Nevada
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DOE/NV--1525

National Nuclear Security Administration

Nevada National Security Site Integrated Groundwater Sampling Plan

Controlled Copy No.: ___
Revision No.: 0

October 2014

UNCLASSIFIED

/s/ Joseph P. Johnston 10/2/2014
Joseph P. Johnston, N-I CO Date

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U.S. Department of Energy
National Nuclear Security Administration
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NEVADA NATIONAL SECURITY SITE INTEGRATED GROUNDWATER SAMPLING PLAN

U.S. Department of Energy, National Nuclear Security Administration
Nevada Field Office
Las Vegas, Nevada

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NEVADA NATIONAL SECURITY SITE
INTEGRATED GROUNDWATER SAMPLING PLAN

Approved by: /s/ Bill R. Wilborn Date: 10/2/2014

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Robert F. Boehlecke
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List of Acronyms and Abbreviations

General Acronyms and Abbreviations

ASTM	ASTM International
BLM	Bureau of Land Management
°C	Degrees Celsius
CADD	Corrective action decision document
CAI	Corrective action investigation
CAIP	Corrective action investigation plan
CAP	Corrective action plan
CAU	Corrective action unit
CFR	*Code of Federal Regulations*
COC	Contaminant of concern
COPC	Contaminant of potential concern
CR	Closure report
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DQI	Data quality indicator
EDD	Electronic data deliverable
EERF	Eastern Environmental Radiation Facility
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ES	Electric submersible
FFACO	*Federal Facility Agreement and Consent Order*
ft	Foot
HASL	Health and Safety Laboratory
HSU	Hydrostratigraphic unit
ICP-AES	Inductively coupled plasma-atomic emission spectrometry
ICP-MS	Inductively coupled plasma-mass spectrometry

List of Acronyms and Abbreviations *(Continued)*

ID	Identification
L	Liter
Lat	Latitude
LJ	Lift jack
LLNL	Lawrence Livermore National Laboratory
Long	Longitude
LQC	Laboratory quality control
MCL	Maximum contaminant level
m	Meter
mg/L	Milligrams per liter
mL	Milliliter
M&O	Management and operating
mrem/yr	Millirem per year
NA	Not available
NAD 27	North American Datum of 1927
NDEP	Nevada Division of Environmental Protection
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
NTTR	Nevada Test and Training Range
pCi/L	Picocuries per liter
PEP	Performance evaluation program
QA	Quality assurance
QAP	Quality Assurance Plan
QC	Quality control
ROTC	Record of Technical Change
RREMP	Routine Radiological Environmental Monitoring Plan
SDWA	*Safe Drinking Water Act*

List of Acronyms and Abbreviations (Continued)

SOP	Standard operating procedure
SOW	Statement of work
TDR	Technical Data Repository
UGTA	Underground Test Area
UIDMS	UGTA Information and Data Management System
USAF	U.S. Air Force
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WL	Water level
μg/L	Micrograms per liter
μm	Micrometer
μmho	Micromho
μmhos/cm	Micromhos per centimeter

List of Acronyms and Abbreviations *(Continued)*

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

AA3	Alluvial aquifer 3
ATCU	Argillic tuff confining unit
BA	Benham aquifer
BFCU	Bullfrog confining unit
BLFA	Basalt lava-flow aquifer
BRA	Belted Range aquifer
BRCU	Belted Range confining unit
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
FCCU	Fortymile Canyon confining unit
LCA	Lower carbonate aquifer
LCA3	Lower carbonate aquifer-upper plate
LCCU1	Lower clastic confining unit 1
LPCU	Lower Paintbrush confining unit
LTCU	Lower tuff confining unit
LTCU1	Lower tuff confining unit 1
LVTA1	Lower vitric-tuff aquifer 1
MPCU	Middle Paintbrush confining unit
OAA	Older alluvial aquifer
OAA1	Older alluvial aquifer 1
OSBCU	Oak Spring Butte confining unit
PBPCU	Post-Benham Paintbrush confining unit

List of Acronyms and Abbreviations (Continued)

PLFA	Paintbrush lava-flow aquifer
RMWTA	Rainier Mesa welded-tuff aquifer
RVA	Redrock Valley aquifer
SPA	Scrugham Peak aquifer
TCA	Tiva Canyon aquifer
THCM	Tannenbaum Hill composite unit
TMCM	Timber Mountain composite unit
TMLVTA	Timber Mountain lower vitric-tuff aquifer
TMWTA	Timber Mountain welded-tuff aquifer
TSA	Topopah Spring aquifer
UCCU	Upper clastic confining unit
UPCU	Upper Paintbrush confining unit

List of Acronyms and Abbreviations *(Continued)*

Elements and Compounds

Ag	Silver
Al	Aluminum
Am	Americium
Ar	Argon
As	Arsenic
Ba	Barium
Br	Bromine
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
Cd	Cadmium
Cl	Chlorine
Cm	Curium
Cr	Chromium
Cs	Cesium
Eu	Europium
F	Fluorine
Fe	Iron
^3H	Tritium
HNO_3	Nitric acid
Ho	Holmium
I	Iodine
K	Potassium
Kr	Krypton
Li	Lithium

List of Acronyms and Abbreviations *(Continued)*

Mg	Magnesium
Mn	Manganese
Na	Sodium
Nb	Niobium
Ni	Nickel
Np	Neptunium
Pb	Lead
Pd	Palladium
Pu	Plutonium
Ra	Radium
Se	Selenium
Si	Silicon
Sm	Samarium
Sn	Tin
SO_4	Sulfate
Sr	Strontium
Tc	Technetium
U	Uranium
Zr	Zirconium

1.0 Introduction

1.1 Purpose and Scope

The purpose of the Nevada National Security Site (NNSS) Integrated Sampling Plan (referred to herein as the Plan) is to provide a comprehensive, integrated approach for collecting and analyzing groundwater samples to meet the needs and objectives of the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO) Underground Test Area (UGTA) Activity. Implementation of this Plan will provide high-quality data required by the UGTA Activity for ensuring public protection in an efficient and cost-effective manner. The Plan is designed to ensure compliance with the UGTA Quality Assurance Plan (QAP) (NNSA/NSO, 2012); *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended); and DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2013).

The Plan's scope comprises sample collection and analysis requirements relevant to assessing the extent of groundwater contamination from underground nuclear testing. This Plan identifies locations to be sampled by corrective action unit (CAU) and location type, sampling frequencies, sample collection methodologies, and the constituents to be analyzed. In addition, the Plan defines data collection criteria such as well-purging requirements, detection levels, and accuracy requirements; identifies reporting and data management requirements; and provides a process to ensure coordination between NNSS groundwater sampling programs for sampling of interest to UGTA.

This Plan does not address compliance with requirements for wells that supply the NNSS public water system or wells involved in a permitted activity. Sampling and analysis requirements associated with these wells are described in their respective permits and are discussed in NNSS Annual Site Environment reports (see Section 5.2). Information used in the Plan development—including the rationale for selection of wells, sampling frequency, and the analytical suite—is discussed under separate cover (N-I, 2014a) and is not reproduced herein.

1.2 Planning and Scheduling

Successful implementation of this Plan requires integration between all organizations participating in activities relevant to the UGTA Activity. Integration will ensure that (1) adequate quality assurance

(QA) protocols are followed; (2) sample collection and analysis criteria are consistent between organizations; (3) data needed for transition to each UGTA Corrective Action Strategy stage are collected and reported; and (4) sampling tasks are performed as efficiently as possible.

Two meetings will be held annually to ensure coordination among these organizations. Both meetings will be led by the Sampling Plan Lead and will include a representative from each organization participating in Plan activities. Through meeting attendance, these representatives will be cognizant of Plan activities and thus can identify overlap or conflict with their own organization and also identify any efficiencies that may be gained as a result of possible collaborations.

The first meeting will identify potential Plan activities for the next fiscal year. The meeting objectives will be to evaluate possible sampling activities; determine whether modifications (e.g., locations, sampling technology, analytes, detection limits) to the Plan activities are needed; and identify required resources. Proposed activities will be considered and recommendations made to DOE by the CAU Lead with the Science Advisors' concurrence. Proposed sampling not included in the Plan must be consistent with the UGTA Corrective Action Strategy stage for the CAU. Proposed deviations from the Plan, including justification, will be documented in task plans provided to DOE for approval.

The second meeting is a kickoff meeting to coordinate DOE-approved sampling and analysis activities for the upcoming fiscal year. The meeting objectives will be to coordinate sampling and analysis requirements, including schedules. Lessons learned from previous sampling events and any deviations from routine sampling and analysis protocols will be discussed. Deviations from the Plan, including justification, will be documented in the Annual UGTA Sampling Report (Section 5.1). The Nevada Division of Environmental Protection (NDEP) Bureau of Federal Facilities will be notified of the upcoming fiscal year sampling schedule.

1.3 Sampling Plan Revision

Data collected in accordance with this Plan will support the FFACO closure process for each CAU by ensuring that appropriate analytical data are available and standardized sampling processes are in place. Distribution and revision of this Plan will be controlled. As such, changes to the Plan require a

Record of Technical Change (ROTC) or equivalent. Revision is not required if the change is a one-time deviation.

This Plan may be referenced in NDEP-approved FFACO documents (Corrective Action Investigation Plan [CAIP], Corrective Action Decision Document [CADD]/Corrective Action Plan [CAP], or Closure Report [CR]), as appropriate. Plan sampling and analysis requirements do not supercede commitments in these documents. Revisions to FFACO documents that reference this Plan require NDEP approval and will be made in accordance with established FFACO protocols.

2.0 Groundwater Contaminants and Regulatory Levels

The UGTA Activity is conducted in compliance with the FFACO (1996, as amended). In turn, the FFACO regulatory requirements are based on *Safe Drinking Water Act* (SDWA) radiological maximum contaminant levels (MCLs) (CFR, 2014). The MCLs are regulatory standards established by the U.S. Environmental Protection Agency (EPA) for chemical and radioactive constituents in drinking water. The MCLs for radionuclides are presented in Table 2-1.

Table 2-1
Maximum Contaminant Levels

Radionuclide Category	MCL
Beta and photon emitters (combined)	4 mrem/yr
Gross alpha particles [a]	15 pCi/L
Radium-226/228 ($^{226/228}$Ra) (combined)	5 pCi/L
Uranium	30 µg/L

[a] Gross alpha MCL includes ^{226}Ra but excludes radon and uranium.

mrem/yr = Millirem per year
pCi/L = Picocuries per liter
µg/L = Micrograms per liter

The MCL for all alpha-emitting radionuclides collectively (i.e., summed together) is 15 pCi/L. Neptunium-237 (^{237}Np), plutonium-238 (^{238}Pu), ^{239}Pu, ^{240}Pu, ^{242}Pu, americium-241 (^{241}Am), ^{243}Am, and curium (^{244}Cm) are the alpha-emitting radionuclides included in the NNSS radionuclide inventory (Bowen et al., 2001). The MCL for these combined radionuclides is therefore 15 pCi/L.

The MCL for beta and photon emitters is based on a calculated dose of 4 mrem/yr. This means that the combined dose from all beta and photon radionuclides present in a particular water source must be than 4 mrem/yr. Each single radionuclide has a unique concentration of radioactivity (measured in pCi/L), which equates to a 4-mrem/yr dose (EPA, 2002). The beta- and photon-emitting radionuclides included in the Bowen et al. (2001) inventory of radionuclides produced by NNSS underground nuclear tests are presented in Table 2-2. The corresponding EPA-derived MCLs in the table indicate the concentration of that single radionuclide which will result in a 4-mrem/yr dose. Thus, the concentrations of all radionuclides in a water source must be considered to determine

Table 2-2
Beta- and Photon-Emitter MCLs

Radionuclide	MCL (pCi/L)	Radionuclide	MCL (pCi/L)
Tritium (^{3}H)	20,000	Technetium-99 (^{99}Tc)	900
Carbon-14 (^{14}C)	2,000	Palladium-107 (^{107}Pd)	--
Aluminum-26 (^{26}Al)	--	Cadmium-113m (^{113m}Cd)	--
Chlorine-36 (^{36}Cl)	700	Tin-121m (^{121m}Sn)	--
Argon-39 (^{39}Ar)	--	Tin-126 (^{126}Sn)	--
Potassium-40 (^{40}K)	--	Iodine-129 (^{129}I)	1
Calcium-41 (^{41}Ca)	--	Cesium-135 (^{135}Cs)	900
Nickel-59 (^{59}Ni)	300	Cesium-137 (^{137}Cs)	200
Nickel-63 (^{63}Ni)	50	Europium-150 (^{150}Eu)	--
Krypton-85 (^{85}Kr)	--	Samarium-151 (^{151}Sm)	1,000
Strontium-90 (^{90}Sr)	8	Europium-152 (^{152}Eu)	200
Niobium-93m (^{93m}Nb)	1,000	Europium-154 (^{154}Eu)	60
Zirconium-93 (^{93}Zr)	2,000	Holmium-166 (^{166}Ho)	90
Niobium-94 (^{94}Nb)	--	Plutonium-241(^{241}Pu)	300

Source: EPA, 2002

-- = Not applicable

compliance with the 4-mrem/yr MCL. The concentration equivalents leading to a 4-mrem/yr dose for some radionuclides included in the inventory have not been established by the EPA.

2.1 Contaminants of Concern and Contaminants of Potential Concern

A contaminant of concern (COC) is defined as a radionuclide that exceeds 10 percent of the associated MCL at sampling locations other than in or near the underground nuclear test cavity (i.e., in sampling locations other than cavity, post-shot wells, or Rainier Mesa tunnels). At this time, ^{3}H is the only COC for sampling locations both on and off the NNSS. Tritium is currently the only radionuclide known to exceed the MCL at sampling locations other than in or near the underground nuclear test cavity (N-I, 2013). Based on these data and the high mobility of ^{3}H in groundwater, ^{3}H has been identified as a COC for all CAUs.

A contaminant of potential concern (COPC) is defined as a radionuclide that has not been detected above 10 percent of the 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. The NNSS radionuclide inventory includes 43 radionuclides produced by NNSS underground nuclear tests (Bowen et al., 2001). Many of these radionuclides are relatively immobile because portions of their inventory are bound within the melt glass produced during nuclear detonation and/or have chemical properties that cause them to bind strongly to solid particles in the aquifer. A smaller set of radionuclides that are more mobile in groundwater and produced in high abundance during nuclear detonation has the greatest potential for impacting groundwater quality. A COPC list has been developed based on the NNSS radionuclide inventory (Bowen et al., 2001), previous sampling and analysis data, an understanding of relative mobility of the inventory radionuclides, and modeling results (Table 2-3).

Table 2-3
CAU-Specific COCs and COPCs

CAU	COC	COPC
Frenchman Flat	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Pahute Mesa (Western and Central)	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I
Rainier Mesa/Shoshone Mountain	^{3}H	^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, and $^{238/239/2340}Pu$
Yucca Flat/Climax Mine	^{3}H	^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I (and ^{90}Sr and ^{137}Cs in Lower Carbonate Aquifer [LCA] samples)

2.2 *Radionuclide Threshold Levels*

Four threshold levels (Investigation, Notification, Action Planning, and Action) have been established to ensure appropriate actions are taken and communicated when radionuclide concentrations deviate from previously established trends, approach MCLs, or reach or exceed MCLs. The threshold levels are defined by the COC concentration in groundwater samples as reported by a certified laboratory. These levels have been established to ensure appropriate actions are taken and communicated in a consistent, defined, and appropriate manner commensurate with the level of risk. For example, the radioactivity levels that trigger a response for wells on the Nevada Test and Training Range (NTTR) are higher because these wells are not water sources for human consumption. The purpose of these wells is to understand and forecast contaminant transport from underground nuclear testing, and the wells were drilled to be potentially downgradient of the nuclear testing. Therefore, it is expected for radioactivity to be detected in these wells long before, if ever, the groundwater travels off government land. The threshold levels and associated responses are summarized in Table 2-4 and are described in the following subsections. The Federal Task Manager for sampling and analyses will be notified as soon as possible if reporting thresholds requiring notifications are reached. There are no Notification, Action Planning, or Action thresholds associated with NNSS results; these results are addressed through feedback processes presented in Section 3.0 and are reported as described in Section 5.0.

Table 2-4
Radionuclide Thresholds Levels and Required Responses

Threshold Levels	Analytical Result	Required Response
Investigation Level	• Initial confirmed detection of COC or COPC. • Increase in COC or COPC radioactivity (≥3 standard deviations from baseline value but less than Notification Level).	• Verify analytical results. • Investigate reason for result (i.e., underground nuclear test). • Change status to COC if COPC concentration is ≥10% of MCL. • Reassess reporting levels to ensure SDWA compliance for multiple radionuclides present.
Notification Level	• First-time detection of COC or COPC is ≥10% of its SDWA MCL for public, private, and BLM land sampling locations. • First-time detection of COC or COPC is ≥50% of its SDWA MCL for NTTR sampling locations.	• Verify analytical results. • Notify NDEP. • Notify USAF for NTTR sampling locations. • Notify land owner or permit holder of permit for public, private, and BLM land sampling locations.
Action Planning Level	• First-time detection of COC or COPC is ≥50% of its SDWA MCL for public, private, and BLM land sampling locations. • COC or COPC concentration is ≥ SDWA MCL for NTTR sampling locations.	• Verify analytical results. • Notify NDEP. • Notify USAF for NTTR sampling locations. • Notify land owner or permit holder for public, private, and BLM land sampling locations. • Implement measures to prevent consumption of water from the well. • Develop action plan to meet anticipated future FFACO and State requirements.
Action Level	• COC or COPC concentration is ≥ SDWA MCL for public, private, and BLM land sampling locations. • Defined per FFACO CR as concurred to by NDEP.	• Implement actions developed under Action Planning Level. • Implement actions developed under the FFACO CR. • Make additional notifications defined in the FFACO CR.

BLM = Bureau of Land Management
USAF = U.S. Air Force

2.2.1 Investigation Level

The **Investigation Level** is reached when the analytical results deviate from a previously established trend and/or the conceptual model of radionuclide migration for the UGTA CAUs. This would include a new detection of a COC or COPC, or an increase in COC or COPC radioactivity that is at or above three standard deviations of the baseline value but is still below the Notification Level reporting limit defined below.

An investigation will be initiated to evaluate the reason for the deviation. The evaluation will begin by verifying the accuracy of the analytical result and may involve sample reanalysis, additional sample collection, and/or additional radioisotope analyses. If a radioisotope is detected at a concentration that is 10 percent of the MCL or greater at a sample location that is not in or near the underground nuclear test cavity, the radionuclide status will be changed to a COC. For sampling locations on the NNSS, the investigation may wait for the next scheduled sampling event to verify the accuracy of the analytical result. Threshold levels for the current and new COCs will be reassessed when multiple radionuclides are present. Formal notification to NDEP is not required at the Investigation Level.

2.2.2 Notification Level

The **Notification Level** is reached when a COC is detected for the first time at or above 50 percent of the MCL in a well on the NTTR, or at or above 10 percent of the MCL for wells on public/private or BLM land. The sample result will be verified, which may include additional sample collection and analysis of additional radioisotopes. NDEP will be formally notified once these respective limits are verified for both NTTR wells and wells on public/private or BLM land. No notifications are required for wells on the NNSS.

2.2.3 Action Planning Level

The **Action Planning Level** is reached when the COC is at or above the MCL in wells on the NTTR, or is at or above 50 percent of the MCL in wells on public/private or BLM land. For wells on the NTTR, NDEP and USAF will be notified and measures will be put in place to ensure that personnel cannot use the wells as a source for drinking water. For wells on public/private lands, NDEP will be notified. The land owner, permit holder (if applicable), and other members of the public will be notified in accordance with NNSA/NFO protocol.

NNSA/NFO, in cooperation with NDEP and the public water system owner, as applicable, will formalize action plans to protect the public from any potential health risk associated with the consumption of water that could exceed the MCL. Future actions could include increasing sampling frequency, instituting modified institutional controls (such as limiting groundwater access), or providing an alternate water supply.

2.2.4 Action Level

The **Action Level** is reached when the COC or COPC is at or above its MCL on public/private or BLM lands, or when COC/COPC concentrations in NTTR or BLM wells reach a level described and concurred to by NDEP in the FFACO CR for the particular CAU. At this level, NNSA/NFO will implement the actions previously developed (Section 2.2.3) and any actions required by the applicable FFACO CR. Notifications will be made to the public in accordance with NNSA/NFO protocols and applicable well permit requirements.

3.0 Sampling and Analysis

Sample locations are categorized into one of six types based on the sampling objectives: Characterization, Source/Plume, Early Detection, Distal, Community, and Inactive. The type therefore dictates the required analytical suite, associated detection limits, and sampling frequency for a given sampling location (Table 3-1). The sample location type—and, subsequently, the sample analytes and analytical detection limits—may change over time for a given location based on analytical results (e.g., increase in radionuclide concentrations), modeling results (e.g., the well is not along a viable flow path), and/or other well-specific conditions (e.g., low groundwater velocity). A sample location is defined as a three-dimensional location within a completed well or open borehole, or a spring. Wells with multiple completion intervals may have multiple sampling locations. The sampling locations may be categorized as different types with different analytical requirements depending on the sampling objectives.

Feedback loops shown in the decision diagrams in this section were established to ensure new data and/or observations are evaluated and used to continually ensure proper sampling frequencies and analytical requirements. These feedback loops allow COC identification and sample location types to evolve as new data are generated and as conditions change. Sample results will be evaluated for consistency with previous samples from the same well, wells from the same hydrostratigraphic unit (HSU), and/or with the conceptual model of groundwater flow and transport. If sufficient confidence exists to support a change in sample location type, the sample location will be recategorized. Confidence is established by evaluating measurement results over time and by qualitatively comparing the results to the conceptual model. Evaluation results and any corrective actions will be presented in the Annual UGTA Sampling Report (see Section 5.1).

Figure 3-1 illustrates the well locations and corresponding sample location type. Sample locations and the associated types are listed in Table A-1 (Frenchman Flat), Table A-2 (Pahute Mesa), Table A-3 (Rainier Mesa/Shoshone Mountain), and Table A-4 (Yucca Flat/Climax Mine).

Table 3-1
Sample Location Type Definitions and Objectives
(Page 1 of 2)

Location Type	Definition	Objective	Analytes [a]	Frequency
Characterization [b]	Used for system characterization or model evaluation	• Support flow and transport model development and/or evaluation. • Identify groundwater flow paths. • Establish COC and COPC presence or absence. • Estimate travel time of contaminants. • To be reclassified and sampled according to its new type when characterization objectives are met.	• Alkalinity, pH, specific conductance • Anions (Br, Cl, F, SO_4) • Total metals (Ag, Al, As, Ba, Ca, Cd, Cr, Fe, K, Li, Mg, Mn, Na, Pb, Se, Si, Sr, U) • Gross alpha and gross beta • Gamma Emitters (^{26}Al, ^{94}Nb, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U, ^{241}Am, ^{243}Am) • ^{3}H (standard and/or low-level) [c] • ^{14}C, ^{36}Cl, ^{99}Tc, ^{90}Sr, ^{129}I, $^{238/239/240}$Pu	3 years, as needed
Source/Plume	Located within the plume from an underground nuclear test (i.e., test-related contamination present), and COCs detected above standard measurement levels (e.g., ^{3}H >300 pCi/L)	• Support flow and transport model development and/or evaluation. • Identify COC for downgradient wells. • Monitor contaminant migration. • Monitor natural attenuation.	• Frenchman Flat: ^{3}H (standard), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I • Pahute Mesa: ^{3}H (standard), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I • Rainier Mesa/Shoshone Mountain: ^{3}H (standard), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I, and $^{238/239/240}$Pu • Yucca Flat/Climax Mine: ^{3}H (standard), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I (plus ^{90}Sr and ^{137}Cs in LCA samples)	4 years
Early Detection	Located downgradient of an underground test or Source/Plume well, and no COCs detected above standard measurement levels (i.e., ^{3}H <300 pCi/L)	• Support flow and transport model development and/or evaluation. • Detect plume edge.	• ^{3}H (low-level)	5 years (Frenchman Flat, Rainier Mesa/ Shoshone Mountain, and Yucca Flat/ Climax Mine) 2 years (Pahute Mesa)

Table 3-1
Sample Location Type Definitions and Objectives
(Page 2 of 2)

Location Type	Definition	Objective	Analytes [a]	Frequency
Distal	Outside the Early Detection area [d]	• Support flow and transport model development and/or evaluation. • Monitor COC (i.e, ^{3}H) below SDWA 1,000-pCi/L detection limit [e].	• ^{3}H (standard)	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)	5 years
Inactive	Not currently sampled but available for sampling if conditions warrant	• Place well on hold until a reason for sampling is identified	• None	None

[a] Required analyses performed by a commercial lab certified by NDEP. See Section 4.2 for a discussion of laboratory analyses.
[b] Characterization locations will transition to another type when a sufficient baseline (a minimum of three samples) is established to support categorization (see Section 3.1).
[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] The Early Detection area is defined as the area directly downgradient of an underground nuclear test where COCs have not been detected above levels detectable using standard analytical methods.
[e] CFR, 2014.

Ag = Silver
Al = Aluminum
Am = Americium
As = Arsenic
Ba = Barium
Br = Bromide
C = Carbon
Ca = Calcium
Cd = Cadmium
Cl = Chlorine
Cr = Chromium
Cs = Cesium
Eu = Europium
F = Fluorine
Fe = Iron
^{3}H = Tritium
I = Iodine
K = Potassium
Li = Lithium
Mg = Magnesium
Mn = Manganese
Na = Sodium
Nb = Niobium
Pb = Lead
Pu = Plutonium
Se = Selenium
Si = Silicon
SO_4 = Sulfate
Sr = Strontium
Tc = Technetium
U = Uranium

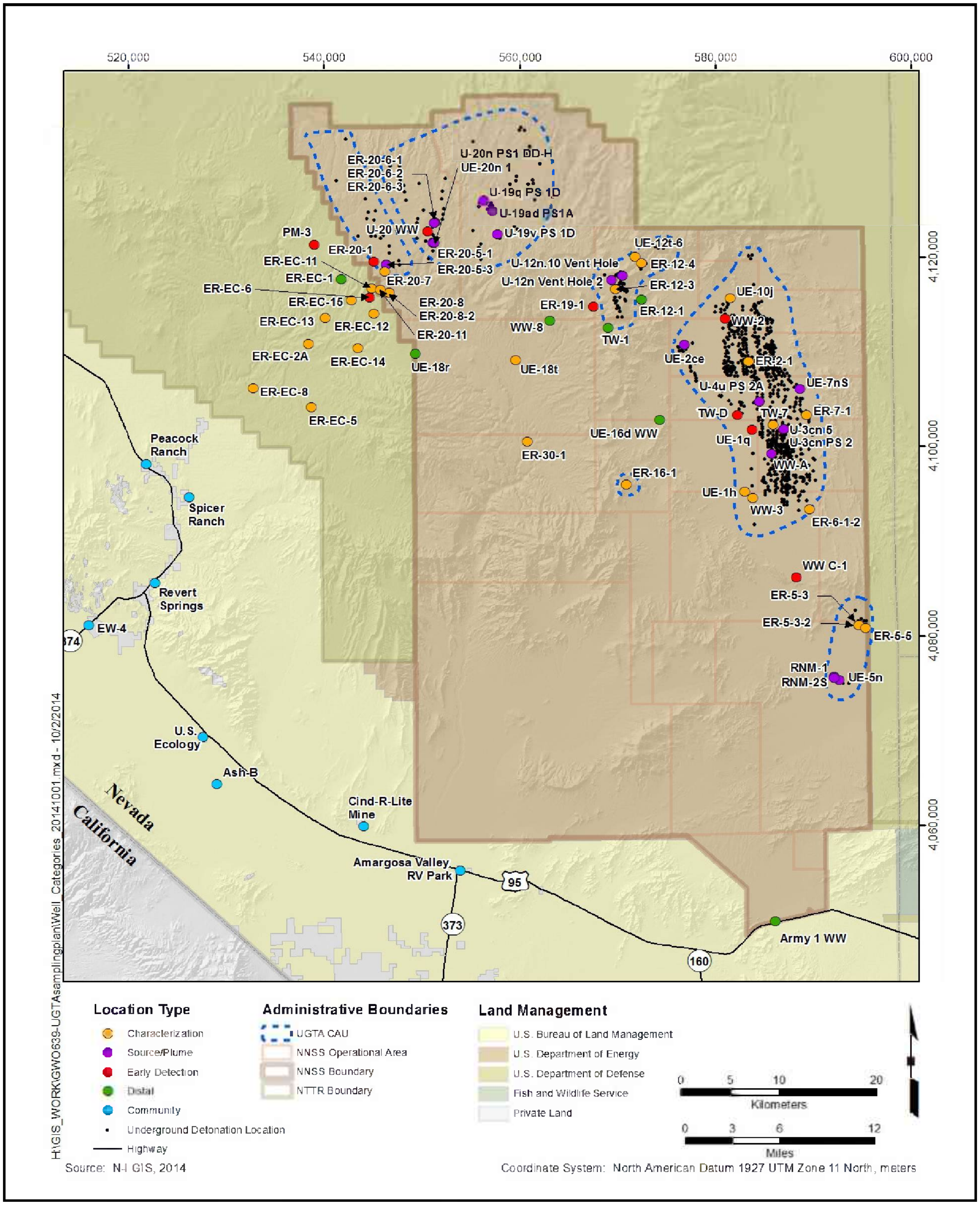

Figure 3-1
Wells and Sample Location Types

3.1 Characterization Sample Locations

Sample locations within new wells drilled to support the UGTA Activity, or existing wells for which insufficient baseline data exists, are categorized as Characterization locations. Figure 3-2 provides the decision diagram used to illustrate the process followed for sampling Characterization locations. Samples from these locations are collected at three-year intervals as needed and may be analyzed for different sets of parameters depending on the UGTA Corrective Action Strategy stage (i.e., CAIP, CAI, CADD/CAP, CR) for the CAU (FFACO, 1996 as amended). New wells drilled during the CAI stage will be sampled a minimum of three times in order to establish a baseline and to properly categorize the sampling locations within the well. The samples from each of the three sampling events will be analyzed for the parameters presented in Table 3-1. Analyses may be expanded beyond those listed in Table 3-1 and the results evaluated to determine whether the COPC/COC list should be revised.

3.1.1 Source/Plume Sample Locations

Source/Plume sample locations have radionuclides at concentrations above standard measurement methods that have been verified to originate from NNSS underground nuclear testing (Figure 3-3) (e.g., ^{3}H >300 pCi/L). Source/Plume sample locations range from those within the detonation cavity to those downgradient of the detonation at the plume edge. Wells within or near the detonation have historically been referred to as hot wells, post-shot holes, or near-field wells. Samples are collected every four years and analyzed using standard analytical methods for ^{3}H and the set of COPCs presented in Table 3-1. Source/Plume sample location analytes include radionuclides that are likely to be detected and have the potential to exceed MCLs based on the radiological inventory published by Bowen et al. (2001), historical and current radionuclide analyses, and/or modeling results. Analytical methods with low detection limits may be used to detect the presence of some radionuclides at very low levels.

Source/Plume analytical results will be evaluated to determine whether additional radionuclides should be analyzed downgradient. A COPC increase could trigger additional analysis in a downgradient Early Detection well. This decision may depend on the radionuclide concentration relative to its MCL.

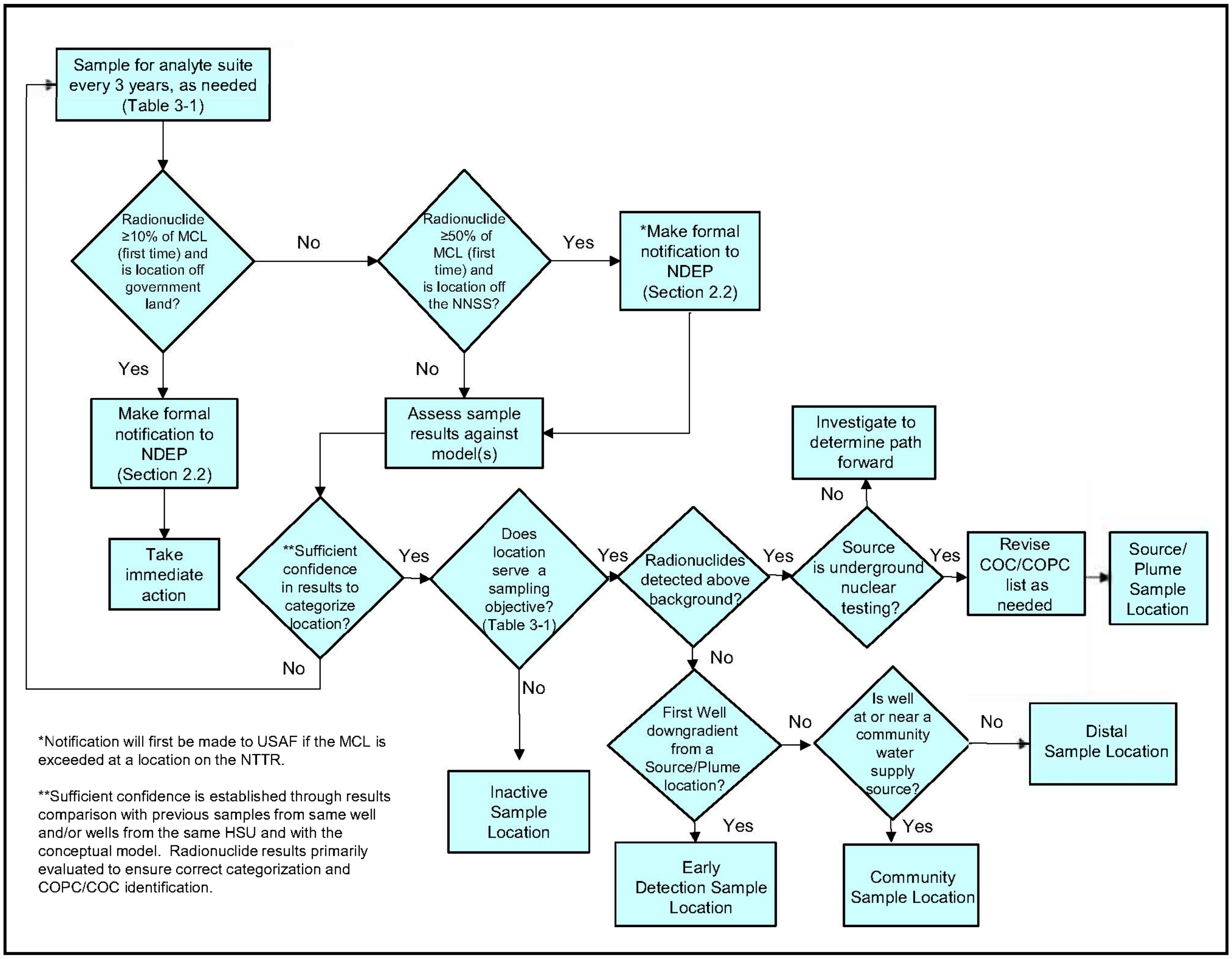

Figure 3-2
Characterization Sampling Flow Chart

3.1.2 Early Detection Wells

Early Detection sample locations do not contain COCs at concentrations above the minimum detection limit of the standard analytical measurement method (i.e., ^{3}H $\leq$300 pCi/L). Early Detection sample locations are downgradient of an underground nuclear test or Source/Plume sample location (Figure 3-4). Depending on the CAU, these sample locations are sampled every two or five years and analyzed for low-level ^{3}H. The sampling frequency and low detection limit ($\leq$10 pCi/L) are used to detect a plume front in a reasonable time frame to allow DOE to perform confirmation sampling, if necessary, and/or consider additional actions. The sampling frequency is every five years for three CAUs (Frenchman Flat, Rainier Mesa/Climax Mine, and Yucca Flat/Climax Mine) because of the

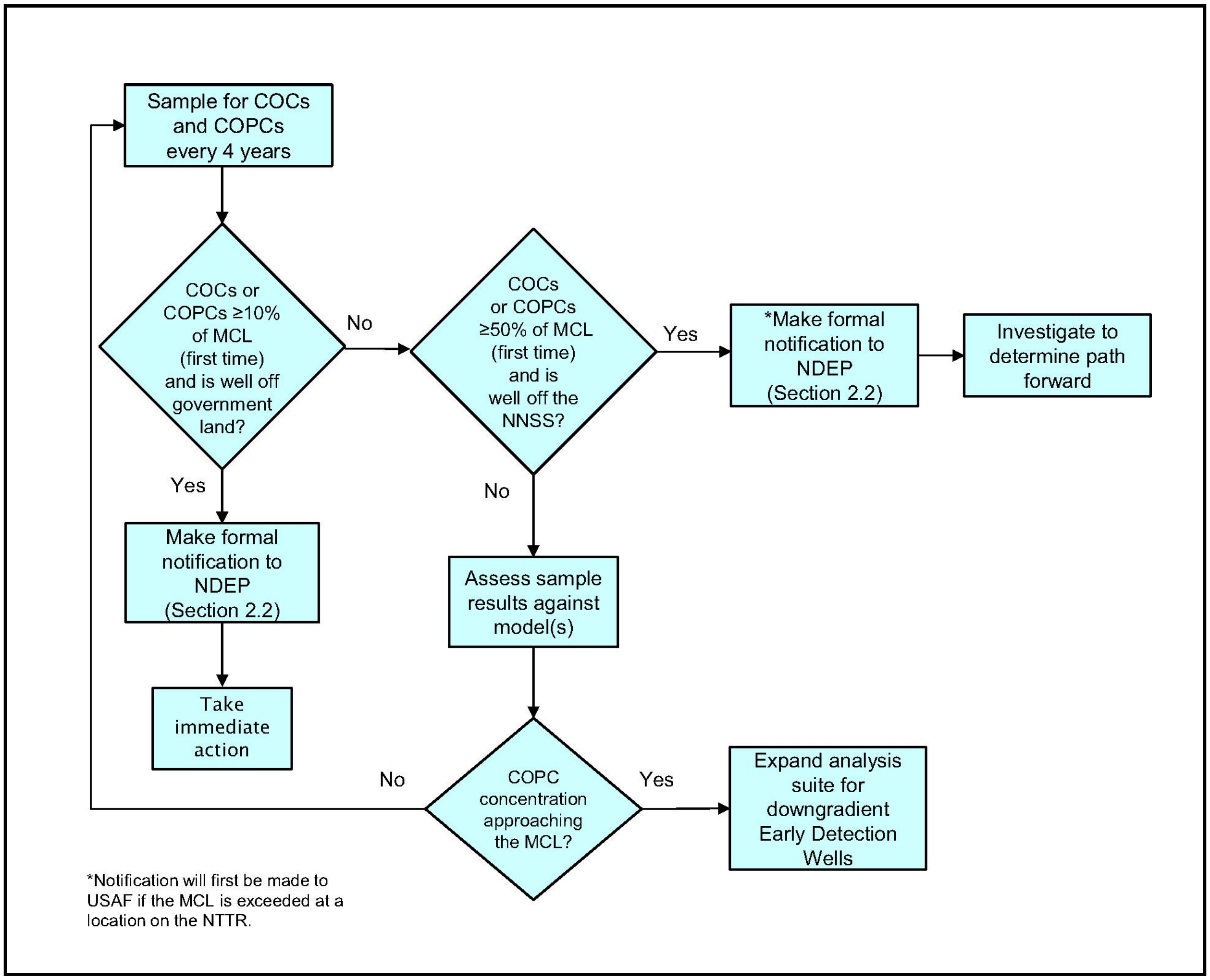

Figure 3-3
Source/Plume Sampling Flow Chart

CAU-specific low groundwater velocity, resulting in slow change in radionuclide concentration with time.

Once a COC is detected at an Early Detection sample location, an investigation is initiated to verify the presence of the COC and confirm that it resulted from an underground nuclear test. This investigation may consist of further well purging, resampling, and/or analyzing COPCs or other indicators (e.g., chlorofluorocarbons, sulfur hexafluoride). If the location is not a Community sample location (see Section 3.1.4) and is not on government land, investigation activities may be deferred until the next scheduled sampling event to verify COC detection. Once the presence of a COC has been verified and it exceeds the detection limit using standard analytical measurements, the Early

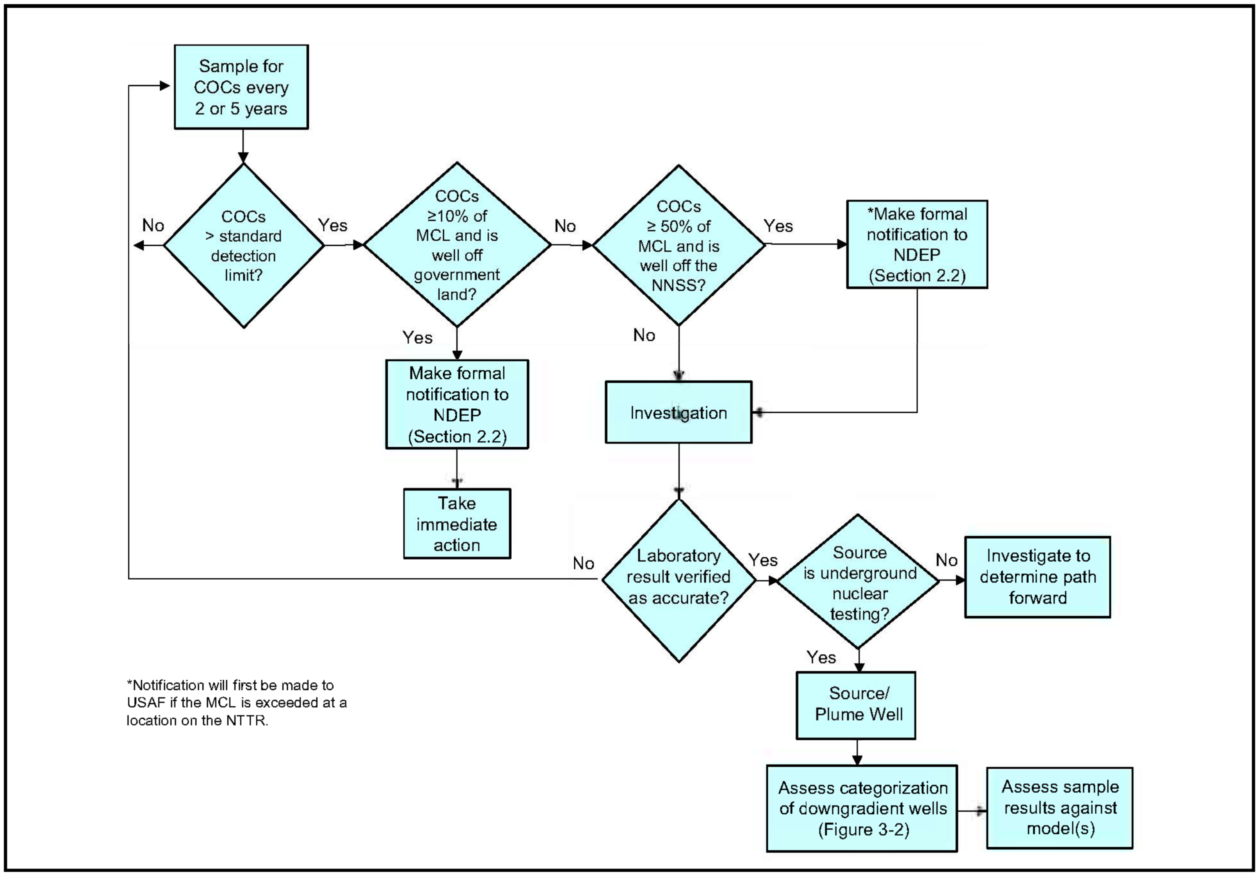

Figure 3-4
Early Detection Sampling Flow Chart

Detection location will be recategorized as a Source/Plume sample location. If the source is not verified as an underground test, the CAU Lead, in consultation with other subject matter experts, will identify future sampling objectives for the location. The suite of analytes and sampling frequency will depend on the sampling objective. The investigation will be described in the Annual UGTA Sampling Report (see Section 5.1). If the sampling location is changed from Early Detection to Source/Plume, an assessment of the downgradient Distal locations will take place to determine whether a Distal location should be changed to an Early Detection location (Figure 3-5).

3.1.3 Distal Sample Locations

Wells that contain Distal sample locations are generally downgradient, but at some distance, from the contamination source or plume. Distal sample locations are analyzed for ^3H using a standard EPA method (see Table B-2) with a detection limit of approximately 300 pCi/L. This provides for ^3H

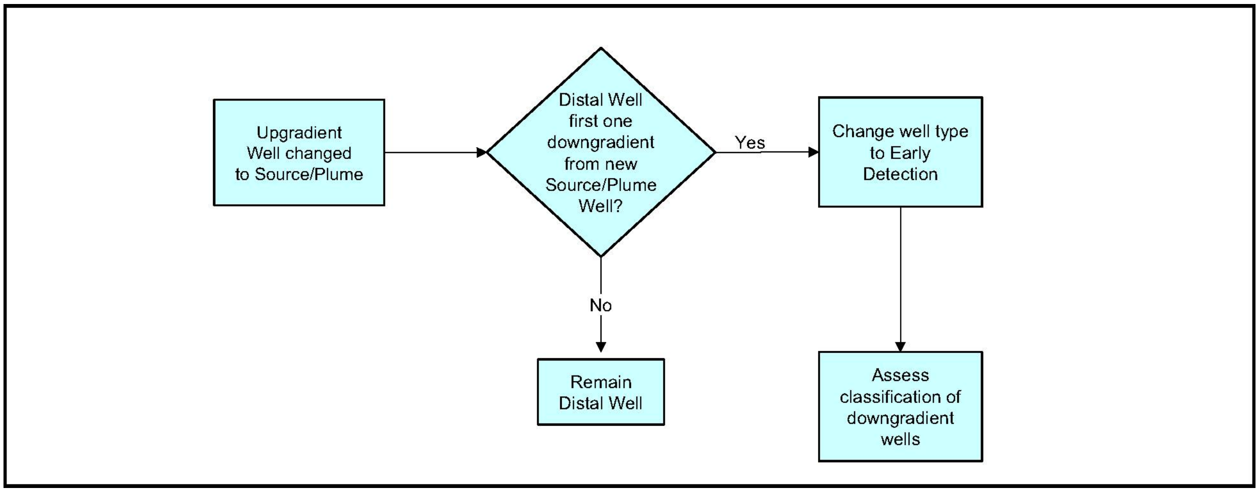

Figure 3-5
Flow Chart for Transition of a Distal to an Early Detection Sampling Location

detection well below the 20,000 pCi/L MCL and below the SDWA required detection limit of 1,000 pCi/L for ^3H (CFR, 2014). Samples are collected at a five-year frequency (Figure 3-6). As illustrated in Figure 3-5, a Distal location may be recategorized as an Early Detection location if ^3H is detected in the upgradient Early Detection location. Sampling frequency will then be increased and/or detection limits for ^3H lowered.

3.1.4 Community Sample Locations

Community sample locations may be in wells or springs that are either used as private, business, or community water supply sources or are located near such a source. Community locations are sampled at a five-year frequency (Figure 3-6) and analyzed for ^3H levels using a 300-pCi/L detection limit. This detection limit is well below the 20,000-pCi/L MCL and below the SDWA required detection limit of 1,000 pCi/L for ^3H (CFR, 2014).

3.1.5 Inactive Sample Locations

Inactive sample locations are in wells located on or in the vicinity of the NNSS but are not regularly sampled. These sample locations may be categorized as Inactive for a variety of reasons, including (1) other nearby wells open to the same HSU are already being sampled; (2) the well is not located on a viable flow path; or (3) the well requires significant work to obtain representative groundwater samples.

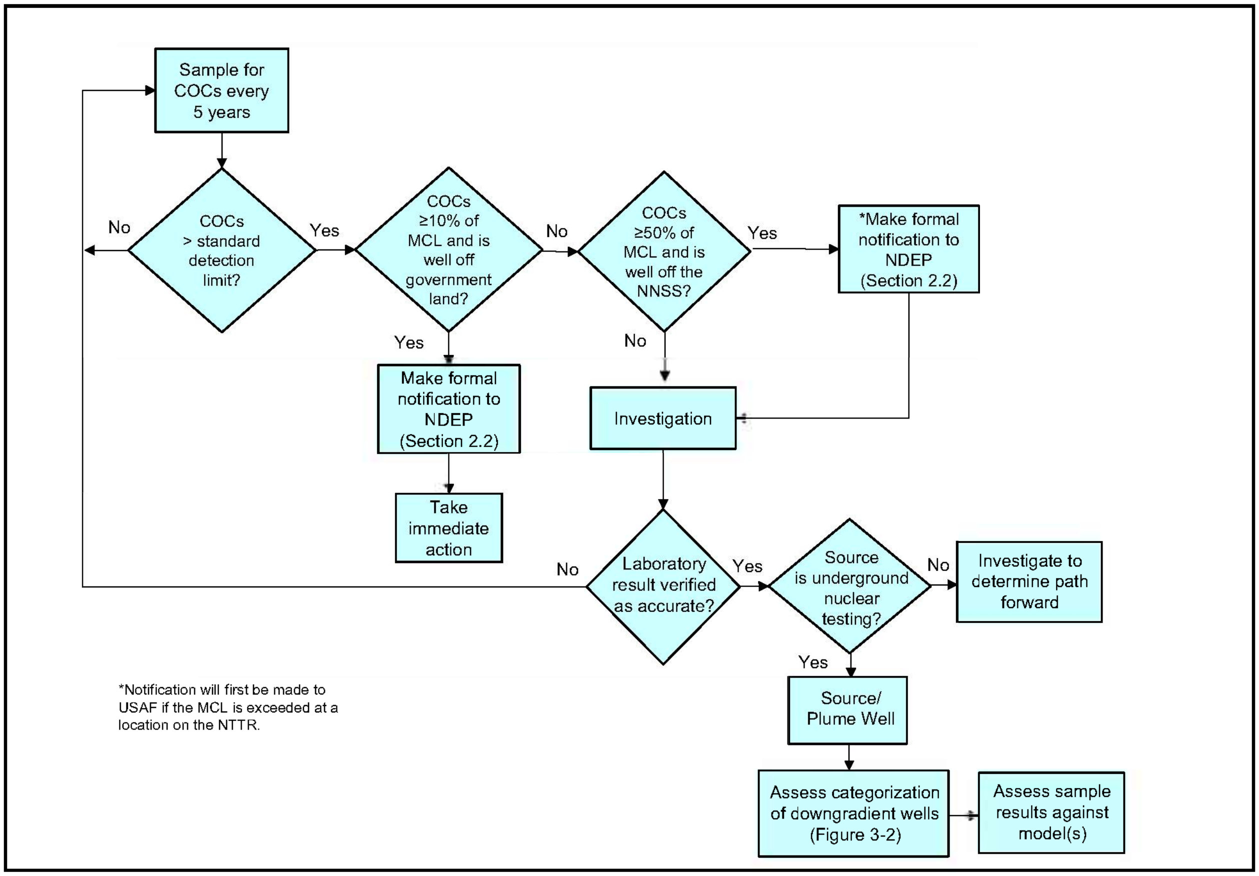

Figure 3-6
Distal and Community Sampling Flow Chart

The UGTA Borehole Index database contains information on all sampling locations in this Plan, including those that have been categorized as Inactive (N-I, 2014b). Inactive locations are evaluated as needed to determine whether they should be sampled. Inactive sampling locations can either be sampled as a one-time event, or recategorized and sampled as part of this Plan.

4.0 Processes and Procedures

One of the Plan objectives is to ensure that data are collected in a consistent, scientifically defensible manner by all current and future DOE contractors. Data collection activities are therefore described in standard operating procedures (SOPs) that must comply with the UGTA Activity QAP (NNSA/NSO, 2012). Oversight assessments are performed to ensure compliance.

This section summarizes the processes and procedures used for sample collection and laboratory analysis. The current Environmental Restoration (ER) and Management and Operating (M&O) contractor SOPs are presented in Appendix B. These SOPs are specific to the current contractors and will be updated as necessary in future Plan revisions.

4.1 Sample Collection

Sample collection procedures and analyte-specific sample requirements (number of containers, container types, preservatives, and holding times) are shown in Tables B-1 and B-2, respectively. Samples are maintained under chain of custody protocols to provide the traceability of possession from the time the samples are collected until disposal. Field quality control (QC) samples are collected and analyzed to assess whether the sample-collection process meets the quality objectives. The rule of thumb for collection of field QC samples is collection of one QC sample for every 20 samples per sampling event. The QC sample may be a blank or duplicate, depending on sampling needs. Blanks (rinsate/equipment or field) are used to assess potential contamination from the sample collection process. Blanks are implemented at specified frequencies, which vary according to the probability of contamination or cross-contamination. Field duplicates are used to assess sampling and analytical variability and may be collected when sample representativeness is a concern (e.g., bailed or low-volume purging). Duplicate collection should be evenly distributed throughout the sampling event.

Possible sample collection methods are presented in Appendix A (Tables A-1 through A-4). In general, wells or completion zones equipped with a permanently installed electric submersible (ES) pump will be sampled using the pump. Otherwise, the sample will be collected with a bailer, lift jack (LJ) pump, or newly installed ES pump, depending on a number of variables including the casing diameter, availability of a piezometer access tube, and number of completions/zones requiring sampling. Spring samples will be collected used a scoop or dipper.

If the well is sampled using a pump, a minimum of three effective well volumes will be withdrawn, and the well will be purged until water-quality parameters (e.g., pH, electrical conductivity, turbidity, and temperature) have stabilized. Procedures for field measurement of water-quality parameters are listed in Table B-1. Bromide is also measured because it is introduced to the groundwater during drilling, and trace amounts may be present due to varying levels of development. Water-quality parameter stabilization criteria should be based on established criteria such as that described by the U.S. Geological Survey (USGS) (2013). The purging amount and rate will be balanced to minimize the potential for pump-induced contaminant migration while ensuring that the groundwater produced from the well represents ambient formation water. If the well is sampled using a wireline deployed bailer, purging may not be feasible; therefore, the decision to purge will be determined on a case-by-case basis. Purging requirements will be documented in an SOP or the field activity work package. All water produced during purging and/or sampling activities must be managed in accordance with the *Fluid Management Plan for the Underground Test Area Project* (NNSA/NSO, 2009).

4.2 Laboratory Analysis

An agreement between DOE and NDEP regarding the use of certified laboratories is documented in Boehlecke (2014) and Murphy (2014). Required analyses (Table 3-1) will be performed by a commercial laboratory that is certified through the NDEP Bureau of Safe Drinking Water and that meets National Environmental Laboratory Accreditation Program or equivalent requirements for those analytes not currently NDEP certified. Commercial laboratories also must participate in the U.S. Department of Energy Consolidated Audit Program (DOECAP) or equivalent.

Analyses not listed in Table 3-1 (i.e., optional analyses) may be performed by non-certified laboratories, and will be identified and justified in the Annual UGTA QA Report (see Section 5.3). These laboratories provide state-of-the-art methods necessary to maximize analytical sensitivity or for analyzing unique parameters not available by a commercial laboratory. These laboratories will be assessed to ensure UGTA QAP compliance at a minimum of every three years.

Analytical methods for required analyses are presented in Table B-2 along with detection limits and sample requirements. The required laboratory quality control (LQC) samples associated with each analysis are described within each SOP. LQC samples will include laboratory control samples, method blanks, laboratory replicates, and matrix spikes, as applicable. Analytical laboratories will participate in a performance evaluation program (PEP) for each analyte and/or method for which they are responsible. Some analytes and/or analytical methods do not have an available PEP, and alternative approaches can be applied. The approaches include interlaboratory comparisons between sample (duplicate, split, or prepared) results, blind samples (i.e., samples with a known or previously measured detectable quantity of analyte), or data evaluation. The PEP results will be presented in the Annual UGTA QA Report in accordance with an UGTA programmatic interface SOP (see Table B-3). The SOP presents acceptance criteria for interlaboratory comparisons and blind samples.

5.0 Reporting

Results of activities associated with this Plan (laboratory analyses and any investigations that take place as a result of Plan implementation) will be presented in annual and/or special reports. These reports are submitted to NDEP and are publicly available. This section describes these reports and defines notification thresholds to be used in reporting groundwater sample results and other pertinent information obtained by Plan implementation.

5.1 Annual UGTA Sampling Report

The Annual UGTA Sampling Report documents all sampling activities and results for samples collected under this Plan during the previous fiscal year. The report is completed within six months of the fiscal year end. The report includes a description of investigations performed, laboratory results, and data evaluations. Analytical results will be evaluated by the CAU Lead, or designee, with respect to the CAU conceptual model of flow and transport. Deviations from the Plan, along with their justification, will also be presented.

5.2 Annual NNSS Environmental Report

The Annual NNSS Environmental Report summarizes data and the compliance status of the NNSA/NFO environmental protection and monitoring programs at the NNSS and other NNSA/NFO facilities. The report satisfies reporting requirements in DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE, 2013), and is consistent with SDWA requirements for reporting water quality for public water supply wells. The Report also includes a summary of analytical data from recent sampling of the locations identified in this Plan.

5.3 Annual UGTA QA Report

The UGTA QAP (NNSA/NSO, 2012) requires NNSA/NFO to issue an Annual UGTA QA Report to NDEP that contains QA activity results. QA activities include conducting assessments, identifying issues, evaluating laboratory performance, publishing documents, and participating in committees. At a minimum, the QA report will include PEP results and the identification and justification for optional analyses performed by non-certified laboratories, as discussed in Section 4.2. Also, all

UGTA assessments—including any findings and corrective actions, and closure dates—are presented, as discussed in Section 7.2

5.4 Special Reports

Data results that differ from previous analyses may require additional investigations. These investigations and associated results may be presented in special reports. Special reports may also be developed to describe other investigations relevant to this Plan (e.g., investigations of well sampling technologies, flow logs to identify optimal sampling depths, and historical analytical results).

5.5 Communications

All communications will follow the protocols established by NNSA/NFO. NNSA/NFO manages all external communications, including communications with NDEP and entities not affiliated with the project. Internal communications will follow processes established by the participant companies.

The notification requirements in this Plan are not mandated by the FFACO or NDEP regulation (Section 2.2). The CRs for each CAU will define the conditions that require mandatory notification to NDEP during long-term groundwater monitoring. The notification requirements in this Plan are meant to ensure that NDEP and USAF are kept apprised of changing conditions in UGTA CAUs throughout the earlier stages FFACO process (CAIP, CAI, and CADD/CAP stages).

6.0 Records and Data Management

Records resulting from implementation of this Plan will be controlled and maintained in the UGTA Document Center and Technical Data Repository (TDR). Entry into the TDR, which is a satellite electronic records location, is described in the "UGTA Information and Data Management System Submittal" procedure. Records associated with Plan implementation are described in the applicable SOPs (see Appendix B).

Requirements for documenting, verifying, and validating laboratory results are described in contract-specific SOPs. The SOPs used for implementing commercial laboratory verification, validation, and review requirements are presented in Table B-1. Requirements for verification and validation of other laboratory results (i.e., optional analyses) are presented in the analysis-specific SOPs (Table B-2). Laboratory data reports including electronic data deliverables (EDDs) will be submitted to the responsible contractor and stored as records in the TDR or equivalent record management system. Sample results, received as an EDD, will be entered into the ER Contractor Analytical Services or UGTA Chemistry database.

Field record reviews ensure forms have been filled out completely, are legible and in accordance with the UGTA QAP (NNSA/NSO, 2012) and associated SOPs, and that the recorded information accurately reflects the performed activities. Laboratory data package review ensures record sets are complete and legible, and analyses are consistent with chain-of-custody requests and compliant with the UGTA QAP. Data validation acceptance criteria will be based upon the intended use of the data and will include an evaluation of method compliance, data calculations, QC data quality indicators (DQIs), instrument calibrations, raw data, and data generation methods. Validation can include qualifying data that may restrict or limit data use; typical qualification codes are as follows:

- **U** Analyte was analyzed for but not detected. The reporting limit is approximate and may be inaccurate or imprecise.
- **J** Reported result is estimated.
- **J+** Reported result is estimated with a positive bias.
- **J-** Reported result is estimated with a negative bias.
- **R** Data rejected, not usable for decision making purposes (will be made unavailable for use).

7.0 Quality Assurance

All UGTA activities presented within this Plan will be performed in compliance with the UGTA QAP (NNSA/NSO, 2012). The UGTA QAP provides requirements to ensure that analytical data are of sufficient known quality to withstand scientific and legal challenge considering the use for which the data were obtained. This section presents the methods used to ensure that QAP requirements are met and that analytical data are scientifically valid, defensible, and of known precision and accuracy.

7.1 Standard Operating Procedures

Implementation of UGTA QAP requirements is achieved through the use of SOPs by all participating organizations. The SOPs that support Plan activities are presented in Appendix B. These SOPS describe the required QC to establish DQI (precision, accuracy, representativeness, and comparability) goals for the described Plan activities. Sample collection and analysis requirements— including field and laboratory QC samples, and verification and validation of the resulting data—are established within the SOPs.

7.2 Assessments

Assessments play an integral role in assuring quality for UGTA data collection, analysis, and reporting activities. The UGTA QAP (NNSA/NSO, 2012) requires that annual assessments are performed. These assessments can be performed by the organization management or by an independent assessment team. NNSA/NFO personnel, or their designees, will also perform oversight assessments periodically to verify compliance with applicable quality requirements, DOE policies, and procedures. NNSA/NFO assessments will be conducted in accordance with NFO Order 226.X, *Line Oversight (LO) Program* (NNSA/NFO, 2013). Issues will be resolved and closure tracked in accordance with UGTA programmatic interface procedures found in Table B-3. All UGTA assessments, including any findings and corrective actions, and closure dates are presented in the Annual UGTA QA Report (Section 5.3).

7.3 Lessons Learned

NNSA/NFO has implemented a lessons learned system as a focal point for reporting and retrieving important information concerning experiences gained through previous activities. Continuous improvement can be fostered through incorporation of applicable lessons learned into work processes and planning activities, including work plan development, budget development, and strategic planning.

8.0 References

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N-I GIS, see Navarro-Intera Geographic Information Systems.

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

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Appendix A

Sample Collection Location Information

Table A-1
Frenchman Flat Sample Collection Locations and Supporting Information

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
5149	ER-5-3	ER-5-3_p2	36.873091	-115.937985	BLFA/OAA1	WL	1,080	LJ Pump
9713	ER-5-5	ER-5-5_m1	36.870096	-115.930288	OAA/BLFA/OAA1	WL	1,088	ES Pump
Source/Plume Wells								
1920	RNM-1	RMN-1_m5	36.824488	-115.966819	AA3	WL	953	ES Pump
1922	RNM-2S	RNM-2S_m1	36.822561	-115.966916		WL	1,156	ES Pump
1919	UE-5n	UE-5n_m1	36.820720	-115.961447		WL	1,437	ES Pump

ft = Foot
ID = Identification
Lat = Latitude
Long = Longitude
NAD 27 = North American Datum of 1927
WL = Water level

AA3 = Alluvial aquifer 3
BLFA = Basalt lava-flow aquifer
OAA = Older alluvial aquifer
OAA1 = Older alluvial aquifer 1

Table A-2
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 1 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
6769	ER-20-7	ER-20-7_m1	37.213043	-116.479108	LPCU/TSA/CHZCM	2,292	2,936	ES Pump
6771	ER-20-8	ER-20-8_p3	37.193087	-116.473975	UPCU/SPA	WL	2,150	Bailer
		ER-20-8_m2			MPCU/TCA/LPCU	2,440	2,940	ES Pump
		ER-20-8_p1			LPCU/TSA/CHZCM	3,070	3,442	LJ Pump
6963	ER-20-8-2	ER-20-8-2_m1	37.193024	-116.474129	BA/UPCU/ SPA/MPCU	WL	2,339	ES Pump
9712	ER-20-11	ER-20-11_m1	37.196125	-116.484182	FCCU/BA/UPCU	2,562	3,004	ES Pump
5151	ER-EC-2A	ER-EC-2A_m3	37.144993	-116.567379	FCCM	1,635	2,236	ES Pump [a] or LJ Pump
4103	ER-EC-5	ER-EC-5_m1-3	37.084548	-116.564561	TMCM	1,169 1,835 2,194	1,443 2,146 2,500	ES Pump
4104	ER-EC-8	ER-EC-8_m1-3	37.102846	-116.631282	FCCM/ TMCM	632 1,388 1,626	1,050 1,558 2,000	ES Pump
6770	ER-EC-11	ER-EC-11_p3	37.197547	-116.494759	FCCU/BA	WL	3,030	LJ Pump
		ER-EC-11_m2			UPCU/TCA	3,196	3,385	ES Pump
		ER-EC-11_p1			TSA/CHCU	3,590	4,148	LJ Pump
6772	ER-EC-12	ER-EC-12_m2	37.173291	-116.491991	THCM/TCA/LPCU	1,854	2,744	ES Pump
		ER-EC-12_p2			TSA/CHCU	3,188	3,770	LJ Pump
6773	ER-EC-13	ER-EC-13_m2	37.169369	-116.548301	FCCM	1,835	2,136	ES Pump
		ER-EC-13_p1			FCCM	2,240	2,680	LJ Pump

Table A-2
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 2 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells (continued)								
6774	ER-EC-14	ER-EC-14_m2	37.14018	-116.511485	RMWTA	1,295	1,704	ES Pump
		ER-EC-14_p1			RMWTA	1,889	2,378	LJ Pump
6775	ER-EC-15	ER-EC-15_m3	37.186141	-116.518152	FCCU/CPA/PBPCU	WL	1,769	ES Pump
		ER-EC-15_p2			TCA/LPCU	2,108	2,427	LJ Pump
		ER-EC-15_p1			TSA/CHCU	2,752	3,255	LJ Pump
Source/Plume Wells								
16	ER-20-5-1	ER-20-5-1_p1	37.220054	-116.477174	TSA/CHZCM	2,249	2,655	ES Pump
21	ER-20-5-3	ER-20-5-3_m1	37.219771	-116.477190	CHZCM	3,348	3,914	ES Pump
18	ER-20-6-1	ER-20-6-1	37.260206	-116.420772	CHZCM	2,437	2,947	LJ Pump
19	ER-20-6-2	ER-20-6-2	37.259935	-116.421166	CHZCM	2,414	2,945	LJ Pump
20	ER-20-6-3	ER-20-6-3_p1	37.259191	-116.421536	CHZCM	2,436	2,807	LJ Pump
5454	U-19ad PS 1A	U-19ad PS 1A_m1	37.270386	-116.354681	PLFA	WL	2,609	ES Pump
3390	U-19q PS 1D	U-19q PS 1D_m1	37.280413	-116.364905	NA	3,665	4,991	ES Pump[a] or LJ Pump
3399	U-19v PS1D	U-19v PS1D_m1	37.247966	-116.349120	BFCU	3,875	3,885	LJ Pump
3533	U-20n PS 1DDh	U-20n PS 1DDh	37.240273	-116.423325	CHZCM	1,250	1,253	ES Pump [a] or LJ Pump
3534	UE-20n 1	UE-20n 1_02	37.240308	-116.421934	CHZCM	2,323	2,824	ES Pump

Table A-2
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 3 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Early Detection Wells								
3468	ER-20-1	ER-20-1_o1	37.222453	-116.491506	TMLVTA/PBPCU/BA/ UPCU/TCA	WL	2,065	LJ Pump
4180	ER-EC-6	ER-EC-6_m4	37.188771	-116.496682	FCCU/BA	1,606	1,948	LJ Pump
3645	PM-3	PM-3_p1	37.239077	-116.560179	TCA/LPCU	1,872	2,192	LJ Pump
		PM-3_p2			UPCU	1,473	1,687	LJ Pump
3647	U-20 WW	U-20 WW_m1	37.251412	-116.429282	CHZCM	2,271	3,268	ES Pump [a] or LJ Pump
Distal Wells								
4178	ER-EC-1	ER-EC-1_m1-3	37.206313	-116.529739	CPA/UPCU/TCA/LPCU/ TSA/CHCU/CFCM	2,258 3,291 4,399	2,867 3,776 4,840	ES Pump
3309	UE-18r	UE-18r_o1	37.134754	-116.444707	TMCM	1,629	5,004	ES Pump
Community Wells								
4917	Ash-B	Ash-B_p1	36.725592	-116.674872	Volcanic Rocks	1,062	1,185	Bailer
		Ash-B_p2			Valley Fill	362	428	Bailer
7067	Peacock Ranch	Peacock Ranch_s1	37.030830	-116.754700	--	--	--	Scoop/Dipper
6531	Revert Springs	Revert Springs_s1	36.917500	-116.744722	--	--	--	Scoop/Dipper
9521	Spicer Ranch	Spicer Ranch_s1	36.998800	-116.705500	--	--	--	Scoop/Dipper
4936	U.S. Ecology	U.S. Ecology_m1	36.770639	-116.690278	NA	453	573	ES Pump

Table A-2
Pahute Mesa Sample Collection Locations and Supporting Information
(Page 4 of 4)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
6768	Amargosa Valley RV Park	Amargosa Valley RV Park_m1	36.642167	-116.396639	NA	WL	1,280	ES Pump
4908	Cind-R-Lite Mine	Cind-R-Lite Mine_m1	36.685000	-116.507222	Valley Fill	WL	460	ES Pump
9715	EW-4	EW-4_m1	36.877644	-116.820737	NA	NA	NA	ES Pump

[a] ES pump needs to be repaired/replaced.

-- = Not applicable
NA = Not available

BA = Benham aquifer
BFCU = Bullfrog confining unit
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
FCCU = Fortymile Canyon confining unit
LPCU = Lower Paintbrush confining unit
MPCU = Middle Paintbrush confining unit
PBPCU = Post-Benham Paintbrush confining unit
PLFA = Paintbrush lava-flow aquifer
RMWTA = Rainier Mesa welded-tuff aquifer
SPA = Scrugham Peak aquifer
TCA = Tiva Canyon aquifer
THCM = Tannenbaum Hill composite unit
TMCM = Timber Mountain composite unit
TMLVTA = Timber Mountain lower vitric-tuff aquifer
TSA = Topopah Spring aquifer
UPCU = Upper Paintbrush confining unit

Table A-3
Rainier Mesa Water Sample Collection Locations and Criteria
(Page 1 of 2)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
3809	ER-30-1	ER-30-1_p1	37.050258	-116.316190	FCCM	677	790	LJ Pump
3117	UE-12t-6	UE-12t-6_o1	37.225480	-116.191195	LTCU/OSBCU/LCCU1	WL	1,461	LJ Pump
5452	ER-12-3	ER-12-3_p1	37.195017	-116.214118	LTCU/OSBCU/ATCU	WL	2,200	LJ Pump
		ER-12-3_m1			LCA3	WL	4,908	ES Pump
5453	ER-12-4	ER-12-4_p1	37.219627	-116.183146	LVTA1/BRCU/ LTCU/OSBCU	WL	1,988	LJ Pump
		ER-12-4_m1			LCA3	WL	3,715	ES Pump
5276	ER-16-1	ER-16-1_m1	37.008566	-116.203090	LCA	WL	4,566	LJ Pump
3311	UE-18t	UE-18t_p1	37.128145	-116.329146	TMCM	120	2,600	LJ Pump
Source/Plume Wells								
3043	U-12n.10 Vent Hole	U-12n.10 Vent Hole_m1	37.207719	-116.205506	LTCU	NA	1,240	Bailer
3069	U-12n Vent Hole 2	U-12n Vent Hole_2_m1	37.203559	-116.218060	LTCU	WL	1,252	Bailer
Early Detection Wells								
3317	ER-19-1	ER-19-1_p2	37.178521	-116.239147	OSBCU	1,301	1,422	LJ Pump or Bailer
		ER-19-1_p1			RVA/ATCU	2,550	2,738	LJ Pump or Bailer

Table A-3
Rainier Mesa Water Sample Collection Locations and Criteria
(Page 2 of 2)

ID	Location Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Distal Wells								
2876	ER-12-1	ER-12-1_m5	37.184905	-116.184217	UCCU	1,641	1,846	ES Pump
3237	TW-1	TW-1_m1	37.158179	-116.222920	OSBCU/RVA/LTCU1/ ATCU/LCA3	1,910	4,206	LJ Pump or Bailer
3235	UE-16d WW	UE-16d WW_m1	37.070112	-116.164283	UCCU	1,145	1,944	ES Pump
3316	WW-8	WW-8_m22	37.165586	-116.289152	BRA	WL	2,031	ES Pump

-- = Not applicable
NA = Not available

ATCU = Argillic tuff confining unit
BRA = Belted Range aquifer
BRCU = Belted Range confining unit
FCCM = Fortymile Canyon composite unit
LCA = Lower carbonate aquifer
LCA3 = Lower carbonate aquifer-upper plate
LCCU1 = Lower clastic confining unit 1
LTCU = Lower tuff confining unit
LTCU1 = Lower tuff confining unit 1
LVTA1 = Lower vitric-tuff aquifer 1
OSBCU = Oak Spring Butte confining unit
RVA = Redrock Valley aquifer
TMCM = Timber Mountain composite unit
UCCU = Upper clastic confining unit

Table A-4
Yucca Flat Water Sample Collection Locations and Criteria
(Page 1 of 2)

ID	Well Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Characterization Wells								
5204	ER-2-1	ER-2-1_m1	37.125278	-116.061899	TMWTA/TMLVTA/LTCU	WL	2,177	ES Pump
5150	ER-5-3-2	ER-5-3-2_m1	36.873115	-115.938328	LCA	4,674	5,683	ES Pump
5203	ER-6-1-2	ER-6-1-2_m1	36.983891	-115.993053	LCA	1,775	3,200	LJ Pump
5199	ER-7-1	ER-7-1_m1	37.073318	-115.995265	LCA	WL	2,500	ES Pump
1747	TW-7	TW-7_m1	37.064863	-116.033776	LTCU	1,710	2,272	LJ Pump
2719	UE-10j	UE-10j_m3	37.185525	-116.081521	LCA	2,232	2,297	ES Pump [a] or LJ Pump
69	UE-1h	UE-1h_o1	37.001333	-116.067373	LCA	WL	3,358	LJ Pump
1971	WW-3	WW-3_m1	36.995230	-116.057958	AA3	WL	2,349	LJ Pump
Source/Plume Wells								
1018	U-3cn PS 2	U-3cn PS 2_m1	37.060419	-116.021768	LTCU	WL	2,603	ES Pump [a] or LJ Pump
1838	U-4u PS 2A	U-4u PS 2A_p1	37.086975	-116.049282	LTCU	1,610	1,770	ES Pump [a] or LJ Pump
319	UE-2ce	UE-2ce_m1	37.142011	-116.135278	LCA3	WL	1,650	ES Pump
2059	UE-7nS	UE-7nS_m1	37.098770	-116.002484	LCA	1,995	2,022	LJ Pump
1745	WW-A	WW-A_m1	37.036876	-116.036238	AA3	WL	1,870	ES Pump [a] or LJ Pump

Table A-4
Yucca Flat Water Sample Collection Locations and Criteria
(Page 2 of 2)

ID	Well Name	Sample Location ID	NAD 27		HSU	Effective Open Interval (ft)		Sample Method
			Lat	Long		Depth to Top	Depth to Bottom	
Early Detection Wells								
549	WW-2	WW-2_m1	37.166234	-116.087622	LCA	2,563	3,422	ES Pump
1892	TW-D	TW-D_m1	37.074440	-116.075018	ATCU/LCA	1,772	1,950	Bailer or LJ Pump
22	UE-1q	UE-1q_o1	37.060342	-116.058332	LCA	2,459	2,600	Bailer or LJ Pump
1970	WW C-1	WW C-1_m1	36.918647	-116.009409	LCA	WL	1,650	ES Pump [a] or LJ Pump
1015	U-3cn 5	U-3cn 5_o1	37.059475	-116.022363	LCA	2,832	3,030	ES Pump
Distal Wells								
3648	Army 1 WW	Army 1 WW_m1	36.591616	-116.037262	LCA	WL	1,946	ES Pump

[a] ES pump needs to be repaired/replaced.

AA3 = Alluvial aquifer 3
ATCU = Argillic tuff confining unit
LCA = Lower carbonate aquifer
LCA3 = Lower carbonate aquifer-upper plate
LTCU = Lower tuff confining unit
TMLVTA = Timber Mountain lower vitric-tuff aquifer
TMWTA = Timber Mountain welded-tuff aquifer

Appendix B

Procedures

B.1.0 Introduction

This section presents the SOPs used by each organization for sample collection, water-quality measurements, and analytical data verification/validation (Table B-1), laboratory analyses (Table B-2), and programmatic interfaces (Table B-3).

Table B-1
Sample Collection, Water-Quality Measurement, Analytical Data Verification/Validation Procedures

Responsible Organization	Procedure
Sample Collection	
ER contractor	UF-DR-2: Fluid Management Status Reporting for Wells in Progress
	UF-EC-4: Small Equipment Decontamination
	Subject Area: UGTA Sample Collection and Processing
M&O contractor	SOP-P420.104: Preparing and Sampling Routine Radiological Environmental Monitoring Plan (RREMP) Groundwater Wells
Water-Quality Measurements	
ER contractor	UF-FMM-2: Field Screening for Lead in Fluid Samples
	UF-FMM-3: Measuring Alkalinity in the Field
	UF-FMM-4: Water Quality Monitoring
	RP-RIC-4: Operation and Calibration of the TriCarb 2900TR Liquid Scintillation Counter
Analytical Data Verification and Validation	
ER contractor	Tier I Data Verification Review Checklist (QA-DV-1, QA-CDV-1, QA-RDV-1)
	Chemical Data Validation, Inorganic (QA-CDV-1)
	Chemical Data Validation, Organic (QA-CDV-2)
	Tier II Radiological Data Review - Data Validation Subject Area (QA-RDV-2, QA-RDV-3, QA-RDV-4)
M&O contractor	Verification, Validation and Data Review of Environmental Monitoring Program Data (OP-P420.117)
	Radioanalytical Data Verification, Data Validation, and Data Review (OP-P420.457)
	Inorganic Data Verification and Validation (OP-P420.459)

Table B-2
Analytes, Analytical Procedures, and Sample Collection Information for Required Analyses
(Page 1 of 2)

Analyte	Preferred Analytical Method [a]	Title	Detection Limit	Number of Containers	Container Type	Preservative	Hold Time	Filtration
General Chemistry								
Alkalinity	EPA 310.2 [b]	Alkalinity (Colorimetric, Automated, Methyl Orange)	20 mg/L as $CaCO_3$	1	1-L (250-mL) [c] polyethylene	Cool/Ice to 6 °C	14 days	Unfiltered
pH	EPA 150.1 [b]	pH (Electrometric)	0.01				24 hours	
Specific Conductance	EPA 120.1 [b]	Conductance (Specific Conductance, µmhos at 25 °C)	1.0 µmhos/cm				28 days	
Br, Cl, F, SO_4	EPA 300.0 [d]	Determination of Inorganic Anions in Drinking Water by Ion Chromatography	0.25–1 mg/L	1	1-L (125-mL) [c] polyethylene	Cool/Ice to 6 °C	28 days	Filtered (0.45-µm)
Metals								
Ag, Al, As, Ba, Ca, Cd, Cr, Fe, K, Li, Mg, Mn, Na, Pb, Se, Si, Sr	EPA 6010 [e]	Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES)	0.001–1.0 mg/L	1	1-L (500-mL) [b] polyethylene	HNO_3 to pH<2	6 months	Unfiltered
U	EPA 6020 [e]	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 [f]	Gamma-Emitting Radionuclides in Drinking Water	10 pCi/L ^{137}Cs	1	1-L polyethylene	HNO_3 to pH<2	180 days	Unfiltered
Gross Alpha and Gross Beta	EPA 900.0 [f]	Gross Alpha/Beta Radioactivity in Drinking Water	3 pCi/L (Gross Alpha)	1	1-L (500-mL) [c] polyethylene	HNO_3 to pH<2		Unfiltered
^{3}H (Low Level)	HASL 300 3H-01-RC (prep) [g] EPA 906.0 [f] (analysis)	Tritium Assay in Water Samples using Electrolytic Enrichment; Tritium (^{3}H) in Drinking Water	3 pCi/L	3	1-L polyethylene	None		Unfiltered
^{3}H	EPA 906.0 [f]	Tritium (^{3}H) in Drinking Water	300 pCi/L	1	250-mL (100-mL) [c] amber glass	None		
^{90}Sr	EPA 905.0 [f]	Strontium-90 (^{90}Sr) in Water	1 pCi/L	1	1-L polyethylene	HNO_3 to pH<2		

Table B-2
Analytes, Analytical Procedures, and Sample Collection Information for Required Analyses
(Page 2 of 2)

Analyte	Preferred Analytical Method [a]	Title	Detection Limit	Number of Containers	Container Type	Preservative	Hold Time	Filtration
^{14}C	EERF C-01 [h] or equivalent	Radiochemical Determination of Carbon-14 (^{14}C) in Aqueous Samples	500 pCi/L	1	1-L (100-mL) amber glass	None	180 days (holding time is required by SOW but not analytical method)	Nonfiltered
^{36}Cl	Lab specific	Chlorine-36 (^{36}Cl)	4 pCi/L	2	1-L amber glass	None		
^{99}Tc	HASL 300 TC-01-RC [g] or equivalent	Technetium-99 (^{99}Tc) in Water	10 pCi/L	1	1-L polyethylene	HNO_3 to pH<2		
^{129}I	EPA 902.0 [f]	Radioactive Iodine in Drinking Water	<1 pCi/L	2	1-L amber glass	None		
$^{238/239/240}Pu$	HASL 300 Pu-10-RC [g] or ASTM D3865-09 [i] or equivalent	Isotopic Plutonium (Pu)	0.1 pCi/L	1	1-L polyethylene	HNO_3 to pH<2		

[a] Equivalent methods promulgated in 40 CFR 141 (CFR, 2014) are also allowed.
[b] EPA, 1983
[c] Sample volume for discrete bailer samples.
[d] EPA, 1993
[e] EPA, 2014
[f] EPA, 1980
[g] DOE, 1997
[h] EPA, 1984
[i] ASTM, 2009

ASTM = ASTM International
°C = Degrees Celsius
$CaCO_3$ = Calcium carbonate
EERF = Eastern Environmental Radiation Facility
HASL = Health and Safety Laboratory
HNO_3 = Nitric acid
ICP-AES = Inductively coupled plasma-atomic emission spectrometry
ICP-MS = Inductively coupled plasma-mass spectrometry
L = Liter
mg/L = Milligrams per liter
mL = Milliliter
SOW = Statement of work
µm = Micrometer
µmhos = Micromho
µmhos/cm = Micromhos per centimeter

Table B-3
UGTA Programmatic Interface Procedures

Procedure	Comments
Annual Quality Assurance (QA) Report (PA-UPI-1)	Describes requirements for developing the Annual QA Report including assessments (findings, corrective actions, and closure dates), PEP results, committee membership, procedure updates, lessons learned, list of activities performed outside normal work scope, and publications.
UGTA Information and Data Management System (UIDMS) Submittal (PA-UPI-2)	Describes the process for receiving, reviewing, and placing contributions from UGTA participants into the UGTA UIDMS. Includes processes for information and data management; development, verification, review, and documentation of software and models; and preparation, review, and issuance of UGTA documents. Processes for handling both shared and published information and data are included.
Issue Tracking (PA-UPI-3)	Describes the processes for entering, administrating, and closing UGTA issues within the issue tracking system.

B.2.0 References

ASTM, see ASTM International.

ASTM International. 2009. *Standard Test Method for Plutonium in Water,* ASTM D3865-09. West Conshohocken, PA.

CFR, see *Code of Federal Regulations.*

Code of Federal Regulations. 2014. Title 40 CFR Part 141, "National Primary Drinking Water Regulations." Washington, DC, U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

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