.

2.0 Sampling and Analysis Methods

A total of 20 Sampling Plan wells (25 intervals) were sampled in 2016 (Tables 2-1 and 2-2). The samples collected in 2016 and the collection method, sample date, sampled intervals (ISPID), and hydrostratigraphic units (HSUs) associated with the sample are presented in Table 2-1. Sample and analysis methods for 2016 and the corresponding results are presented in this section and in Section 3.0, respectively. Some wells sampled in 2016 are single-zone completions where samples are collected from one depth interval and other wells are multiple-completions sampling several depth intervals. Table 2-2 presents other sampling relevant to the UGTA Activity including inactive wells (i.e., not routinely sampled for the Sampling Plan). These sampling locations, and the sampling and analytical methods, are described within this section.

Table 2-1
2016 Sample Collection Summary
NNSS Integrated Sampling Plan Locations
(Page 1 of 2)

Location Type	Well Name	ISPID	Sample Date	HSU	Collection Method
Frenchman Flat (CAU 98)					
Characterization	ER-5-5	ER-5-5_m1	05/16/2016	BLFA/OAA	ES Pump
	ER-5-3-2	ER-5-3-2_m1	05/19/2016	LCA	ES Pump
	ER-5-3	ER-5-3_p2	06/07/2016	BLFA/OAA	Bailer
Source/Plume	UE-5n	UE-5n_m1	05/05/2016	AA	ES Pump
	RNM-2S	RNM-2S_m1	05/10/2016	AA	ES Pump
Pahute Mesa (CAUs 101 and 102)					
Characterization	ER-20-12	ER-20-12_m1	08/19/2016	PBRCM	ES Pump
		ER-20-12_p1	07/06/2016	BRA	Rod Pump
		ER-20-12_p3	06/10/2016	CHCZM	Bailer
		ER-20-12_p4	08/31/2016	TMWTA	Bailer
	ER-EC-12	ER-EC-12_m2	07/20/2016	THCM/TCA/LPCU	ES Pump
	ER-EC-8	ER-EC-8_m1-3	09/29/2016	FCCM/TMCM	ES Pump
	ER-EC-2A	ER-EC-2A_m3	10/11/2016	FCCM	ES Pump
Early Detection	PM-3	PM-3_p1	09/13/2016	TCA/LPCU	Bailer
		PM-3_p2	09/13/2016	UPCU	Bailer
Distal	ER-EC-1	ER-EC-1_m1-3	07/15/2016	CPA/UPCU/TCA/LPCU/ TSA/CHCU/CFCM	ES Pump

Table 2-1
2016 Sample Collection Summary
NNSS Integrated Sampling Plan Locations
(Page 2 of 2)

Location Type	Well Name	ISPID	Sample Date	HSU	Collection Method
RM/SM (CAU 99)					
Characterization	ER-12-3	ER-12-3_p1	07/26/2016	LTCU/OSBCU/ATCU	Bailer
		ER-12-3_p1	09/07/2016		Rod Pump
	ER-12-4	ER-12-4_p2	09/22/2016	OSBCU	Bailer
	UE-18t	UE-18t_p1	10/28/2016	TMCM	Rod Pump
Early Detection	ER-19-1	ER-19-1_p1	11/16/2016	RVA/ATCU	Bailer
		ER-19-1_p2	11/16/2016	OSBCU	Bailer
Distal	UE-16d WW	UE-16d WW_m1	01/26/2016	UCCU	ES Pump
	WW-8	WW-8_m26	01/26/2016 04/19/2016 07/26/2016 10/25/2016	BRA	ES Pump
YF/CM (CAU 97)					
Characterization	ER-3-3	ER-3-3_m1	12/16/2016	LCA	ES Pump
	ER-4-1	ER-4-1_m1	04/12/2016	LCA	Discharge
Source/Plume	UE-2ce	UE-2ce_m1	12/14/2016	LCA3	ES Pump

ES = Electric submersible

AA = Alluvial aquifer
ATCU = Argillic tuff confining unit
BLFA = Basalt lava-flow aquifer
BRA = Belted range aquifer
CFCM = Crater Flat composite unit
CHCU = Calico Hills confining unit
CHZCM = Calico Hills zeolitic composite unit
CPA = Comb Peak aquifer
FCCM = Fortymile Canyon composite unit
LCA = Lower carbonate aquifer
LCA3 = Lower carbonate aquifer-upper plate
LPCU = Lower Paintbrush confining unit
LTCU = Lower tuff confining unit
OAA = Older altered alluvium
OSBCU = Oak Springs Butte confining unit
PBRCM = Pre-Belted Range composite unit
RVA = Redrock Valley aquifer
TCA = Tiva Canyon aquifer
THCM = Tannenbaum Hill composite unit
TMCM = Timber Mountain composite unit
TMWTA = Timber mountain welded-tuff aquifer
TSA = Topopah Spring aquifer
UCCU = Upper clastic confining unit
UPCU = Upper Paintbrush confining unit

Table 2-2
Inactive Well Samples Collected in 2016

Location Type	Well Name	ISPID	Sample Date
Inactive	ER-11-2	ER-11-2_m1	04/19/2016 and 06/29/2016
	U-20AA PS1D	U-20AA PS1D_m1	10/05/2016
	E-Tunnel	E-Tunnel_mine1	10/18/2016

2.1 Sample Collection Methods

Sample collection methods are based, in part, on the physical attributes and configurations of the well. Some wells are equipped with dedicated pumps and are sampled from the associated plumbing (e.g., spigots) at the wellhead, while wells without pumps may be sampled via a wireline bailer or a portable pumping system. All water samples are generally collected in a manner that best ensures they represent ambient formation water following the sampling methods described in standard operating procedures. While the well is not purged when sampled using a bailer, purging of the well is required for collecting samples using a pump. Purging is considered adequate once a minimum of three effective well volumes are discharged and the water-quality parameters meet the following criteria: (1) the pH has stabilized, and measurements remained constant within 0.1 standard unit (SU); (2) specific electrical conductance (SEC) and temperature have stabilized, and vary by no more than 10 percent for at least three consecutive readings; and (3) the turbidity has stabilized below 10 nephelometric turbidity units (NTUs). Stabilization of these water-quality parameters indicates that formation water is being sampled instead of stagnant water from within and surrounding the well. The amount of groundwater purged before sample collection is presented in Table 3-1.

Documentation, sample handling, chain of custody, and QC requirements associated with sample collection are performed in accordance with the UGTA QAP (NNSA/NFO, 2015a). Chain of custody is implemented to provide traceability of sample possession from the time the samples are collected until disposition. UGTA Activity sampling is performed in compliance with the UGTA "Sample Collection and Processing" procedure (Navarro, 2016b), and sampling performed by the management and operating (M&O) contractor is in compliance with SOP-P420.104: "Preparing and Sampling Routine Radiological Environmental Monitoring Plan (RREMP) Water Locations" (NSTec, 2016). Water-quality monitoring was conducted in accordance with the *Field Instruction for the Underground Test Area Activity Well Development, Hydraulic Testing, and Groundwater Sampling* (N-I, 2012). Fluids produced during well purging were managed according to the UGTA Waste Management Plan (NNSA/NSO, 2009) and the associated fluid management strategy letter.

2.2 Analytical Methods

Analyses specified in the Sampling Plan (i.e., required analyses) are performed by a commercial laboratory that is certified through the Nevada Division of Environmental Protection (NDEP) Bureau of Safe Drinking Water, and that meets National Environmental Laboratory Accreditation Program or equivalent requirements. Commercial laboratories also must participate in the U.S. Department of Energy Consolidated Audit Program (DOECAP). Standard analytical methods are used by the commercial laboratories (Table 2-3). Other analytes require specialized methodology and cannot be analyzed by a commercial laboratory certified by NDEP. These analyses are not required by the Sampling Plan (i.e., optional analyses) and may be performed by non-certified laboratories. These laboratories provide state-of-the-art methods necessary to maximize analytical sensitivity to obtain reduced detection limits, or for analyzing unique parameters not available by a commercial laboratory (Table 2-4). These analytes support groundwater source, flow path, and groundwater mixing evaluations. As shown in Table 2-4, LLNL provides specialized laboratory analyses with much lower MDCs than the commercial laboratory.

Samples collected from all early detection wells and from some characterization wells are enriched before being analyzed for ^{3}H. These wells are expected to have ^{3}H levels less than 300 pCi/L, which is the approximate MDC using a standard analysis method. The enrichment process (DOE, 1997), referred to throughout this report as low-level ^{3}H analysis, concentrates ^{3}H in a sample to provide lower MDCs, which range from approximately 2 to 40 pCi/L depending on the laboratory performing the enrichment process. For samples with expected levels of ^{3}H above the laboratory's standard detection capability or at distal and community locations that require only standard analysis (Table 1-1), ^{3}H enrichment is not performed. The MDCs for standard analyses (approximately 300 pCi/L) are below the EPA SDWA-required detection limit of 1,000 pCi/L for ^{3}H (CFR, 2016). Standard methods are used for analysis of COPCs and are performed by State of Nevada certified commercial laboratories. The MDCs must be at or below the SDWA MCL. The MDCs for gross alpha and beta radioactivity are 2 and 4 pCi/L, respectively, and satisfy their EPA SDWA required detection limits of 3 and 4 pCi/L, respectively. NNSS potable wells are also monitored for gross beta at the 50-pCi/L screening level.

The majority of the radioisotopes are reported as non-detects by the commercial laboratory. While this is usually satisfactory for ensuring RNs do not exceed the MCLs, it is insufficient for

Table 2-3
Analytical Procedures for Required Analyses

Analyte	Preferred Analytical Method [a]	Title	Detection Limit
General Chemistry			
Alkalinity	EPA 310.2 [b]	Alkalinity (Colorimetric, Automated, Methyl Orange)	20 mg/L as $CaCO_3$
pH	EPA 150.1 [b]	pH (Electrometric)	0.01
Specific Conductance	EPA 120.1 [b]	Conductance (Specific Conductance, µmhos at 25 °C)	1.0 µmhos/cm
Br, Cl, F, SO_4	EPA 300.0 [c]	Determination of Inorganic Anions in Drinking Water by Ion Chromatography	0.25–1 mg/L
Metals			
Ag, Al, As, Ba, Ca, Cd, Cr, Fe, K, Li, Mg, Mn, Na, Pb, Se, Si, Sr	EPA 6010 [d]	Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	0.001–1.0 mg/L
U	EPA 6020 [d]	Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)	0.0001 mg/L
Radioisotopes			
Gamma Emitters (^{26}Al, ^{94}Nb, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, ^{241}Am, ^{243}Am)	EPA 901.1 [e]	Gamma-Emitting Radionuclides in Drinking Water	10 pCi/L ^{137}Cs
Gross Alpha and Gross Beta	EPA 900.0 [e]	Gross Alpha/Beta Radioactivity in Drinking Water	3 pCi/L (Gross Alpha)
^{3}H (Low Level)	HASL 300 3H-01-RC (prep) [f] EPA 906.0 [e] (analysis)	Tritium Assay in Water Samples using Electrolytic Enrichment; Tritium (^{3}H) in Drinking Water	3 pCi/L
^{3}H	EPA 906.0 [e]	Tritium (^{3}H) in Drinking Water	300 pCi/L
^{90}Sr	EPA 905.0 [e]	Radioactive Strontium-90 (^{90}Sr) in Drinking Water	1 pCi/L
^{14}C	EERF C-01 [g] or equivalent	Radiochemical Determination of Carbon-14 (^{14}C) in Aqueous Samples	500 pCi/L
^{36}Cl	Laboratory specific	Chlorine-36 (^{36}Cl)	4 pCi/L
^{99}Tc	HASL 300 TC-01-RC [f] or equivalent	Technetium-99 (^{99}Tc) in Water	10 pCi/L
^{129}I	EPA 902.0 [e]	Radioactive Iodine in Drinking Water	<1 pCi/L
$^{238/239/240}$Pu	HASL 300 Pu-10-RC [f] or ASTM D3865-09 [h] or equivalent	Isotopic Plutonium (Pu) in Water	0.1 pCi/L

[a] Equivalent methods promulgated in 40 CFR 141 (CFR, 2016) or as certified by the State of Nevada are also allowed.
[b] EPA, 1983
[c] EPA, 1993
[d] EPA, 2011
[e] EPA, 1980
[f] DOE, 1997
[g] EPA, 1984
[h] ASTM, 2015

Ag = Silver
As = Arsenic
Ba = Barium
Br = Bromide
Ca = Calcium
$CaCO_3$ = Calcium carbonate
Cd = Cadmium
Cr = Chromium
F = Fluorine
Fe = Iron
K = Potassium
Li = Lithium
Mg = Magnesium
Mn = Manganese
Na = Sodium
Se = Selenium
Si = Silicon
SO_4 = Sulfate

ASTM = ASTM International
EERF = Eastern Environmental Radiation Facility
HASL = Health and Safety Laboratory
mg/L = Milligrams per liter
µmhos = Micromho
µmhos/cm = Micromhos per centimeter

Table 2-4
Non-certified (Specialized) Laboratory Analytical Procedures

Analytes	Procedure	Title	Detection Limit
Desert Research Institute			
^{14}C (DOC)	Accelerator Mass Spectrometry	NSF-Arizona AMS Facility Quality Assurance Manual	N/A
Lawrence Livermore National Laboratory			
δ^2H, $\delta^{18}O$	SOP-UGTA-128	Analysis of ^{18}O and ^2H in Groundwater Samples	N/A
DIC, $\delta^{13}C$	SOP-UGTA-116	Analysis of TDIC, TDOC, and ^{13}C in Groundwater Samples	0.01 mg/L (TDIC) N/A ($\delta^{13}C$)
Noble Gases (Ar, Kr, Ne, Xe, ^3He, ^4He, $^{3/4}He$, $^{3/4}He$ [R/R_a])	SOP-NGMS-122	Collection and Analysis of Groundwater for Determination of Noble Gas Abundance and Helium Isotopic Composition	1.4E-15 – 1.0E-05 cm^3 STP/g (Ar, Kr, Ne, Xe, ^3He, ^4He); 2.8E-06 ($^{3/4}He$); 0.02 ($^{3/4}He$ [R/R_a])
^3H (Low Level)	SOP-NGMS-121	Collection and Analysis of Groundwater for Determination of Tritium by Helium-3 Accumulation	1 pCi/L
^3H	SOP-UGTA-131	Liquid Scintillation Counting Method for Analyses of ^3H in Groundwater Sample Using a ^3H Column	300 pCi/L
^{14}C	SOP-UGTA-136	Extraction and Analysis of ^{14}C in Groundwater Samples	10E-03 pCi/L
^{36}Cl	SOP-UGTA-120 SOP-UGTA-115	Determination of Inorganic Anions by Ion Chromatography Analysis of ^{36}Cl in Aqueous Samples	10E-06 pCi/L
$^{87/86}Sr$	SOP-UGTA-133 SOP-UGTA-134 SOP-UGTA-117	ICP/MS Sample Preparation Sample Analysis by Quadrupole ICPMS ^{87}Sr /^{86}Sr Analysis of Groundwater Samples	N/A
^{99}Tc	SOP-UGTA-133 SOP-UGTA-134 SOP-UGTA-111	ICP/MS Sample Preparation Sample Analysis by Quadrupole ICPMS Analysis of ^{99}Tc Samples	10E-03 pCi/L
^{129}I	SOP-UGTA-123	Analysis of I-129 in Aqueous Samples	10E-07 pCi/L
^{234}U, ^{235}U, ^{236}U, ^{238}U	SOP-UGTA-133 SOP-UGTA-134 SOP-UGTA-118	ICP/MS Sample Preparation Sample Analysis by Quadrupole ICPMS Uranium Isotopic Analysis of Groundwater Samples	N/A
$^{238/239/240}Pu$	SOP-UGTA-135	Analysis of Plutonium in Groundwater Samples by MC-ICP-MS	10E-03 pCi/L
U.S. Geologic Survey			
$^{34/32}S$	USGS-YM-GCP-44	Sulfur Isotope Analysis of Dissolved Sulfate in H_2O	N/A

cm^3 STP/g = Cubic centimeters of gas at standard temperature and pressure per gram.
MC-ICP-MS = Multicollector-inductively coupled plasma-mass spectrometry.
R/R_a = Ratio in sample relative to ratio in air.

Ar = Argon
DIC = Dissolved inorganic carbon
DOC = Dissolved organic carbon
^2H = Deuterium
H_2O = Water
He = Helium
Kr = Krypton
Ne = Neon
O = Oxygen
S = Sulfur
TDIC = Total dissolved inorganic carbon
TDOC = Total dissolved organic carbon
Xe = Xenon
δ^2H = Delta deuterium
$\delta^{13}C$ = Delta carbon-13
$\delta^{18}O$ = Delta oxygen-18

AMS = Accelerator Mass Spectrometry
N/A = Not applicable
NSF = National Science Foundation
SOP = Standard operating procedure
USGS = U.S. Geologic Survey

quantitatively evaluating contaminant migration. In some cases, commercial laboratories have difficulty detecting RNs at levels that exceed the MCL (e.g., ^{129}I). For these cases, the specialized laboratory analyses is necessary to ensure to ensure the MCL has not been exceeded. Confidence in the results is also gained by using different methods between labs. USGS and DRI also perform or are responsible for specialized analyses (Table 2-4). These analyses support characterization of groundwater flow paths and travel time estimates. Analyses performed by laboratories that are not NDEP certified are identified and justified in the Annual UGTA Quality Assurance (QA) Report (e.g., NNSA/NFO, 2016b).

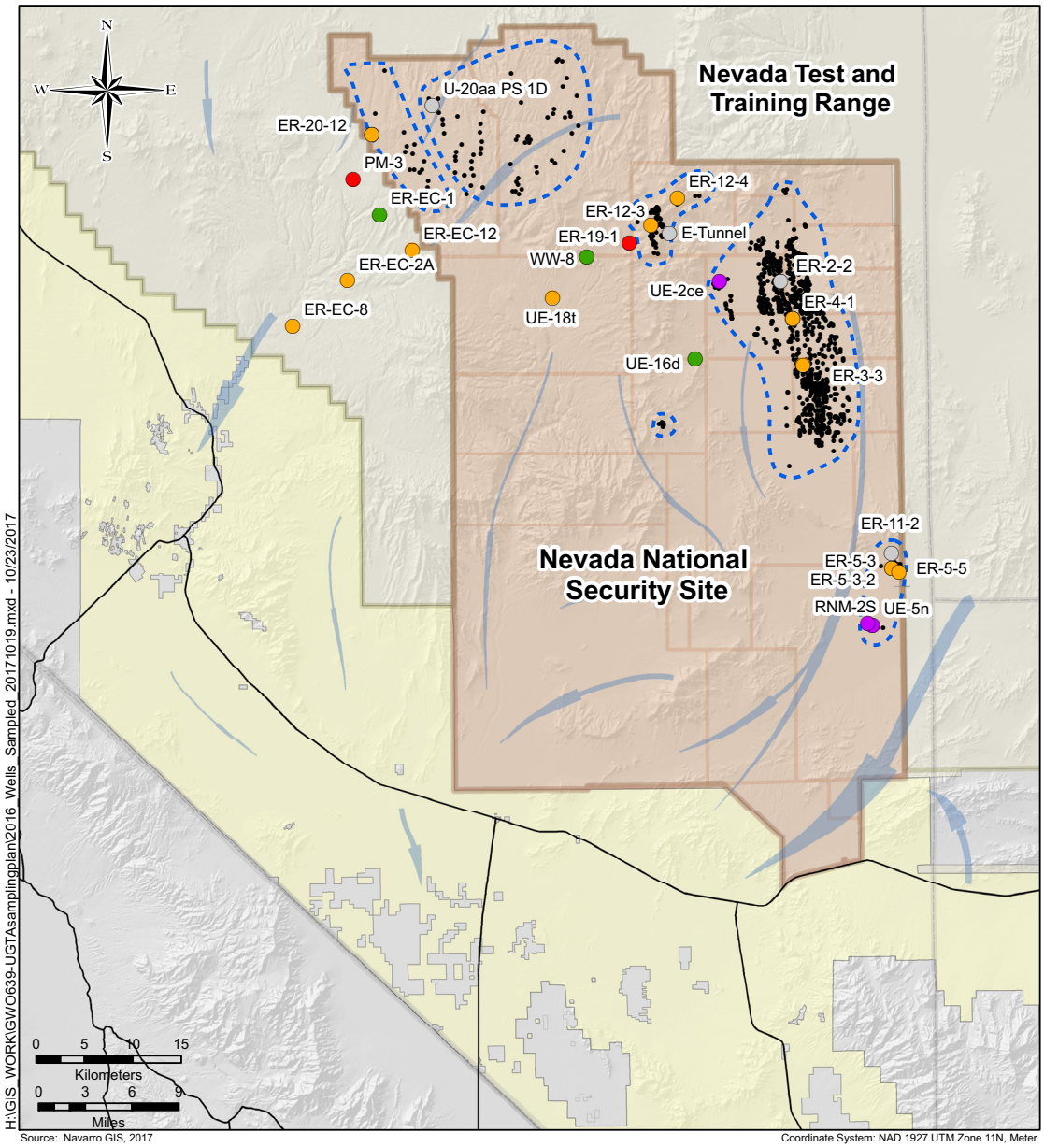
3.0 Sampling and Analysis Results

Sampling in 2016 took place in five UGTA CAUs (Table 3-1 and Figure 3-1). Sampling and the associated results within each CAU are described in this section, and the analytical results are presented in Appendix B. Field water-quality parameters, purge volumes and flow rates at the time of sample collection are provided in Table 3-1. The 2016 results along with historical data reported within this section are maintained within the UGTA Chemistry Database (Navarro, 2017b). The database is a repository for historical and current analytical chemistry data associated with the Sampling Plan locations and additional locations used for CAU investigations.

This section includes comparisons of the 2016 sample results to the results of previous samples from the same location. The objective is to evaluate trends in the radioisotope data and to evaluate consistency of other chemical parameters. For characterization samples and other samples for which major ions were analyzed, Piper diagrams are presented to facilitate these comparisons. The Piper diagram presents relative concentrations of major ions in percent milliequivalents per liter (%meq/L) and is used to classify various groundwater chemistry types, or facies, and illustrate the relationships that may exist between water samples. The major ions consist of calcium (Ca^{2+}), potassium (K^{+}), magnesium (Mg^{2+}), sodium (Na^{+}), chloride (Cl^{-}), sulfate (SO_4^{2-}), bicarbonate (HCO_3^{-}), and carbonate (CO_3^{2-}). The dissolved constituents in groundwater provide a record of the minerals encountered as water moves through an aquifer; therefore, the major-ion characteristics of groundwater can provide insight on groundwater source areas and flow directions.

Two ongoing geochemical evaluations are in progress. A Phase II Pahute Mesa geochemical evaluation is in progress to update the Phase I evaluations presented in Thomas et al. (2002), Kwicklis et al. (2005), and Rose et al. (2006). An evaluation of the noble gas data measured by LLNL over the last 15 years is also ongoing. This report will therefore defer noble gas and Pahute Mesa geochemistry evaluations to future reports focusing specifically on these data. In addition, Frenchman Flat sampling is now required by the CR for long-term closure monitoring (NNSA/NFO, 2015b). While the 2016 results for Frenchman Flat samples are presented within this report, further discussion is presented in the Frenchman Flat Post-Closure Monitoring Report (DOE/EMNV, 2017c).

Table 3-1 presents water-quality data at the time of collection for pumped samples in each CAU.



Explanation

- Characterization
- Source/Plume
- Early Detection
- Distal
- Inactive
- Underground Nuclear Test Location
- UGTA CAU
- U.S. Bureau of Land Management
- Groundwater flow direction – Arrow width indicates relative flow volume. Green and blue colors denote alluvial-volcanic and carbonate flow systems, respectively. Modified from Fenelon et al. (2010)

Figure 3-1
Samples Collected in 2016

Table 3-1
Purge Volumes and Field Water-Quality Data

Date	ISPID	Volume (gal)	Flow Rate (gpm)	Temp (°C)	DO (mg/L)	pH (SU)	SEC (µS/cm)	Turbidity (NTU)	Bromide (mg/L)
Frenchman Flat (CAU 98)									
04/19/2016	ER-11-2_m1 [a]	N/A	N/A	26.43	--	8.14	1,550	80.1	--
05/16/2016	ER-5-5_m1	4,951	28.48	25.3	--	8.38	402	8.8	--
05/19/2016	ER-5-3-2_m1	37,543	25.88	27.9	--	6.89	1,057	6.0	--
05/05/2016	UE-5n_m1	38,289	14.48	23.61	--	7.75	406	8.2	--
05/10/2016	RNM-2S_m1	124,880	585	23.95	--	7.64	381	9.4	--
06/07/2016	ER-5-3_p2 [a]	N/A	N/A	27.65	--	8.04	380	28.1	--
Pahute Mesa (CAUs 101 and 102)									
07/06/2016	ER-20-12_p1	23,057	2.64	26.61	3.01	7.91	689	6.2	1.18
07/15/2016	ER-EC-1_m1-3	44,034	28.35	31.65	5.12	8.05	888	8.5	--
08/19/2016	ER-20-12_m1	32,692	28.19	39.65	2.07	7.87	784	172	2.5
07/20/2016	ER-EC-12_m2	54,310	35.5	38.18	1.68	8.73	404	35.3	--
09/29/2016	ER-EC-8_m1-3	38,382	28	35.41	5.41	7.65	--	10.6	--
10/11/2016	ER-EC-2A_m3	34,906	29.97	35.84	4.5	8.3	674	8.5	--
09/13/2016	PM-3_p1 [a]	N/A	N/A	28.8	--	8.12	782	--	--
09/13/2016	PM-3_p2 [a]	N/A	N/A	29.9	--	7.59	832	34	--
RM/SM (CAU 99)									
09/07/2016	ER-12-3_p1	4,682	2.5	18.04	2.93	7.26	254	36.2	0.355
09/22/2016	ER-12-4_p2 [a]	N/A	N/A	16.68	61	8.07	352	205	0.428
10/28/2016	UE-18t_p1	6,636	2.51	30.37	3.32	8.08	295	11.8	--
YF/CM (CAU 97)									
12/15/2016	ER-3-3_m1	9,461	13	19.44	2.32	10.05	480	316	0.169
12/14/2016	UE-2ce_m1	20,187	14.21	32.87	2.72	7.12	674	15.8	--
12/15/2016	UE-2ce_m1	40,279	14.04	32.84	3.18	7.25	676	24.1	--
12/16/2016	UE-2ce_m1	56,307	14.14	32.0	3.69	7.24	678	16.6	--

[a] Sample was collected with a bailer.

DO = Dissolved oxygen
gal = Gallon
gpm = Gallons per minute
µS/cm = Microsiemens per centimeter

-- = Not analyzed

3.1 Frenchman Flat

In 2016, six wells were sampled in the Frenchman Flat CAU: three characterization wells, ER-5-5 (Section 3.1.1), ER-5-3-2 (Section 3.1.2), and ER-5-3 (Section 3.1.3); two source plume wells, UE-5n (Section 3.1.4) and RNM-2S (Section 3.1.5); and one inactive well, ER-11-2 (Section 3.1.6). Field water-quality data were collected for ER-11-2 and ER-5-3, and are provided in Table 3-1. ER-11-2 is considered an inactive well according to the Sampling Plan but is part of the monitoring network defined in the Frenchman Flat CR (NNSA/NFO, 2015b). Therefore, ER-11-2 will be monitored along with the other five Frenchman Flat wells for five consecutive years. The analytical results for these samples are provided in Section B.1.0 of Appendix B. In the Sampling Plan, the objective for ER-5-3-2 is to monitor the regional carbonate aquifer downgradient of the YF/CM CAU. ER-5-3-2 is also included as part of the monitoring network defined in the Frenchman Flat CR and is therefore discussed within this section.

3.1.1 ER-5-5

ER-5-5 is a characterization location constructed with one piezometer and one main completion (see Figure C-1). On May 16, 2016, groundwater samples were collected from ER-5-5_m1 after purging 4,951 gal of water using a submersible pump sampling the BLFA and OAA HSUs. The purge volumes and field water-quality data are provided in Table 3-1, and laboratory results are presented in Table B.1-1. Two samples and duplicates were collected and analyzed for the full characterization suite by the commercial laboratory. One set of samples was sent to ALS Laboratory Group (ALS), and another was sent to General Engineering Laboratories (GEL). No RNs were detected in the samples by the commercial laboratories including ^{3}H by GEL using the enrichment process with an MDC of 3.65 pCi/L (Table B.1-1). ALS did not analyze for low-level ^{3}H.

3.1.2 ER-5-3-2

ER-5-3-2 is also a characterization location constructed with one main completion in the LCA (see Figure C-2). A groundwater sample was collected on May 19, 2016, and the purge volumes and field water-quality data are provided in Table 3-1. No RNs were detected by the commercial laboratory, including ^{3}H using the enrichment process with an MDC of 3.71 pCi/L (see Table B.1-1).

3.1.3 ER-5-3

ER-5-3 is a characterization location constructed with a main completion and two piezometers (see Figure C-3). The shallow piezometer (ER-5-3_p2) was bailed on June 7, 2016, sampling the BLFA and OAA HSUs (Figure C-3). The samples were analyzed for the reduced characterization suite required for samples collected using a bailer (NNSA/NFO, 2016a). No RNs were detected by the commercial laboratory, including ^{3}H using the enrichment process with an MDC of 3.73 pCi/L (see Table B.1-1).

3.1.4 UE-5n

UE-5n is a source plume well that was constructed in 1976 to a depth of 1,687 ft bgs and perforated from 720 to 730 ft bgs, This well is open to the alluvium (see Figure C-4). A groundwater sample was collected for ^{3}H and the Frenchman Flat-specific COPCs on May 5, 2016. The purge volumes and field water-quality data are provided in Table 3-1, and laboratory results are presented in Table B.1-2. Tritium was measured at 135,000 pCi/L by the commercial laboratory; the COPCs were below their MDCs.

3.1.5 RNM-2S

RNM-2S was constructed in 1974 to a depth of 1,156 ft bgs and is open below the water table to approximately 430 ft of alluvium (see Figure C-5). On May 10, 2016, after purging 68,000 gal of water, a sample and duplicate were collected from the main completion for ^{3}H and Frenchman Flat specific COPCs. The purge volumes and field water-quality data are provided in Table 3-1, and laboratory results are presented in Table B.1-2. The ^{3}H results were reported at 75,000 and 76,000 pCi/L; the COPCs were below their MDCs.

3.1.6 ER-11-2

ER-11-2 consists of a piezometer that is open to the LTCU HSU as shown in Figure C-6. Pumping for a sample is not possible because of the well construction and the low yield of the LTCU. The well was sampled twice in 2016 (Table B.1-3). The first sample was collected on April 19, 2016, and a ^{3}H activity of 17.48 pCi/L was reported. The well was sampled again on June 29, 2016, to verify the results of the first sample because the presence of ^{3}H is not expected at this location (N-I, 2014).

Samples were sent to the commercial laboratory and LLNL. No ^{3}H was detected above the 2.99 pCi/L (commercial laboratory) and 0.33 pCi/L (LLNL) MDC in the second sample set. The first reported result (17.48 pCi/L) was determined to be an anomalous result suspected to result from contaminated sampling equipment, sample mishandling, and/or laboratory contamination.

3.2 Central and Western Pahute Mesa

Six wells were sampled in the Central and Western Pahute Mesa CAUs in 2016: four characterization wells, ER-20-12 (Section 3.2.1), ER-EC-12 (Section 3.2.2), ER-EC-8 (Section 3.2.3), and ER-EC-2A (Section 3.2.4); one early detection well, PM-3 (Section 3.2.5); and one distal well ER-EC-1 (Section 3.2.6). The analytical results for these samples are reported in Section B.2.0 of Appendix B.

A Piper diagram illustrating the major-ion results for characterization location samples is presented in Figure 3-2. Samples from previous years are included for comparison purposes. In general, samples collected from the same location plot similarly on the Piper diagram. All samples are dominated by Na+K (cations) and have varying relative proportions of HCO_3, Cl, and SO_4 (anions).

3.2.1 ER-20-12

Drilling of an additional Phase II well, ER-20-12, was initiated in October 2015 and was completed in January 2016. ER-20-12 has one main completion and four piezometers (Figure C-7) and is located in the far northwestern portion of the NNSS approximately 1.4 miles (mi) south–southwest of the HANDLEY UGT and approximately 3.2 mi north–northeast of PM-3 (Figure 3-1). The objective for well ER-20-12 is to evaluate ^{3}H migration from the HANDLEY UGT toward PM-3 (N-I, 2015a). ER-20-12 was specifically designed to characterize the hydrogeology and vertical distribution of ^{3}H in the well. The borehole penetrated several aquifers and confining units, and was completed with the main casing located in the unit most likely to be responsible for ^{3}H migration (PBRCM).

Well development and testing of the ER-20-12 main completion was completed in September 2016. During well development and testing, characterization samples and duplicates were collected from the main completion (ER-20-12_m1) using an ES pump and from the deepest piezometer (ER-20-12_p1) using a rod pump. ER-20-12_m1 accesses the PBRCM, and ER-20-12_p1 accesses the BRA. Field water-quality measurements are provided in Table 3-1; and laboratory results are

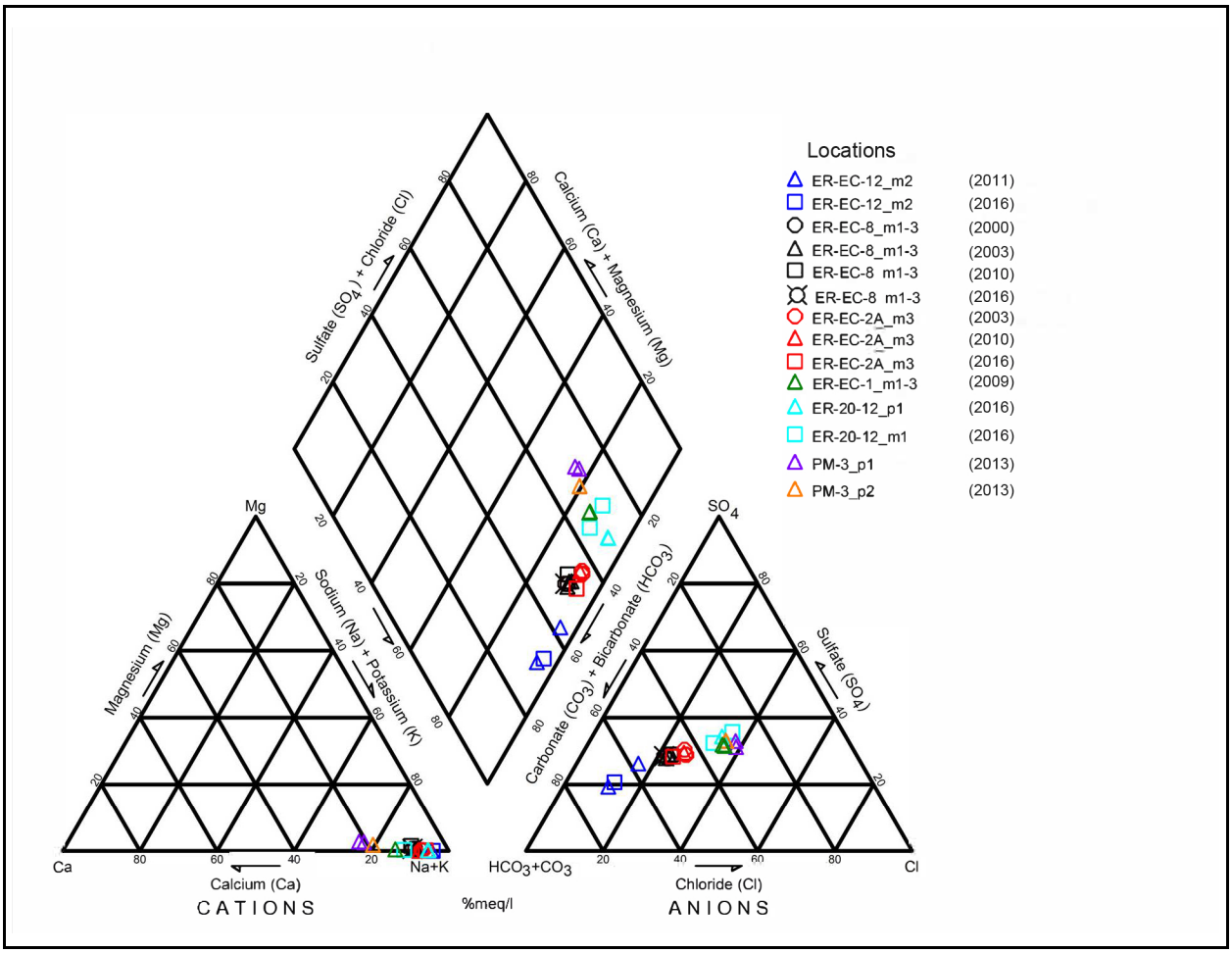


Figure 3-2
Piper Diagram Illustrating Groundwater
Major-Ion Chemistry of Pahute Mesa Characterization Samples

presented in Table B.2-1, and for specialized analysis of environmental tracers and noble gases by LLNL and $^{34/32}S$ by USGS (see Table B.2-2). The ^{3}H was reported as 34,000 and 33,600 pCi/L (ER-20-12_m1) and 18,900 and 18,600 pCi/L (ER-20-12_p1) for the samples and duplicates (see Table B.2-1).

The groundwaters from ER-20-12 are a mixed Na+K-HCO_3-SO_4-Cl type with roughly equal relative concentrations of HCO_3, Cl^-, and SO_4^{2-} (Figure 3-2). The samples also plot similarly to samples from PM-3 and ER-EC-1, which is expected to occur for samples collected along the same flowpath. This groundwater type is characteristic of groundwater that has moved through hydrothermally altered volcanic rocks with elevated levels of Cl^- and SO_4^{2-}(Kwicklis et al., 2005). Additional

geochemical analysis will be provided in a future report (*Well Development and Testing for ER-20-12 Report*).

3.2.2 ER-EC-12

ER-EC-12 is a characterization location. The well was drilled in 2010 to a depth of 4,069 ft. The well has two main completions separated by a bridge plug and three piezometers which access the TCA and TSA HSUs (see Figure C-8). A sample and duplicate were collected on July 20, 2016, with a submersible pump from the upper interval (ER-EC-12_m2) in the TCA HSU. The samples were analyzed for the characterization suite by the commercial laboratory (see Table B.2-1) as well as for DOC, $\delta^{13}C$ DOC, and ^{14}C by DRI and the University of Arizona; and for $^{34/32}S$ by USGS (see Table B.2-2). The purge volumes and field water-quality data are reported in Table 3-1. The results of the low-level ^{3}H analyses show no ^{3}H was detected above the MDC of 0.19 pCi/L by LLNL. ER-EC-12_m2 has been sampled two times (2011 and 2016) with no detection above the MDC of 2.99 pCi/L. The 2011 results are from the ER-EC-12_m1 completion and show no ^{3}H was detected above the MDC of 1.0 pCi/L. Groundwaters from 2011 and 2016 plot nearly identical and are an Na+K-HCO_3type (Figure 3-2).

3.2.3 ER-EC-8

ER-EC-8 is a characterization location that was drilled in 1999 to a depth of 2,000 ft. The well samples three intervals in the main completion (ER-EC-8_m1-3) across the FCCM, Buttonhook Wash welded-tuff aquifer (BWWTA), and Ammonia Tanks welded-tuff aquifer (ATWTA) HSUs (see Figure C-9). Samples were collected on September 29, 2016, using a dedicated submersible pump and analyzed for the characterization suite by the commercial laboratory (see Table B.2-1). They were also analyzed for DOC, $\delta^{13}C$ DOC, and ^{14}C by DRI and the University of Arizona; and for $^{34/32}S$ by USGS (see Table B.2-2). The purge volumes and field water-quality data are reported in Table 3-1, and the laboratory results are reported in Tables B.2-1 and B.2-2. No ^{3}H was detected above the MDCs of 3.79 and 3.66 pCi/L for the sample and duplicate. These results were for the reanalysis of the sample after the laboratory reported a value of 10.8 pCi/L for the duplicate. This value was determined to be the result of laboratory contamination based on the results from the regular sample and the reanalysis. ER-EC-8 has been sampled three times (2003, 2010, and 2016). These samples plot nearly identically on the Piper diagram and are an Na+K-HCO_3 type (Figure 3-2).

3.2.4 ER-EC-2A

ER-EC-2A is a characterization location that was drilled in 2000 to a depth of 4,974 ft. The well is completed with three main completion intervals that are separated by bridge plugs (see Figure C-10). On October 11, 2016, the shallow zone (ER-EC-2A_m3) was sampled with a dedicated ES pump. The purge volumes and field water-quality data are reported in Table 3-1. The results of the low-level ^{3}H analyses show no ^{3}H was detected above the MDC of 2.9 pCi/L (see Table B.2-1). The shallow zone of this well has been sampled three times (2003, 2010 and 2016). These samples plot very similarly to ER-EC-8 in Pahute Mesa on the Piper diagram (Figure 3-2), indicating similar relative major ion composition. ER-EC-2A is planned to be recategorized as a distal location.

3.2.5 PM-3

PM-3 is located outside the NNSS boundary on the Nevada Test and Training Range (NTTR) and is an early detection location. The well is completed with two piezometers: PM-3_p1 (deep) is screened across the TCA, and PM-3_p2 (shallow) is screened across the UPCU (see Figure C-11). PM-3 was the subject of an investigation to verify the presence of ^{3}H observed during annual monitoring in 2010 in PM-3_p2. As part of this investigation, both piezometers were developed and sampled using a jack pump in 2013 (N-I, 2015a). In 2014, depth-discrete-bailed samples were collected, and a discussion of these efforts and conclusions are reported in the UGTA Calendar Year 2014 Annual Sampling Analysis Report (NNSA/NFO, 2016a).

On September 13, 2016, samples were collected from both piezometers with a depth-discrete bailer. Field water-quality data are reported in Table 3-1, and laboratory results are presented in Table B.2-3. The ^{3}H in these samples were reported as 124 and 34.2 pCi/L for the sample and duplicate in PM-3_p1, and 194 and 185 pCi/L for the sample and duplicate in PM-3_p2. The large difference between the PM-3_p1 sample and the duplicate possibly represents impacts of bailing the sample. Figure 3-3 presents a graph of the previous samples from the commercial laboratory collected in PM-3. The samples collected in 2013 were pumped, and all other samples were collected with a bailer. The ^{3}H activity has decreased in the PM-3_p2 samples since the 2013 pumping. The high variability in the reported ^{3}H results makes detecting a trend in the PM-3_p2 samples difficult. Trends in the ^{3}H must consider the different sampling technologies used to collect the samples. Both are

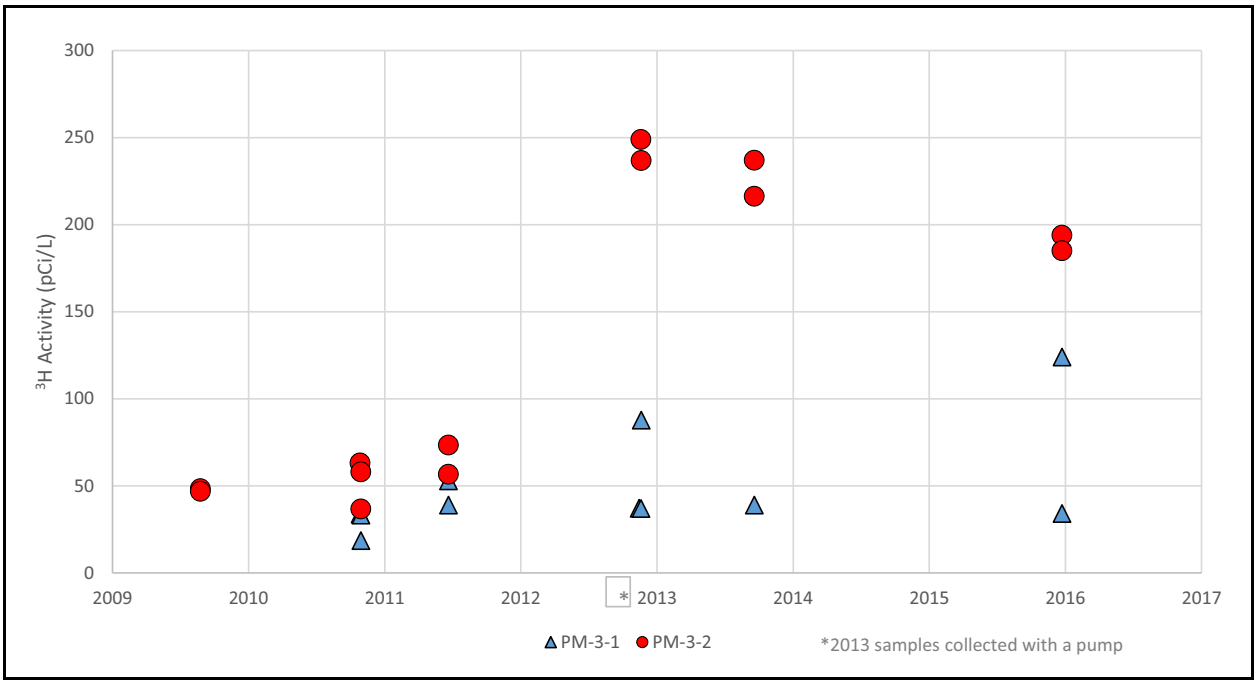


Figure 3-3
^{3}H Activities for PM-3 Samples
Note: ^{3}H activity (130 pCi/L) for the 2014 PM-3_p2 sample is not shown.

below the level (300 pCi/L) used to recategorize PM-3 to a source plume location. PM-3 will continue to be sampled every two years as an early detection location.

3.2.6 ER-EC-1

ER-EC-1 is distal location located on the NTTR but is planned to be recategorized as an early detection location in a future update to the Sampling Plan. The well was drilled in 1999 to a depth of 5,000 ft and completed with three screened intervals in the main casing. All three zones are open and connected; therefore, the sample is a composite across the following HSUs: CPA, UPCU, TCA, LPCU, TSA, CHZCM and CFCM. ER-EC-1 was pumped using a dedicated ES pump and was sampled on July 15, 2016. Two samples and duplicates were collected and analyzed for low-level ^{3}H (see Table B.2-4). No ^{3}H was detected above the MDCs of 2.87 and 3.05 by the commercial laboratory. The results reported by LLNL also indicate no ^{3}H detection (see Table B.2-4). The 0.37 pCi/L value reported by LLNL is considered a non-detect because it is less than the MDC (0.28 pCi/L) plus the error (0.14 pCi/L).

3.3 Rainier Mesa/Shoshone Mountain

Six wells were sampled in the RM/SM CAU: three characterization wells, ER-12-3 (Section 3.3.1), ER-12-4 (Section 3.3.2), and UE-18t (Section 3.3.3); one early detection well, ER-19-1 (Section 3.3.4); and two distal wells, UE-16d (Section 3.3.5) and WW-8 (Section 3.3.6). The analytical results for these samples are presented in Section B.3.0 of Appendix B. The Piper diagram presented in Figure 3-4 illustrates the difference between the 2016 samples (LTCU) and samples previously collected from ER-12-3_m1 (LCA3). The groundwater is an Na+K-HCO_3 type, typical of other volcanic groundwaters in the RM/SM CAU.

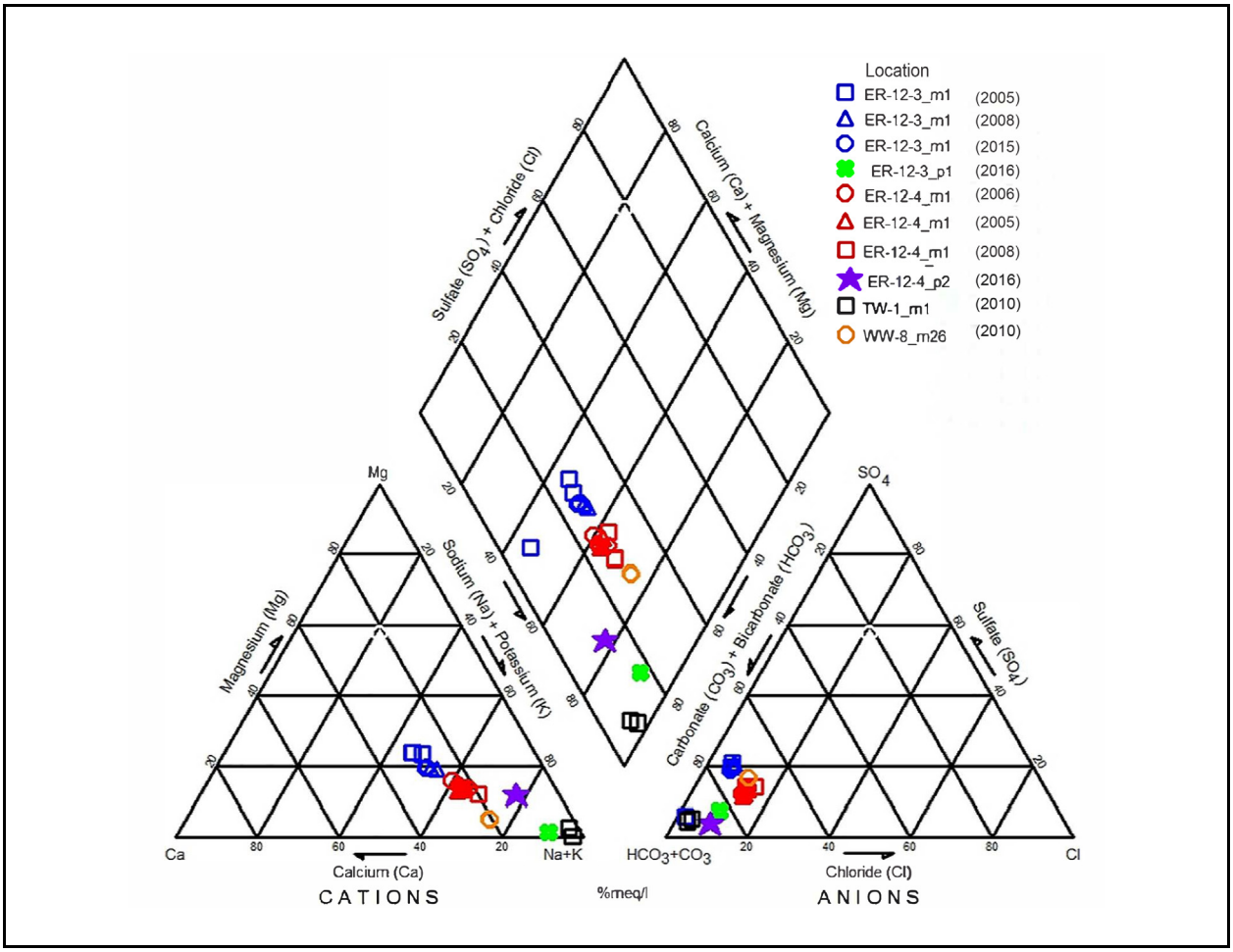


Figure 3-4
Piper Diagram Illustrating Groundwater Major-Ion Chemistry of RM/SM Samples

3.3.1 ER-12-3

ER-12-3 is completed to a depth of 4,908 ft bgs (see Figure C-12). The main completion (ER-12-3_m1) access the lower carbonate aquifer 3-Thrust plate (LCA3). The piezometer (ER-12-3_p1) is installed between the borehole wall and the 13.375-inch (in.) casing, and is open to the LTCU, OSBCU, and ATCU HSUs. Groundwater samples were collected from the piezometer with a bailer on July 26, 2016, and with a jack pump on September 7, 2016. The bailed sample was analyzed for low-level ^{3}H, and the pumped sample was analyzed for the characterization suite by the commercial laboratory (see Table B.3-1). Analyses of environmental tracers and noble gases were conducted by LLNL (see Table B.3-2). The purge volumes and field water-quality data are reported in Table 3-1.

For the bailed sample and duplicate collected in July, the commercial laboratory reported ^{3}H at 21.6 and 23.5 pCi/L (see Table B.3-1), and LLNL reported ^{3}H at 22.25 and 21.03 pCi/L (see Table B.3-2). In the pumped sample, ^{3}H was also detected at 24.4 and 27.3 pCi/L in the sample and duplicate, respectively (see Table B.3-1) from the commercial laboratory. No other RNs were detected in the pumped sample.

3.3.2 ER-12-4

ER-12-4 was drilled to a depth of 3,023 ft bgs with the main completion and two piezometers (see Figure C-13). The main completion (ER-12-4_m1) and deep piezometer (ER-12-4_p1) access the LCA3. The shallow piezometer (ER-12-4_p2) is installed between the borehole wall and the 13.375-in. casing, and is open to the lower vitric-tuff aquifer (LVTA), Belted Range confining unit (BRCU), LTCU, and OSBCU HSUs.

On September 22, 2016, samples were collected with a bailer from ER-12-4_p2. This is the first time ER-12-4_p2 has been sampled. The field water-quality data are reported in Table 3-1. The reduced characterization suite for bailed sample was analyzed for these samples (see Table B.3-1). Tritium was detected at 7.62 pCi/L by the commercial laboratory with the low-level detection method.

The Piper diagram presented in Figure 3-4 illustrates an Na+K-HCO_3 hydrochemical facies, typical of other volcanic groundwaters in the RM/SM CAU.

3.3.3 UE-18t

UE-18t is a characterization well southwest of the E-Tunnel complex on Rainier Mesa. The well was drilled as an exploratory hole to a depth of 2,600 ft. The completion consists of a 2.375-in. casing installed to 1,896 ft and is an open borehole in the Rainier Mesa welded-tuff aquifer (RMWTA) from 1,896 to 2,600 ft (see Figure C-14). Purge volumes and field water-quality data are reported in Table 3-1. Samples were collected from the piezometer (p1) with a submersible pump and were analyzed for the full characterization suite (see Table B.3-1). Two samples and duplicates were collected and analyzed for low-level ^{3}H. The results of the low-level ^{3}H analyses show no ^{3}H was detected above the MDC of 3.07 pCi/L.

3.3.4 ER-19-1

ER-19-1 is completed to a depth of 3,595 ft bgs (see Figure C-15) with two screens across the LCCU in the main completion and two piezometers completed in the PBRCM. On November 17, 2016, the two piezometers (ER-19-1_p1 and ER-19-1_p2) were sampled with a bailer for low-level ^{3}H. Two samples and duplicates from each piezometer show no ^{3}H was detected in ER-19-1_p1 above the 2.87-pCi/L MDC and ER-19-1_p2 above the 2.99-pCi/L MDC (see Table B.3-3). The 3.31-pCi/L value reported is considered a non-detect because it is less than the MDC (3.09 pCi/L) plus the error (1.98 pCi/L).

3.3.5 UE-16d

UE-16d is a distal location currently used for construction water supply and is monitored annually by the M&O contractor. A sample was collected from this well on January 26, 2016, and analyzed for ^{3}H using the standard method. No ^{3}H was detected above the 180 pCi/L MDC (see Table B.3-4).

3.3.6 WW-8

WW-8 is both a distal and public water supply well, and is sampled quarterly by the M&O contractor. This well has been used for water supply since 1963. In 2016, quarterly samples were analyzed for ^{3}H and gross alpha and gross beta (see Table B.3-4). No ^{3}H was detected above the MDCs (110 to 236 pCi/L). Gross alpha and gross beta radioactivity were found at concentrations slightly

greater than their MDCs in a few of the 2016 samples and are believed to represent the presence of naturally occurring RNs.

3.4 Yucca Flat/Climax Mine

The CAI stage of the UGTA strategy has been completed for the YF/CM CAU. The flow and transport model was completed and reviewed by an external peer review committee (N-I, 2015b) and responses to the PRC were completed (Navarro, 2016a). Sampling in 2016 was performed in support of the CADD/CAP model evaluation (DOE/EMNV, 2017b) and included two new characterization wells, ER-3-3 (Section 3.4.1) and ER-4-1 (Section 3.4.2); and one source/plume well, UE-2ce (Section 3.4.3). The analytical results for these samples are presented in Section B.4.0 in Appendix B.

3.4.1 ER-3-3

ER-3-3 was drilled in 2016 and is completed with three piezometers and two screened intervals in the main completion (see Figure C-16). The well has one main completion interval from 3,018 to 3,097 ft bgs (ER-3-3_m1) in the LCA and a second main completion interval from 2,203 to 2,441 ft bgs in the LTCU, Timber Mountain lower vitric-tuff aquifer (TMLVTA), TMWTA, and Timber Mountain upper vitric-tuff aquifer (TMUVTA) separated by a bridge plug at 2,560 ft bgs. The deep piezometer is completed across the LCA from 2,999 to 3,091 ft bgs (ER-3-3_p1). A second piezometer is completed across the TMLVTA, TMWTA, and TMUVTA from 2,203 to 2,444 ft bgs (ER-3-3_p2). The third piezometer is completed across the TMUVTA from 1,760 to 1,880 ft bgs (ER-3-3_p3).

Groundwater sampling of the main completion and piezometers was conducted at the end of the well development and testing activity. On November 9, 2016, bailed samples were collected from ER-3-3_p1 and ER-3-3_p2 (see Table B.3-1). The third piezometer (ER-3-3_p3) was not sampled after it was determined to be impacted by drilling fluids. After purging approximately 9,461 gal of groundwater using a pump, samples were collected from ER-3-3_m1. The field water-quality data are reported in Table 3-1. Samples were analyzed for the full characterization suite by the commercial laboratory (see Table B.4-1). Additional samples were collected for environmental tracers and noble gas analysis were conducted by LLNL (see Table B.4-2). The commercial laboratory did not detect ^{3}H above the MDCs of 310 pCi/L in the piezometers and main completion. Additional

geochemical analysis will be provided in a future report (*Well Development and Testing for ER-3-3 and ER-4-1 Report*).

3.4.2 ER-4-1

ER-4-1 is a characterization well that was drilled and completed in 2016. Samples were bailed during drilling operations and are reported in the *Completion Report for Well ER-4-1 Corrective Action Unit 97: Yucca Flat/Climax Mine* (DOE/EMNV, 2017a). A sample was collected from the discharge during drilling from the LCA, and ^{3}H is reported as <2.16 pCi/L. Additional geochemical analysis will be provided in a future report (*Well Development and Testing for ER-3-3 and ER-4-1 Report*). Sampling for the full characterization suite is planned in 2017 after the well has been developed.

3.4.3 UE-2ce

UE-2ce is a source/plume well that was completed on January 25, 1977. The well has been extensively pumped and sampled over its history. The nearest UGT is NASH (U-2ce), located 600 ft to the southeast. Samples collected in 2008 and 2001 by Los Alamos National Laboratory (LANL) had reported average ^{3}H activities of 147,500 and 261,875 pCi/L. The well was drilled to a depth of 1,650 ft and has a main completion interval from 1,378 to 1,624 ft bgs in the LCA (see Figure C-17). Samples were collected from December 14 to 16, 2016, from UE-2ce_m1. Time-series ^{3}H sampling was conducted to evaluate the concentrations ^{3}H and COPCs as a function of the purge volume. Field measurements at the time of sampling are presented in Table 3-1. This will be evaluated as part of the model evaluation and documented in a subsequent report.

The ^{3}H activities were reported by the commercial laboratories as 120,000, 134,000, 134,000, 142,000 and 144,000 pCi/L (see Table B.4-3). LLNL has not yet reported a ^{3}H activity and other COPCs (^{36}Cl and ^{137}Cs) (see Table B.4-4).

4.0 Quality Assurance/Quality Control

This section summarizes QA/QC results associated with 2016 Sampling Plan implementation. The data verification and validation process, QC sample results, and nonconformances are presented. Sampling and analysis methods associated with Sampling Plan implementation are described in Section 2.0, and the associated requirements are identified in the UGTA QAP (NNSA/NFO, 2015a). The QAP provides a systematic approach to evaluate analytical data that are essential to sustaining data quality.

Data verification reviews for compliance and completeness of commercial laboratory data packages were performed on all UGTA packages to ensure documentation was complete. Sampling information was reviewed (e.g., preservation, temperature, chain-of-custody documentation and analytical hold-time compliance). Upon completion of data verification, data validation was performed to determine analytical quality. This included evaluations of instrument calibrations, QC and sample results, standard reference material certifications, and their appropriateness of use. UGTA 2016 analytical data were acceptable for use. Several data points were estimated and annotated with qualifying flags; explanations are described within the text below. No data were rejected.

NDEP Bureau of Safe Drinking Water certified laboratories were used for the analyses required by the Sampling Plan (Table 1-1). These certifications meet National Environmental Laboratory Accreditation Program credentials. For analyses/analytes not certified by NDEP, the Navarro Analytical Services department reviews laboratories' performance evaluation program results, demonstrations of capability, and procedures for the analytes of concern for acceptability of use. Additional analyses may be performed by non-certified laboratories. Commercial laboratories (ALS Laboratory Group; GEL Laboratories, LLC; and American Radiation Services, Inc.) are certified by the State of Nevada. DRI, LLNL, LANL, and USGS provide analytical data not available from commercial laboratories.

Analytical processes routinely include laboratory QC samples such as duplicates, blanks, and spikes; and field QC samples such as field blanks, equipment rinsates, and field duplicates (FDs). Laboratory QC samples used to measure precision and accuracy are analyzed with each batch of samples submitted for analysis. When QC criteria are exceeded, associated sample results are considered to be

estimated. Estimated data, as determined by the validation process, are identified in the database and records packages with a "J" qualifier. Documentation of data qualifications are retained in the Navarro Analytical Services and Geochemistry databases (Navarro, 2017a and c) and in the data packages located in Navarro's Central Files and the Technical Data Repositories.

4.1 Accuracy

Accuracy is defined as the nearness of a measurement to the true or accepted reference value. Laboratory control samples (LCSs) are analyzed by the laboratories to evaluate method accuracy; matrix spikes (MSs) are analyzed to evaluate the effect of the sample matrix on method accuracy; and tracers are used to determine accuracy for certain radiochemical analytes. In all cases (LCSs, MSs, and tracers), samples are spiked with known concentrations, prepared, and analyzed; then results are expressed as a recovery percentage or chemical yield.

Radiochemistry

LCS results were acceptable with the exception of three analytes (^{14}C, ^{129}I, and gross alpha). Twenty percent of the ^{14}C results were qualified for accuracy because the LCSs were reported outside of the required control limits. The previous reporting year, the Navarro Analytical Services department reported a trend for failing ^{129}I to the laboratory, and a nonconformance report (NCR) was initiated. The root cause analysis determined that the National Institute of Standards and Technology (NIST) standard used to spike the LCSs was defective. In CY 2016, LCS recoveries were acceptable, indicating that the corrective action taken by the laboratory was sufficient. Seven percent of gross alpha results were estimated because their associated MSs exceeded control criteria.

All other sample results were reported with LCS, MS, and tracer recoveries within the control limits.

Inorganic Chemistry

Six percent of SO_{4-2} and 4 percent each of the results for alkalinity and bicarbonate alkalinity as $CaCO_3$ were estimated because their associated LCS exceeded control criteria. Sixteen, 2, 2, 19, 4, and 4 percent, respectively, for each of the results for Cl, Al, Fe, Li, alkalinity, and bicarbonate alkalinity as $CaCO_3$ were estimated because their associated MSs exceeded control criteria. The Li and Fe failures were deemed due to matrix interferences in the samples causing failed recoveries in

the spike. One result for Ag was rejected because the matrix spike grossly exceeded the control criteria. When evaluating the high Cl content of the sample as evidenced by the reported value, it was apparent that either precipitated out as AgCl or that the metal had photo-reduced in its container. All other sample results had LCS and MS results that were within the control limits.

Additionally, calibration verification and/or quantitation limit check standard criteria were not met for Ca, Fe, and Na analyses. Associated data were estimated and flagged with a "J" qualifier. Control limits associated with serial dilutions were exceeded for Li, Mn, K, Sr, and U. The associated sample results were qualified as estimates because of the potential for a matrix effect.

4.2 Precision

Precision is a measure of the reproducibility of the measurement process. FD samples were used to evaluate overall precision of the measurement process, including variability resulting from sampling, sample preparation, and analysis. The relative percent difference (RPD) between the FD result and the corresponding sample result is a measure of the variability in the process caused by the sampling uncertainty (e.g., matrix heterogeneity, collection variables) and measurement uncertainty (field and laboratory). When results are greater than 10 times the MDCs or minimum detection limits (MDLs), RPD control limits are set at 25 percent; when this value is exceeded, it indicates the reported results do not meet QA requirements and thus are considered for further evaluation. One hundred fifteen groundwater samples were collected and submitted to commercial laboratories for analyses in 2016; of the 115, 48 were FDs. Sixty-eight samples (19 of which were FDs) were collected and submitted to UGTA participating laboratories (USGS, LLNL, DRI).

Laboratory duplicate samples are used to evaluate overall precision of the sample preparation and measurement process. The RPD between the laboratory duplicate result and the corresponding field sample result should correspond more precisely than between field and FD samples because they do not include variability from sampling. As a result, the control limits are more restrictive for laboratory duplicates than for FDs. The control limits are different depending on whether the analysis is for radiochemistry or inorganic chemistry. Inorganic chemistry includes general chemistry and metals as shown in Table 2-3.

Radiochemistry

Control limits for laboratory duplicates (split samples) are dependent on the level of the analyte for radiochemistry. If the analyte is present at greater than or equal to five times the MDC, the RPD must agree within 20 percent (control limit); and if the analyte is present at less than five times the MDC, the normalized difference (ND) must be between -2 and 2. The ND is calculated as the difference between two results divided by the square root of the sums of the squares of their total propagated uncertainties. Seven percent of gross alpha, 14 percent of gross beta, 3 percent of thorium-227 (^{227}Th), and 9 percent of low-level ^{3}H data were estimated because their associated duplicate samples exceeded control criteria.

Inorganic Chemistry

Control limits for laboratory duplicates (split samples) are dependent on the level of the analyte with respect to its reporting limit (RL) for inorganic chemistry. The RL is the concentration that the laboratory must be able to detect in a sample and is generally less than 10 percent of the analyte's MCL. If the analyte is present at greater than or equal to five times the RL, the RPD must not exceed 20 percent; and if the analyte is present at less than five times the RL, the absolute difference (AD) must not be above the RL (this criterion is used because increased uncertainty occurs when results are reported at levels at or near instrument and method sensitivity levels). Two percent of Al and 5 percent of Fe data were estimated because their associated duplicate samples exceeded control criteria.

4.3 Blank Samples

Blank samples have not been exposed to sample streams and are analyzed to monitor contamination that might be introduced during sampling, transport, storage, or analysis. Blanks establish background values and are sometimes used to adjust or correct analytical results. The four types of blanks used are as follows:

- Equipment blanks (i.e., analyte-free media used to rinse sampling equipment)
- Field blanks (reagent water used to measure ambient sampling conditions)
- Laboratory method blanks (MBs)
- Preparation blanks

These QC samples are used to assess reporting false positive results. Exceedances are defined as the number of blank samples with analytes detected above the MDC plus the 2 sigma (σ) error for radiochemistry and the number of blank samples with analytes detected above the MDL for general chemistry. For radiochemistry, there were no RNs detected above the blank control criteria.

For general chemistry, contamination was observed in one laboratory blank for Ba. The associated sample result was qualified as non-detect ("U" flag).

4.4 Other Quality-Related Issues

One sample's results for Cl and SO_4^{-2} were qualified because the sample was analyzed outside of the required holding time. The laboratory issued an NCR because this was an accidental oversight. Another sample was received by the laboratory with insufficient time to prepare and analyze the sample before the required holding time for sulfide. Thus, the result for this sample was estimated.

There are other reasons for estimating results than those described in the aforementioned discussion. One hundred percent of pH data was estimated because the samples were received at the laboratory after the required holding time. The holding time for pH is 24 hours, and all shipments are to offsite laboratories, so missing the holding time is unavoidable. Although data may be qualified, that does not necessarily mean that the data are inaccurate; instead, it may mean that some form of documentation or associated QC does not meet requirements. These qualifiers are flags to the data users, so that the associated data are evaluated based on their intended use.

5.0 Regulatory Requirements

5.1 Environmental Compliance

A Well-Specific Fluid Management Strategy Letter is required by the Fluid Management Plan (FMP) (NNSA/NSO, 2009) and approved by NDEP. Typically, the letter provides the site layout, specifies the number and kind of containment to be constructed to support fluid management, and dictates onsite monitoring requirements and transition contingencies. Deviations or special requirements not included in the FMP are also addressed by the strategy letter.

As specified in the Well-Specific Fluid Management Strategy for each well, all fluids generated during sampling operations with ^{3}H activity greater than 400,000 pCi/L were contained in the onsite lined sumps or discharged to designated infiltration areas. Each well pad has two sumps with one of the sumps incorporating an overflow pipe to allow for discharge to the ground surface. During the pumping phase at each well site, fluids were pumped through the main discharge line or the bypass discharge line. Both lines were routed to the sump that incorporates the overflow pipe. The total volume of fluid discharged to each sump was documented, and an FMP sample was collected from the sump at the end of discharge (Table 5-1).

In accordance with the FMP, ^{3}H monitoring samples were collected daily from the discharge line during fluid-generating activities. The results of onsite ^{3}H monitoring were compared to the FMP discharge criteria.

Depth-discrete bailer samples do not produce discharge; therefore, an FMP sample is not required.

5.1.1 FMP Sampling on Frenchman Flat

In Frenchman Flat, wells ER-5-5, ER-5-3-2, UE-5n, and RNM-2S were pumped and discharged to a sump or infiltration area. All FMP sample results (metals, gross alpha, gross beta, and ^{3}H) were below the FMP criteria (Table 5-2). The highest ^{3}H result was from UE-5n, with a concentration of 132,000 pCi/L. The gross alpha measurement from UE-5n was 3.1 pCi/L, and the gross beta was 7.8 pCi/L.

Table 5-1
Discharge Volumes to Sump or Infiltration Area

Site	Date	Sump No.	Volume (gal)	Lined	FMP Criteria Met
Frenchman Flat (CAU 98)					
ER-5-5	05/16/2016	2	7,343	Yes	Yes
ER-5-3-2	05/19/2016	1	39,466	No	Yes
UE-5n	05/05/2016	Infiltration Area	39,720	N/A	Yes
RNM-2S	05/10/2016	Cambric Ditch	124,880	N/A	Yes
Pahute Mesa (CAUs 101 and 102)					
ER-20-12_m1	08/19/2016	1	32,692	Yes	Yes
ER-20-12_p1	07/06/2016	1	23,586	Yes	Yes
ER-EC-12	07/20/2016	1	62,665	No	Yes
ER-EC-8	09/29/2016	1	38,382	No	Yes
ER-EC-2A	10/11/2016	1	40,962	No	Yes
ER-EC-1	07/15/2016	1	49,129	No	Yes
RM/SM (CAU 99)					
ER-12-3	09/07/2016	2	4,690	No	Yes
UE-18t	10/28/2016	1	7,342	No	Yes
YF/CM (CAU 97)					
ER-3-3	12/15/2016	1	9,461	Yes	Yes
UE-2ce	12/16/2016	Infiltration Area	58,547	N/A	Yes

5.1.2 FMP Sampling on Pahute Mesa

On Pahute Mesa, wells ER-20-12, ER-EC-12, ER-EC-8, ER-EC-2A, and ER-EC-1 were pumped and discharged to a sump. All FMP sample results (metals, gross alpha, gross beta, and ^{3}H) were below the FMP criteria (Table 5-2). The highest ^{3}H result was from ER-20-12, with a concentration of 31,000 pCi/L. Gross alpha measurement from ER-20-12 was 8.5 pCi/L, and the gross beta was 7.2 pCi/L.

5.1.3 FMP Sampling on Rainier Mesa

On Rainier Mesa, two wells (ER-12-3 and UE-18t) were pumped and discharged to the sump (Table 5-1). Groundwater produced from the purging of ER-12-3 was directed into an unlined sump at the well site. Activities at ER-12-4 included bailer sample collection. Groundwater from distal wells (UE-16d and WW-8) sampling was discharged to the ground. All FMP samples were below the criteria (Table 5-2).

5.1.4 FMP Sampling in Yucca Flat

In Yucca Flat, well ER-3-3 was discharged to a sump, and well UE-2ce was discharged to an infiltration area. Groundwater produced from the purging of ER-3-3 was directed into a lined sump at the well site. Daily ^{3}H and wellhead sampling port results met FMP criteria.

A sample was collected from ER-4-1 for ^{3}H analysis from the drilling discharge. Tritium activities were below detection limits (<2.16 pCi/L), and all FMP samples collected during drilling were below the criteria.

Sampling activities UE-2ce at included collection of the initial discharge ^{3}H, ^{3}H time-series, groundwater characterization, and FMP samples. Results from the FMP samples collected at well UE-2ce were below criteria limits for discharge of fluids to an infiltration area (Table 5-2).

Table 5-2
Fluid Management Decision Criteria Limits
(Page 1 of 2)

FMP Parameters	RCRA Levels	FMP Criteria [a]	5 × FMP Criteria [b]	20 × FMP Criteria [c]
Arsenic	5.0 mg/L	0.010 mg/L	0.050 mg/L	0.2 mg/L
Barium	100.0 mg/L	2 mg/L	10 mg/L	40 mg/L
Cadmium	1.0 mg/L	0.005 mg/L	0.025 mg/L	0.1 mg/L
Chromium	5.0 mg/L	0.100 mg/L	0.500 mg/L	2 mg/L
Lead	5.0 mg/L	0.015 mg/L	0.075 mg/L	0.3 mg/L
Selenium	1.0 mg/L	0.050 mg/L	0.250 mg/L	1 mg/L
Silver	5.0 mg/L	0.100 mg/L	0.500 mg/L	2 mg/L
Mercury	0.2 mg/L	0.002 mg/L	0.010 mg/L	0.04 mg/L

Table 5-2
Fluid Management Decision Criteria Limits
(Page 2 of 2)

FMP Parameters	RCRA Levels	FMP Criteria [a]	5 × FMP Criteria [b]	20 × FMP Criteria [c]
Gross Alpha	N/A	15 pCi/L	75 pCi/L	300 pCi/L
Gross Beta	N/A	50 pCi/L	250 pCi/L	1,000 pCi/L
Tritium	N/A	20,000 pCi/L	100,000 pCi/L	400,000 pCi/L

[a] Limit for discharge to the ground surface for wells outside NNSS or as designated in the Well-Specific Fluid Management Strategy Letter.
[b] Limit for discharge to the ground surface for wells inside the NNSS.
[c] Limit for discharge to an unlined sump or infiltration area for wells inside the NNSS.

6.0 Summary and Conclusions

The NNSS Integrated Groundwater Sampling Plan ensures routine sampling that is critical to understanding contaminant transport near and downgradient of the underground nuclear testing areas. Analytical data are generated in compliance with the UGTA QAP (NNSA/NFO, 2015a), FFACO (1996, as amended), and DOE Order 458.1 (DOE, 2013).

The maximum ^{3}H concentrations for the most current samples from each Sampling Plan location are presented in Appendix A. These data are summarized for each location type and CAU in Table 6-1. Table 6-1 identifies the location type in each CAU, the number (n) of ^{3}H detections for each location type (>MDC), and the number of locations where ^{3}H has exceeded the 20,000-pCi/L MCL (>MCL). It is important to note that while in some cases (e.g., Frenchman Flat), there are currently no early detection or distal locations; the characterization locations will likely be transitioned into these types once a baseline has been established.

Table 6-1
Number of ^{3}H Measurements (n), Detections (>MDC), and MCL Exceedances (>MCL) for Each Location Type and CAU

CAU	Criteria	Characterization	Source/Plume	Early Detection	Distal	Community
Frenchman Flat	n	3	3	0	0	0
	>MDC	0	3	0	0	0
	>MCL	0	2	0	0	0
Pahute Mesa	n	27	10	7	2	9
	>MDC	14	10	3	0	0
	>MCL	3	8	0	0	0
Rainier Mesa [a]	n	9	2	0	6	0
	>MDC	3	2	0	1	0
	>MCL	0	2	0	0	0
Yucca Flat	n	8	5	5	1	0
	>MDC	2	5	0	0	0
	>MCL	0	3	0	0	0

[a] No ^{3}H data are available for three characterization and one distal location.

A total of 20 wells (25 separate intervals) (Table 2-1) were sampled in 2016 to directly support the Sampling Plan. The analytical results for all of these samples are presented in Appendix B, except the results not received by the time of this report. Those results will be presented in the 2017 Sampling Analysis Report. Samples were collected from five UGTA CAUs.

Fifteen characterization locations were sampled in 2016: three in Frenchman Flat, seven in Pahute Mesa, three in RM/SM, and two in YF/CM. Of these locations, six were sampled using a bailer (ER-5-3_p2, ER-20-12_p3, ER-20-12_p4, ER-12-3_p1, ER-12-4_p2, and ER-3-3_p1). Nine of the remaining locations were sampled using a pump for the full characterization suite. Results from the characterization samples were consistent with previously collected samples, as shown in the Piper diagrams for each CAU.

Three source/plume locations were sampled in 2016: two in Frenchman Flat (RNM-2S and UE-5n) and one in YF/CM in 2016 (UE-2ce). The ^{3}H activity exceeded the MCL for both locations in Frenchman Flat but has decreased since 2014. Most of the other RNs analyzed by the commercial laboratory and LLNL are below the analytical detection limits. In YF/CM, UE-2ce was sampled for RN analysis by the commercial laboratory. Most of the RNs analyzed by the commercial laboratory are below the analytical detection limits. Gross alpha detected at 19.7 with an duplicate value of 17.8 pCi/L, and gross beta detected 21 and 20.1 pCi/L. Tritium results report 120,000 to 144,000 pCi/L.

Four early detection locations were sampled in 2016: two in Pahute Mesa (PM-3_p1 and PM-3_p2) and two in RM/SM (ER-19-1_p1 and ER-19-1_p2). These samples were bailed from the wells, and the low-level ^{3}H results show no detection for ER-19-1_p1 or ER-19-1_p2. PM-3_p1 reports a result of 34.2 and 124 pCi/L, and PM-3_p2 reports 194 and 185 pCi/L for the sample and a duplicate.

Three distal well locations were sampled in 2016: one in Pahute Mesa (ER-EC-1_m1-3) and two in RM/SM (UE-16d WW_m1 and WW-8_m26). Distal wells are located potentially downgradient of testing, and no ^{3}H was detected in the samples.

No community wells were sampled in 2016.

7.0 References

ASTM, see ASTM International.

ASTM International. 2015. *Standard Test Method for Plutonium in Water,* ASTM D3865-09(2015). West Conshohocken, PA.

CFR, see *Code of Federal Regulations.*

Code of Federal Regulations. 2016. Title 40 CFR Part 141, "National Primary Drinking Water Regulations." Washington, DC: U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

DOE/EMNV, see U.S. Department of Energy Environmental Management Nevada Program.

EPA, see U.S. Environmental Protection Agency.

FFACO, see *Federal Facility Agreement and Consent Order.*

Federal Facility Agreement and Consent Order. 1996 (as amended March 2010). Agreed to by the State of Nevada; U.S. Department of Energy, Environmental Management; U.S. Department of Defense; and U.S. Department of Energy, Legacy Management. Appendix VI, which contains the Underground Test Area Strategy, was last modified June 2014, Revision No. 5.

Fenelon, J.M., D.S. Sweetkind, and R.J. Laczniak. 2010. *Groundwater Flow Systems at the Nevada Test Site, Nevada: A Synthesis of Potentiometric Contours, Hydrostratigraphy, and Geologic Structures,* Professional Paper 1771. Reston, VA: U.S. Geological Survey.

Finnegan, D.L., S.M. Bowen, J.L. Thompson, C.M. Miller, P.L. Baca, L.F. Olivas, C.G. Geoffrion, D.K. Smith, W. Goishi, B.K. Esser, J.W. Meadows, N. Namboodiri, and J.F. Wild. 2016. *Nevada National Security Site Radionuclide Inventory, 1951–1992: Accounting for Radionuclide Decay through September 30, 2012,* LA-UR-16-21749. Los Alamos, NM: Los Alamos National Laboratory.

Kwicklis, E.M., T.P. Rose, and F.C. Benedict, Jr. 2005. *Evaluation of Groundwater Flow in the Pahute Mesa-Oasis Valley Flow System Using Groundwater Chemical and Isotopic Data,* LA-UR-05-4344. Los Alamos, NM: Los Alamos National Laboratory.

Navarro GIS, see Navarro Geographic Information Systems.

N-I, see Navarro-Intera, LLC.

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office.

NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

NSTec, see National Security Technologies, LLC.

National Security Technologies, LLC. 2016. Written communication. Subject: "Preparing and Sampling Routine Radiological Environmental Monitoring Plan (RREMP) Water Locations," SOP-P420.104. Las Vegas, NV.

Navarro. 2016a. *Response to External Peer Review Team Report for Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada National Security Site, Nye County, Nevada,* Rev. 1, N/0002653--031-REV. 1. Las Vegas, NV.

Navarro. 2016b. Written communication. Subject: "Standards-Based Management System." Las Vegas, NV.

Navarro. 2016c. *Water Pollution Control Permit NEV 96021, E-Tunnel Wastewater Disposal System Quarterly Monitoring Report and Annual Summary, Nevada National Security Site, Fourth Quarter, Calendar Year 2015.* Prepared for U.S. Department of Energy, National Nuclear Security Administration, Nevada Field Office. Las Vegas, NV.

Navarro. 2017a. Written communication. Subject: "Analytical Services Database." Las Vegas, NV.

Navarro. 2017b. Written communication. Subject: "UGTA Chemistry Database (UCDB)," UGTA Technical Data Repository Database Identification Number UGTA-4-1197. Las Vegas, NV.

Navarro. 2017c. Written communication. Subject: "UGTA Geochemistry Database," UGTA Technical Data Repository Database Identification Number UGTA-4-129. Las Vegas, NV.

Navarro Geographic Information Systems. 2017. ESRI ArcGIS Software.

Navarro-Intera, LLC. 2012. *Field Instruction for the Underground Test Area Activity Well Development, Hydraulic Testing, and Groundwater Sampling*, Rev. 1, N-I/28091--028-REV. 1. Las Vegas, NV.

Navarro-Intera, LLC. 2013. *Yucca Flat/Climax Mine CAU Flow and Transport Model, Nevada National Security Site, Nye County, Nevada,* Rev. 0, N-I/28091--065. Las Vegas, NV.

Navarro-Intera, LLC. 2014. *Model Evaluation Report for Corrective Action Unit 98: Frenchman Flat, Nevada National Security Site, Nye County, Nevada*, Rev. 1, N-I/28091--088. Las Vegas, NV.

Navarro-Intera, LLC. 2015a. *Evaluation of PM-3 Chemistry Data and Possible Interpretations of ^3H Observations,* Rev. 0, N-I/28091--092. Las Vegas, NV.

Navarro-Intera, LLC. 2015b. *External Peer Review Team Report for Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada National Security Site, Nye County, Nevada*, Rev. 0, N-I/28091--091. Las Vegas, NV.

Pohlmann, K., J. Healey, B, Lyles, C., Cooper, and R.L. Hershey. 2017. *Hydrophysical Evaluation of Wells TW-B, TW-7, UE-6d, U-2gg PSE 3A, U-10L 1, and UE-6e in Yucca Flat,* DOE/NV/0000939-40; Publication No. 45274. Las Vegas, NV: Desert Research Institute, Division of Hydrologic Sciences.

Reimus, P.W., and H. Boukhalfa. 2014. *Chancellor Water Colloids: Characterization and Radionuclide Associated Transport*, LA-UR-14-27538-MS. Los Alamos, NM: Los Alamos National Laboratory.

Rose, T.P., F.C. Benedict, Jr., J.M. Thomas, W.S. Sicke, R.L. Hershey, J.B. Paces, I.M. Farnham, and Z.E. Peterman. 2006. *Geochemical Data Analysis and Interpretation of the Pahute Mesa-Oasis Valley Groundwater Flow System, Nye County, Nevada, August 2002*, UCRL-TR-224559. Livermore, CA: Lawrence Livermore National Laboratory; Reno, NV: GeoTrans, Inc., and Desert Research Institute; Denver, CO: U.S. Geological Survey; and Las Vegas, NV: Harry Reid Center for Environmental Studies.

Rose, T.P., Q. Hu, P. Zhao, C.L. Conrado, R. Dickerson, G.F. Eaton, A.B. Kersting, J.E. Moran, G. Nimz, B.A. Powell, E.C. Ramon, F.J. Ryerson, R.W. Williams, P.T. Wooddy, and M. Zavarin. 2011. *Radionuclide Partitioning in an Underground Nuclear Test Cavity*, LLNL-TR-409817. Livermore, CA: Lawrence Livermore National Laboratory.

SNJV, see Stoller-Navarro Joint Venture.

Stoller-Navarro Joint Venture. 2006. *Geochemical and Isotopic Evaluation of Groundwater Movement in Corrective Action Unit 97: Yucca Flat/Climax Mine, Nevada Test Site, Nevada*, Rev. 0, S-N/99205--070. Las Vegas, NV.

Thomas, J.M., F.C. Benedict, Jr., T.P. Rose, R.L. Hershey, J.B. Paces, Z.E. Peterman, I.M. Farnham, K.H. Johannesson, A.K. Singh, K.J. Stetzenbach, G.B. Hudson, J.M. Kenneally, G.F. Eaton, and D.K. Smith. 2002. *Geochemical and Isotopic Interpretations of Groundwater Flow in the Oasis Valley Flow System, Southern Nevada,* DOE/NV/11508-56; Publication No. 45190. Las Vegas, NV: Desert Research Institute.

U.S. Department of Energy. 1997. *The Procedures Manual of the Environmental Measurements Laboratory,* HASL-300. 28th Edition, Vol. I. February. New York, NY.

U.S. Department of Energy. 2006. *Nevada Test Site Environmental Management End State Vision*, DOE/NV--958. Prepared by the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. Las Vegas, NV.

U.S. Department of Energy. 2013. *Radiation Protection of the Public and the Environment*, DOE Order 458.1, Change 3. Washington, DC: Office of Health, Safety and Security.

U.S. Department of Energy Environmental Management Nevada Program. 2017a. *Completion Report for Well ER-4-1 Corrective Action Unit 97: Yucca Flat/Climax Mine,* DOE/NV--1576. Las Vegas, NV.

U.S. Department of Energy Environmental Management Nevada Program. 2017b. *Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 97: Yucca Flat/Climax Mine Nevada National Security Site, Nevada,* Rev. 1, DOE/NV--1566-REV. 1. Las Vegas, NV.

U.S. Department of Energy Environmental Management Nevada Program. 2017c. *Post-Closure Monitoring Report for Corrective Action Unit 98, Frenchman Flat, Underground Test Area, Nevada National Security Site, Nevada for Calendar Year 2016 (January 2016–December 2016),* DOE/NV--1572. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2013. Written communication. Subject: *Alternative Modeling Strategy and New FFACO UGTA Strategy Decision Process for Underground Test Area Corrective Action Unit 99 Rainier Mesa/Shoshone Mountain.* Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014. *Nevada National Security Site Integrated Groundwater Sampling Plan, Nevada National Security Site, Nevada*, Rev. 0, DOE/NV--1525. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2015a. *Underground Test Area Activity Quality Assurance Plan, Nevada National Security Site, Nevada*, Rev. 2, DOE/NV--1450-Rev. 2. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2015b. *Underground Test Area (UGTA) Closure Report for Corrective Action Unit 98: Frenchman Flat Nevada National Security Site, Nevada*, Rev. 1, DOE/NV--1538. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016a. *Underground Test Area Calendar Year 2014 Annual Sampling Analysis Report Nevada National Security Site, Nevada*, Rev. 0, DOE/NV--1555. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016b. *Underground Test Area Fiscal Year 2015 Quality Assurance Report Nevada National Security Site, Nevada*, Rev. 0, DOE/NV--1540. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2009. *Underground Test Area Project Waste Management Plan*, Rev. 3, DOE/NV--343; *Attachment 1 Fluid Management Plan for the Underground Test Area Project*, Rev. 5; DOE/NV--370-Rev.5. Las Vegas, NV.

U.S. Environmental Protection Agency. 1980. *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032. Cincinnati, OH: Environmental Monitoring and Support Laboratory Office of Research and Development.

U.S. Environmental Protection Agency. 1983. *Methods for the Chemical Analysis of Water and Wastes,* EPA/600/4-79-020. Cincinnati, OH: Environmental Monitoring and Support Laboratory Office of Research and Development.

U.S. Environmental Protection Agency. 1984. *Eastern Environmental Radiation Facility Radiochemical Procedures Manual,* EPA 520/5-84-006. Montgomery, AL: Office of Radiation Programs, Eastern Environmental Radiation Facility (renamed the National Air and Radiation Environmental Laboratory [NAREL] in 1989).

U.S. Environmental Protection Agency. 1993. *Determination of Inorganic Anions by Ion Chromatography,* Method 300.0. Cincinnati, OH: Environmental Monitoring Systems Laboratory Office of Research and Development.

U.S. Environmental Protection Agency. 2002. *Radionuclides in Drinking Water: A Small Entity Compliance Guide,* EPA 815-R-02-001. Washington, DC: Office of Ground Water and Drinking Water.

U.S. Environmental Protection Agency. 2011. *SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.* As accessed at http://www.epa.gov/epawaste/hazard/testmethods/sw846 on 23 March.

Appendix A

COC and COPC Concentrations for NNSS Integrated Sampling Plan Locations

Table A.1-1
Maximum ^{3}H Concentrations for Most Recent Year Sampled COC
(Page 1 of 4)

Type	Sampling Locations	ISPID	HSU	Sample Year	Maximum ^{3}H Concentration (pCi/L) [a]
Frenchman Flat					
Characterization	ER-5-3	ER-5-3_p2	BLFA/OAA	**2016**	**<3.73**
	ER-5-3-2	ER-5-3-2_m1	LCA	**2016**	**<3.71**
	ER-5-5	ER-5-5_m1	BLFA/OAA	**2016**	**<3.65**
Source/Plume	RNM-1	RNM-1_m5	AA	2014	620
	RNM-2S	RNM-2S_m1	AA	**2016**	**76,000**
	UE-5n	UE-5n_m1	AA	**2016**	**135,000**
Pahute Mesa (Central and Western)					
Characterization	ER-20-7	ER-20-7_m1	LPCU/TSA/CHZCM	2014	15,600,000
	ER-20-8	ER-20-8_p3	UPCU/SPA	2014	1,770
		ER-20-8_p2	MPCU/TCA/LPCU	2014	8,800
		ER-20-8_m2	MPCU/TCA/LPCU	2015	4,590
		ER-20-8_p1	LPCU/TSA/CHZCM	2014	128
	ER-20-8-2	ER-20-8-2_m1	BA/UPCU/SPA/MPCU	2014	2,600
	ER-20-11	ER-20-11_m1	FCCU/BA/UPCU	2013	191,000
	ER-20-12	ER-20-12_m1	PBRCM	**2016**	**33,600**
		ER-20-12_p1	BRA	**2016**	**18,900**
		ER-20-12_p3	CHCZM	**2016**	**U 267**
	ER-EC-2A	ER-EC-2A_m3	FCCM	**2016**	**<2.9**
	ER-EC-5	ER-EC-5_m1-3	TMCM	2003	<320 [b]
	ER-EC-8	ER-EC-8_m1-3	FCCM/TMCM	**2016**	**<4.52**
	ER-EC-11	ER-EC-11_p3	FCCU/BA	2014	16,100
		ER-EC-11_p2	UPCU/TCA	2014	12.1
		ER-EC-11_p1	TSA/CHCU	2014	11.8
	ER-EC-12	ER-EC-12_m2	THCM/TCA/LPCU	**2016**	**<2.99**
		ER-EC-12_m1	TSA/CHCU	2012	4.2
	ER-EC-13	ER-EC-13_m2	FCCM	2012	<2.5
		ER-EC-13_m1	FCCM	2013	<3.0
	ER-EC-14	ER-EC-14_m2	RMWTA	2014	<2.2
		ER-EC-14_m1	RMWTA	2014	<2.0
	ER-EC-15	ER-EC-15_m3	FCCU/CPA/PBPCU	2013	<2.2
		ER-EC-15_m2	TCA/LPCU	2014	<2.1
		ER-EC-15_m1	TSA/CHCU	2014	<2.0

Table A.1-1
Maximum ^{3}H Concentrations for Most Recent Year Sampled COC
(Page 2 of 4)

Type	Sampling Locations	ISPID	HSU	Sample Year	Maximum ^{3}H Concentration (pCi/L) [a]
Source/Plume	ER-20-5-1	ER-20-5-1_m1	TSA/CHZCM	2015	24,800,000
	ER-20-5-3	ER-20-5-3_m1	CHZCM	2015	84,000
	ER-20-6-1	ER-20-6-1_m1	CHZCM	1998	3,200
	ER-20-6-2	ER-20-6-2_m1	CHZCM	1997	71,000
	ER-20-6-3	ER-20-6-3_m1	CHZCM	1998	1,110
	U-19ad PS 1A	U-19ad PS1A_m1	PLFA	2008	12,900,000
	U-19q PS 1D	U-19q PS1D_m1	N/A	2003	11,000,000
	U-19v PS 1D	U-19v PS1D_m1	BFCU	2009	84,900,000
	U-20n PS 1D	U-20n PS1D_m2	CHZCM	2005	33,300,000
	UE-20n1	UE-20n1_o2	CHZCM	2012	55,500,000
Early Detection	ER-20-1	ER-20-1_o1	TMLVTA/PBPCU/BA/ UPCU/TCA	2015	<2.12
	U-20 WW	U-20 WW_m1	CHZCM	1999	<29
	PM-3	PM-3_p1	TCA/LPCU	**2016**	**124**
		PM-3_p2	UPCU	**2016**	**194**
	ER-EC-6	ER-EC-6_m4	FCCU/BA	2015	5.18
Distal	ER-EC-1	ER-EC-1_m1-3	CPA/UPCU/TCA/LPCU/ TSA/CHCU/CFCM	**2016**	**<2.87**
	UE-18r	UE-18r_o1	TMCM	2007	<22
Community	Ash-B	Ash-B_p1	Volcanic rocks	2014	<183
		Ash-B_p2	Valley fill	2014	<177
	U.S. Ecology	U.S. Ecology_m1	N/A	2012	<22
	Cind-R-Lite Mine	Cind-R-Lite Mine_m1	Valley fill	2012	<24
	Peacock Ranch	Peacock Ranch_s1	N/A	2012	<21
	Revert Spring	Revert Spring_s1	N/A	2012	<22
	Spicer Ranch	Spicer Ranch_s1	N/A	2012	<21
	Amargosa Valley RV Park	Amargosa Valley RV Park_m1	N/A	2012	<24
	EW-4	EW-4 m1	N/A	2011	<30
RM/SM					
Characterization	ER-12-3	ER-12-3_p1	LTCU/OSBCU/ATCU	**2016**	**27.3**
	ER-12-4	ER-12-4_p2	OSBCU	**2016**	**7.62**
	UE-12t-6	UE-12t-6_o1	LTCU/OSBCU/LCCU	--	--
	ER-16-1	ER-16-1_m1	LCA	2008	<340
	UE-18t	UE-18t_p1	TMCM	**2016**	**<3.07**
	ER-30-1	ER-30-1_p1	FCCM	1996	<215

Table A.1-1
Maximum ^{3}H Concentrations for Most Recent Year Sampled COC
(Page 3 of 4)

Type	Sampling Locations	ISPID	HSU	Sample Year	Maximum ^{3}H Concentration (pCi/L) [a]
Source/Plume	U-12n.10 Vent Hole	U-12n.10 Vent Hole_m1	LTCU	2008	6,260,000
	U-12n Vent Hole 2	U-12n Vent Hole_2_m1	LTCU	2011	1,030,000
Early Detection	ER-12-4	ER-12-4_m1	LCA3	2015	<0.2
	ER-12-3	ER-12-3_m1	LCA3	2015	0.5
	ER-19-1	ER-19-1_p1	RVA/ATCU	**2016**	**<2.87**
		ER-19-1_p2	OSBCU	**2016**	**<3.05**
Distal	ER-12-1	ER-12-1_m5	UCCU	2015	18.4
	TW-1	TW-1_m1	OSBCU/RVA/ LTCU/ATCU/LCA3	2013	<21
	UE-16d WW	UE-16d WW_m1	UCCU	**2016**	**<180**
	WW-8	WW-8_m26	BRA	**2016**	**<235**
YF/CM					
Characterization	ER-2-1	ER-2-1_m1	TMWTA/ TMLVTA/LTCU	2015	1,013
	ER-3-3	ER-3-3_m1	LCA	**2016**	**<310**
	ER-4-1	ER-4-1_m1	LCA	**2016**	**<2.16**
	ER-6-1-2	ER-6-1-2_o1	LCA	2004	<370
	ER-7-1	ER-7-1_m1	LCA	2014	<3.8
	TW-7	TW-7_m1	LTCU	2015	<2.5
	UE-1h	UE-1h_o1	LCA	2014	<2.0
	UE-10j	UE-10j_m3	LCA	1997	<210
	WW-3	WW-3_m1	AA	2015	6.3
Source/Plume	UE-2ce	UE-2ce_m1	LCA3	**2016**	**144,000**
	U-3cn PS 2	U-3cn PS 2_m1	LTCU	2007	7,680,000
	WW-A	WW-A_m1	AA	2012	355
	U-4u PS 2A	U-4u PS 2A_p1	LTCU	2008	24,100,000
	UE-7nS	UE-7nS_m1	LCA	2015	53.3
Early Detection	UE-1q	UE-1q_o1	LCA	2013	<26
	WW-2	WW-2_m1	LCA	2015	<2.18
	U-3cn 5	U-3cn 5_o1	LCA	2011	<6.5
	TW-D	TW-D_m1	ATCU/LCA	2013	<27
	WW C-1	WW C-1_m1	LCA	2012	<27

Table A.1-1
Maximum ^{3}H Concentrations for Most Recent Year Sampled COC
(Page 4 of 4)

Type	Sampling Locations	ISPID	HSU	Sample Year	Maximum ^{3}H Concentration (pCi/L) [a]
Distal	Army 1 WW	Army 1 WW_m1	LCA	2015	<229

BA = Benham aquifer
BFCU = Bullfrog confining unit
FCCU = Fluorspar Canyon composite unit
LCCU = Lower clastic confining unit
MPCU = Middle Paintbrush confining unit
PBPCU = Post-Benham Paintbrush confining unit
PLFA = Paintbrush lava-flow aquifer
SPA = Scrugham Peak aquifer

-- = Location has never been sampled.

[a] The largest ^{3}H concentration for the most recent year sampled is reported. Commercial laboratory values for standard analyses are reported when available and when ^{3}H concentrations exceed 300 pCi/L. Values below the detection limit are reported as "<MDC."
[b] ^{3}H was reported as 7.3 pCi/L in 2003. This detection is suspected to have resulted from post-sampling contamination. Samples were stored near other samples that contained high levels of ^{3}H. Low-level ^{3}H analyses have not been performed since 2003.

Notes:
(1) Locations sampled in CY 2016 are in bold type.
(2) Values highlighted in blue exceed the 20,000 pCi/L SDWA MCL (EPA, 2002).

Table A.1-2
Maximum Most Recent COPC Concentrations (pCi/L) for Characterization and Source/Plume Locations
(Page 1 of 4)

Location	ISPID	Sampled Year	^{14}C	^{36}Cl	^{90}Sr	^{99}Tc	^{129}I	^{137}Cs	^{238}Pu	$^{239/240}Pu$
Frenchman Flat										
Characterization										
ER-5-3	ER-5-3_m2	**2016** [a]	**<460 ***	4.3E-04	<0.56	<4.7	<4.7 **	<7.9	<0.07	<0.02
ER-5-3-2	ER-5-3-2_m1	**2016**	**J <400 ***	**<3.1**	**<0.26**	**<7.4**	**<0.93 ***	**<8.5**	**<0.03**	**<0.02**
ER-5-5	ER-5-5_m1	**2016**	**<166**	**<2.6**	**<0.97 ***	**<5.9**	**<0.75 ***	**<6.0**	**<0.02**	**<0.03**
Source/Plume										
RNM-1	RNM-1_m4-5	2014	J <8.3	3.6E-04	8.90 [b]	<4.5E-04	1.8E-05	0.68 [c]	J <0.1	J <0.1
RNM-2S	RNM-2S_m1	**2016**	**J <400 ***	**<3.2**	**<0.40**	**<6.8**	**<0.69 ***	<3.6 [d]	<0.02 [e]	<0.03 [e]
UE-5n	UE-5n_m1	**2016**	**J <420 ***	<2.6	**<0.45**	**<7**	**<0.73**	<8.3 [c]	<0.02 [c]	<0.01 [c]
Pahute Mesa										
Characterization										
ER-20-7	ER-20-7_m1	2014	118	2.52	<0.5	<7.0	0.14	<6.2	<0.01	U 0.04
ER-20-8	ER-20-8_m1 [e]	2011	0.06	9.2E-04	<0.47	<7.1	3.5E-05	<0.05	<0.02	<0.001
	ER-20-8_m2	2015	J- 0.34	5.4E-03	<0.46	<7.2	3.8E-04	<6.9	<0.03	<0.024
ER-20-8-2	ER-20-8-2_m1	2014	J- 0.22	3.4E-03	<0.48	0.067	2.4E-04	<7.8	<0.02	<0.02
ER-20-11	ER-20-11_m1	2013	3.84	7.3E-02	<0.39	0.953	4.4E-03	6.2	<0.02	<0.02
ER-20-12	ER-20-12_m1	**2016**	**0.24**	TBD	**<0.98 ***	**<7.82**	**<6.4 ****	**<4.5**	**<0.04**	**<0.02**
	ER-20-12_p1	**2016**	**0.16**	TBD	**<0.83 ***	**--**	**--**	**<4.8**	**--**	**--**
ER-EC-2A	ER-EC-2A_m3	**2016**	**0.025**	**9.2E-04**	**<0.97 ***	**<8.2**	**<1.1 ****	**<4.0**	**<0.03**	**<0.04**
ER-EC-5	ER-EC-5_m1-3	2003	<340 *	3.0E-04	<0.55	<5.2	<3.5 **	<8.0	<0.03	<0.03
ER-EC-8	ER-EC-8_m1-3	**2016**	**0.047**	**7.7E-04**	**<0.89 ***	**<8.0**	**<0.87 ***	**<7.4**	**<0.04**	**<0.05**
ER-EC-11	ER-EC-11_p1	2014	0.09	8.0E-04	<0.28	<4.5E-04	1.3E-06	<7.5	<0.02	<0.03
	ER-EC-11_p2	2014	0.08	1.6E-03	<0.35	<4.5E-04	2.3E-04	<7.3	<0.03	<0.03
	ER-EC-11_p3	2014	J- 0.63	7.8E-03	<0.29	<4.5E-04	3.8E-04	<6.8	<0.02	<0.02

Table A.1-2
Maximum Most Recent COPC Concentrations (pCi/L) for Characterization and Source/Plume Locations
(Page 2 of 4)

Location	ISPID	Sampled Year	^{14}C	^{36}Cl	^{90}Sr	^{99}Tc	^{129}I	^{137}Cs	^{238}Pu	$^{239/240}Pu$
ER-EC-12	ER-EC-12_m1	2012	0.14	4.6E-03	U 0.67	<5.8	3.7E-04	<0.02	<0.03	<0.04
	ER-EC-12_m2	**2016**	**0.03**	**2.9E-04**	**<0.74**	**<5.3**	**<0.98 ***	**<5.05**	**<0.0457**	**<0.0603**
ER-EC-13	ER-EC-13_m1	2013	0.14	9.8E-04	<0.42	<6.2	1.8E-07	<0.06	<0.02	<0.03
	ER-EC-13_m2	2012	0.03	1.0E-03	<0.28	J <6.5	1.3E-07	<0.08	<0.01	<0.02
ER-EC-14	ER-EC-14_m1	2014	0.07	3.6E-04	1.10 [b]	<4.5E-04	1.8E-07	<7.3	<0.02	<0.004
	ER-EC-14_m2	2014	0.02	3.6E-04	<0.32	J 0.006	1.1E-07	<8.7	J <0.05	<0.004
ER-EC-15	ER-EC-15_m1	2014	0.01	5.3E-04	<0.37	<0.34	1.5E-06	<7.6	J <0.13	<0.004
	ER-EC-15_m2	2014	0.02	1.0E-03	<0.33	J 0.002	7.1E-06	<6.6	--	<0.004
	ER-EC-15_m3	2013	0.08	1.1E-03	<0.37	<4.2E-04	1.2E-06	<8.9	--	<0.004
Source/Plume										
ER-20-5-1	ER-20-5-1_m1	2015	165	5.7	<0.55	0.428	0.195	<6.7	<0.033	0.4
ER-20-5-3	ER-20-5-3_m1	2015	2.74	1.4E-02	<0.54	0.009	4.0E-04	<6.1	<0.039	<0.052
ER-20-6-1	ER-20-6-1_m1	1998	0.04	6.0E-04	2.19 [f]	<0.03	<1.3 **[,g]	UJ 17.2	<0.03 [g]	<0.03 [g]
ER-20-6-2	ER-20-6-2_m1	1997	0.07	6.9E-04	<0.57 [f]	<3.7	<3.6 **	<3.9	0.02	<0.05
ER-20-6-3	ER-20-6-3_m1	1998	0.02	3.3E-04	4.21 [f]	<0.008	<3.7 **[,g]	UJ 16.2	<0.03 [g]	<0.05 [g]
U-19ad PS 1A	U-19ad PS1A_m1	2008	158	7.2	1,780 [e]	25.4	1.3	28,900	3.76	47
U-19q PS 1D	U-19q PS1D_m1	2003	293	1.8E-02	<0.75 [d]	0.08 [d]	2.0E-03	11.9	<10.8	<0.02
U-19v PS 1D	U-19v PS1D_m1	2009	76.4	33	--	2.89	2.7	0.57 [f]	--	<0.004
U-20n PS 1D	U-20n PS1D_m2	2005	183	0.48	J 202	0.93	0.14	1,970 [c]	<1.21 [c]	0.46
UE-20n 1	UE-20n 1_o2	2012	218	0.89	--	49.2	0.32	0.003	--	<0.004

Table A.1-2
Maximum Most Recent COPC Concentrations (pCi/L) for Characterization and Source/Plume Locations
(Page 3 of 4)

Location	ISPID	Sampled Year	^{14}C	^{36}Cl	^{90}Sr	^{99}Tc	^{129}I	^{137}Cs	^{238}Pu	$^{239/240}Pu$
RM/SM										
Characterization										
ER-30-1	ER-30-1_p2	1996	--	--	<0.42	<2.3	--	7.88	<0.06	<0.06
UE-12t-6	UE-12t-6_o1	--	--	--	--	--	--	--	--	--
ER-12-3	ER-12-3_p1	**2016**	**0.087**	TBD	**<0.99 ***	**<5.6**	**<0.6 ***	**<3.73**	**<0.021**	**<0.017**
ER-12-4	ER-12-4_p2	**2016** [a]	--	--	--	--	--	--	--	--
ER-16-1	ER-16-1_m1	--	--	--	--	--	--	--	--	--
UE-18t	UE-18t_p1	**2016**	**0.02**	TBD	**<0.84 ***	**<8.5**	**<0.98 ***	**<4.34**	**0.04**	**<0.05**
Source/Plume										
U-12n Vent Hole 2	U-12n Vent Hole 2_m1	2011	6.57	2.2	<0.28	0.005	<0.60 *	1.2	<109	1.2
U-12n.10 Vent Hole	U-12n.10 Vent Hole_m1	2008	150	100	--	0.19	0.99	3.3	--	1.6
YF/CM										
Characterization										
ER-2-1	ER-2-1_m1	2015	J+ 0.06	2.1E-04	<0.58	<7.3	<0.87 *	<7.3	<0.084	<0.067
ER-6-1-2	ER-6-1-2_m1	2003	0.01	2.1E-04	--	--	--	--	--	--
ER-7-1	ER-7-1_m1	2014	0.08	1.5E-04	<0.52	<6.7	<0.74 *	<6.7	<0.02	<0.02
TW-7	TW-7_m1	1958	--	--	<6	--	--	--	--	--
TW-D	TW-D_m1	2012	J <235 *	--	J <0.52	<7.6	--	<2.9	<0.03	<0.03
UE-1h	UE-1h_o1		--	--	--	--	--	--	--	--
UE-10j	UE-10j_m3	1997	--	1.8E-04	--	--	--	--	--	--
WW-3	WW-3_m1	2015	J+ 0.01	2.7E-04	<0.42	<6.7	J <0.73 *	<7.1	<0.014	<0.014
ER-3-3	ER-3-3_m1	**2016**	**<390 ***	**<2.8**	**<0.23**	**<7.2**	**<0.64 ***	**<7.7**	**<0.033**	**<0.016**

Table A.1-2
Maximum Most Recent COPC Concentrations (pCi/L) for Characterization and Source/Plume Locations
(Page 4 of 4)

Location	ISPID	Sampled Year	^{14}C	^{36}Cl	^{90}Sr	^{99}Tc	^{129}I	^{137}Cs	^{238}Pu	$^{239/240}Pu$
Source/Plume										
U-3cn PS 2	U-3cn PS 2_m1	2007	258	24	2.35 [g]	35.7	0.19	1.0	<0.08 [g]	0.06
U-4u PS 2A	U-4u PS 2A_p1	2008	326 [c]	19	3.11 [g]	26.5	0.15	92	0.03 [d]	0.44
UE-2ce	UE-2ce_m1	**2016**	**0.95**	TBD	**<0.86 ***	TBD	TBD	**<4.69**	--	--
UE-7nS[m]	UE-7nS_m1	2012	<235 *	2.4E-04	<0.52	<7.64	4.1E-05	<5.64	<0.03	<0.04
WW-A	WW A_m1	2012	<235 *	--	<0.52 [h]	<7.69 [h]	--	<3.35	<0.03	<0.03

*The MDC is too large to determine whether the concentration is below one-tenth of the MCL.
**The MDC is too large to determine whether the concentration is below the MCL.

[a] A sample was collected in 2016 using a bailer and only ^{3}H and ^{14}Cl were analyzed for ER-5-3 and only ^{3}H was analyzed for ER-12-4_p2. All other ER-5-3 reported data are for a sample collected from ER-5-3_m1-2 in 2001.
[b] The presence of other RNs or interferences may cause positive bias in the target analyte's measured and reported concentration.
[c] These data are not available for this sample. The result is associated with a sample collected in 2014.
[d] These data are not available for this sample. This result is associated with a sample collected in 1998.
[e] These data are not available for this sample. This result is associated with a sample collected in 2004.
[f] These data are not available for this sample. This result is associated with a sample collected in 1996.
[g] These data are not available for this sample. This result is associated with a sample collected in 1997.
[h] These data are not available for this sample. This result is associated with a sample collected in 2011.

J = Result is estimated.
J- = Result is estimated and is biased low.
J+ = Result is estimated and is biased high.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.

TBD = To be determined
-- = Not analyzed

Notes:
(1) Locations sampled in 2016 are in bold type.
(2) Values highlighted in blue exceed the SDWA MCL (EPA, 2002).

A.1.0 References

EPA, see U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency. 2002. *Radionuclides in Drinking Water: A Small Entity Compliance Guide,* EPA 815-R-02-001. Washington, DC: Office of Ground Water and Drinking Water.

Appendix B

2016 Analytical Results

B.1.0 Frenchman Flat

This section presents commercial laboratory (Tables B.1-1 and B.1-2) results for three characterization (ER-5-3, ER-5-3-2, ER-5-5) and two source/plume (RNM-2S and UE-5n) wells collected in 2016. Table B.1-3 presents the results of low-level ^{3}H from ARS, GEL, and LLNL laboratories collected at ER-11-2.

Table B.1-1
Commercial Laboratory Results for Frenchman Flat Characterization Locations
(Page 1 of 2)

Analyte	ER-5-5_m1[a] 05/16/2016		ER-5-5_m1[b] 05/16/2016	ER-5-3-2_m1 05/19/2016	ER-5-3_p2[c] 06/07/2016
Major and Minor Constituents (mg/L)					
Alkalinity as $CaCO_3$	150	150	145	540	160
HCO_3 [d]	182.85	182.85	170.66	658.26	195.04
CO_3 [d]	<12	<12	3.072	<12	<12
Br	<0.06	<0.06	J 0.103	J 0.065	0.47
Cl	15	15	13.3	39	19
F	3.2	3.1	2.79	1.7	1.4
SO_4	42	41	39.9	76	3.3
Ca	7.4 | --	7.4 | --	7.16 | --	76 | --	14 | --
Mg	3.4 | --	3.3 | --	3.21 | --	27 | --	3.0 | --
K	7.4 | --	7.5 | --	6.42 | --	16 | --	8.0 | --
Na	75 | --	76 | --	J+ 77.9 | --	140 | --	53 | --
Al	U 0.2 | --	U 0.2 | --	<0.068 | --	J- 0.031 | --	U 0.2 | --
Fe	0.34 | --	0.19 | --	0.163 | --	0.29 | --	J 1.7 | --
Silica [e]	96.08	96.08	91.05	100.66	50.33
Trace Constituents (µg/L)					
Ag	<1.1 | --	<1.1 | --	J 1.25 | --	U 10 | --	<1.1 | --
As	16 | --	15 | --	J 17.1 | --	J- 8.4 | --	J 4.3 | --
Ba	U 100 | --	U 100 | --	J 2.31 | --	200 | --	UJ 100 | --
Cd	<0.33 | --	<0.33 | --	<1 | --	<0.21 | --	<0.33 | --
Cr	J- 1.2 | --	J- 1.3 | --	J 1.69 | --	U 10 | --	<0.51 | --
Li	J 19 | --	J 19 | --	15.1 | --	360 | --	J 24 | --
Mn	J- 4.7 | --	J- 4.7 | --	J 4.78 | --	52 | --	290 | --
Pb	<1.3 | --	<1.3 | --	<3.3 | --	7.0 | --	5.2 | --
Se	<2.7 | --	J 3.9 | --	<6.0 | --	<3.0 | --	<2.7 | --
Sr	J 23 | --	J 24 | --	22.7 | --	910 | --	J 60 | --
U	J 8.4 | --	J 8.6 | --	9.54 | --	J 12 | --	0.22 | --

Table B.1-1
Commercial Laboratory Results for Frenchman Flat Characterization Locations
(Page 2 of 2)

Analyte	ER-5-5_m1[a] 05/16/2016		ER-5-5_m1[b] 05/16/2016	ER-5-3-2_m1 05/19/2016	ER-5-3_p2[c] 06/07/2016
RNs (pCi/L) [f]					
Gross Alpha	4.1	7.1	J 9.46	9.1	J <1.7
Gross Beta	8.7	8.4	J 7.42	J 14.9	7.4
^{3}H	<350	<350	<249	<340	<360
^{3}H (Low Level)	--	--	<3.65	<3.71	<3.73
^{14}C	J <410	J <410	<166	J <400	<420
^{26}Al	<13.1	<7.9	<7.92	<12.1	--
^{36}Cl	<2.8	<2.6	<3.54	<3.1	--
^{90}Sr	U 0.26	U 0.39	<0.966	<0.26	--
^{94}Nb	<9.4	<6.9	<6.02	<7.6	--
^{99}Tc	<7	<7.2	<5.93	<7.4	--
^{129}I	<0.76	<0.75	<0.836	<0.93	--
^{137}Cs	<9.9	<7.3	<6.05	<8.5	--
^{152}Eu	<45	<36	<17.2	<47	--
^{154}Eu	<49	<39	<20.8	<49	--
^{235}U	<51	<37	<31	<35	--
^{238}Pu	<0.027	<0.015	<0.0362	<0.033	--
$^{239/240}Pu$	<0.036	<0.033	<0.0362	<0.024	--
^{241}Am	<340	<250	<39.9	<9.2	--
^{243}Am	<1,140	<850	<10.5	<590	--

[a] Sample was analyzed by GEL.
[b] Sample was bailed and therefore analyzed for a reduced parameter suite.
[c] Sample was analyzed by ALS.
[d] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying by 1.219 mg/L HCO_3 / mg/L $CaCO_3$ (HCO_3) and 0.6 mg/L CO_3 / mg/L $CaCO_3$ (CO_3).
[e] Values converted from laboratory reported (silicon) by multiplying by 2.139 mg silica / mg silicon.
[f] Only candidates for inclusion into the source-term inventory (Finnegan et al., 2016) and those required by the sampling plan are included in this table.

J = Result is estimated.
J- = Result is estimated and is biased low.
J+ = Result is estimated and is biased high.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
UJ = Result was above the detection limit and is biased low.
-- = Not analyzed

Notes:
(1) Values reported with a "|" indicate unfiltered | filtered sample results. Only filtered samples were collected and reported when a single metal result is shown. Unfiltered samples were analyzed for RNs.
(2) Two columns for each ISPID report the sample and duplicate results.
(3) Non-detects are reported as "<MDC."

Table B.1-2
Commercial Laboratory Results for Frenchman Flat Source/Plume Locations

Analyte	UE-5n_m1 05/05/2016	RNM-2S_m1 05/10/2016	
	(pCi/L)		
^{3}H	135,000	76,000	75,000
^{14}C	J <420	J <400	J <410
^{36}Cl	<2.6	<3.3	<3.2
^{90}Sr	<0.45	<0.43	<0.40
^{99}Tc	<7.0	<6.9	<6.8
^{129}I	<0.73	<0.69	<0.69

J = Result is estimated.

Note: Non-detects are reported as "<MDC."

Table B.1-3
ER-11-2 Low-Level ^{3}H Results

Sample Date	ER-11-2_m1
	(pCi/L)
04/19/2016 [a]	J 17.48
06/29/2016 [b]	<2.99
06/29/2016 [c]	<0.33

[a] Sample analyzed by ARS. Result is considered anomalous, suspected to be a result of contaminated sampling equipment, sample mishandling, and/or laboratory contamination.
[b] Sample analyzed by GEL.
[c] Sample analyzed by LLNL.

J = Result is estimated.

B.2.0 Pahute Mesa

This section presents the commercial laboratory (Table B.2-1) and LLNL (Table B.2-2) results for four characterization wells (ER-20-12, ER-EC-12, ER-EC-8, and ER-EC-2A), one early detection well (Table B.2-3), and one distal well (Table B.2-4) in the Pahute Mesa CAUs.

Table B.2-1
Commercial Laboratory Results for Pahute Mesa Characterization Locations
(Page 1 of 3)

Analyte	ER-20-12_p1 07/06/2016		ER-20-12_m1 08/19/2016		ER-EC-12_m2 07/20/2016		ER-EC-8_m1-3 09/29/2016	ER-EC-2A_m3 10/11/2016
Miscellaneous								
pH (SU)	--	--	J- 8.16	J- 8.17	--	--	--	--
SEC (µS/cm)	--	--	767	780	397	398	--	--
Major and Minor Constituents (mg/L)								
Alkalinity as $CaCO_3$	108.8[b]	--	J+ 93.7	127	132	133	150	150
HCO_3[a]	132.63[b]	--	J+ 114.22	154.81	151.16	152.38	170.66	182.85
CO_3[a]	0.0[b]	--	<2.898	<0.87	4.85	4.85	6.0	<0.87
Br	0.489	0.462	0.444	0.452	J 0.122	J 0.128	0.24	0.278
Cl	80.7	80.9	82.4	J- 86.0	16.6	16.6	42.7	J+ 53.2
F	1.96	1.85	1.87	1.87	4.7	4.7	4.94	J+ 4.41
SO_4	112	112	112	112	37.1	37.0	76.6	85.4
Ca	7.68 | 7.32	7.18 | 7.14	17.5 | 15.8	17.9 | 16.6	3.21 | --	3.27 | --	11	7.41
Mg	J 0.149 | J 0.157	J 0.123 | J 0.144	0.305 | J 0.216	0.305 | J 0.183	<0.11 | --	<0.11 | --	0.453	<0.11
K	5.52 | 5.26	5.24 | 5.19	J 4.45 | J 3.97	J 4.6 | J 4.12	0.676 | --	0.639 | --	5.17	2.34
Na	145 | 149	146 | 147	149 | 141	150 | 149	85.2 | --	85.3 | --	122	134
Al	<0.068 | <0.068	<0.068 | <0.068	1.03 | <0.068	1.18 | <0.068	0.44 | --	0.379 | --	<0.068	<0.068
Fe	7.62 | 3.92	4.68 | 3.81	9.55 | 0.116	9.55 | 0.183	0.183 | --	0.174 | --	J 0.0334	J 0.0536
Silica [c]	62.24 | 59.68	58.61 | 58.39	44.28 | 37.22	46.63 | 39.14	31.66 | --	32.09 | --	48.34	44.71
Sulfide	--	--	--	--	37.1	37	76.6	85.4

Table B.2-1
Commercial Laboratory Results for Pahute Mesa Characterization Locations
(Page 2 of 3)

Analyte	ER-20-12_p1 07/06/2016		ER-20-12_m1 08/19/2016		ER-EC-12_m2 07/20/2016		ER-EC-8_m1-3 09/29/2016	ER-EC-2A_m3 10/11/2016
Trace Constituents (μg/L)								
Ag	<1.0 | <1.0	<1.0 | <1.0	J 1.01 | <1.0	<1.0 | <1.0	<1.0 | --	<1.0 | --	<1.0	R
As	<5.0 | <5.0	<5.0 | <5.0	<5.0 | <5.0	<5.0 | <5.0	<5.0 | --	<5.0 | --	J 8.58	J 6.6
Ba	7.48 | 6.17	6.56 | 6.07	15.2 | J 3.06	16.7 | J 3.21	5.85 | --	5.97 | --	J 1.6	6.14
Cd	<1.0 | <1.0	<1.0 | <1.0	<1.0 | <1.0	<1.0 | <1.0	<1.0 | --	<1.0 | --	<1.0	<1.0
Cr	31.7 | J 1.23	7.22 | J 1.11	9.15 | <1.0	9.5 | <1.0	<1.0 | --	<1.0 | --	J 1.77	J 1.07
Hg	<0.067 | <0.067	<0.067 | <0.067	<0.067 | <0.067	<0.067 | <0.067	<0.067 | --	<0.067 | --	--	--
Li	80.8 | 85.4	86.4 | 85.0	96.2 | 106	99.8 | 100	126 | --	130 | --	209	197
Mn	142 | 112	117 | 110	330 | 188	333 | 167	12.7 | --	12.5 | --	<2.0	<2.0
Pb	<3.3 | <3.3	<3.3 | <3.3	<3.3 | <3.3	<3.3 | <3.3	<3.3 | --	<3.3 | --	<0.5	J 0.659
Se	<6.0 | <6.0	<6.0 | <6.0	<6.0 | <6.0	<6.0 | <6.0	<6.0 | --	<6.0 | --	<2.0	<2.0
Sr	13.4 | 14.0	14.3 | 14.2	40.7 | 34.3	41.7 | 37.5	12.8 | --	12.1 | --	J 1.33	26
U	J 0.143 | J 0.123	J 0.117 | J 0.127	2.78 | 2.97	3.36 | 3.55	2.98 | --	2.93 | --	5.59	7.46
RNs (pCi/L) [d]								
Gross Alpha	<2.94	<2.52	10.8	10.5	9.28	7.66	11.5	19.5
Gross Beta	5.73	3.74	6.07	7.49	U 2.41	U 2.78	6.45	4.02
^{3}H	18,900	18,600	34,000	33,600	<195	<195	<208	<251
^{3}H (Low Level)	--	--	--	--	<3.11	<2.99	<3.79 | <3.66 [e]	<3.11 | <2.9
^{14}C	--	--	--	<343	<296	<292	<285	<346
^{26}Al	<4.93	<4.92	<5.35	<5.47	<4.83	<4.26	<5.63	<5.25
^{36}Cl	--	--	<23.6	<23.8	<3.03	<2.87	<2.84	<3.30
^{90}Sr	<0.832	<0.852	<0.987	<0.982	<0.744	<0.738	<0.888	<0.971
^{94}Nb	<4.11	<4.68	<3.76	<4.18	<4.32	<6.84	<6.44	<4.74

Table B.2-1
Commercial Laboratory Results for Pahute Mesa Characterization Locations
(Page 3 of 3)

Analyte	ER-20-12_p1 07/06/2016		ER-20-12_m1 08/19/2016		ER-EC-12_m2 07/20/2016		ER-EC-8_m1-3 09/29/2016	ER-EC-2A_m3 10/11/2016
^{99}Tc	--	--	<7.95	<7.82	<5.31	<5.34	<7.98	<8.20
^{129}I	--	--	--	<6.43	<1.03	<0.984	<0.869	<1.12
^{137}Cs	<4.92	<4.83	<4.46	<4.5	<5.05	<7.31	<7.40	<3.96
^{152}Eu	<14	<13	<11.5	<12.2	<13.7	<16.6	<16.7	<13.8
^{154}Eu	<11.9	<11.4	<12	<10.8	<14.3	<21.9	<21.1	<14
^{235}U	<28.5	<28.8	<25.9	<25.5	<29.9	<34.8	<32.4	<34.2
^{238}Pu	--	--	<0.0504	<0.0356	<0.047	<0.0457	<0.0383	<0.031
$^{239/240}Pu$	--	--	<0.0701	<0.0182	<0.06	<0.073	<0.0527	<0.0399
^{241}Am	<15.5	<16.4	<26.8	<16.5	<19.6	<10.9	<26.4	<36.4

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L HCO_3/mg/L $CaCO_3$ (HCO_3) and 0.6 mg/L CO_3/mg/L $CaCO_3$ (CO_3).
[b] Values from field analysis.
[c] Values converted from laboratory reported (silicon) by multiplying times 2.139 mg silica/mg silicon.
[d] Only candidates for inclusion into the source-term inventory (Finnegan et al., 2016) and those required by the sampling plan are included in this table.
[e] Result represents the reanalysis of the sample and duplicate. Contamination during the enrichment process was determined to be the source of 10.8 pCi/L ^3H reported for the original analysis of the duplicate sample. The original reported result for the sample was <4.52.

J = Result is estimated.
J- = Result is estimated and is biased low.
J+ = Result is estimated and is biased high.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
R = Result rejected, not usable for decision making purposes (will be made unavailable for use).
-- = Not analyzed

Notes:
(1) Values reported with a "|" indicate unfiltered | filtered sample results. Only filtered samples were collected and reported when a single metal result is shown. Unfiltered samples were analyzed for RNs.
(2) Two columns for each ISPID report the sample and duplicate results.
(3) Non-detects are reported as "<MDC."

Table B.2-2
Specialized Laboratory Results for Pahute Mesa Characterization Locations
(Page 1 of 3)

Analyte	ER-20-12_p1 07/06/2016		ER-20-12_m1 08/19/2016		ER-EC-12_m2 07/20/2016	ER-EC-8_m1-3 09/29/2016	ER-EC-2A_m3 10/11/2016
LLNL							
Environmental Tracers							
H-2/1 (‰)	-115.86	-116	-115.3	-116	-113.6 | -113.8	-113.7	-115.4
C-13/12 (‰)	-2.34	-2.39	-3.38	-3.3	-4.61 | -4.61	-0.41	-1.02
O-18/16 (‰)	-14.76	-14.85	-14.78	-14.83	-15.05 | -14.93	-14.7	-14.91
DIC (mg/L)	31.6	31.3	32.6	32.7	33.4 | 33.6	39.0	34.9
^{14}C (pmc)	--	--	--	118.33	13.8 |12.95	19.63	11.93
$^{36}Cl/Cl$ (ratio)	6.41 E-12	6.43E-12	9.41E-12	3.53E-12	5.17E-13 | 5.04 E-13	5.04E-13	5.32E-13
$^{129}I/^{127}I$ (ratio)	8.39E-09	8.95E-09	1.19E-08	1.17E-08	--	--	--
Noble Gases (atoms/g)							
Ar	9.13 E+15	--	TBD	TBD	TBD	TBD	5.31 E+15
^{40}Ar	9.28 E+15	--	TBD	TBD	TBD	TBD	5.29 E+15
^{3}He	1.71 E+06	--	TBD	TBD	TBD	TBD	7.45 E+06
^{4}He	1.34 E+12	--	TBD	TBD	TBD	TBD	5.75 E+12
$^{3}He/^{4}He$ (R/Ra) [a]	0.927	--	TBD	TBD	TBD	TBD	--
Kr	2.12 E+12	--	TBD	TBD	TBD	TBD	1.2 E+12
Ne	4.98 E+12	--	TBD	TBD	TBD	TBD	3.82 E+12
^{20}Ne	5.51 E+12	--	TBD	TBD	TBD	TBD	3.46 E+12
Xe	2.34 E+11	--	TBD	TBD	TBD	TBD	1.64 E+11
^{130}Xe	1.12 E+10	--	TBD	TBD	TBD	TBD	6.72E+09

Table B.2-2
Specialized Laboratory Results for Pahute Mesa Characterization Locations
(Page 2 of 3)

Analyte	ER-20-12_p1 07/06/2016		ER-20-12_m1 08/19/2016		ER-EC-12_m2 07/20/2016	ER-EC-8_m1-3 09/29/2016	ER-EC-2A_m3 10/11/2016
RNs (pCi/L)							
^{3}H (Low Level)	--	--	--	--	U 0.76 | <0.19	<0.61 | <0.4	< 0.4 | <0.61
^{14}C	0.1595	0.1597	0.237	0.237	0.0265	0.0467	0.0254
^{36}Cl	0.0126	0.0126	0.0185	0.00695	1.02E-03 | 9.9E-04	1.04E-03	9.91E-04
$^{87/86}$Sr	0.709231	0.709224	0.709294	0.709297	--	--	--
^{99}Tc	<0.00056	--	0.00109	0.00536	--	--	--
^{129}I	3.11E-05	3.31E-05	4.64E-05	4.61E-05	--	--	--
$^{239/240}$Pu	TBD	TBD	TBD	TBD	--	--	--
^{234}U	--	0.071	7.14	6.88	--	--	--
$^{234/235}$U	--	0.024419	0.028618	0.028645	--	--	--
^{235}U	--	0.001014	0.0871	0.0838	--	--	--
$^{234/238}$U	--	1.77E-04	2.08E-04	2.08E-04	--	--	--
$^{235/238}$U	--	1.77E-04	2.08E-04	2.08E-04	--	--	--
^{236}U	--	<4.1E-06	<4.1E-06	<4.1E-06	--	--	--
$^{236/235}$U	--	<7.5E-06	<7.6E-06	<7.7E-06	--	--	--
^{238}U	--	0.022	1.89	1.82	--	--	--
DRI/University of Arizona							
DOC	--	--	--	--	TBD	TBD	TBD
C-13/12 DOC (‰)	--	--	--	--	TBD	TBD	TBD
^{14}C DOC (pmc)	--	--	--	--	TBD	TBD	TBD

Table B.2-2
Specialized Laboratory Results for Pahute Mesa Characterization Locations
(Page 3 of 3)

Analyte	ER-20-12_p1 07/06/2016		ER-20-12_m1 08/19/2016		ER-EC-12_m2 07/20/2016	ER-EC-8_m1-3 09/29/2016	ER-EC-2A_m3 10/11/2016
USGS							
S-34/32 (‰)	--	--	19.2	19.46	15.56 | 15.66	17.925	18.9

[a] Reported as ratio, not atoms/g.

atoms/g = Atoms per gram
DIC = Dissolved inorganic carbon
pmc = Percent modern carbon

-- = Not analyzed

Notes:
(1) Values reported with a "|" indicate sample | duplicate results.
(2) Non-detects are reported as "<MDC."

Table B.2-3
Commercial Laboratory Results for Pahute Mesa Early Detection Locations

Analyte	PM-3_p1 09/13/2016		PM-3_p2 09/13/2016	
	(pCi/L)			
^{3}H (Low Level)	124 [a]	34.2	194	185

[a] The sample was dark black in color and collected from a separate bailer than the duplicate. The difference between the sample and duplicate results likely represents the impact of not purging the well and the subsequent differences in groundwater collected from the two separate bailers at this location.

Table B.2-4
Commercial Laboratory Results for Pahute Mesa Distal Well Location

Analyte	ER-EC-1_m1-3 07/15/2016	
	(pCi/L)	
^{3}H (Low Level)	<2.87 | <3.05	U 0.37[a] | <0.25[a]

[a] Sample analyzed by LLNL.

U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect

Note: Values reported with a "|" indicate sample | duplicate results.

B.3.0 Rainier Mesa/Shoshone Mountain

This section presents the commercial laboratory (see Tables B.3-1 and B.3-3, and B.3-4) and LLNL (Table B.3-2) results for three characterization (Tables B.3-1 and B.3-2), one early detection (Table B.3-3), and two distal (Table B.3-4) wells in the RM/SM CAU. Although E-Tunnel is not currently a characterization location, it was evaluated as such in 2016. The results are therefore included in Tables B.3-1 and B.3-2.

Table B.3-1
Commercial Laboratory Results for RM/SM Characterization Locations
(Page 1 of 2)

Analyte	ER-12-3_p1		ER-12-4_p2	UE-18t_p1	E-Tunnel
	07/26/2016[a]	09/07/2016	09/21/2016[a]	10/28/2016	10/18/2016
Major and Minor Constituents (mg/L)					
Alkalinity as $CaCO_3$	--	109 | 109	156	J+ 118	176 | 178
HCO_3 [b]	--	132.9 | 132.9	190.16	J+ 143.84	215 | 217
CO_3 [b]	--	<0.87 | <0.87	<0.87	<0.87	<0.87 | <0.87
Br	J 0.107 | J 0.115	J 0.151 | J 0.144	J 0.185	<0.067	J 0.068 | J 0.081
Cl	9.56 | 9.38	J+ 9.05 | J+ 9.02	11.6	3.17	J+ 8.61 | J+ 8.61
F	J 0.092 | J 0.077	J 0.087 | J 0.087	0.133	8.43	0.14 | 0.13
SO_4	5.74 | 5.75	9.4 | 9.3	6.29	12.2	15.7 | 15.7
Ca	--	4.4 | 3.85	J+ 10.6	3.74	3.03 | 2.95
Mg	--	0.51 | 0.43	7.04	J 0.217	0.94 | 0.98
K	--	2.56 | 2.58	15.1	2.32	1.23 | 1.27
Na	--	54 | 52.1	79.1	59.4	J+ 81.7 | J+ 81.5
Al	--	1.07 | 0.88	63.3	J 0.371	2.68 | 3.05
SiO_2 [c]	--	48.13 | 45.99	303.79 | 305.88	32.51	56.68 | 60.75
Fe	--	J 20 | J 10.1	712	5.5	2.03 | 2.31
Trace Constituents (µg/L)					
Ag	--	J 1.17 | <1	<10	<1	<1 | <1
As	--	<5 | <5	<50	J 17.6	<5 | <5
Ba	--	8.21 | 5.29	124	74.7	17.1 | 17.2
Cd	--	<1 | <1	<10	<1	<1 | <1
Cr	--	7.71 | J 2.67	<10	J 2.56	<1 | <1
Li	--	29.7 | 30.3	69.6	92.7	49.3 | 49.9
Mn	--	363 | 238	3,820	363	22.5 | 25.0
Pb	--	J 1.6 | J <0.678	22.3	35.8	J 0.87 | J 1.0

Table B.3-1
Commercial Laboratory Results for RM/SM Characterization Locations
(Page 2 of 2)

Analyte	ER-12-3_p1		ER-12-4_p2	UE-18t_p1	E-Tunnel
	07/26/2016[a]	09/07/2016	09/21/2016[a]	10/28/2016	10/18/2016
Se	--	<2 | <2	J 4.06	<2	<2 | <2
Sr	--	7 | 5.39	<10	107	7.78 | 7.78
U	--	0.891 | 0.693	J 10.6	J 0.069	2.28 | 2.37
RNs (pCi/L)					
Gross Alpha	--	<2.91 | U 3.01	--	U 2.47	12.6 |10.4
Gross Beta	--	<2.42 | U 2.83	--	3.83	20.8 | 20.8
^{3}H	--	<188 | <195	<250	<116	3.13E+05 | 2.98E+05
^{3}H (Low Level)	21.6 | 23.5	24.4 | 27.3	7.62	<3.11 | <3.07	--
^{14}C	--	<337 | <334	--	<330	<345 | <344
^{26}Al	--	<3.38 | <3.5	--	<5.44	<6.68 | <5.58
^{36}Cl	--	<2.27 | 2.52	--	<3.13	<27.9 | 32.4
^{90}Sr	--	<0.994 | <0.966	--	<0.843	<0.89 | <0.811
^{94}Nb	--	<3.75 | <4.56	--	<4.53	<3.58 | <4.47
^{99}Tc	--	<5.9 | <5.6	--	<8.54	<8.11 | <8.05
^{129}I	--	<0.6 | <0.757	--	<0.97	<0.85 | <1.08
^{137}Cs	--	<3.73 | <4.55	--	<4.34	18.5 | 18.6
^{152}Eu	--	<11.3 | <10.8	--	<12.9	<13.8 | <15.4
^{154}Eu	--	<9.97 | <12	--	<14.4	<14.5 | <10.9
^{155}Eu	--	<13.7 | <15.8	--	<15.9	<19.3 | 19.8
^{235}U	--	<26.6 | <27.6	--	<29.9	<33.3 | <36.2
^{238}Pu	--	<0.0385 | <0.0209	--	<0.0433	0.303 | 0.201
$^{239/240}Pu$	--	<0.0214 | <0.017	--	<0.0496	1.77 | 1.85
^{241}Am	--	<14.4 | <23.2	--	<20.7	<43.9 | <34.2

[a] Sample was bailed on 9/21 and 9/22/2016.
[b] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L HCO_3/mg/L $CaCO_3$ (HCO_3) and 0.6 mg/L CO_3/mg/L $CaCO_3$ (CO_3).
[c] Values converted from laboratory reported (silicon) by multiplying times 2.139 mg silica/mg silicon.

J+ = Result is estimated and is biased high.
J = Result is estimated.
U = Result was above the detection limit but below the detection limit plus error and is considered a non-detect.
-- = Not analyzed

Note: Values reported with a "|" indicate unfiltered | filtered sample results.

Table B.3-2
Specialized Laboratory Results for RM/SM Characterization Locations

Analyte	ER-12-3_p1 09/07/2016		UE-18t_p1 10/28/2016	E-Tunnel 10/18/2016
LLNL				
Environmental Tracers				
H-2/1 (‰)	-100.2	-101.2	-109.5	-101.7 | -102.4
C-13/12 (‰)	-11.16	-11.66	-5.92	-14.22 | -14.32
O-18/16 (‰)	-13.7	-13.57	-14.57	-13.61 | - 13.74
Noble Gases (atoms/g)				
Ar	TBD	TBD	7,52 E+15	TBD
^{40}Ar	TBD	TBD	7.49 E+15	TBD
^{3}He	TBD	TBD	5.81 E+06	TBD
^{4}He	TBD	TBD	1.84 E+13	TBD
^{3}He/^{4}He (R/Ra)	TBD	TBD	--	TBD
Kr	TBD	TBD	1.76 E+12	TBD
Ne	TBD	TBD	4.72 E+12	TBD
^{20}Ne	TBD	TBD	4.27 E+12	TBD
Xe	TBD	TBD	2.56 E+11	TBD
^{130}Xe	TBD	TBD	1.05 E+10	TBD
RNs (pCi/L)				
^{3}H (Low Level)	22.25 [a] | 21.03 [a]	20.98 | 21.57	< 0.4	--
^{14}C	0.088	0.087	0.02	13.83 | 14.21
^{36}Cl	0.00159	0.00156	0.00115	13.1 | 13.2
^{99}Tc	--	--	--	0.406 | 0.35
^{129}I	--	--	--	0.0203 | 0.0202

[a] Sample was bailed on 07/26/2016.

J+ = Result is estimated and is biased high.
NA = Not available at the time of reporting.
-- = Not analyzed

Note: Values reported with a "|" indicate sample | duplicate results.

Table B.3-3
Commercial Laboratory Results for RM/SM Early Detection Locations

Analyte	ER-19-1_p1	ER-19-1_p2
	11/16/2016	11/16/2016
RNs (pCi/L)		
Gross Alpha	--	--
Gross Beta	--	--
^{3}H	<2.87 | U 3.31	<2.99 | <3.05

-- = Not analyzed

Note: Values reported with a "|" indicate sample | duplicate results.

Table B.3-4
Commercial Laboratory Results for RM/SM Distal Well Location

Analyte	UE-16D_m1	WW 8_m26			
	01/26/2016	01/26/2016	04/19/2016	07/26/2016	10/25/2016
RNs (pCi/L)					
Gross Alpha	--	<2.0	<1.4	1.2	<1.7 | <1.8
Gross Beta	--	2.2	1.5	2.4	2.1 | 2.2
^{3}H	<180	<177	<110	<196	<235 | <236

-- = Not analyzed

Note: Values reported with a "|" indicate sample | duplicate results.

B.4.0 Yucca Flat/Climax Mine

This section presents the commercial (see Tables B.4-1 and B.4-3) laboratory and LLNL (see Tables B.4-2 and B.4-4) results for one characterization (Tables B.4-1 and B.4-2), and one source/plume (Tables B.4-3 and B.4-4) well in the YF/CM CAU.

Table B.4-1
Commercial Laboratory Results for YF/CM Characterization Locations
(Page 1 of 2)

Analyte	ER-3-3_m1 12/15/2016	
Major and Minor Constituents (mg/L)		
Alkalinity as $CaCO_3$	170	200
HCO_3 [a]	158.47	146.28
CO_3 [a]	21	49.8
Br	J 0.08	J 0.1
Cl	8.6	9.0
F	2.2	2.1
SO_4	52	56
Ca	15	36
Mg	3.6	7.0
K	14	13
Na	100	100
Al	J 6.5	J 13
Fe	5.0	9.2
Silica [b]	201.32	251.65
Trace Constituents (µg/L)		
Ag	<1.1	<1.1
As	24	24
Ba	J 28	J 71
Cd	<0.33	<0.33
Cr	21	24
Li	90	98
Mn	110	270
Pb	18	29
Se	5.9	8.6
Sr	89	160
U	4.1 | 4.1	3.7 | 3.7

Table B.4-1
Commercial Laboratory Results for YF/CM Characterization Locations
(Page 2 of 2)

Analyte	ER-3-3_m1 12/15/2016	
RNs (pCi/L) [c]		
Gross Alpha	5.6	13.1
Gross Beta	J 19.6	J 19.8
^{3}H	<310	<310
^{14}C	<410	<390
^{26}Al	<9	<11.8
^{36}Cl	<2.8	<3.1
^{90}Sr	<0.23	<0.26
^{94}Nb	<7.9	<8.5
^{99}Tc	<7.5	<7.2
^{129}I	<0.64	<0.74
^{137}Cs	<7.7	<8.0
^{152}Eu	<39	<47
^{154}Eu	<44	<47
^{235}U	<38	<43
^{238}Pu	<0.045	<0.033
$^{239/240}Pu$	<0.016	<0.017
^{241}Am	<270	<47

[a] Values converted from the laboratory reported units (mg/L as $CaCO_3$) by multiplying times 1.219 mg/L HCO_3/mg/L $CaCO_3$ (HCO_3) and 0.6 mg/L CO_3/mg/L $CaCO_3$ (CO_3).
[b] Values converted from laboratory reported (Silicon) by multiplying by 2.139 mg silica / mg silicon.
[c] Only candidates for inclusion into the source-term inventory (Finnegan et al., 2016) and those required by the sampling plan are included in this table.

J = Result is estimated.

Notes:
(1) Values reported with a "|" indicate sample | duplicate results.
(2) Non-detects are reported as "<MDC."

Table B.4-2
Specialized Laboratory Results for YF/CM Characterization Locations

Analyte	ER-3-3_m1 12/15/2016
LLNL	
Environmental Tracers	
H-2/1 (‰)	-107
C-13/12 (‰)	-5.92
O-18/16 (‰)	-13.79
Noble Gases (atoms/g)	
Ar	2.59 E+16
^{40}Ar	2.58 E+16
^{3}He	1.17 E+07
^{3}He/^{4}He (R/Ra) [a]	--
^{4}He	2.15 E+13
Kr	4.8 E+12
Ne	3.54 E+13
^{20}Ne	3.2 E+13
Xe	5.38 E+11
^{130}Xe	2.21 E+10
RNs (pCi/L)	
^{3}H	--
^{3}H (Low Level)	< 1.0
^{14}C	0.0198
^{36}Cl	5.85 E-13

[a] Reported as ratio, not atoms/g.

-- = Not analyzed

Note: Non-detects are reported as “<MDC.”

Table B.4-3
Commercial Laboratory Results for YF/CM Source/Plume Locations

Analyte	UE-2ce_m1				
	12/14/2016	12/15/2016		12/16/2016	
RNs (pCi/L)					
Gross Alpha	--	--	--	19.7	17.8
Gross Beta	--	--	--	21	20.1
^{3}H	120,000	134,000	134,000	142,000	144,000
^{14}C	--	--	--	<318	<318
^{26}Al	<4.74	<8.53	<9.18	<5.28	--
^{36}Cl	--	--	--	<24.9	<24.8
^{90}Sr	<0.858	<0.887	<0.906	<0.96	--
^{94}Nb	<4.6	<6.65	<6.02	--	--
^{99}Tc	--	--	--	<7.4	<7.64
^{129}I	--	--	--	<1	<0.637
^{137}Cs	<4.69	<6.08	<6.80	<6.32	--
^{152}Eu	<12.4	<14.3	<18.2	<16	--
^{154}Eu	<8.72	<20.3	<20.3	<16.7	--
^{235}U	<26.7	<25.5	<38	<29.7	--
^{241}Am	<17.3	<7.16	<37.1	--	--
^{243}Am	<6.3	<4.48	<11.5	--	--

J = Result is estimated.
-- = Not analyzed

Note: Two columns for each sampling date report the sample and duplicate results.

Table B.4-4
Specialized Laboratory Results for YF/CM Source/Plume Locations
(Page 1 of 2)

Analyte	UE-2ce_m1		
	12/14/2016	12/15/2016	12/16/2016
LLNL			
RNs (pCi/L)			
^{3}H	TBD	TBD	TBD
^{14}C	0.9264	0.9524 | 0.9564	0.9554
^{36}Cl	TBD	TBD	TBD
^{99}Tc	<2.2 E-04 | <5.6 E-04	<2.2 E-04 | <5.6 E-04	< 2.3 E-04 | <5.6 E-04
^{129}I	0.00998	0.00959 | 0.01	0.00932

Table B.4-4
Specialized Laboratory Results for YF/CM Source/Plume Locations
(Page 2 of 2)

Analyte	UE-2ce_m1		
	12/14/2016	12/15/2016	12/16/2016
LANL			
^{137}Cs	TBD	TBD	TBD

TBD = Not available at the time of reporting.

B.5.0 References

Finnegan, D.L., S.M. Bowen, J.L. Thompson, C.M. Miller, P.L. Baca, L.F. Olivas, C.G. Geoffrion, D.K. Smith, W. Goishi, B.K. Esser, J.W. Meadows, N. Namboodiri, and J.F. Wild. 2016. *Nevada National Security Site Radionuclide Inventory, 1951–1992: Accounting for Radionuclide Decay through September 30, 2012,* LA-UR-16-21749. Los Alamos, NM: Los Alamos National Laboratory.

Appendix C

Well Completion Diagrams

Well ID: ER-5-5		UTM NAD 27	Northing: 4,080,793.08 m	Easting: 595,344.32 m
Start Date: 07/31/2012	Stop Date: 08/12/2012	NSPC NAD 83	Northing: 6,235,460.34 m	Easting: 565,574.64 m
Drilling Program: Frenchman Flat		Lat/Long NAD 83	Deg N: 36.870051	Deg W: 115.931151
Environmental Contractor: UGTA/N-I		Surface Elevation	3,337.27 ft amsl	1,017.20 m amsl
Drilling Contractor: United Drilling, Inc.		Drill Method:	Rotary Air Foam	Drilled Depth: 1,087.52 ft bgs
Well Construction Diagram (Current as of 11/15/2016)				

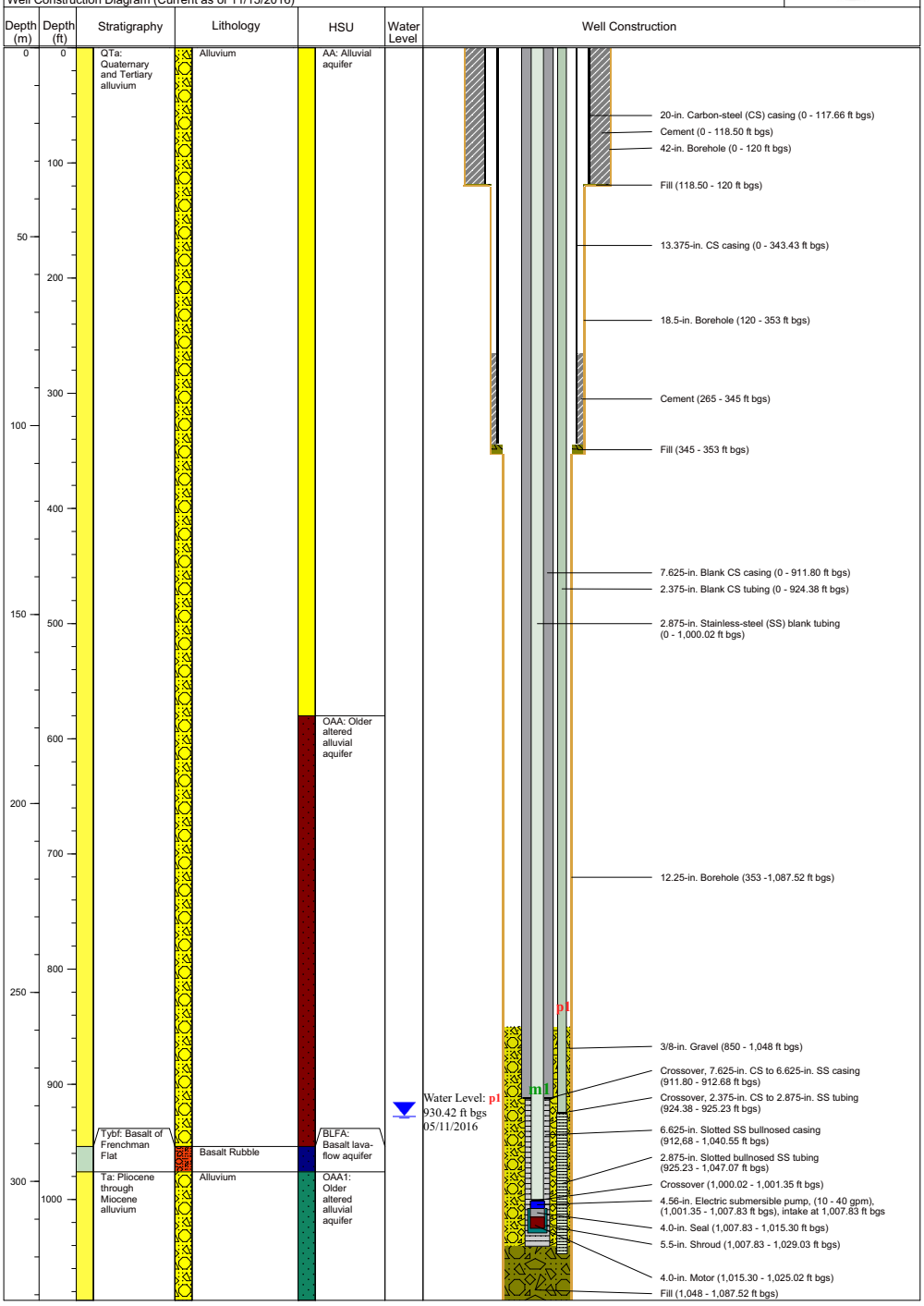


Figure C-1
Well Completion Diagram for ER-5-5

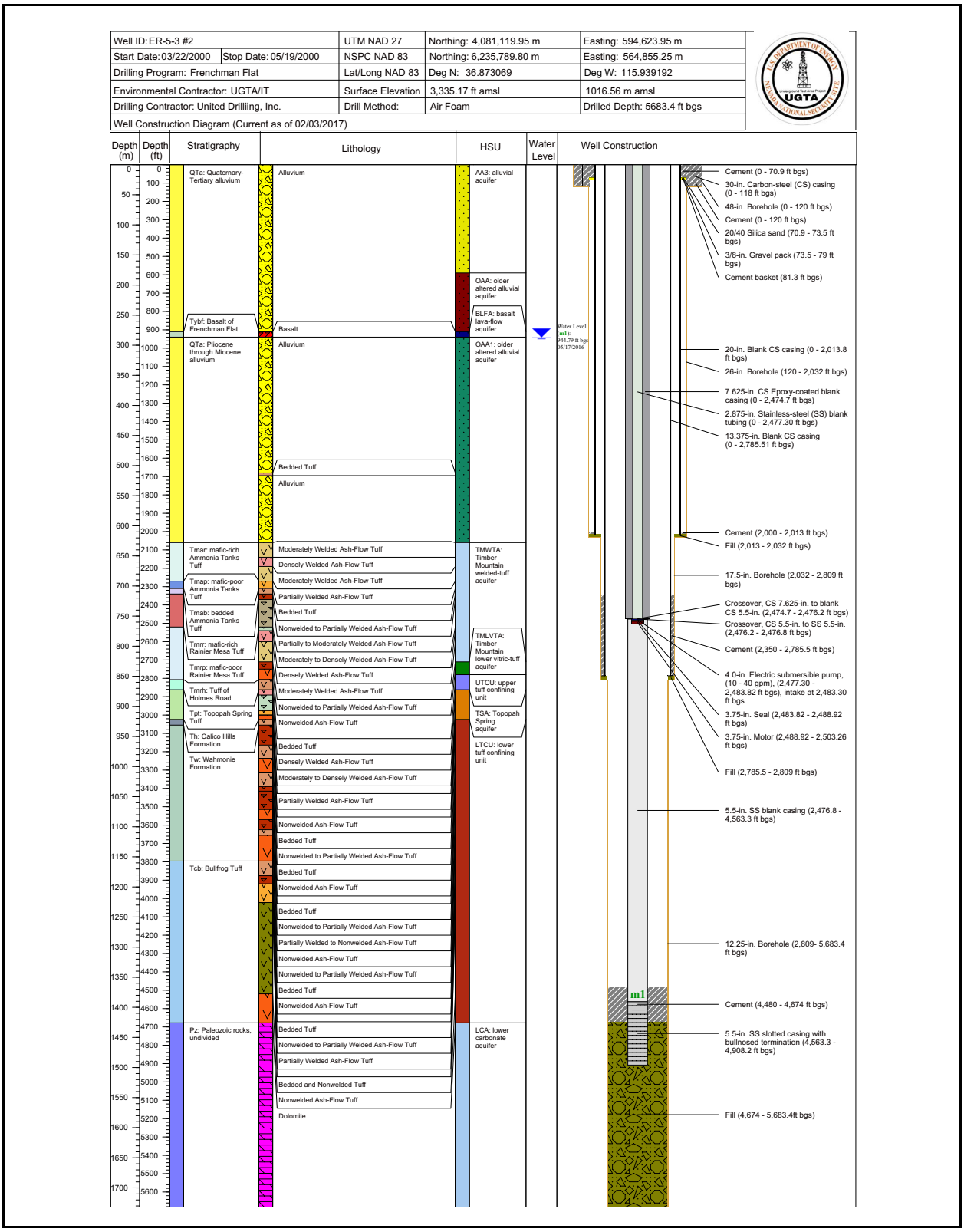


Figure C-2
Well Completion Diagram for ER-5-3-2

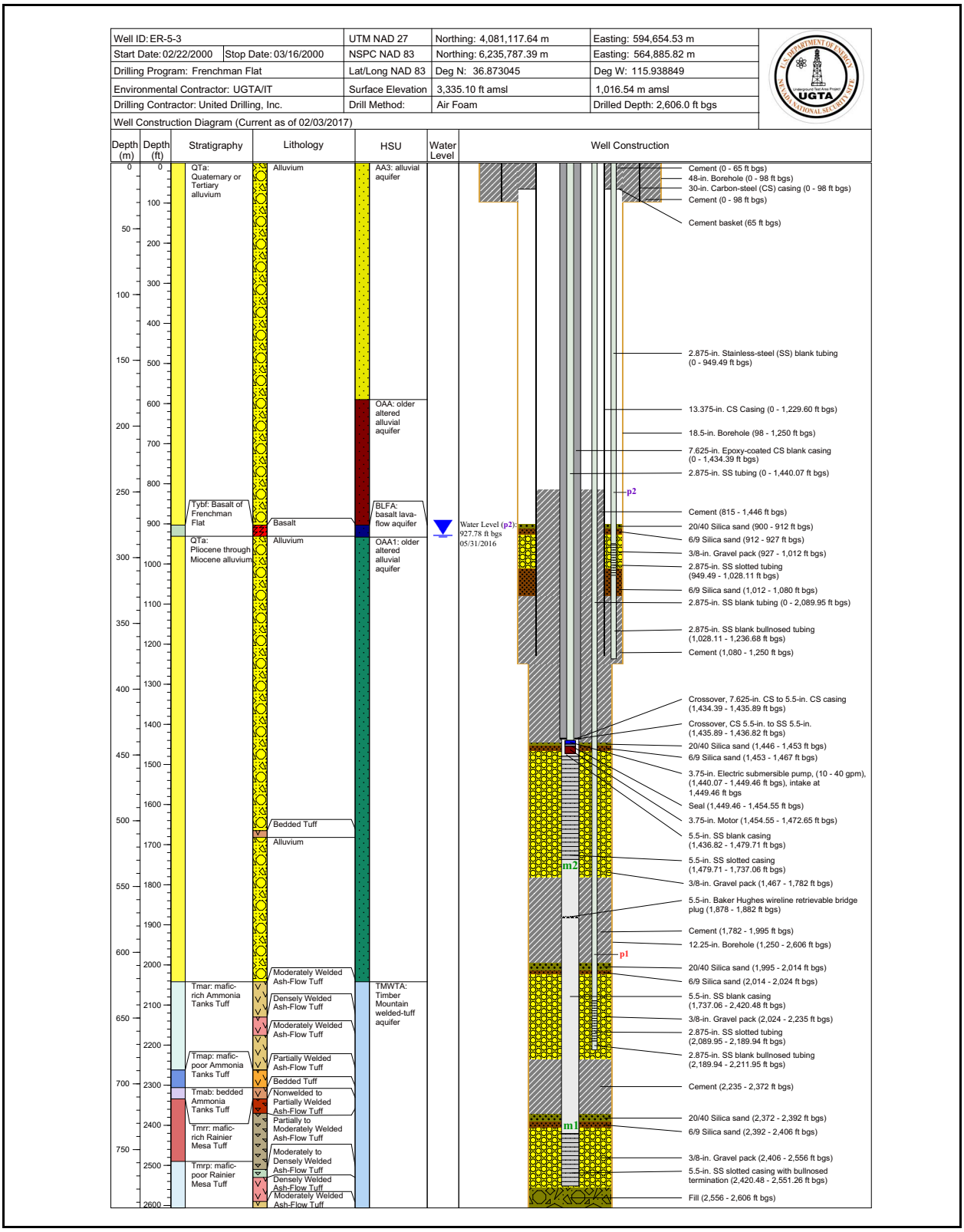


Figure C-3
Well Completion Diagram for ER-5-3

Well ID: UE-5n		UTM NAD 27	Northing: 4,075,284.87 m	Easting: 592,626.39 m
Start Date: 02/09/1976	Stop Date: 03/01/1976	NSPC NAD 83	Northing: 6,229,960.18 m	Easting: 562,836.83 m
Drilling Program: Exploratory Borehole		Lat/Long NAD 83	Deg N: 36.820673	Deg W: 115.96231
Environmental Contractor: Fenix & Scission, Inc.		Surface Elevation	3,113.36 ft amsl	948.95 m amsl
Drilling Contractor: REECo		Drill Method:	Reverse Circulation	Drilled Depth: 1,687 ft bgs
Well Construction Diagram (Current as of 12/05/2016)				

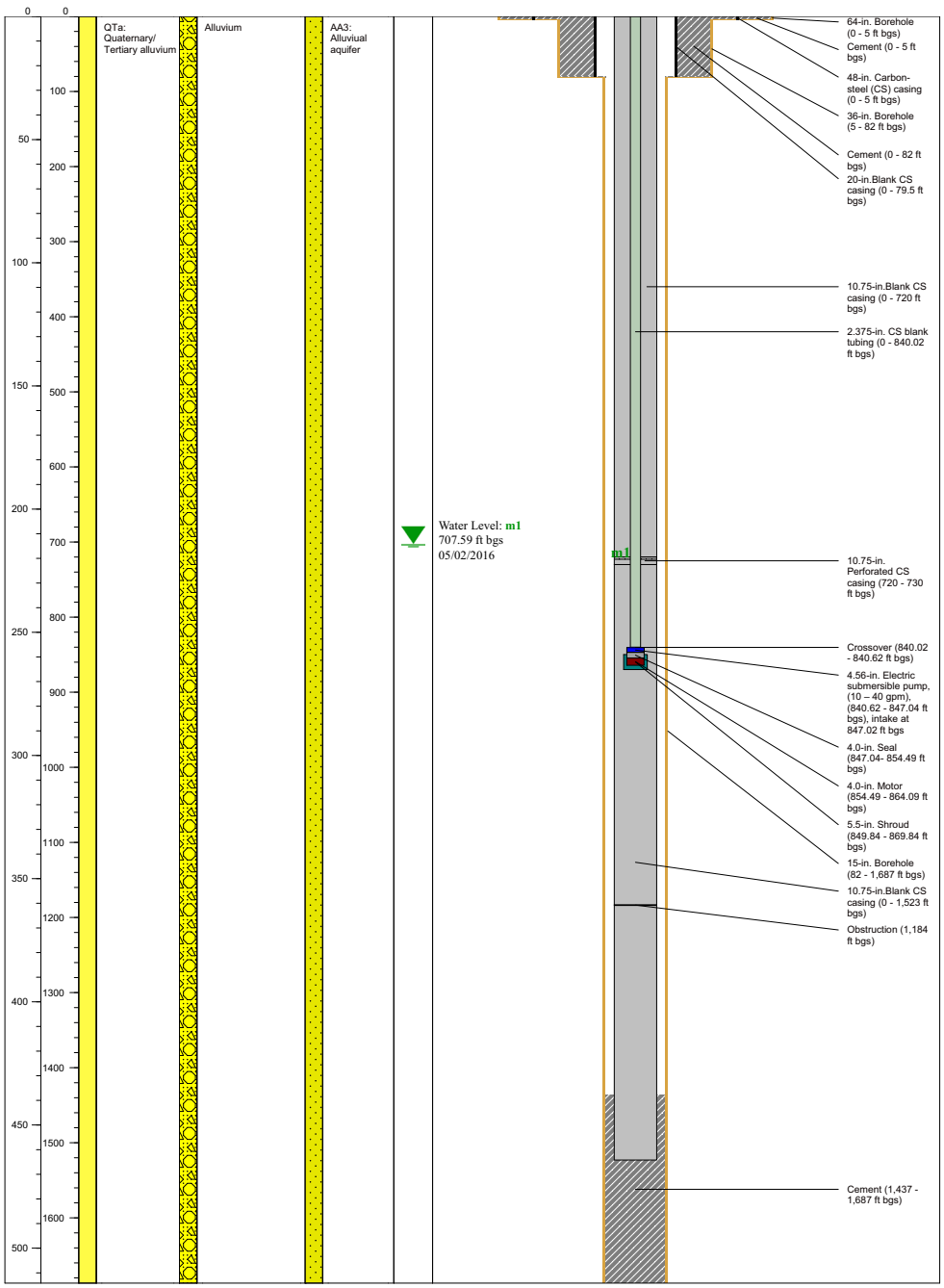


Figure C-4
Well Completion Diagram for UE-5n

Well ID: RNM-2s		UTM NAD 27	Northing: 4,075,483.95 m	Easting: 592,136.58 m
Start Date: 03/22/1974	Stop Date: 04/01/1974	NSPC NAD 83	Northing: 6,230,161.02 m	Easting: 562,347.59 m
Drilling Program: Hydrologic Test Hole		Lat/Long NAD 83	Deg N: 36.822515	Deg W: 115.967780
Environmental Contractor: Fenix & Scission, Inc.		Surface Elevation	3,130.45 ft amsl	954.2 m amsl
Drilling Contractor: REECo		Drill Method:	Reverse Circulation	Drilled Depth: 1,156 ft bgs
Well Construction Diagram (Current as of 11/16/2016)				

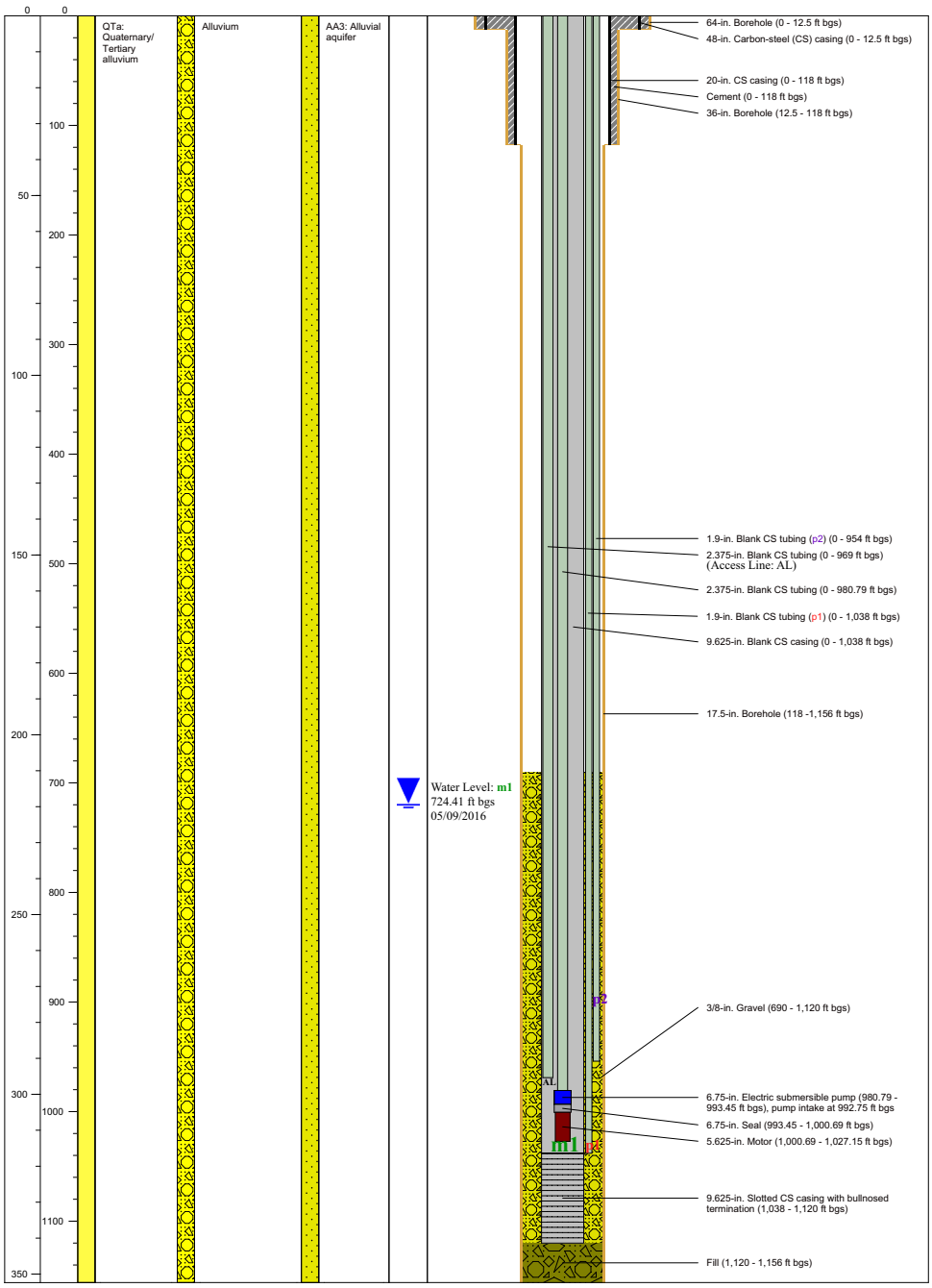


Figure C-5
Well Completion Diagram for RNM-2S

Well ID: ER-11-2		UTM NAD 27	Northing: 4,082,694.92 m	Easting: 594,576.47 m
Start Date: 08/18/2012	Stop Date: 08/23/2012	NSPC NAD 83	Northing: 6,237,365.34 m	Easting: 564,813.25 m
Drilling Program: Frenchman Flat		Lat/Long NAD 83	Deg N: 36.887269	Deg W: 115.939528
Environmental Contractor: UGTA/N-I		Surface Elevation	3,573.23 ft amsl	1,089.12 m amsl
Drilling Contractor: UDI		Drill Method:	Rotary Air Foam	Drilled Depth: 1,310.90 ft bgs
Well Construction Diagram (Current as of 11/14/2016)				

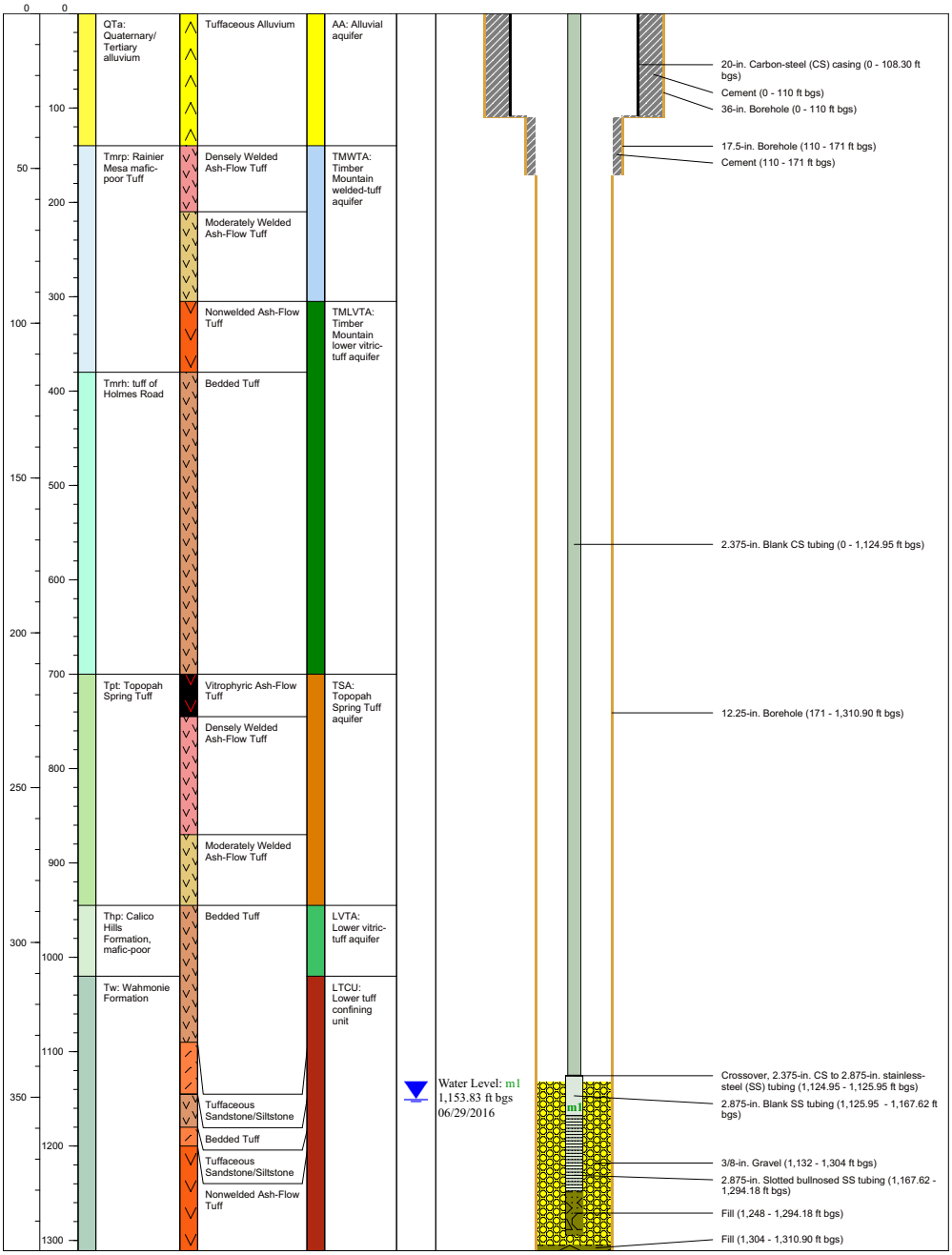


Figure C-6
Well Completion Diagram for ER-11-2

Well ID: ER-20-12	UTM NAD 27	Northing: 4,125,952.84 m	Easting: 540,925.06 m
Start Date: 10/08/2015 Stop Date: 01/06/2016	NSPC NAD 83	Northing: 6,280,822.82 m	Easting: 511,298.95 m
Drilling Program: Pahute Mesa Phase II	Lat/Long NAD 83	Deg N: 37.281047	Deg W: 116.539246
Environmental Contractor: UGTA/Navarro	Surface Elevation	6,258.40 ft amsl	1,907.56 m amsl
Drilling Contractor: UDI	Drill Method:	Conventional-Air/Foam	Drilled Depth: 4,543.33 ft bgs
Current Well Construction Diagram (11/03/2016)			

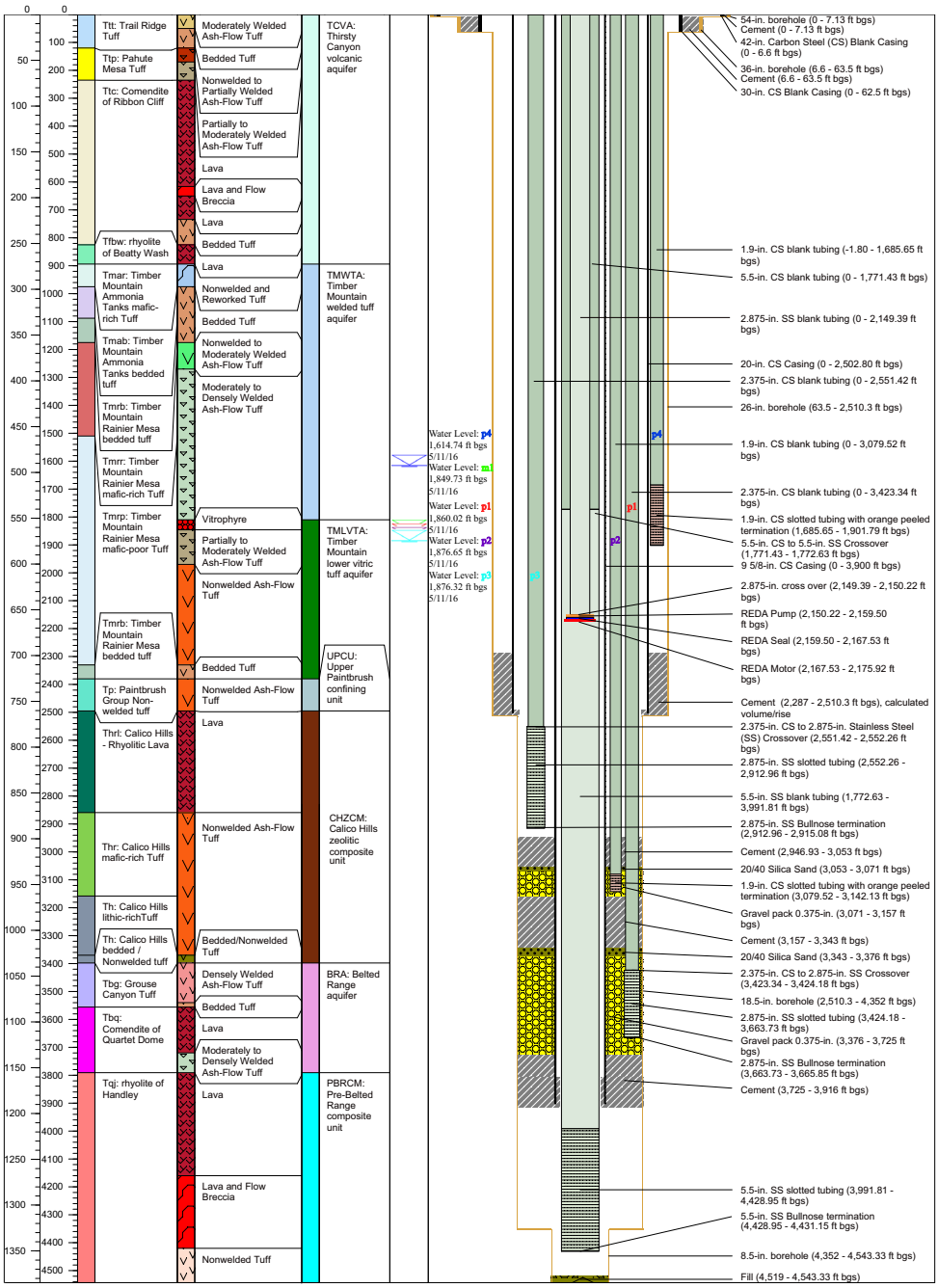


Figure C-7
Well Completion Diagram for ER-20-12

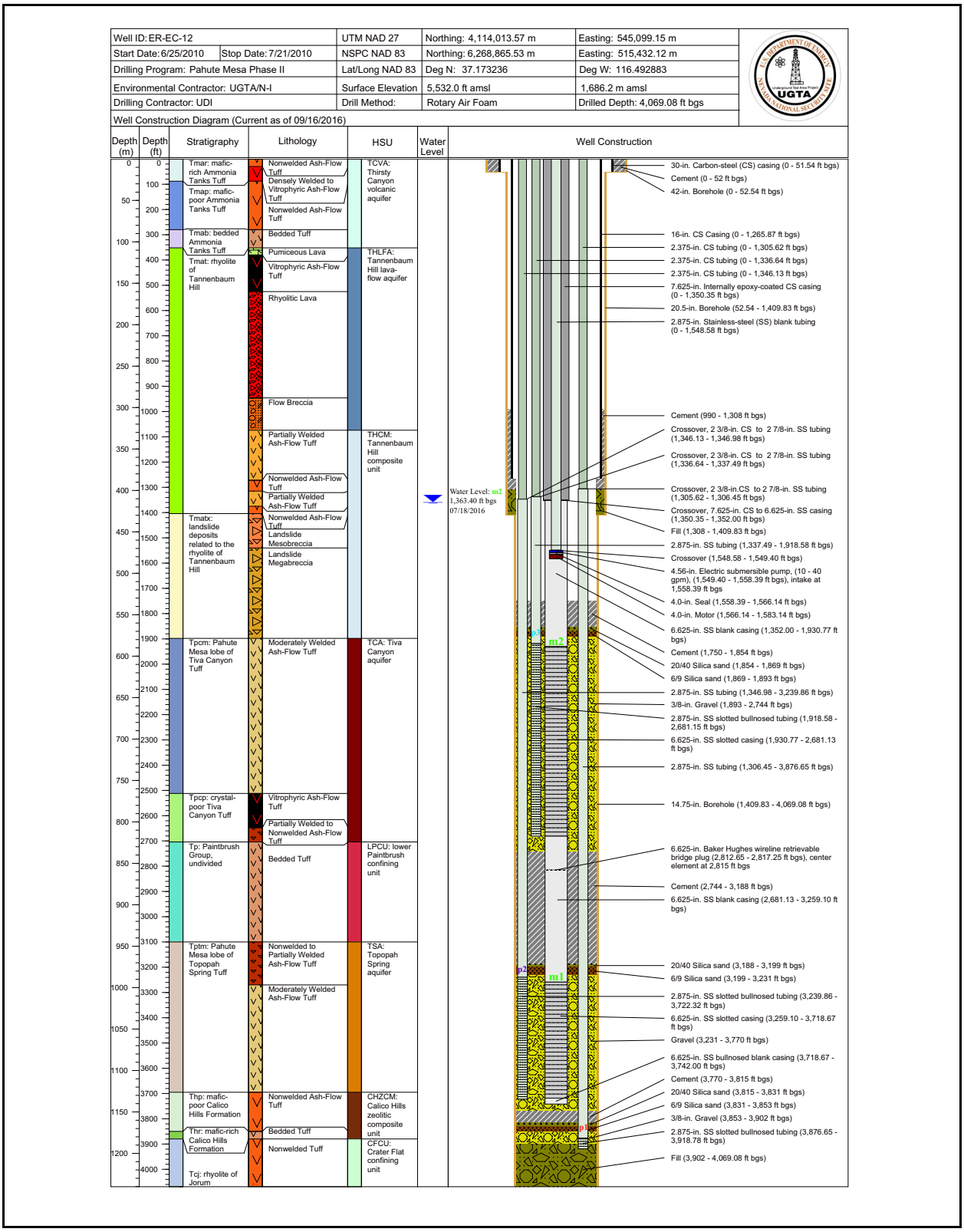


Figure C-8
Well Completion Diagram for ER-EC-12

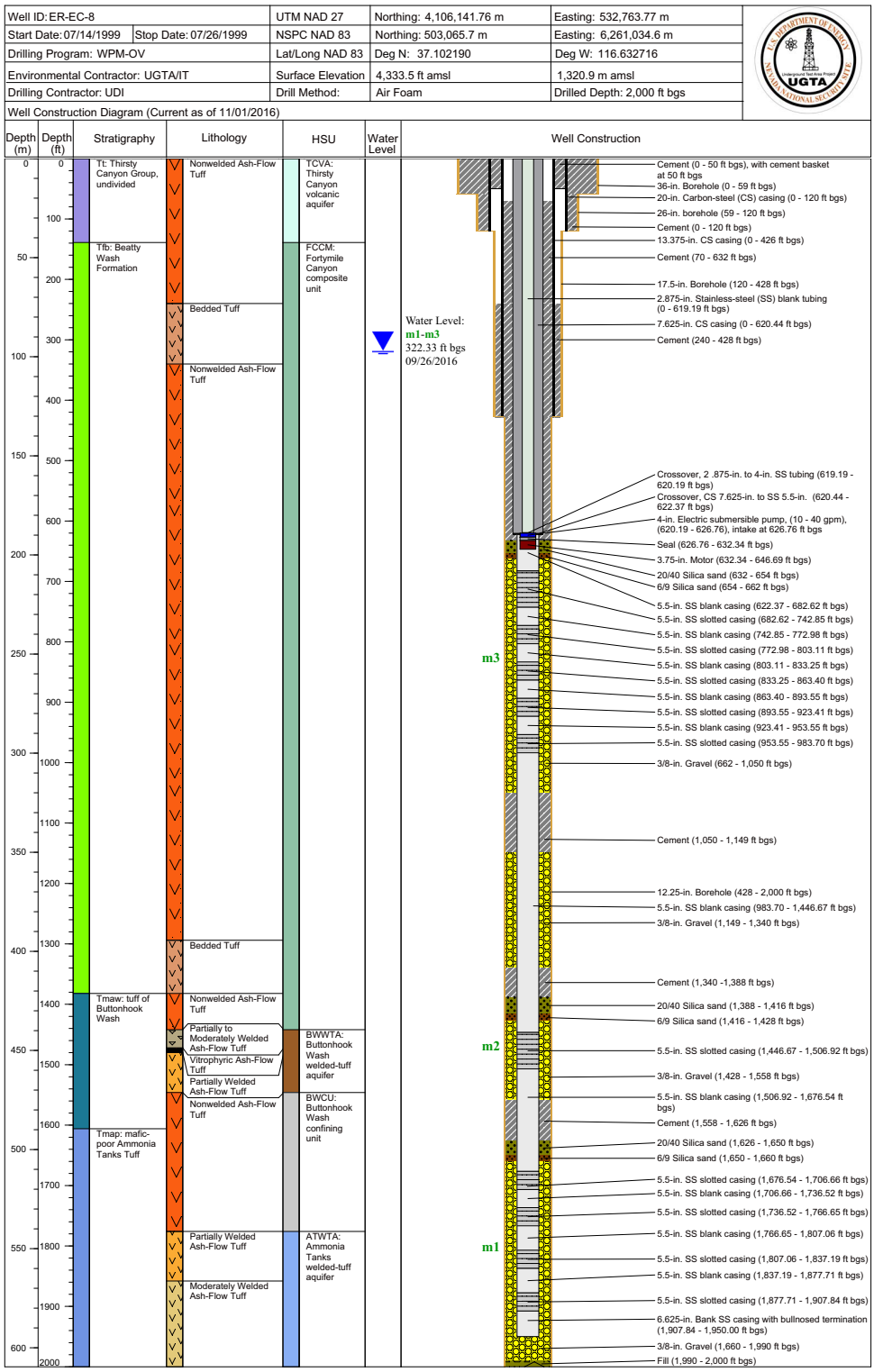


Figure C-9
Well Completion Diagram for ER-EC-8

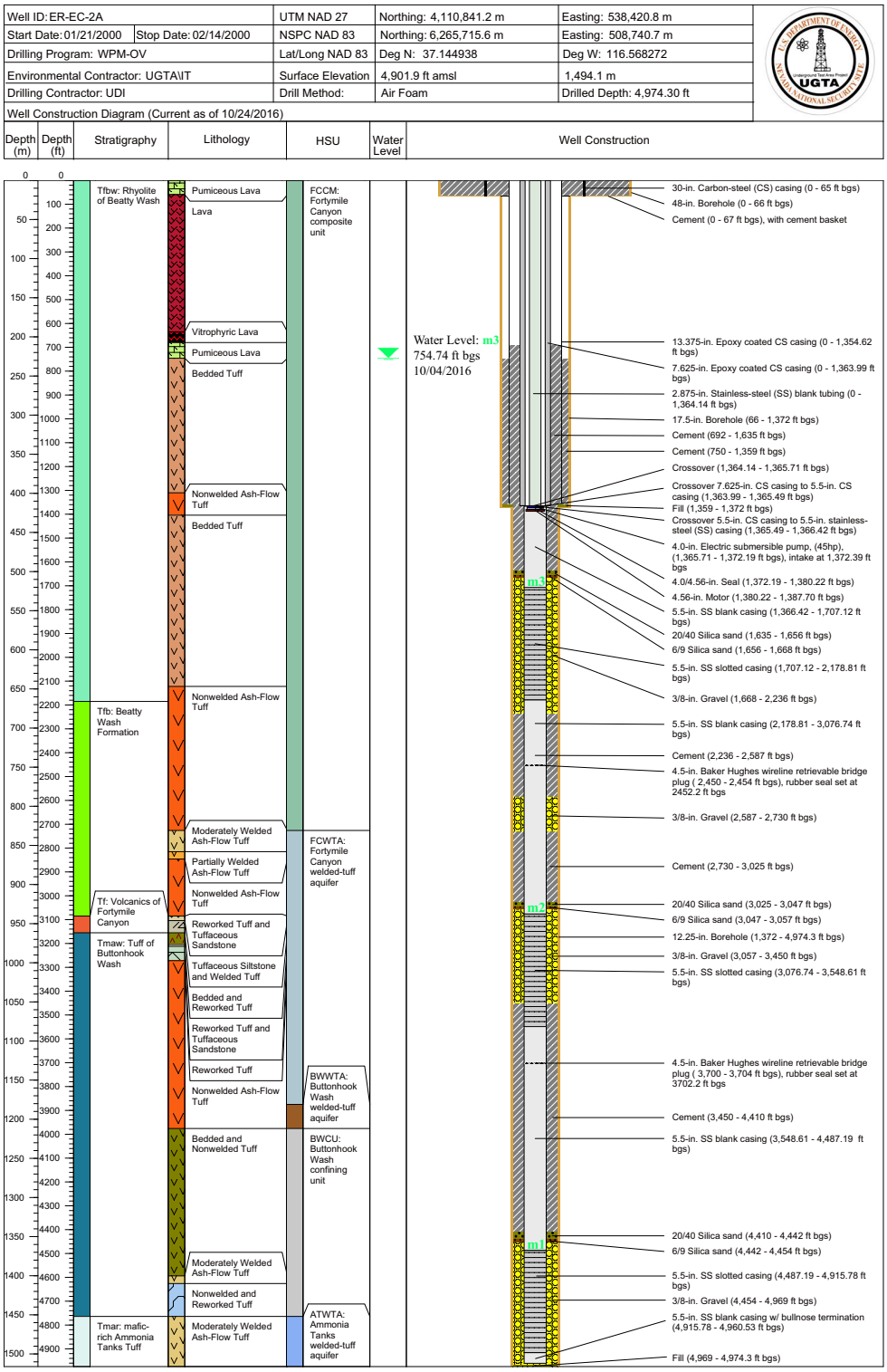


Figure C-10
Well Completion Diagram for ER-EC-2A

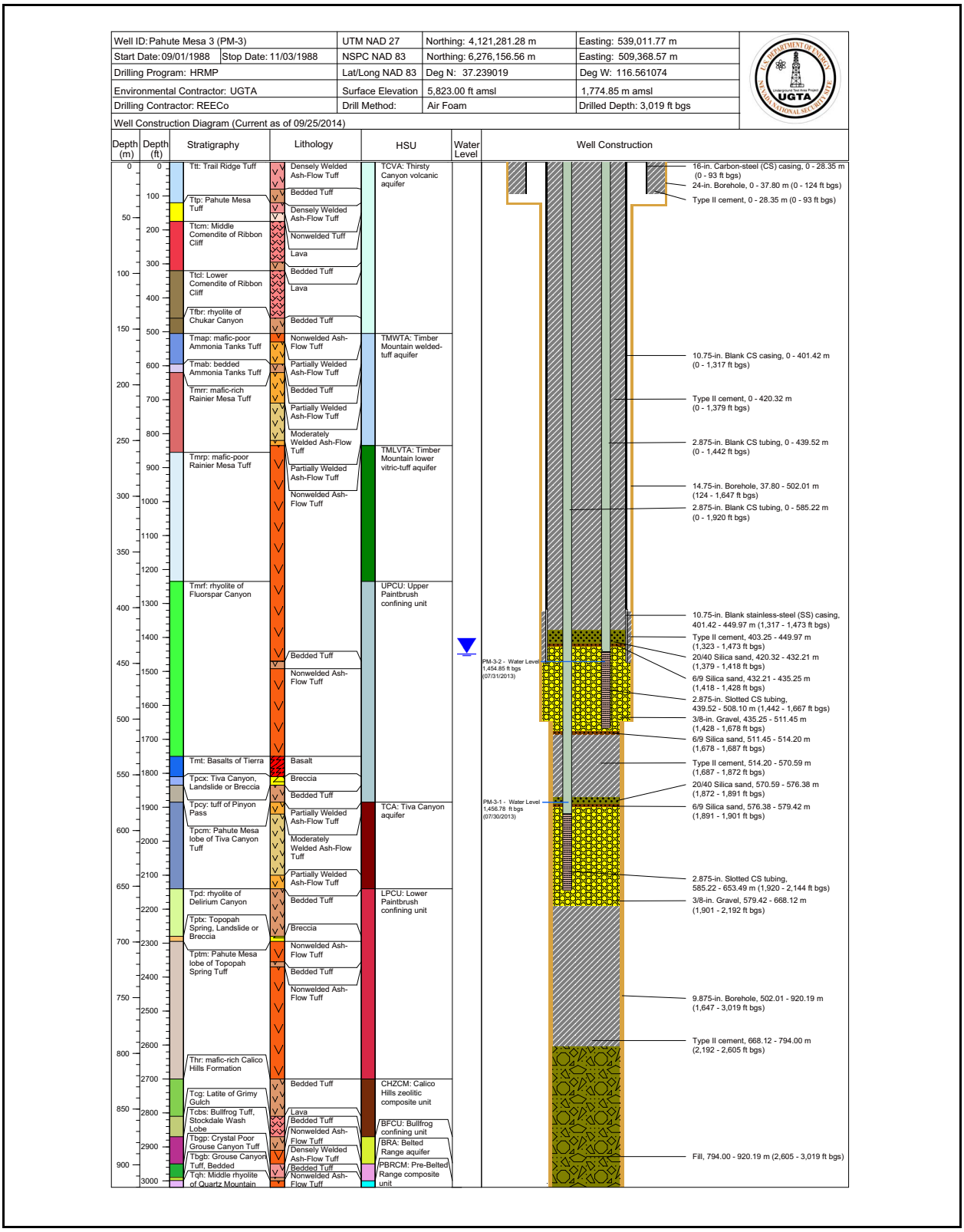


Figure C-11
Well Completion Diagram for PM-3

Well ID: ER-12-3		UTM NAD 27	Northing: 4,116,592.2 m	Easting: 569,748.3 m
Start Date: 03/26/2005	Stop Date: 04/28/2005	NSPC NAD 83	Northing: 6,271,358.5 m	Easting: 540,097.2 m
Drilling Program: Rainier Mesa-Shoshone Mountain		Lat/Long NAD 83	Deg N: 37.194968	Deg W: 116.214993
Environmental Contractor: UGTA/SNJV		Surface Elevation	7,390.8 ft amsl	2,252.7 m amsl
Drilling Contractor: UDI		Drill Method:	Rotary Air Foam	Drilled Depth: 4,908 ft bgs
Well Construction Diagram (Current as of 12/06/2016)				

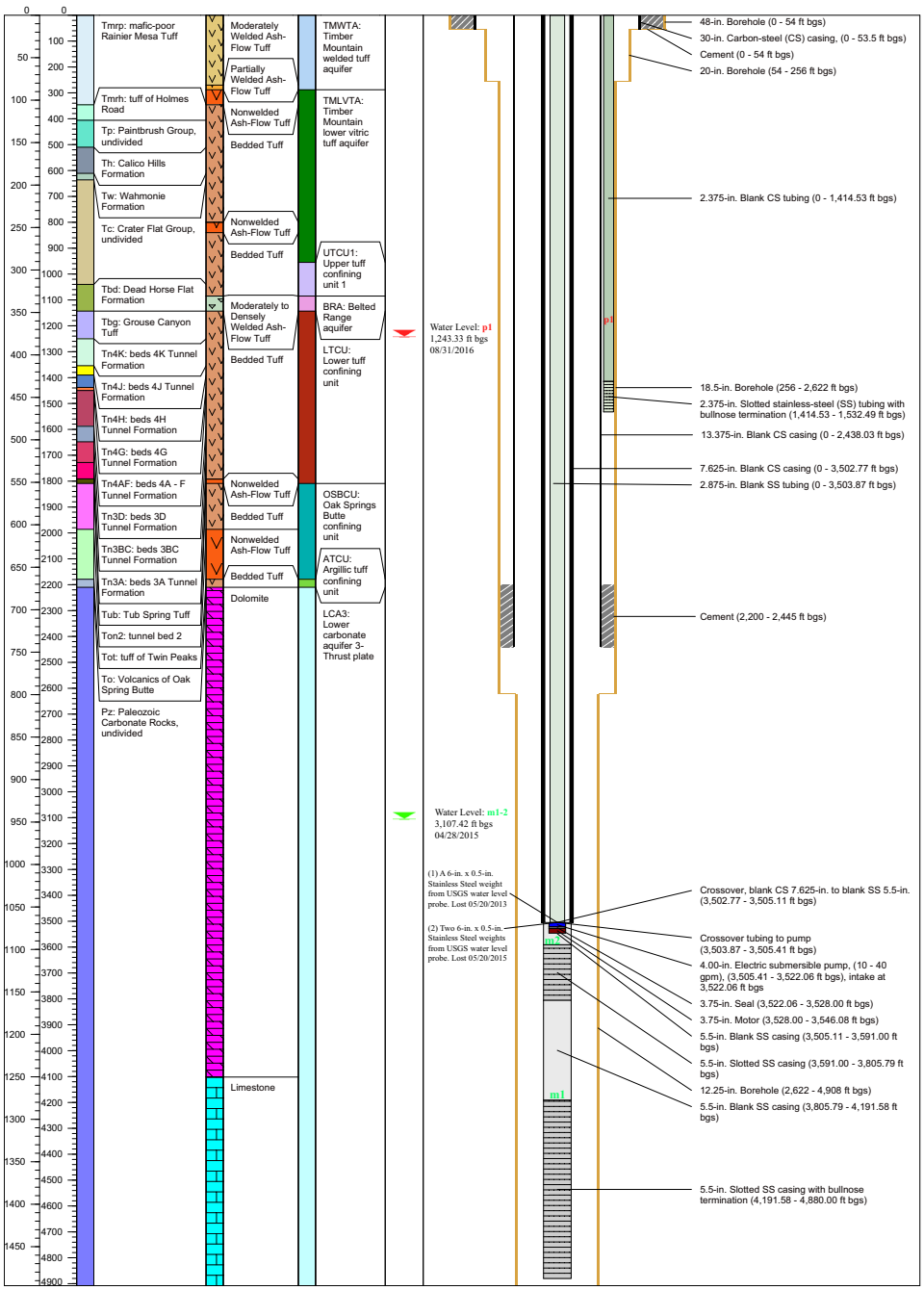


Figure C-12
Well Completion Diagram for ER-12-3

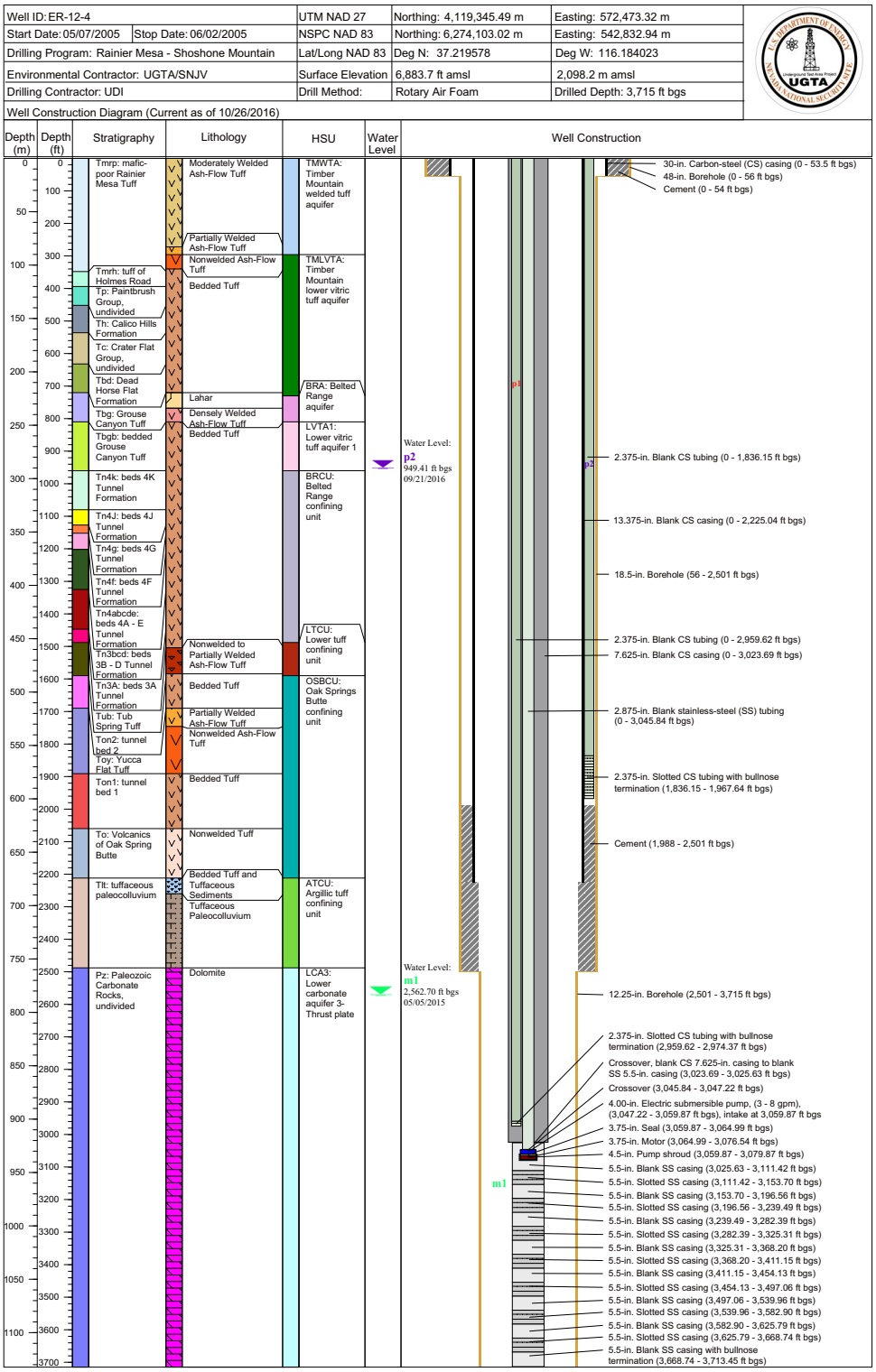


Figure C-13
Well Completion Diagram for ER-12-4

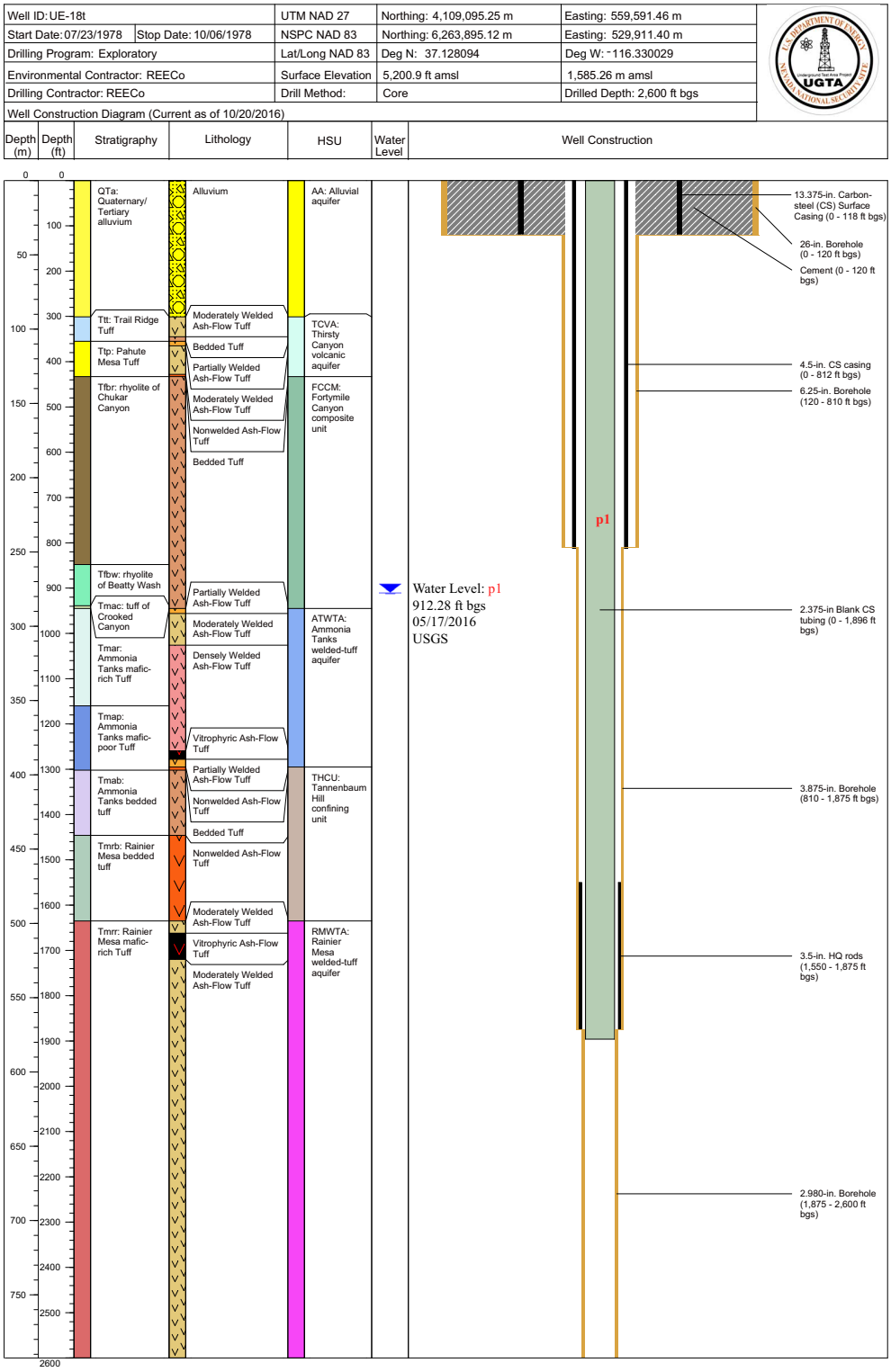


Figure C-14
Well Completion Diagram for UE-18t

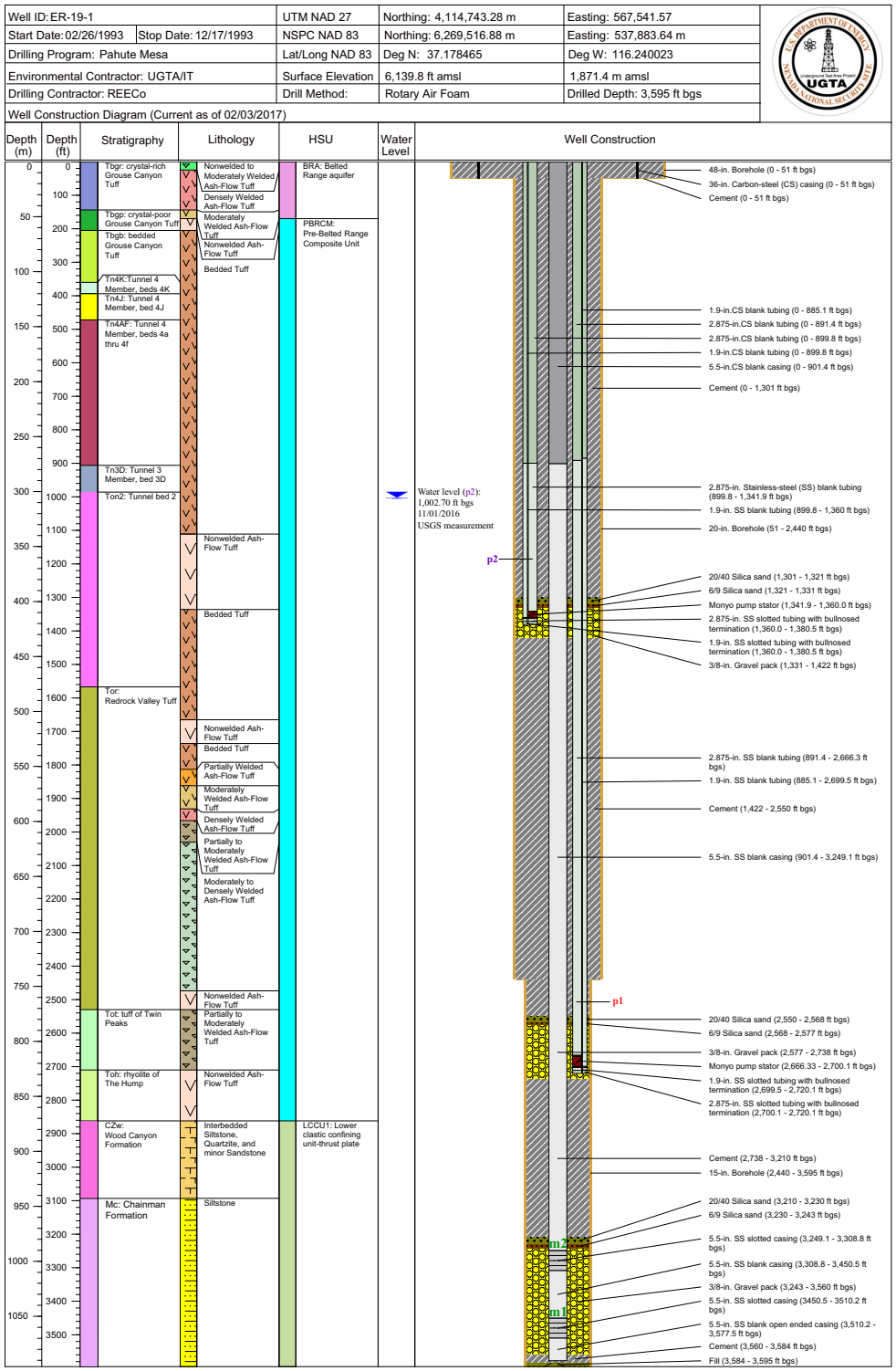


Figure C-15
Well Completion Diagram for ER-19-1

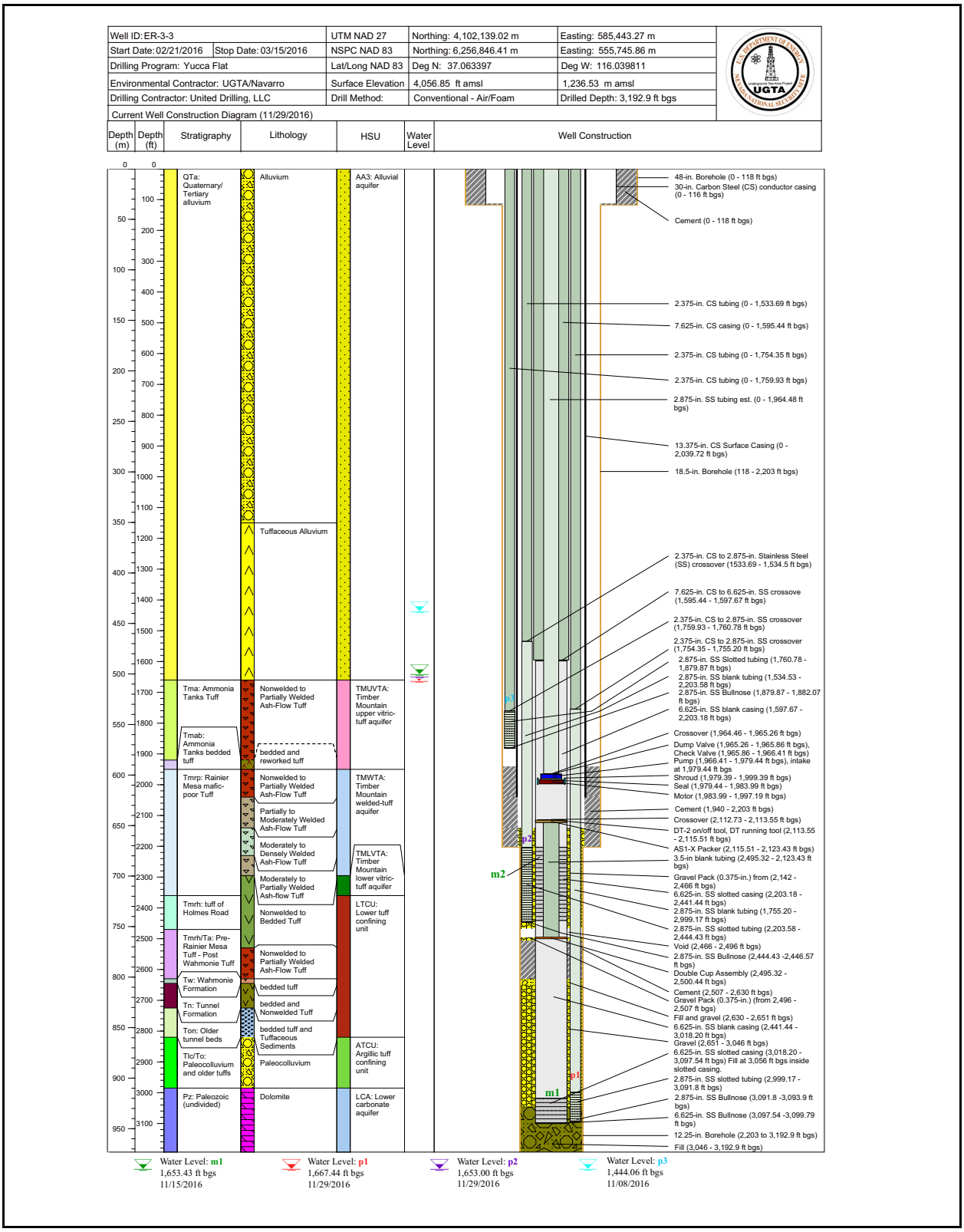


Figure C-16
Well Completion Diagram for ER-3-3

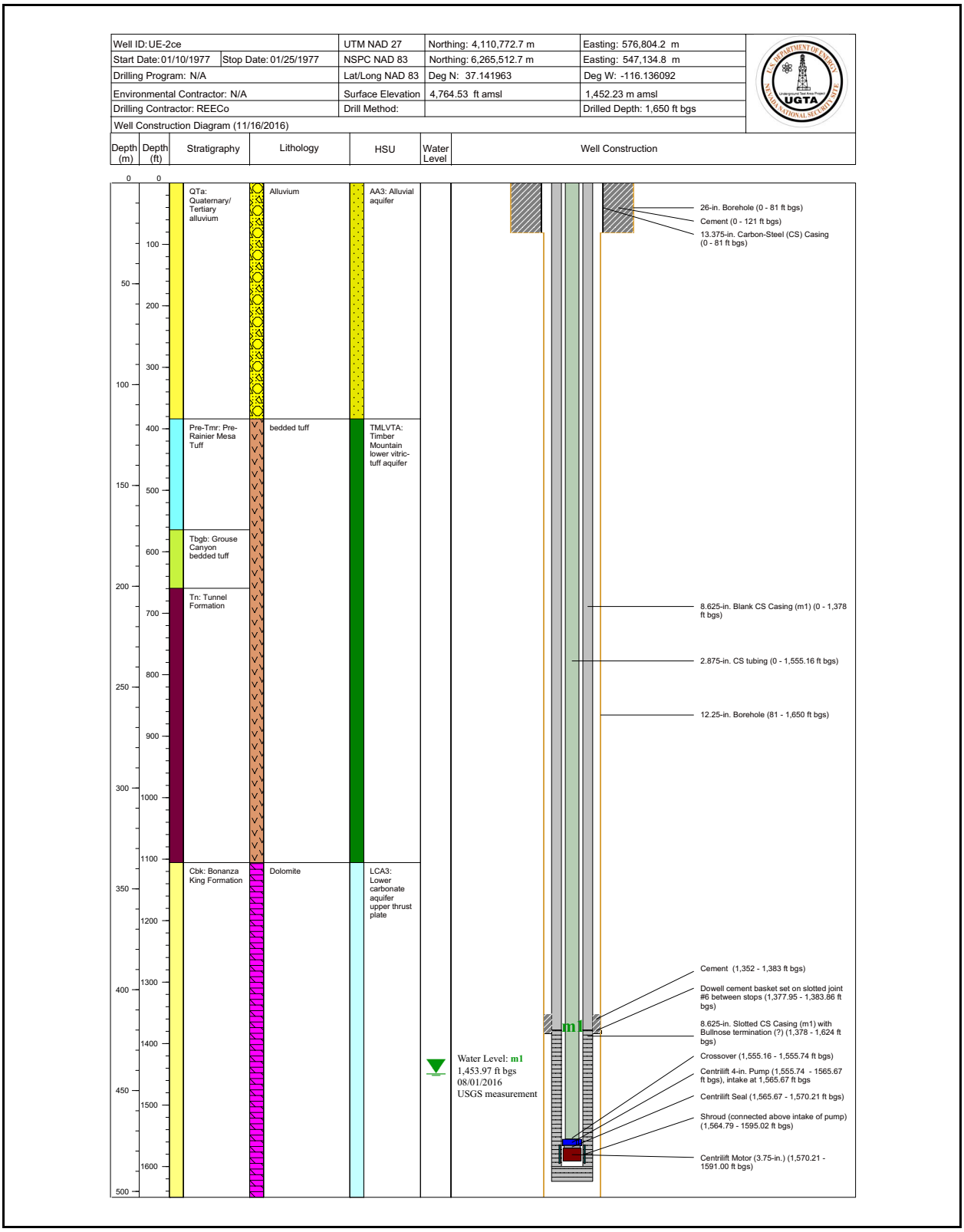


Figure C-17
Well Completion Diagram for UE-2ce

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