Environmental
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DOE/NV--1572

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)

Controlled Copy No.: _____
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June 2017

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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)

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

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FOR CORRECTIVE ACTION UNIT 98,
FRENCHMAN FLAT,
UNDERGROUND TEST AREA,
NEVADA NATIONAL SECURITY SITE, NEVADA
FOR CALENDAR YEAR 2016

(JANUARY 2016–DECEMBER 2016)

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Table of Contents

List of Figures . . . iii
List of Tables . . . v
List of Acronyms and Abbreviations . . . vi
Executive Summary . . . ES-1

1.0 Introduction . . . 1

2.0 Site Location and Background . . . 3

2.1 Summary of Corrective Action Activities . . . 4

3.0 Geologic and Hydrologic Setting . . . 6

4.0 Monitoring Program Objectives and Activities . . . 7

4.1 Water-Quality Monitoring . . . 7
4.1.1 Northern Testing Area . . . 9
4.1.2 Central Testing Area . . . 10
4.2 Water-Quality Results . . . 10
4.2.1 Northern Testing Area . . . 10
4.2.2 Central Testing Area . . . 12
4.3 Water-Level Monitoring . . . 12
4.4 Water-Level Results . . . 17
4.5 Institutional Control Monitoring . . . 23
4.6 Institutional Control Monitoring Results . . . 26
4.6.1 UR Verification . . . 26

5.0 Site Inspection and Verification of Well Functionality and Effectiveness . . . 28

6.0 Data Evaluation . . . 29

6.1 Corrective Action Thresholds/Triggers . . . 29
6.2 Data Consistency with Model Assumptions and Model Forecasts, Contaminant Boundaries, and Regulatory Boundary . . . 29
6.2.1 Determination of Water-Level Consistency . . . 29
6.2.2 Determination of Radiochemistry Consistency . . . 34
6.3 Evaluation of Effectiveness of Institutional Controls and URs, and Identification of Any New Land Use Impacts . . . 35
6.4 Viability of Closure Strategy for Protecting Human Health and the Environment . . . 42

7.0 Summary and Recommendations . . . 45

8.0 References . . . 47

Table of Contents *(Continued)*

Appendix A - Additional Analytical Data for 2016 Water Samples

Appendix B - Water-Level Analyses

B.1.0 Water-Level Analyses B-1

B.1.1 Hydrographs B-1
B.1.1.1 ER-5-3 and ER-5-3-3 . . . . . B-1
B.1.1.2 Observation Wells in the Alluvial Aquifer in the Northern Testing Area B-2
B.1.1.3 Observation Wells in the Alluvial Aquifer in the Central Testing Area B-2
B.1.1.4 Water-Supply Wells in the Alluvial Aquifer B-4
B.1.1.5 Wells in the Volcanic Aquifer B-4
B.1.1.6 Well in the Carbonate Aquifer B-5
B.1.2 Groundwater Flow Gradients B-5

B.2.0 References B-10

Appendix C - Use Restriction and Institutional Control Information

C.1.0 Use Restriction and Institutional Control Information C-1

Attachment C-1 - Use Restriction and Institutional Control Information

Appendix D - Monitoring Network Inspections and Maintenance

D.1.0 Monitoring Network Inspections and Maintenance D-1

List of Figures

Number	Title	Page
1-1	Location of Frenchman Flat within the NNSS	2
4-1	Location of Water-Quality Wells for CAU 98	8
4-2	Trend in ^{3}H Concentration Measured in Samples from RNM-2S	13
4-3	Trend in ^{3}H Concentration Measured in Samples from UE-5n	13
4-4	Location of Water-Level Monitoring Wells in Frenchman Flat, Measured for the Closure Monitoring Program	15
4-5	Groundwater Levels at the Monitoring Wells from 01/01/2004 to 10/24/2016	20
4-6	Water-Level Trends in Frenchman Flat Observation Wells	22
4-7	UR Areas for CAU 98, within the Context of the NNSS, NTTR, and the Frenchman Flat Hydrographic Basin Boundary	24
6-1	Groundwater Flow Directions and Gradients ($x10^{-3}$) Calculated from the Monitoring Measurements and from Heads Simulated by the BASE-USGSD Alternative and NHA Models	32
6-2	Measured ^{3}H Concentrations at UE-5n and Concentrations Forecast by the Groundwater Flow and Transport Model	35
6-3	Measured ^{3}H Concentrations at RNM-2S and Concentrations Forecast by the Groundwater Flow and Transport Model	36
6-4	Past and Present Groundwater Production Wells in the Frenchman Flat Area	37
6-5	Annual Water Production from Wells WW-4, WW-4A, and WW-5B	38
6-6	Total Annual Withdrawals for Wells Completed in the Alluvial Aquifer of Frenchman Flat	39
6-7	Hydrographic Basin Locations, Names, and Numbers in the Vicinity of Frenchman Flat	40
6-8	Contaminant Boundaries within the UR and Regulatory Boundaries	43

List of Figures *(Continued)*

Number	Title	Page
B.1-1	Water Levels in ER-5-3 and ER-5-3-3	B-1
B.1-2	Water Levels in Alluvium Aquifer Wells in the Northern Testing Area	B-3
B.1-3	Water Levels in Alluvial Aquifer Wells in the Central Testing Area	B-3
B.1-4	Water Levels at Pumping Wells in the Alluvial Aquifer	B-4
B.1-5	Water Levels in Wells in the Volcanic Aquifer in the (a) Northern Testing Area and (b) Central Testing Area	B-5
B.1-6	Water Levels in ER-5-3-2 in the Carbonate Aquifer	B-6

List of Tables

Number	Title	Page
2-1	Underground Nuclear Tests within CAU 98	3
4-1	Water-Quality Monitoring Wells for CAU 98	7
4-2	^{3}H, ^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I Analytical Results	11
4-3	Wells Used for Monitoring Water Levels Important to the CAU 98 Closure	14
4-4	Water-Level Data for 2016	18
4-5	Mann-Kendall Trend Analysis for Water-Level Data from 2004 to 2016	21
6-1	Wells Used To Determine Directions and Magnitudes of Groundwater Flow Gradients in the Alluvial Aquifer for 3 Regions of Frenchman Flat	31
6-2	Summary of Directions and Magnitudes of Groundwater Flow Gradients Calculated Using Measured Water Levels and Model-Simulated Heads	33
6-3	Active Annual Duty in 2016 and Actual Groundwater Pumpage in 2015 for Hydrographic Basins near Frenchman Flat	41
A.1-1	Additional Analytical Results for 2016 Water Samples	A-1
B.1-1	Gradient Analysis for the Entire Testing Area of Frenchman Flat	B-7
B.1-2	Gradient Analysis for the Northern Testing Area of Frenchman Flat	B-8
B.1-3	Gradient Analysis for the Central Testing Area of Frenchman Flat	B-9
D.1-1	Inspection Results in 2016 for Frenchman Flat Water-Quality Monitoring Wells	D-1
D.1-2	Inspection Results for 2016 for Frenchman Flat Water-Level Monitoring Wells	D-2

List of Acronyms and Abbreviations

General Acronyms and Abbreviations

BLM	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
CB	Contaminant boundary
cfs	Cubic feet per second
COC	Contaminant of concern
CP	Control Point
CR	Closure report
CS	Carbon steel
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
EM	Environmental Management
FFACO	*Federal Facility Agreement and Consent Order*
FS	U.S. Forest Service
ft	Foot
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information Systems
HST	Hydrologic source term
kt	Kiloton
LCA	Lower carbonate aquifer
LLNL	Lawrence Livermore National Laboratory
m	Meter
MCL	Maximum contaminant level
MDL	Minimum detection limit
M&O	Management and operating

List of Acronyms and Abbreviations *(Continued)*

mol/kg	Moles per kilogram
NA	Not available
NAD	North American Datum
NDEP	Nevada Division of Environmental Protection
NDWR	Nevada Division of Water Resources
NGVD	National Geodetic Vertical Datum
N-I	Navarro-Intera, LLC
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
NWIS	National Water Information System
pCi/L	Picocuries per liter
QA	Quality assurance
REOP	Real Estate/Operations Permit
RWMC	Radioactive waste management complex
SD	Standard deviation
SDWA	*Safe Drinking Water Act*
UGTA	Underground test area
UR	Use Restriction
USAF	U.S. Air Force
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
µg/L	Micrograms per liter
µS/cm	Microsiemens per centimeter

Symbols for Elements and Compounds

Ag	Silver
Al	Aluminum
Am	Americium
As	Arsenic

List of Acronyms and Abbreviations (Continued)

Ba	Barium
Br	Bromide
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
Cd	Cadmium
Cl	Chlorine
CO_3	Carbonate
Cr	Chromium
Cs	Cesium
Eu	Europium
F	Fluorine
Fe	Iron
^3H	Tritium
HCO_3	Bicarbonate
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

Executive Summary

Corrective Action Unit (CAU) 98: Frenchman Flat on the Nevada National Security Site was the location of 10 underground nuclear tests. CAU 98 underwent a series of investigations and actions in accordance with the *Federal Facility Agreement and Consent Order* to assess contamination of groundwater by radionuclides from the tests. A Closure Report completed that process in 2016 and called for long-term monitoring, use restrictions (URs), and institutional controls to protect the public and environment from potential exposure to contaminated groundwater. Three types of monitoring are performed for CAU 98: water quality, water level, and institutional control. These are evaluated to determine whether the UR boundaries remain protective of human health and the environment, and to ensure that the regulatory boundary objectives are being met. Additionally, monitoring data are used to evaluate consistency with the groundwater flow and contaminant transport models because the contaminant boundaries (CBs) calculated with the models are the primary basis of the UR boundaries.

Six wells were sampled for water-quality monitoring in 2016. Contaminants of concern (COCs) were detected only in the two source/plume wells already known to contain contamination as a result of a radionuclide migration experiment. The tritium concentration in both wells is slowly decreasing, consistent with forecasts from the contaminant transport models.

The water-level monitoring network includes 16 wells. Depth to water measured in 2016 in all wells is consistent with recent measurements. A declining water-level trend exists in most of the wells completed in the alluvium and is primarily attributed to drawdown from basin-scale pumping. Groundwater production has occurred from wells in the central and southern part of the basin since the 1950s. Greater variability in flow direction and hydraulic gradient magnitude is calculated from the water-level measurements than simulated by the groundwater models. Though observed gradients are generally lower in magnitude than modeled, flow directions tend to the south rather than southeast, basin-wide, and in the Northern Testing Area; and water levels in the Central Testing Area suggest west- and northwest-directed groundwater flow. Local gradients, not simulated at the flow model scale, may account for the discrepancies, such as gradients in the area of the radionuclide migration experiment in the Central Testing Area. The differences between modeled and observed hydraulic gradients are not of immediate concern because a number of features of the models, CBs, and URs provide assurance of their ability to prevent exposure to COCs. These include buffer zones

around many CBs within the UR areas, and model configurations that tend to overpredict contaminant migration.

Institutional control monitoring confirmed the URs are recorded in U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office and U.S. Air Force land management systems, and that no activities within Frenchman Flat basin are occurring that could potentially affect the CBs. Survey of groundwater resources in basins surrounding Frenchman Flat similarly identify no current or pending development that would indicate the need to increase monitoring activities or would otherwise cause concern for the closure decision.

The Underground Test Area closure strategy of closure in place with monitoring and institutional controls remains viable, based on the monitoring results. The URs continue to prevent exposure of the public, workers, and the environment to COCs by preventing use of potentially contaminated groundwater.

In summary, the monitoring results from 2016 indicate the regulatory controls on the closure of CAU 98 remain effective in protection of human health and the environment. Recommendations resulting from this first year of monitoring activities include formally incorporating wells UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 into the groundwater-level monitoring network given their strategic location in the basin; and early development of a basis for trigger levels for the groundwater-level monitoring given the observed trends. Additionally, it is recommended to improve the Real Estate/Operations Permit process for capturing information important for evaluating the impact of activities on groundwater resources, and to shift the reporting requirement for this annual report from the second quarter of the federal fiscal year (end of March) to the second quarter of the calendar year (end of June).

1.0 Introduction

Corrective Action Unit (CAU) 98: Frenchman Flat on the Nevada National Security Site (NNSS) was the site of 10 underground nuclear tests, some of which have impacted groundwater near the tests (Figure 1-1). The U.S. Department of Energy (DOE), Environmental Management (EM) Nevada Program has addressed the groundwater impacts through actions conducted in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) Underground Test Area (UGTA) Strategy (FFACO, 1996 as amended).

The *Underground Test Area (UGTA) Closure Report for Corrective Action Unit 98: Frenchman Flat Nevada National Security Site, Nevada* (NNSA/NFO, 2016b), establishes the contaminant boundaries (CBs), regulatory boundary and regulatory boundary objectives, monitoring program, use restrictions (URs), and other institutional controls agreed to by the DOE, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) and the Nevada Division of Environmental Protection (NDEP) for closure of CAU 98. It calls for an annual long-term monitoring report (this report) documenting the groundwater monitoring analytical results, monitoring system inspections, institutional control verifications, consistency of results as compared to models and CBs, and adherence to UR and regulatory boundaries.

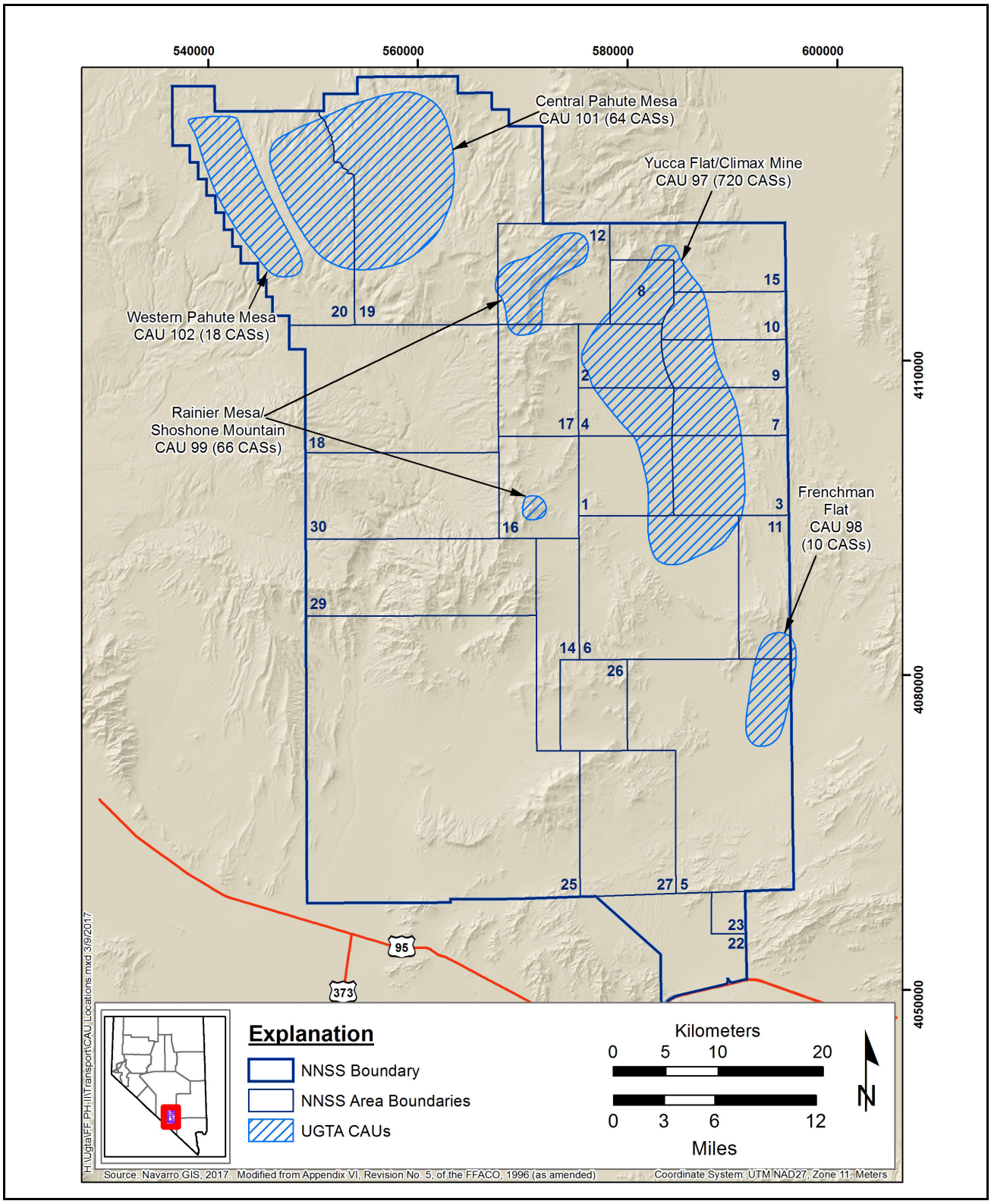

Figure 1-1
Location of Frenchman Flat within the NNSS

2.0 Site Location and Background

CAU 98 is located in the Frenchman Flat closed drainage basin on the NNSS (Figure 1-1). The NNSS is approximately 65 miles northwest of Las Vegas, Nevada, and Frenchman Flat is in the southeastern portion of the site. The first nuclear test at the NNSS occurred at Frenchman Flat in 1951, and additional atmospheric tests occurred in the basin through 1962.

Ten underground nuclear tests were conducted in Frenchman Flat between 1965 and 1971. Seven were detonated in the northern part of CAU 98, and three were in the central part (Table 2-1). Although only the CAMBRIC test was conducted below the water table, radionuclide contamination of groundwater is assumed for all of them because the others were detonated within 100 meters (m) (328 feet [ft]) of the water table (DOE/NV, 1997). All of the tests were detonated in alluvium with the exception of PIN STRIPE, which was detonated within volcanic rock (vitric tuff). All of the tests have yields less than 20 kilotons (kt) (NNSA/NFO, 2015).

Table 2-1
Underground Nuclear Tests within CAU 98

Test Name	CAS Number	Hole Name	Test Date	Latitude (NAD 27)	Longitude (NAD 27)	Depth (ft)	Yield (kt)
Central Testing Area							
CAMBRIC	05-57-003	U5e	05/14/1965	36.823384	-115.966836	-967	0.75
DILUTED WATERS	05-57-002	U5b	06/16/1965	36.818049	-115.956061	-632	<20
WISHBONE	05-57-001	U5a	02/18/1965	36.818008	-115.949229	-574	<20
Northern Testing Area							
DERRINGER	05-57-004	U5i	09/12/1966	36.875888	-115.950695	-837	7.8
DIAGONAL LINE	11-57-005	U11g	11/24/1971	36.879227	-115.934707	-868	<20
DIANA MOON	11-57-003	U11e	08/27/1968	36.877213	-115.931075	-794	<20
MILK SHAKE	05-57-005	U5k	03/25/1968	36.871719	-115.931131	-868	<20
MINUTE STEAK	11-57-004	U11f	09/12/1969	36.877213	-115.92850	-868	<20
NEW POINT	11-57-002	U11c	12/13/1966	36.877255	-115.937912	-785	<20
PIN STRIPE	11-57-001	U11b	04/25/1966	36.887452	-115.940797	-970	<20

CAS = Corrective action site
NAD = North American Datum

Source: Modified from NNSA/NFO, 2015; to NAD27 coordinate system

In addition to nuclear testing, Frenchman Flat was the location of a long-term radionuclide migration experiment related to the CAMBRIC underground test. The Area 5 Radioactive Waste Management Complex (RWMC) is located in Frenchman Flat and receives low-level radioactive waste generated at the NNSS and other DOE sites.

2.1 Summary of Corrective Action Activities

The corrective action strategy for CAU 98 follows the UGTA process defined in Appendix VI of the FFACO (1996, as amended). It is a four-stage sequential approach of a Corrective Action Investigation Plan (CAIP), Corrective Action Investigation (CAI), Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP), and finally a Closure Report (CR). The process began for Frenchman Flat with a value of information analysis (IT, 1997) that guided development of the CAIP (DOE/NV, 1999). The CAIP focused efforts on development of a groundwater flow and transport model. Subsequent peer review of that model (IT, 1999 and 2000) led to a determination that additional data collection was required.

A CAIP addendum (NNSA/NV, 2001) prescribed data collection and modeling activities that are known as Phase II of the CAI. Phase II data collection included well drilling, geophysical investigations, and hydrogeologic and geochemical investigations, all providing data for a new groundwater flow and transport model (SNJV, 2006; NNES, 2010). A significant addition to the modeling process was a broader analysis of model uncertainty, including examination of alternate conceptual models. CBs were calculated using the models. The Phase II groundwater flow and transport model successfully completed peer review and was accepted by NDEP, closing out the CAI stage in 2010.

The CADD/CAP document (NNSA/NSO, 2011) presented the recommended corrective action alternative of closure in place with modeling, monitoring, and institutional controls. It also specified a model evaluation process designed to ensure that the existing models provide adequate guidance for developing monitoring and institutional controls for the site. Data collection activities occurred according to this plan, focused on addressing key uncertainties in the flow and transport models. Additionally, the EM Nevada Program and NDEP agreed to initial UR boundaries and CAU regulatory boundary objectives. Results of the model evaluation activities substantiated the suitability

of the models for the purpose of developing monitoring and institutional controls. NDEP approval of the model evaluation report (N-I, 2014) ended the CADD/CAP stage in 2014.

The CR (NNSA/NFO, 2016b), approved by NDEP in 2016, describes the regulatory boundary objectives; and the final contaminant, UR, and regulatory boundaries agreed upon by NDEP and NNSA/NFO for CAU 98. It also specifies the monitoring program that will be followed for the first five years. The CR calls for an annual long-term monitoring report to verify corrective action effectiveness. This annual report, contained herein, serves to document groundwater monitoring analytical results and water levels, monitoring system inspections, institutional control verifications, consistency of results with models and CBs, and adherence to URs and regulatory boundaries.

3.0 Geologic and Hydrologic Setting

Frenchman Flat is a closed-drainage topographic basin in the southeastern portion of the NNSS. It is defined by surrounding mountain ranges and hills, with a valley floor that slopes gently to a usually dry lake bed, Frenchman Lake playa. Total relief from the low-lying playa to the crest of the surrounding hills is about 1,700 ft. The basin is filled with sedimentary and volcaniclastic rocks above regionally deposited carbonate rocks (Bright et al., 2001).

Frenchman Flat basin contains two semi-independent aquifer systems: a semi-perched groundwater system in alluvial and volcanic rocks, and a deeper regional flow system in carbonate rocks (the lower carbonate aquifer [LCA]). The shallower semi-perched system is separated from the LCA by a thick sequence of tuff confining units that limit vertical flow. Water levels in both the alluvial and volcanic aquifers within Frenchman Flat are several meters higher than water levels in the LCA that underlies and surrounds the basin. Groundwater in the alluvial and volcanic rocks only leaves the basin by draining downward into the LCA or laterally into the LCA along the basin margins. In some parts of the basin, the intervening low-permeability tuff confining unit is overpressured, preventing vertical migration.

The shallow groundwater system has low horizontal hydraulic gradients, interpreted as indicating low flow rates, consistent with the limited groundwater recharge in the arid environment (NNES, 2010). Groundwater flow through the alluvial and volcanic units is driven by the limited recharge within the basin and by flow from an area of higher head in the CP sub-basin to the west. Flow within the deeper LCA in Frenchman Flat may be largely directed along the Rock Valley fault system, toward the southwest, a flow path addressed by the alignment of the regulatory boundary with the fault.

4.0 Monitoring Program Objectives and Activities

Three types of monitoring are performed for CAU 98: water quality, water level, and institutional control. The objective of all these monitoring activities is to determine whether the UR boundaries remain protective of human health and the environment, and to ensure that the regulatory boundary objective is met. Additionally, the water-quality and water-level monitoring are used to evaluate consistency with the groundwater flow and contaminant transport conceptual and numerical models because the models are the primary basis for the UR boundaries.

4.1 Water-Quality Monitoring

Six wells in Frenchman Flat are sampled for water-quality monitoring (Table 4-1; Figure 4-1). The objective(s) are specific to each well, but the general intent is to provide information useful to evaluating the groundwater flow and transport model, while also specifically measuring the concentration of contaminants of concern (COCs). The COCs are those radionuclides contributing to the CB, being ^{3}H, ^{14}C, ^{36}Cl, ^{129}I, and ^{99}Tc (NNSA/NSO, 2011).

Table 4-1
Water-Quality Monitoring Wells for CAU 98

Well Name	Latitude (NAD 27)	Longitude (NAD 27)	Aquifer	Sample Method	Category [a]	Sample Date
ER-5-3_p2	36.873091	-115.937985	Basalt Lava-Flow & Older Alluvial	Bailer	Characterization	06/07/2016
ER-5-3-2	36.873115	-115.938328	Lower Carbonate	Submersible Pump	Characterization	05/19/2016
ER-5-5	36.870096	-115.930288	Alluvial & Basalt Rubble	Submersible Pump	Characterization	05/16/2016
ER-11-2	36.887314	-115.938667	Lower Tuff Confining Unit	Bailer	Inactive	04/19/2016 06/29/2016
RNM-2S	36.822561	-115.966916	Alluvial	Submersible Pump	Source/Plume	05/10/2016
UE-5n	36.820720	-115.961447	Alluvial	Submersible Pump	Source/Plume	05/05/2016

[a] Analytical suite for each category is as follows (bailed samples may have a reduced suite):
Characterization: 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, Uranium), Gross alpha, Gross beta, Gamma emitters (^{26}Al, ^{94}Nb, ^{137}Cs, $^{152/154}Eu$, ^{235}U, ^{241}Am, ^{243}Am), ^{3}H (low-level or standard, see below), ^{14}C, ^{36}Cl, ^{99}Tc, ^{90}Sr, ^{129}I, and $^{238/239/240}Pu$. *Inactive:* ^{3}H (low-level; MDL as low as 1 pCi/L)
Source/Plume: ^{3}H (standard; MDL approximately 300 pCi/L), ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I.

MDL = Minimum detection limit
pCi/L = Picocuries per liter

Note: Because "U" is used as a qualifier within this document, "uranium" will be spelled out when used without an isotope number.

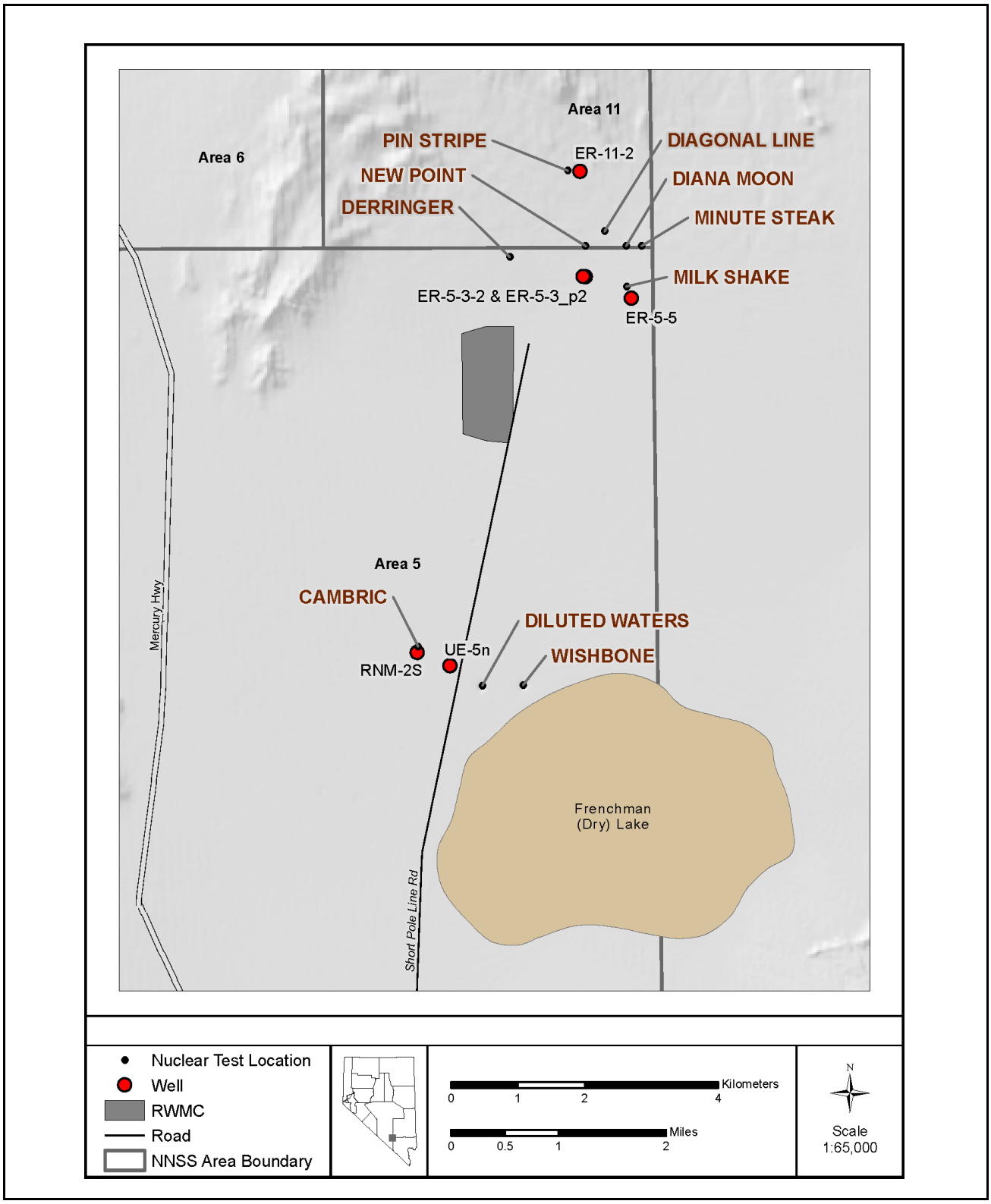

Figure 4-1
Location of Water-Quality Wells for CAU 98

The rationale for each monitoring well and general monitoring conditions are described in the following subsections. The wells are presented according to their location in either the Northern Testing Area (four wells) or Central Testing Area (two wells). The monitoring wells are also part of the NNSS Integrated Groundwater Sampling Plan (NNSA/NFO, 2014), where they are categorized into three types: characterization, source/plume, or inactive. The category is associated with a specific analytical suite. Water-quality sampling in 2016 was conducted by Navarro in accordance with their procedures UF-FMM-4 "Water Quality Monitoring" and UF-SC-8 "Fluid Sample Collection, Field Filtration, and Processing," which are part of their "UGTA Field Measurements and Monitoring" and "UGTA Sample Collection and Processing" subject areas, respectively (Navarro, 2017). Water-quality samples for the six monitoring wells were collected from April to June 2016 (Table 4-1). Analyses are performed by laboratories certified by the NDEP Bureau of Safe Drinking Water.

4.1.1 Northern Testing Area

ER-5-3_p2 (shallow piezometer) is completed in the basalt lava-flow aquifer and alluvium of the older altered alluvial aquifer. This well is the closest water table monitoring location to five underground nuclear tests, including being generally downgradient of the DERRINGER test.

ER-5-3-2 is a deep well within the ER-5-3 well cluster, being completed in the LCA. This well monitors the carbonate aquifer to detect vertical migration of contaminants from upgradient tests.

ER-5-5 was drilled as a model evaluation well and is located within the CB calculated for the MILK SHAKE test. The well is completed in a thin basalt rubble zone and adjacent alluvium. It is located to monitor contaminant migration from the MILK SHAKE test and is anticipated to be an early detection location.

ER-11-2 was drilled as a model evaluation well downgradient from the PIN STRIPE test. Geologic and hydrologic information from ER-11-2 revealed the presence of a fault-related barrier between the nuclear test and the monitoring well, and also found the well completed in a low-permeability aquitard. The well is identified for ^{3}H monitoring because of its proximity to the PIN STRIPE test.

4.1.2 Central Testing Area

RNM-2S is located south of the CAMBRIC underground nuclear test. It was completed in alluvium as the pumping well for a long-term experiment gathering data regarding migration of radionuclides through groundwater. Breakthrough of radionuclides originating from the CAMBRIC cavity was observed at RNM-2S within the first year of pumping (in 1975), and pumping continued for almost 16 years. RNM-2S monitors the contaminant plume from the CAMBRIC pumping test.

UE-5n is located southeast of the CAMBRIC test and is completed in alluvium. The water pumped as part of the long-term radionuclide migration experiment at the CAMBRIC test was discharged into a ditch adjacent to UE-5n and infiltrated to the water table. As a result, UE-5n is located within the CB associated with the CAMBRIC test. UE-5n monitors the natural attenuation of the radionuclide-contaminated water that infiltrated from the ditch.

4.2 Water-Quality Results

The analytical results for the COCs in CAU 98 monitoring wells are discussed in the following subsections. Results for additional parameters are reported in Appendix A. Laboratory MDLs specified for the monitoring analyses are below the *Safe Drinking Water Act* (SDWA) standards (maximum contaminant level [MCL] values) for each radionuclide (CFR, 2016). In many cases, the reported concentration is less than the MDL or less than the MDL plus measurement error (laboratory qualifier code "U"). Trends are not assessed unless concentrations exceed the MDL.

4.2.1 Northern Testing Area

ER-11-2 has been sampled five times for ^{3}H, including twice in 2016. All previous analyses have been below the MDL or below the MDL plus error. The first 2016 sample, collected April 19, 2016, has an estimated ^{3}H concentration of 17.48 ± 5.45 pCi/L (Table 4-2); but the result is flagged as not meeting laboratory quality assurance (QA) standards and as an anomalous result suspected of influence by contaminated sampling equipment, sample mishandling, and/or lab contamination. Tritium in a second sample, collected June 29, 2016, was below the MDL of 2.99 pCi/L.

ER-5-3_p2 was sampled for the first time in 2016, and ^{3}H and ^{14}C were below analytical MDLs.

Table 4-2
^{3}H, ^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I Analytical Results

Well	Date	Type [a]	^{3}H	^{3}H, Low Level	^{14}C	^{36}Cl	^{99}Tc	^{129}I
MCL (pCi/L) [b]			20,000		2,000	700	900	1
			Results (pCi/L)					
ER-5-3_p2	06/07/2016	R	<360	<3.73	<420	NA	NA	NA
ER-5-3-2	05/19/2016	R	<340	<3.71	J <400	<3.1	<7.4	<0.93
ER-5-5	05/16/2016	R	<350	<3.65	J <410	<2.8	<7	<0.76
		FD	<350	NA	J <410	<2.6	<7.2	<0.75
		D	<249	NA	<166	<3.54	<5.93	<0.836
ER-11-2	04/19/2016	R	NA	J 17.48	NA	NA	NA	NA
	06/29/2016	R	NA	<2.99	NA	NA	NA	NA
RNM-2S	05/10/2016	R	76,000	NA	J <400	<3.3	<6.9	<0.69
		FD	75,000	NA	<410	<3.2	<6.8	<0.69
UE-5n	05/05/2016	R	135,000	NA	J <420	<2.6	<7	<0.73

[a] R = Regular sample; D = Duplicate sample analyzed by a different laboratory; FD = Field duplicate sample.
[b] The COCs are regulated as beta emitters in the SDWA (CFR, 2016), and limited to an MCL for all beta and photon emitters combined of 4 mrem/yr, meaning the combined dose from all beta and photon radionuclides present must be equal to or less than 4 mrem/yr. The MCL presented here is the concentration of each single radionuclide, which equates to a 4 mrem/yr dose as if it were the only radionuclide present.

J = Estimated result.

NA = Not available

ER-5-3-2 has a record of radionuclide analyses starting in 2001. The majority of radionuclides are below the MDL historically and currently (Table 4-2). ^{36}Cl was reported in 2001 at a concentration of 0.00029 pCi/L; the 2016 result is below an MDL of 3.1 pCi/L. ^{129}I was reported in 2001 as an estimated value of 8.6 ± 1.8 pCi/L. This sample was a field duplicate, and the concentration reported for the regular sample is <1.3 pCi/L. The 2016 analysis is <0.93 pCi/L, consistent with the regular sample results in 2001.

ER-5-5 was sampled for radionuclides twice in 2013. Many of the radionuclides analyzed were below detection in those earlier samples and remain so in 2016 (Table 4-2). All ^{3}H measurements in previous samples and in the 2016 samples are below the MDL, or below the MDL plus error. This includes two ultra-low detection limit analyses performed by Lawrence Livermore National

Laboratory [LLNL], one in 2013 and one in 2016. (Note that because LLNL is not certified by the NDEP Bureau of Safe Drinking Water, these analyses are not part of the post-closure monitoring program.) All ^{14}C measurements have been below detection with the exception of a sample collected on May 11, 2013, with an activity of 0.1341 pCi/L. The 2013 sample exceeded the specified hold time before analysis, which may have biased the result higher than actual (N-I, 2014). All of the 2016 analyses are below the MDL of 166 to 410 pCi/L. The one prior ^{36}Cl analysis reports a concentration of 3.3697×10^{-4} pCi/L. The 2016 analyses are below the MDL of 2.6 to 3.54 pCi/L. The one previous ^{129}I analysis, for a sample collected on May 11, 2013, reports an activity of 2.47×10^{-6} pCi/L. All of the 2016 analyses were below the MDL of 0.75 to 0.836 pCi/L.

4.2.2 Central Testing Area

Both monitoring wells in the Central Testing Area contain ^{3}H at concentrations in excess of the SDWA standard (Table 4-2) (CFR, 2016). The ^{3}H in both wells is the result of the long-term radionuclide migration experiment, with RNM-2S pumping and drawing contaminated water from the CAMBRIC underground nuclear test, and UE-5n affected by the infiltration below the discharge ditch. The pumping and discharge occurred from October 1975 to August 1991, with two additional short periods in October 1999 and April to July 2003. The ^{3}H concentration in RNM-2S from the 2016 sampling is consistent with values measured in the well in the past decade, showing a slowly decreasing trend subsequent to the peak breakthrough in 1980 (Figure 4-2). The ^{3}H concentration in UE-5n continues a trend of decreasing concentration exhibited since 2009 (Figure 4-3).

The other radionuclides (^{14}C, ^{36}Cl, ^{129}I, and ^{99}Tc) measured in the RNM-2S and UE-5n samples were at concentrations below the analytical MDL (Table 4-2).

4.3 Water-Level Monitoring

The objective of long-term FFACO monitoring of water levels is to identify whether changes have occurred in the hydrologic system that could impact closure decisions and CB forecasts. Long-term FFACO water-level monitoring wells can be divided into two groups (Navarro, 2016). The contaminant-boundary scale wells are those influential for determining local gradient and local contaminant migration. The CAU flow-model scale wells are those influential for monitoring boundary conditions controlling contaminant migration beyond the local scale.

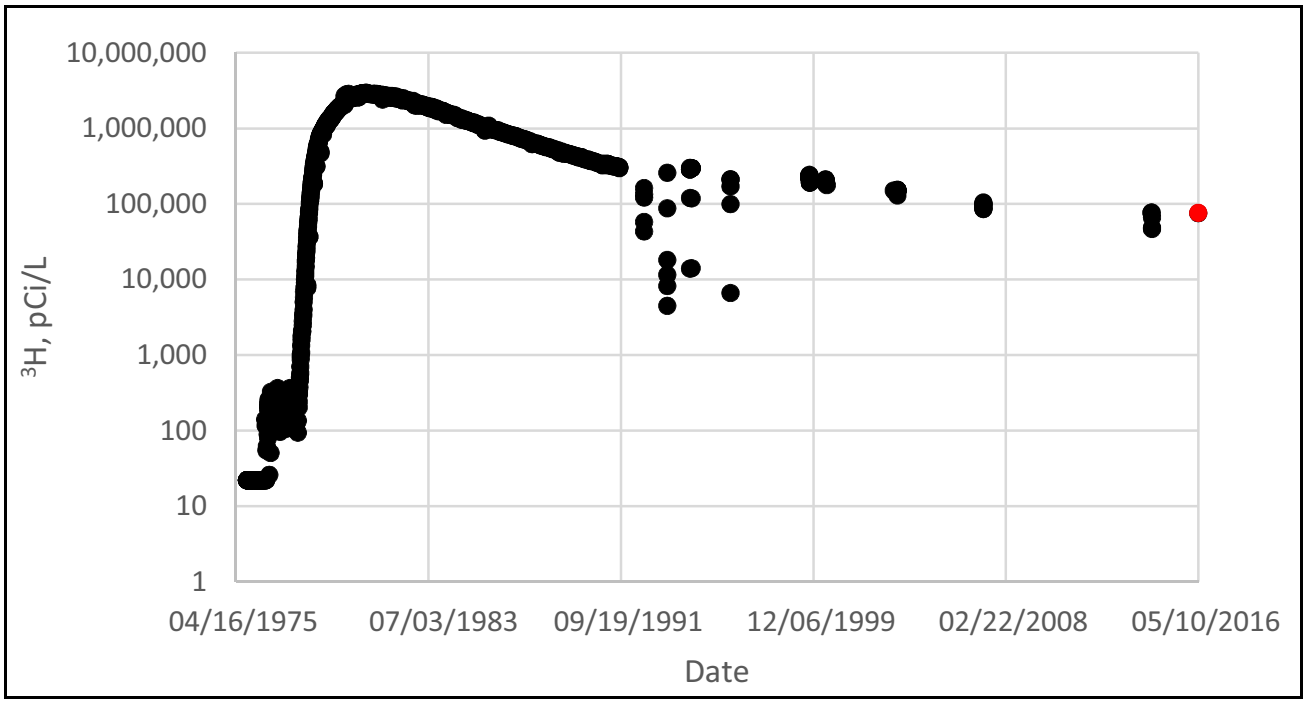

Figure 4-2
Trend in ^{3}H Concentration Measured in Samples from RNM-2S
Note: The 2016 monitoring sample is shown in red.

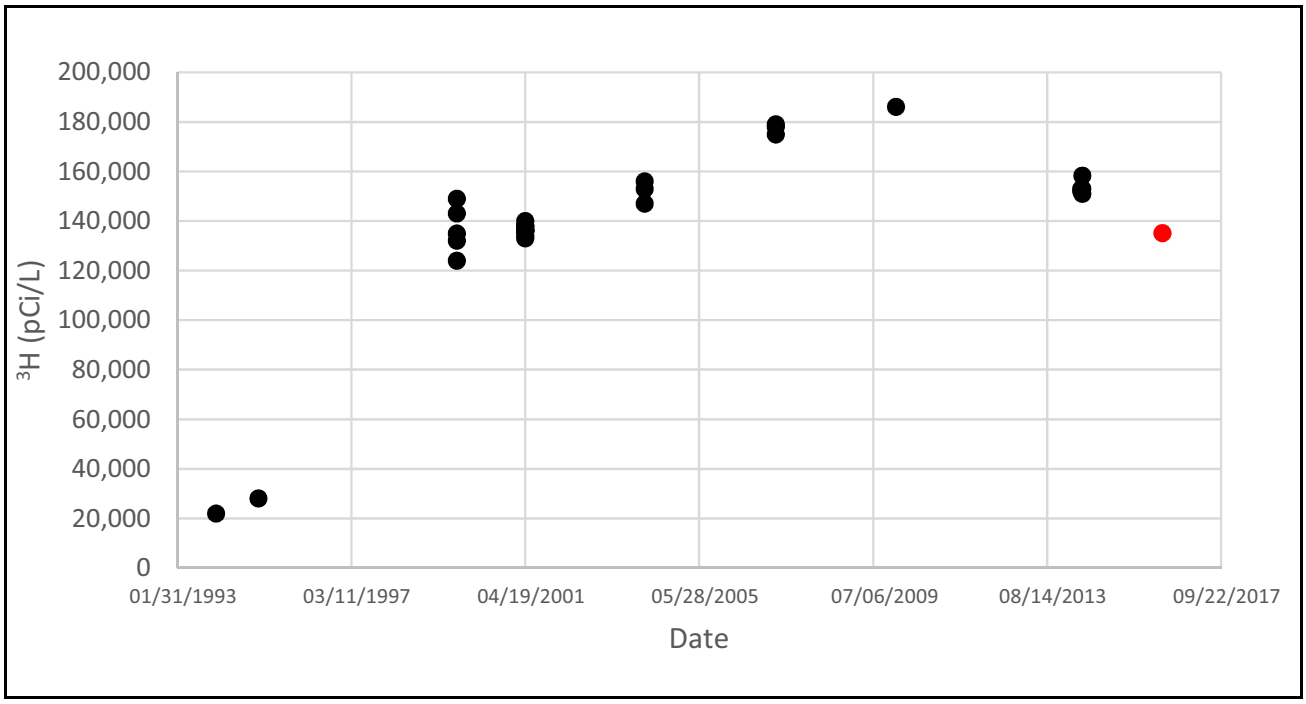

Figure 4-3
Trend in ^{3}H Concentration Measured in Samples from UE-5n
Note: The 2016 monitoring sample is shown in red.

Sixteen wells are specified for the post-closure water-level network (Table 4-3; Figure 4-4). An important global purpose for monitoring water levels in the Northern and Central Testing Area wells is to provide data on possible impacts from pumping in southern Frenchman Flat. Groundwater in southern Frenchman Flat has been pumped to supply water for NNSS operations for decades, and the associated water-level declines have the potential to affect groundwater flow throughout the basin (Elliott and Fenelon, 2010).

Table 4-3
Wells Used for Monitoring Water Levels Important to the CAU 98 Closure

Well Name	Latitude (NAD 27)	Longitude (NAD 27)	Aquifer	Category [a]
ER-5-3 deep piezometer	36.873091	-115.937985	Alluvial/Volcanic	Local
ER-5-3 main (upper zone)	36.873091	-115.937985	Alluvial	Local
ER-5-3-2	36.873115	-115.938328	Lower Carbonate	Boundary Conditions
ER-5-3-3	36.873339	-115.938130	Alluvial	Local
ER-5-4 main	36.824271	-115.963453	Alluvial/Volcanic	Local
ER-5-4 piezometer	36.824271	-115.963453	Alluvial	Local
ER-5-4-2	36.823996	-115.963457	Volcanic	Boundary Conditions
ER-5-5	36.870096	-115.930288	Alluvial	Local
RNM-1	36.824488	-115.966819	Alluvial	Local
RNM-2S	36.822561	-115.966916	Alluvial	Local
UE-5n	36.820720	-115.961447	Alluvial	Local
WW-5A	36.776477	-115.958100	Alluvial	Boundary Conditions
WW-5B	36.801257	-115.968977	Alluvial	Boundary Conditions
WW-4	36.904952	-116.024001	Volcanic	Boundary Conditions
WW-4A	36.903195	-116.027433	Volcanic	Boundary Conditions
ER-11-2	36.887315	-115.938664	Volcanic	Local and Boundary Conditions

[a] Local = wells influential for determining local gradient and plume migration; Boundary Condition = wells influential for boundary conditions controlling contaminant migration.

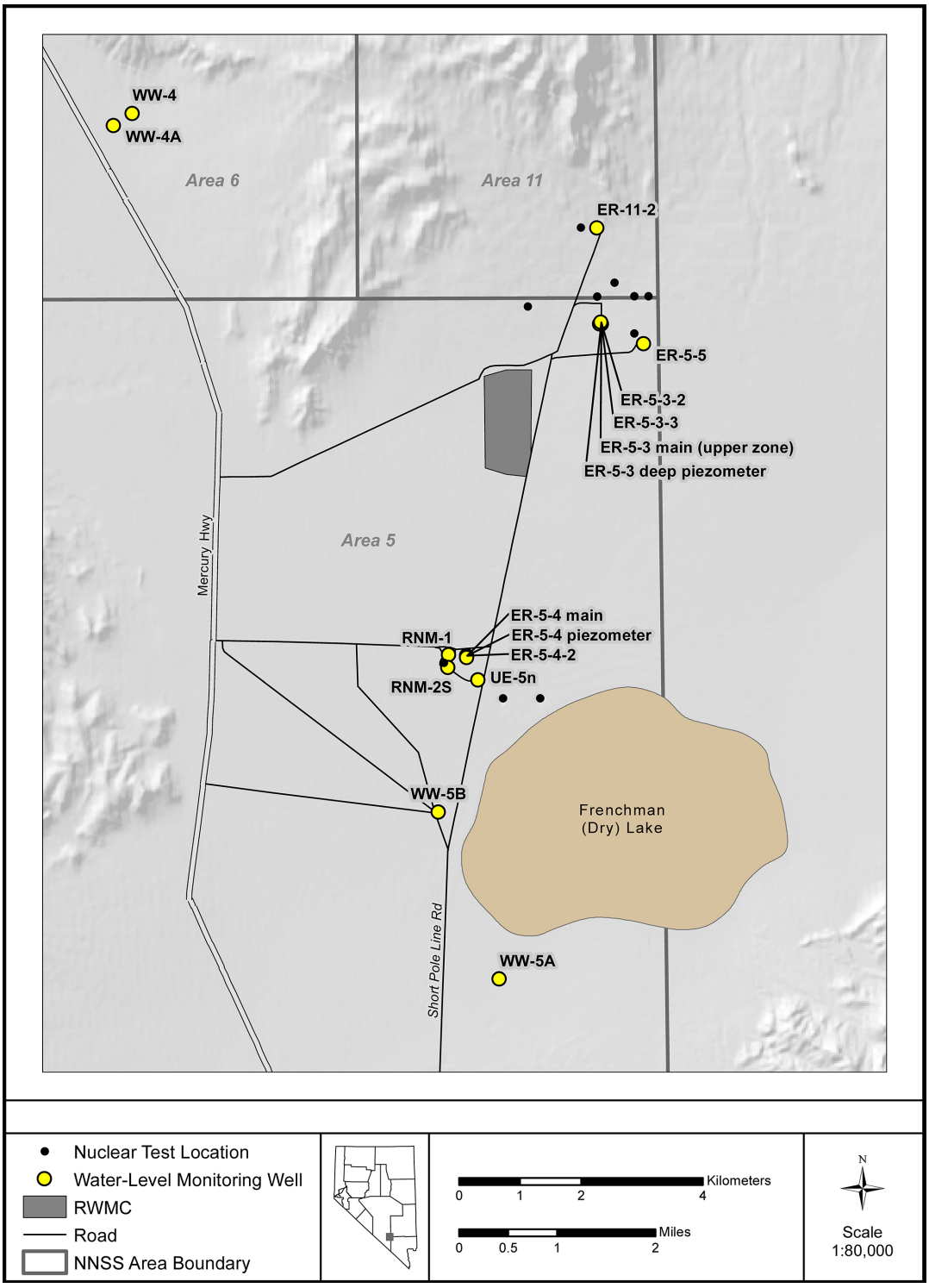

Figure 4-4
Location of Water-Level Monitoring Wells in Frenchman Flat, Measured for the Closure Monitoring Program

The specific purpose for monitoring the water level in each well is provided below:

- **ER-5-3 deep piezometer:** Monitors the deep alluvial/volcanic system in the Northern Testing Area. Provides local gradient data.
- **ER-5-3 main (upper zone):** Monitors the alluvial system in the Northern Testing Area. Provides local gradient data.
- **ER-5-3-2:** Monitors the regional carbonate in the Northern Testing Area. Provides regional hydraulic gradient data. Monitors impacts from pumping the carbonate aquifer.
- **ER-5-3-3:** Monitors the alluvial system in the Northern Testing Area. Provides local gradient data.
- **ER-5-4 Main:** Monitors the alluvial/volcanic system in the Central Testing Area. Provides local gradient data near CAMBRIC.
- **ER-5-4 piezometer:** Monitors the alluvial system in the Central Testing Area. Provides local gradient data near CAMBRIC.
- **ER-5-4-2:** Monitors the deep volcanic confining unit in the Central Testing Area. Provides data confirming an upward vertical gradient and no vertical pathway for contaminants to enter the carbonate aquifer.
- **ER-5-5:** Monitors the alluvial system in the Northern Testing Area. Provides local gradient data near MILKSHAKE.
- **RNM-1:** Monitors the alluvial system in the Central Testing Area. Provides local gradient data near CAMBRIC.
- **RNM-2S:** Monitors the alluvial system in the Central Testing Area. Provides local gradient data near CAMBRIC.
- **UE-5n:** Monitors alluvial system in Central Testing Area. Provides local gradient data near the Cambric Ditch.
- **WW-5A:** Monitors impacts from pumping of the alluvial aquifer in southern Frenchman Flat.
- **WW-5B:** Monitors impacts from pumping of the alluvial aquifer in southern Frenchman Flat.
- **WW-4:** Monitors impacts from pumping the volcanic aquifer in the CP sub-basin portion of northwestern Frenchman Flat.

- **WW-4A:** Monitors impacts from pumping the volcanic aquifer in the CP sub-basin portion of northwestern Frenchman Flat.
- **ER-11-2:** Monitors the volcanic confining unit in the Northern Testing Area. Provides local gradient data near PIN STRIPE and boundary conditions on the northern edge of Frenchman Flat.

Water-level measurements in 2016 were conducted by the U.S. Geological Survey (USGS) according to their procedure USGS-WL-COLLECT-01, "Procedure for Manually Measuring Depth-to-Water with Steel Tapes, Electric Tapes, and Wirelines for the U.S. Department of Energy, National Nuclear Security Administration" (USGS, 2014). Water levels are measured quarterly and within a narrow time frame to allow for synoptic analysis. The time frame is coordinated with measurements performed by the NNSS management and operating (M&O) contractor at the Area 5 RWMC pilot water-table wells (UE-5 PW-1, PW-2, and PW-3) to facilitate data comparison. In 2016, the Frenchman Flat water levels were measured on March 7, June 6, August 15, and October 24 (Table 4-4).

4.4 Water-Level Results

In order to identify changes in the hydrologic system, the water-level measurements are evaluated relative to previous measurements. Water-level data are maintained by USGS in the National Water Information System (NWIS), accessible at https://waterdata.usgs.gov/nv/nwis/nwis (USGS, 2017). Analysis of water levels and trends for Frenchman Flat wells has been performed by Bright et al. (2001) for the period 1954 to 1998; by Stoller-Navarro Joint Venture (SNJV) (2004) for measurements before 2004; by SNJV (2006) with particular attention to revised land elevation measurements; by Fenelon et al. (2010) for data through 2009; and by Navarro-Intera, LLC (N-I) (2014) for data through 2013 with an emphasis on uncertainty analysis. The analysis here evaluates the monitoring results relative to water levels collected from 2004 forward because the majority of wells have complete records through the period, and measurements in this time frame are coincident (synoptic) with those at the Area 5 RWMC wells (UE-5 PW-1, PW-2, and PW-3). The trend analysis thus focuses on data collected subsequent to the Frenchman Flat hydrologic data documentation package (SNJV, 2004). The water levels in the data documentation package were used to determine static hydraulic head targets for flow model calibration. The 2004–2016 data allow identification of changes in the hydrologic system subsequent to model development.

Table 4-4
Water-Level Data for 2016 [a]

Name	03/07/2016		06/06/2016		08/15/2016		10/24/2016	
	Depth (ft)	Elevation (m)	Depth (ft)	Elevation (m)	Depth (ft)	Elevation (m)	Depth (ft)	Elevation (m)
WW-5A	704.09	728.02	704.17	728.00	704.25	727.97	704.26	727.97
WW-5B	688.48	732.63	688.78	732.54	689.02	732.47	688.12	732.74
UE-5n	706.32	733.57	706.33	733.57	706.46	733.53	706.62	733.48
RNM-2S	723.77	733.49	723.86	733.46	723.99	733.42	724.11	733.38
ER-5-4-2	649.7	756.53	649.78	756.51	649.93	756.46	649.97	756.45
ER-5-4 main	725.66	733.36	725.79	733.32	725.92	733.28	725.97	733.27
ER-5-4 piezometer	725.35	733.46	725.24	733.49	725.31	733.47	725.38	733.45
RNM-1	729.82	733.15	729.91	733.12	730.04	733.08	730.16	733.05
UE-5 PW-1	771.79	733.53	771.88	733.50	772.01	733.46	772.12	733.43
UE-5 PW-2	838.92	733.71	839.2	733.63	839.34	733.58	839.48	733.54
UE-5 PW-3	888.35	733.74	888.42	733.72	888.48	733.70	888.65	733.65
ER-5-5	930.01	733.73	930.15	733.69	930.32	733.64	930.42	733.61
ER-5-3 main (upper zone)	927.33	733.89	927.58	733.81	927.72	733.77	927.75	733.76
ER-5-3 deep piezometer	928.36	733.57	928.45	733.55	928.58	733.51	928.62	733.50
ER-5-3-2	NA	NA	944.75 [b]	728.60	NA	NA	NA	NA
ER-5-3-3	927.25	733.92	927.51	733.85	927.64	733.81	927.7	733.79
ER-11-2	1,153.72	737.46	1153.83	737.43	1153.94	737.40	1,153.99	737.38
WW-4	839.24	841.94	838.74	842.09	839.12	841.97	839.22	841.94
WW-4A	839.37	843.17	839.47	843.14	839.12	843.24	839.53	843.12

[a] Groundwater depth is reported in feet below ground surface, consistent with the measurement units. Elevation is in meters, relative to National Geodetic Vertical Datum (NGVD) of 1929, consistent with the CAU model units.
[b] Measurement on 05/16/2016 when transducer removed from well, providing access.

The 2016 monitoring data are similar to prior measurements (Figure 4-5). Detailed hydrographs are located in Appendix B. The Mann-Kendall trend test (Mann, 1945; Kendall and Gibbons, 1990) is used to detect water-level trends. The null hypothesis (default position) assumes no trend or serial correlation (repeating patterns) among time series values, whereas the alternative hypothesis assumes there is a monotonic trend (entirely increasing or decreasing). Water-level measurements at the 16 wells in the post-closure water-level network (Table 4-3) are evaluated, along with three nearby wells (UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3). The three additional wells are completed at the water table in the alluvial (UE-5 PW-1 and PW-2) and volcanic units (UE-5 PW-3). The results are presented in Table 4-5.

There is a declining trend in water levels in 12 of the 19 wells analyzed, and a rising trend in seven (Figure 4-6). Every monitoring well completed in alluvium exhibits a declining water-level trend, with the exception of WW-5A. This long-term decline in alluvial water levels is attributed by Elliott and Fenelon (2010) as the result of pumping in the Frenchman Flat basin. Five wells located in the central and southern part of the basin (RNM-2S, UE-5c WW, WW-5A, WW-5B, and WW-5C) have historically had large water withdrawals, although only WW-5B and WW-5C have significant pumping from year 2000 onward. Long-term drainage of the shallow aquifer as it equilibrates with reduced recharge in a post-pluvial environment may contribute to the observed decline. Two wells completed in volcanic units immediately below alluvium (ER-5-4 main and UE-5 PW-3) also exhibit declining trends.

With the exception of ER-5-3-2 (completed in the carbonate aquifer), all of the rising trends are associated with wells interpreted as recovering from decreases in pumping or nearby pumping, whether for water-supply or part of well development and testing (Elliot and Fenelon, 2010). For example, water-level increases at WW-5A were found to be significantly correlated with decreases in pumping at nearby well WW-5C (Bright et al., 2001). Both ER-5-4-2 and ER-5-3 deep piezometer are slowly recovering from development and testing (Elliott and Fenelon, 2010).

Carbonate well ER-5-3-2 has exhibited a rising water-level trend from 2004 until 2011, but this reversed in the 2014-2016 time frame. The water levels in the carbonate aquifer may have been responding to wetter-than-normal climate conditions during the pre-2011 period, or the well may have been exhibiting long-term recovery from drilling and development (Elliott and Fenelon, 2010).

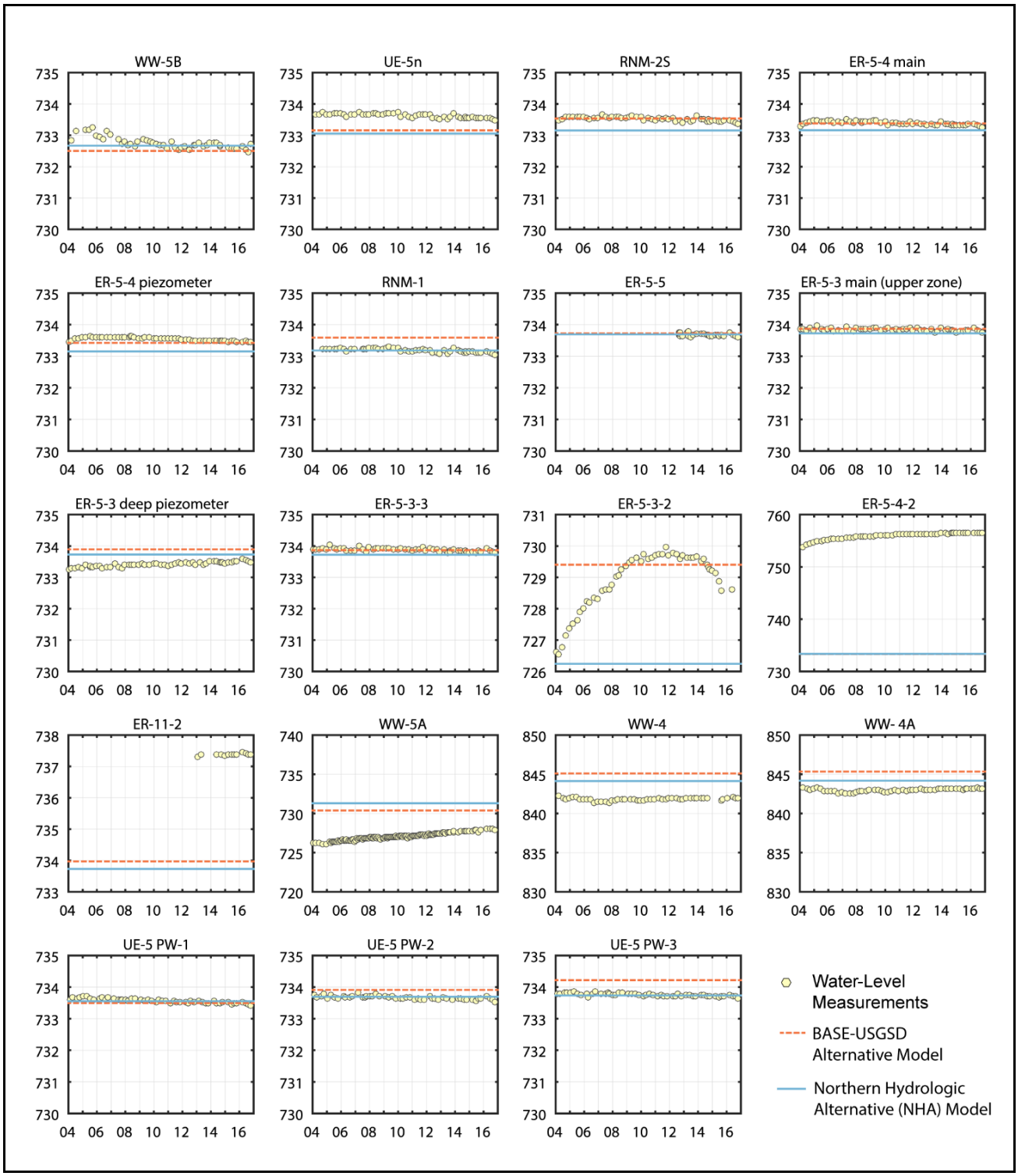

Figure 4-5
Groundwater Levels at the Monitoring Wells from 01/01/2004 to 10/24/2016

Note: UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 are not in the closure-monitoring network, but are located in the area. The steady-state heads simulated by the BASE-USGSD alternative model and the NHA model (see Section 6.2.1) for the well locations are also shown.

Table 4-5
Mann-Kendall Trend Analysis for Water-Level Data from 2004 to 2016

Well Name	Aquifer	Water-Level Trends 2004–2016			Trend Explanation
		N	Trend	p	Elliott and Fenelon, 2010
WW-5A	Alluvial	140	↑	0	Recovery from basin-scale pumping
WW-5B	Alluvial	49	↓	0	Drawdown from basin-scale pumping
UE-5n	Alluvial	54	↓	0	Drawdown from basin-scale pumping or recovery from termination of infiltration during the radionuclide migration experiment
RNM-2S	Alluvial	54	↓	0	Drawdown from basin-scale pumping
ER-5-4-2	Volcanic	54	↑	0	Equilibration from development & testing
ER-5-4 main	Alluvial/ Volcanic	56	↓	0	Drawdown from basin-scale pumping
ER-5-4 piezometer	Alluvial	56	↓	0	Drawdown from basin-scale pumping
RNM-1	Alluvial	53	↓	0	Drawdown from basin-scale pumping
UE-5 PW-1	Alluvial	52	↓	0	Drawdown from basin-scale pumping
UE-5 PW-2	Alluvial	51	↓	0	Drawdown from basin-scale pumping
UE-5 PW-3	Volcanic	52	↓	0	Drawdown from basin-scale pumping
ER-5-5	Alluvial	32	↓	0.019	Indeterminate due to short period of record
ER-5-3 main (upper zone)	Alluvial	55	↓	0.001	Drawdown from basin-scale pumping
ER-5-3 deep piezometer	Alluvial/ Volcanic	56	↑	0	Equilibration from development & testing
ER-5-3-3	Alluvial	56	↓	0	Drawdown from basin-scale pumping
ER-5-3-2	Carbonate	51	↑	0	Climate effect
ER-11-2	Volcanic	13	↑	0.042	Equilibration from development & testing (note short period of record)
WW-4	Volcanic	49	↑	0.006	Drawdown then recovery from pumping
WW- 4A	Volcanic	53	↑	0	Drawdown then recovery from pumping

Notes:
Statistically significant at 5% level of significance, ↑ means rising trend, ↓ means declining trend.
N: the number of measurements; p: probability that null hypothesis is rejected when it is false.

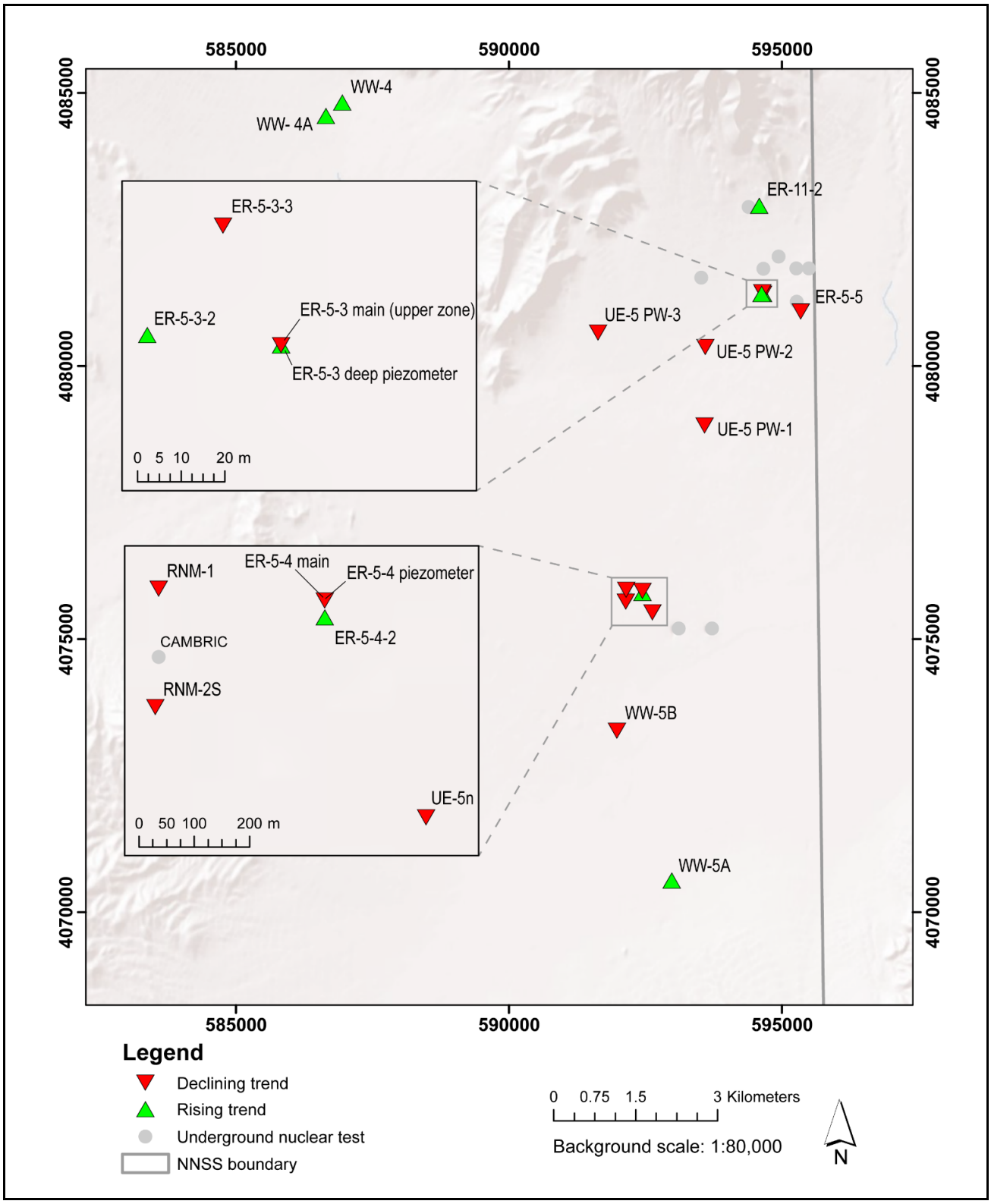

Figure 4-6
Water-Level Trends in Frenchman Flat Observation Wells
Note: Data used to calculate the water-level trends are from 01/01/2004 to 10/24/2016.

Bright et al. (2001) correlated long-term (5 years or more), cyclic-type water-level fluctuations in other LCA-completed wells in the Frenchman Flat area to precipitation variations.

The Mann-Kendall test identifies an upward trend in WW-4 and adjacent WW-4A. Visual inspection identifies declines in both of these wells until 2006. The subsequent rise in water levels coincides with reduced production from these supply wells.

The CR (NNSA/NFO, 2016b) expressly calls for considering water-level changes as a result of climate change and earthquake faulting (seismicity). As noted above, data from ER-5-3-2 record increasing and decreasing water levels tentatively attributed to short-term cyclic climate variations. Additionally, the long-term declines in water levels in the alluvium, while interpreted as primarily due to pumping in the basin, may also reflect basin-wide drainage as a result of reduction in recharge since the last pluvial period. High-frequency water-level measurements are necessary to observe dynamic earthquake-induced fluctuations. Continuous measurements in several Frenchman Flat wells at the time of recorded earthquakes did not show any response to the events (Bright et al., 2001). Previous measurements in Frenchman Flat wells do not indicate any shifts to new elevated or depressed equilibrium as a result of seismic activity (Bright et al., 2001), but the periodic monitoring conducted for the closure monitoring network should identify such long-term effects if they occur.

4.5 Institutional Control Monitoring

Institutional controls are an important and inherent part of the corrective action chosen for CAU 98. The objective of institutional controls is to limit access to potentially contaminated groundwater, and thereby prevent exposure of the public, workers, and the environment to COCs from the Frenchman Flat underground nuclear tests.

The Frenchman Flat hydrographic basin covers most of the southeastern portion of the NNSS and a portion of the adjacent Nevada Test and Training Range (NTTR) (Figure 4-7). The NNSS and the NTTR are located on land that has been withdrawn from public use for the purpose of military activities. The first withdrawal occurred in October 1940 as part of a rapid expansion of U.S. military operations associated with World War II. The expansion included the acquisition of large amounts of real estate for ground and air reservations (Fine and Remington, 1989). More than 3.5 million acres of

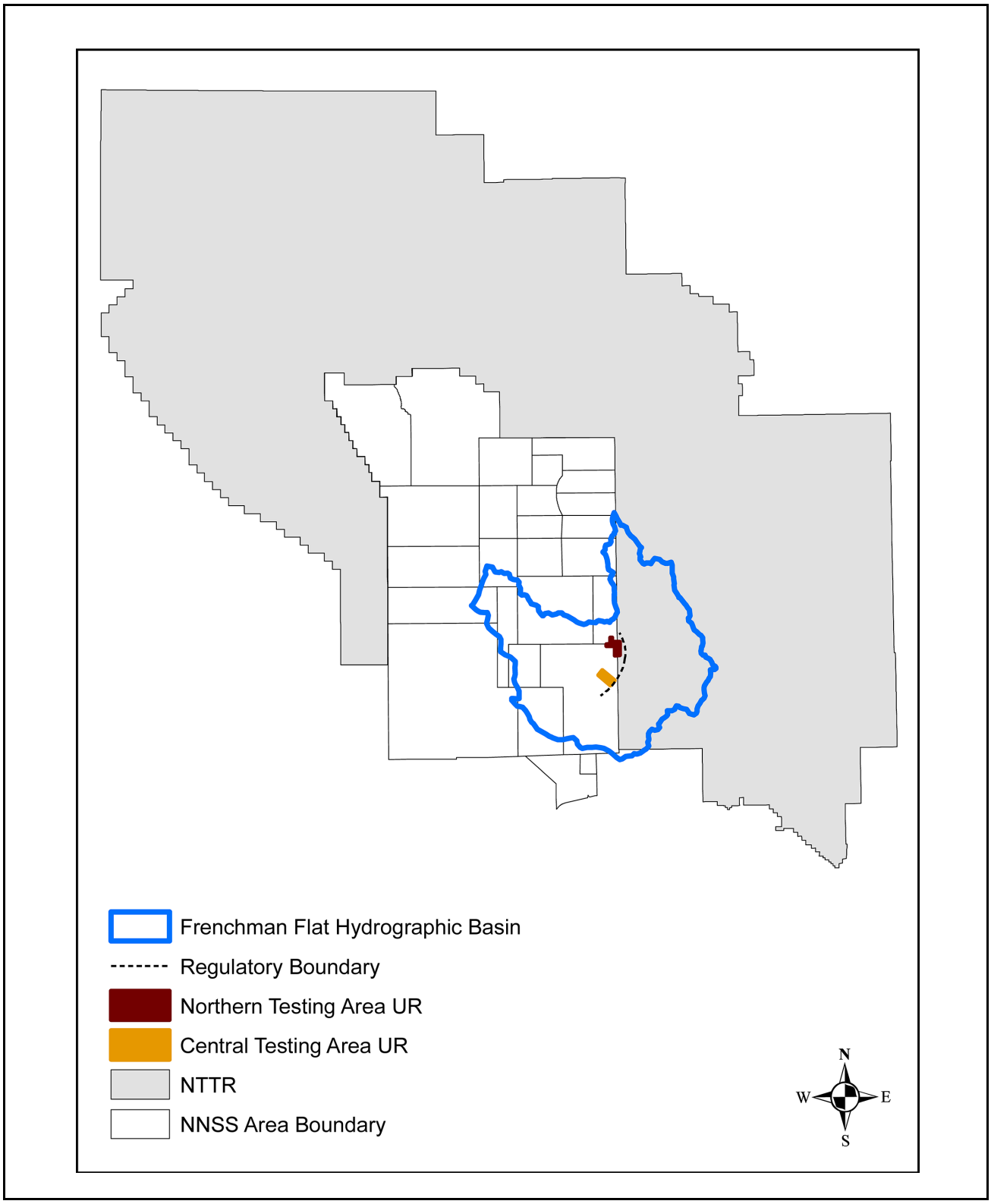

Figure 4-7
UR Areas for CAU 98, within the Context of the NNSS, NTTR, and the Frenchman Flat Hydrographic Basin Boundary

federal land southeast of Tonopah, Nevada, were withdrawn through Executive Order No. 8578 to create an aerial bombing and gunnery range (DOE/NV, 1996).

The NNSS, formerly the Nevada Test Site, was formed through four Public Land Orders (PLO 805, 1662, 2568, and 3759) issued by the Bureau of Land Management (BLM, 1952, 1958, 1961, and 1965). After several revocations and expansions, the NNSS now covers an area of 870,400 acres; and the NTTR, operated by the U.S. Air Force (USAF), encompasses nearly 2.9 million acres.

The most recent withdrawal related to the NTTR occurred in October 1999 under Title XXX of Public Law 106-65, the "National Defense Authorization Act for Fiscal Year 2000" (Statutes at Large, 2000). This authorization expires November 6, 2021. USAF has filed an application requesting an extension of the existing land withdrawal, plus the withdrawal of additional acreage (BLM, 2016).

The institutional controls established through the CR (NNSA/NFO, 2016a and b) are restrictions that apply within the UR boundaries and upgradient of the regulatory boundary negotiated between NNSA/NFO and NDEP. Two UR areas were identified, one for the Northern Testing Area and one for the Central Testing Area. The perimeter of each UR area encompasses all of the CBs within that area (Figure 4-7). Because the UR areas are within the NNSS and the NTTR boundaries, and because the restrictions apply to groundwater that is over 500 ft below land surface, the URs do not require onsite postings or physical barriers.

The following restrictions apply to activities within the UR areas:

1. **Land-use and real property controls, notifications, and restrictions:** All subsurface activities—including drilling, pumping, and testing of wells—must be communicated to the EM Nevada Program UGTA Federal Activity Lead before field activities begin. These controls are administered through NFO orders establishing requirements for use of and operations on the NNSS. The current order, NFO Order 410.X1, describes the screening and siting process and Real Estate/Operations Permit (REOP) processes (NNSA/NFO, 2013).

2. **Groundwater control:** Groundwater used for human consumption, irrigating crops, and any industrial use (such as dust control) must be preceded by laboratory analysis for COCs, and must meet SDWA standards (CFR, 2016). In addition, effects of pumping on contaminant migration will be evaluated to verify UR boundaries are protective.

The Frenchman Flat Central UR boundary is located completely within Area 5 of the NNSS. The Frenchman Flat Northern UR boundary covers portions of Areas 5 and 11, as well as continuing eastward by about 430 m onto NTTR land.

The institutional controls are monitored by confirming the registration and visibility of the URs in land management systems operated by NNSA/NFO, the EM Nevada Program, and USAF. The additional groundwater control of evaluating the effects of pumping on contaminant migration is monitored by considering changes and potential changes in groundwater use in the broader area around the URs.

4.6 Institutional Control Monitoring Results

The institutional controls in place to limit access to areas of potentially contaminated groundwater at CAU 98 include government ownership, access control, federal oversight, and a State of Nevada water-use application process. These controls are monitored annually to verify performance.

The NNSS and NTTR remain federally controlled, secure sites. Both sites retain access control through active and passive means, prohibiting entry except for approved personnel for approved purposes. NNSA/NFO and the EM Nevada Program continue to manage federal oversight of activities on the NNSS. USAF continues oversight of activities on the NTTR. The Nevada Department of Water Resources (NDWR) continues to maintain responsibility for managing water use in the state.

4.6.1 UR Verification

The URs must be verified annually. The initial registration of the URs in the M&O Geographic Information Systems (GIS) was confirmed by letter from Morris to Dinsman dated September 22, 2016 (Morris, 2016a), and amended October 18, 2016 (Morris, 2016b). The continued registration and visibility of the URs in the land management system operated by NNSA/NFO was confirmed through a January 9, 2017, UR Report (see Appendix C). The initial USAF registry of the URs was

asserted by letter from Kan to Dinsman dated January 25, 2017 (Kan, 2017b). In addition, the following three items require annual documentation:

1. Have there been encroachments due to drilling or new uses for the groundwater within and adjacent to the UR boundary that could conceivably impact the CB or be a potential threat to human health or the environment within one year of the inspection?

   Verification: NDWR did not grant any new applications for water use in the Frenchman Flat basin (Basin 160) during 2016. NNSA/NFO and the EM Nevada Program have not applied for any new drilling permits within Area 5 during 2016, nor report any facilities or activities on the planning horizon that would increase groundwater use in the area (Allen, 2017). USAF has drilled no wells nor has plans to drill wells in the Frenchman Flat basin, and has no facilities or activities on the planning horizon that would increase groundwater use in the area (Kan, 2017a).

2. Are there any changes to or new REOPs that affect the UR?

   Verification: No new REOPs were established within Area 5 of Frenchman Flat during 2016. There are a total of 51 primary REOPs in Areas 5 and 5A, and 54 secondary REOPs (see Appendix C). These were inspected in the Facility Data Warehouse on February 16, 2017. Administrative changes are common to the REOPs as they are reviewed and updated for personnel changes and similar matters. No technical changes were recorded for the primary REOPs that have the potential for affecting the UR or substantively increasing groundwater usage.

3. Do monitoring data suggest that the URs should be modified?

   Verification: Monitoring data do not suggest any need to modify the URs. As discussed elsewhere in this monitoring report, the water-quality samples and water-level measurements are consistent with the CAU 98 CBs that provide the basis for the URs.

5.0 Site Inspection and Verification of Well Functionality and Effectiveness

The 16 wells in the water-level monitoring network are inspected quarterly, coincident with the water-level measurement process. This inspection verifies that the well is locked and properly marked; the survey point is marked and undamaged; the well pad is clear and in good condition; and the area around the well pad is not damaged or eroded. Any damage to the well or pad is noted. In 2016, these quarterly inspections were performed by USGS and recorded on their field form USGS-WL-COLLECT-frm-01, Rev. No. 5. A summary of those inspections is included in Appendix D. No adverse conditions were noted for the 16 well locations in 2016, although several opportunities for improvement were identified (see Appendix D).

The same inspection items discussed above are checked before groundwater sampling for the six wells used for water-quality monitoring. Additionally, the conditions of the wells, sumps, discharge areas, and areas surrounding the wells are inspected for damage before groundwater sampling; and are assessed to determine whether the infiltration area remains viable, whether any new roads of facilities have been constructed, and whether there have been changes to the drainage pattern or area. Navarro conducted the presampling inspections in 2016 and found no adverse conditions.

6.0 Data Evaluation

6.1 Corrective Action Thresholds/Triggers

Monitoring data are often evaluated by comparing results to threshold or trigger values. For example, a contaminant concentration may be compared to a permissible concentration allowed by a regulation. For the first five years of monitoring at CAU 98, no thresholds or triggers will be established (NNSA/NFO, 2016). Instead, the EM Nevada Program and NDEP will establish corrective action thresholds or triggers based on the results from the first five years of monitoring, and will use them from that point to determine whether the corrective action decision for CAU 98 continues to protect the health and safety of the public.

6.2 Data Consistency with Model Assumptions and Model Forecasts, Contaminant Boundaries, and Regulatory Boundary

As summarized in the CADD/CAP (NNSA/NFO, 2011) the modeling activities that supported the calculation of CBs for CAU 98 are many and varied. They include a hydrostratigraphic model, flow model, source term model, transport model, and multiple alternatives for each of these. The long-term monitoring data can be used to perform an ongoing evaluation of the validity of some model aspects and, in the case of measured radionuclide concentrations, an evaluation of the overall forecasts. Specifically, the water-level measurements speak to conceptualization and implementation of the flow models, whereas the radiochemical data allow comparison to the contaminant transport forecasts that form the CBs.

6.2.1 Determination of Water-Level Consistency

The 2016 water-level measurements are generally consistent with static head predictions by the two numerical models used during model evaluation: the BASE-USGSD alternative model and the NHA model [SNJV, 2006; NNES, 2010] (Figure 4-5). Disagreement between predicted heads and observed heads at WW-4, WW-4A, and WW-5A is interpreted as due to current or past pumping at or near these wells lowering heads relative to those simulated in the steady-state models of predevelopment conditions [N-I, 2014]. Results from model evaluation well ER-11-2 changed the conceptualization of the local hydrostratigraphy from aquifer to bedded-tuff aquitard, and this accounts for the

difference observed there (N-I, 2014). Measured water levels are higher than the model simulated values for ER-5-4-2, and for one of the model alternatives at ER-5-3-2. ER-5-4-2 is considered to intercept a confined aquifer representing hydraulic head conveyed from higher elevations bordering Frenchman Flat; this pressurized zone was not included within the numerical flow model (NNES, 2010). ER-5-3-2, monitoring the LCA, may not have reached an equilibrium water level, posing a challenge for steady-state model calibration. During transport model development, the head simulated by the NHA model more closely matched observations at that time for ER-5-3-2 (NNES, 2010). The current monitoring results for ER-5-3-2 are better represented now by the BASE-USGSD alternative model. Both ER-5-3-2 and ER-5-4-2 have deep completion intervals relative to the underground nuclear tests in Frenchman Flat and the relatively larger difference between model and observed heads at those greater depths is not critical for the CB calculations.

Dominant features of all conceptual flow models for Frenchman Flat include the high hydraulic heads in the CP sub-basin in the northwest, higher hydraulic head in the alluvial and volcanic aquifers relative to the underlying regional LCA, and horizontal groundwater flow from northwest to south–southeast across the basin in the alluvial and volcanic aquifers. The monitoring data demonstrate higher hydraulic heads at WW-4 and WW-4A in CP sub-basin, and a downward gradient between hydrologic horizons measured at the ER-5-3 well group, including lower head at the one LCA monitoring well, ER-5-3-2. The upward gradient observed at the ER-5-4 well group from the volcanic confining unit to the overlying alluvium is coincident with a pressure barrier simulated in volcanic units of the Central Testing Area in the flow model (SNJV, 2006).

Water-level measurements from 2014 through 2016 were used to determine the groundwater flow directions and gradients in the alluvial aquifer across three regions of Frenchman Flat: the entire testing area of Frenchman Flat, the Northern Testing Area, and the Central Testing Area (Table 6-1). Multiple linear regression (Devlin, 2003) was adopted to calculate horizontal groundwater flow directions and gradients because it is suitable for use in situations where flow is relatively uniform and the water levels are near planar, as in Frenchman Flat. Only measurements collected on a single day were considered synoptic for this analysis. It should be noted that many wells show impacts from pumping either locally or regionally (Elliott and Fenelon, 2010). As a result, calculated gradients and directions of groundwater flow are expected to change over time as water levels reach equilibrium.

Table 6-1
Wells Used To Determine Directions and Magnitudes of Groundwater Flow Gradients in the Alluvial Aquifer for 3 Regions of Frenchman Flat

Entire Basin	Northern Testing Area	Central Testing Area
ER-5-3-3	ER-5-3 main (upper zone)	ER-5-4 Piezometer
ER-5-5	ER-5-3-3	UE-5n
RNM-1	ER-5-5	RNM-1
RNM-2S	UE-5 PW-1	RNM-2S
UE-5n	UE-5 PW-2	
WW-5B	UE-5 PW-3	
UE-5 PW-3		

McKenna and Wahi (2006) found that uncertainty in gradient calculations can be reduced by limiting the analysis to include only well combinations that form triangles with ratios of base length to height within the range of 0.5 to 5.0. Applying these geometric constraints to the wells in the entire Frenchman Flat testing area provides seven unique combinations of seven wells for the gradient analysis (Tables 6-1 and B.1-1). The calculated mean gradient is directed toward the south (azimuth of 181 degrees) with associated magnitudes in the range of 3.1×10^{-5} to 1.5×10^{-4} (Figure 6-1a; Table 6-2). Gradients calculated using water levels simulated by the BASE-USGSD alternative and NHA models for the same well locations are directed more to the southeast (mean azimuths of 134 and 167 degrees, respectively) and have higher magnitudes. Model-simulated gradients are higher than observed gradients in part because southernmost well WW-5A, where observed water levels are lowest, is not included in the analysis. The location of WW-5A far to the south prevents its inclusion in any well combinations that meet the base length-to-height ratio constraints. The mean gradient for the entire basin has an azimuth of 131 degrees and a magnitude of 7.3×10^{-4} when these geometric constraints are removed and WW-5A is included in the analysis. Basin-wide gradients calculated using observed WW-5A water levels will likely decrease as water levels in this well continue to recover from pumping that ended there in 1970.

In the Northern Testing Area, synoptic measurements were analyzed for 11 unique well combinations of six wells in the alluvial aquifer (Tables 6-1 and B.1-2). The measurements indicate groundwater flow to the south at a mean azimuth of 184 degrees, while the BASE-USGSD alternative and NHA models simulate flow directed to the southeast (Figure 6-1b; Table 6-2). The magnitudes of the

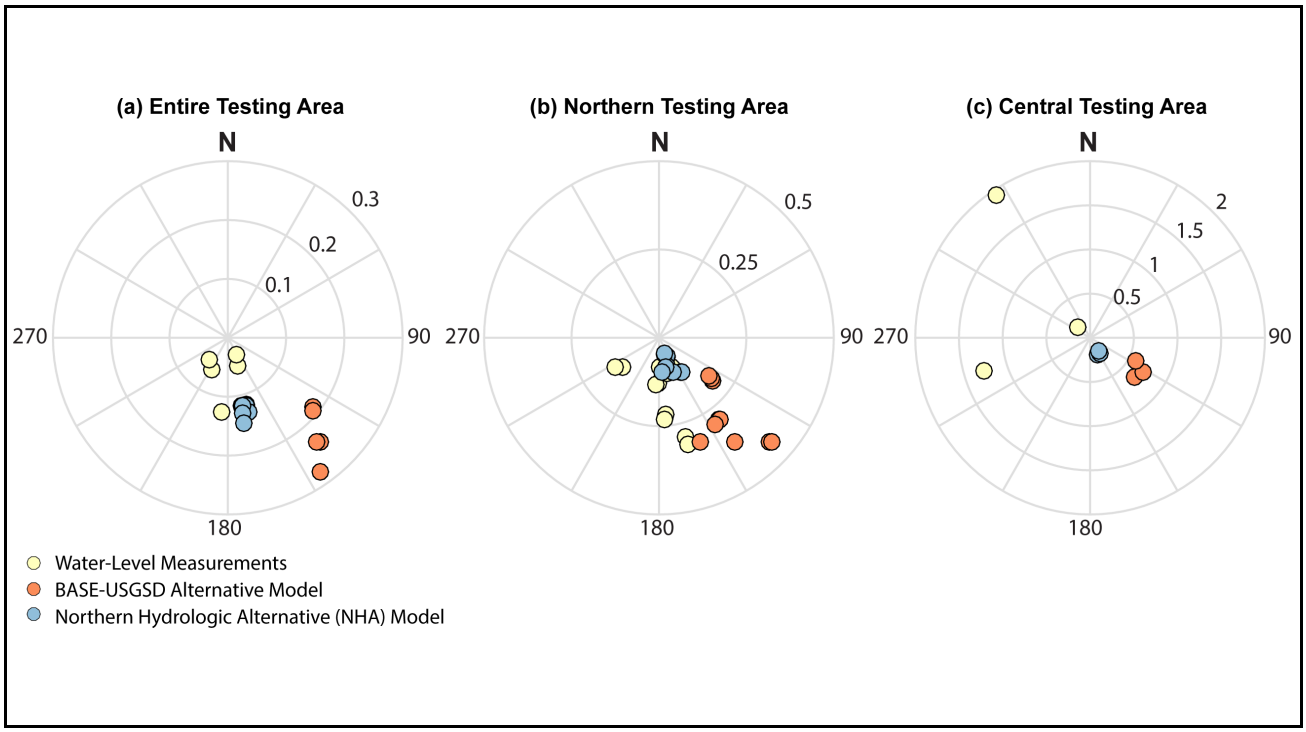

Figure 6-1
Groundwater Flow Directions and Gradients (x10^{-3}) Calculated from the Monitoring Measurements and from Heads Simulated by the BASE-USGSD Alternative and NHA Models

Note: Figure shows (a) entire testing area of Frenchman Flat, (b) Northern Testing Area, and (c) Central Testing Area. Note that different scales are used to display the magnitude for each area.

observed gradients range from 8.4×10^{-5} to 3.2×10^{-4}, and are higher than magnitudes simulated by the NHA model and lower than magnitudes simulated by the BASE-USGSD alternative model. Overall, gradients calculated in the Northern Testing Area are slightly higher than those in the entire basin, and there is a greater degree of overlap in their magnitudes.

The CAU flow and transport models for the Central Testing Area (NNES, 2010) depict low gradients to the south–southeast (Figure 6-1c and Table 6-2), with a larger CB imprint caused by infiltration along a drainage ditch of discharge from the CAMBRIC radionuclide migration experiment. The hydrologic source term (HST) model (Carle et al., 2007), centered closely on the CAMBRIC radionuclide migration experiment, identified ambient groundwater flow to the north. Multiple linear regression was applied to three unique well combinations (Tables 6-1 and B.1-3). The flow directions calculated from the measurements are significantly different depending on the well group, with the two groups that include both ER-5-4 piezometer and RNM-2S providing a gradient to the northwest,

Table 6-2
Summary of Directions and Magnitudes of Groundwater Flow Gradients Calculated Using Measured Water Levels and Model-Simulated Heads

	Entire Testing Area			Northern Testing Area			Central Testing Area		
	Meas.	BASE-USGSD	NHA	Meas.	BASE-USGSD	NHA	Meas.	BASE-USGSD	NHA
Direction (Azimuth) [a]									
Minimum	152	129	164	154	127	146	253	116	147
Mean	181	134	167	184	137	160	297	123	150
Maximum	221	145	169	238	158	175	326	130	155
Magnitude ($x10^{-3}$) [a]									
Minimum	0.03	0.19	0.12	0.08	0.18	0.05	0.20	0.58	0.17
Mean	0.08	0.22	0.13	0.17	0.29	0.08	1.14	0.66	0.20
Maximum	0.15	0.28	0.15	0.32	0.44	0.12	1.94	0.73	0.22

[a] Flow directions are given as azimuth, in degrees from north. Magnitudes of the gradients are given as multiples of 10^{-3}.

and the other group providing a gradient to the southwest (Figure 6-1c). Although the northwest gradients are roughly consistent with the HST model, all of the flow directions calculated from the monitoring data are inconsistent with flow directions forecast by the CAU models. This discrepancy highlights the possibility for local gradients to vary from the overall basin-wide expectation of groundwater movement to the southeast, in this case possibly resulting from local effects of the radionuclide migration experiment (UE-5n to the southeast and adjacent to the Cambric Ditch has the highest water levels in the Central Testing Area). Although hydraulic heads from the steady-state CAU models were mapped onto the Central Testing Area sub-CAU model boundary to ensure consistency in hydraulic gradients between the CAU and sub-CAU models, the hydraulic properties of the Central Testing Area model were calibrated to the radionuclide migration experiment. As a result, gradients within the sub-CAU model may differ somewhat from those of the CAU model.

Overall, the water-level monitoring data are consistent with many of the assumptions and features of the flow models. In contrast, by their very nature, the observed trends in water levels are not consistent with other model assumptions. The CAU model team considered transient effects during model development, but based on available data concluded that a steady-state flow model was adequate for CB calculations in the Northern Testing Area and that supply well pumping effects could

be neglected in the transient model of the Central Testing Area (transient effects of pumping at RNM-2S for the radionuclide migration experiment were included). Flow directions inferred from gradients calculated with the monitoring data differ for some well combinations from the directions depicted in the CAU models. A tendency to more southerly, rather than southeasterly, flow is observed in the Northern Testing Area and basinwide, with more significant differences in the Central Testing Area (north and northwest observed rather than southeast). The variations highlight uncertainty in flow direction at the local scale.

6.2.2 Determination of Radiochemistry Consistency

The extent of CBs throughout CAU 98 is dominated by ^{3}H, ^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I. These radionuclides are modeled as non-sorbing and available for immediate transport outside the nuclear melt glass encompassing the alpha-emitting radionuclides.

Three of the water-quality monitoring wells (ER-5-3-2, ER-5-3_p2, and ER-11-2) are located outside the CBs. Note that ER-11-2 was located within the original CB associated with the PIN STRIPE test, but is outside the CB extent associated with the revised conceptual model developed during the model evaluation process (N-I, 2014). Consistent with being outside a CB, these three wells do not have concentrations above the MCL for any of the radionuclide-specific analyses (indeed, concentrations are below detection limits).

The current CB forecasts overlap three of the six wells sampled for water quality. Two of these (RNM-2S and UE-5n) are source/plume wells in the Central Testing Area. The measured radionuclide concentrations in these wells are consistent with the model assumption of being within the contaminant transport zone resulting from the radionuclide migration experiment from the CAMBRIC cavity. The ^{3}H concentration measured at UE-5n in 2016 continues the trend forecast by the transport model (Figure 6-2). The ^{3}H concentration at RNM-2S in 2016 is somewhat higher than would be anticipated from the model results but is consistent with the slow decline in forecasted concentration (Figure 6-3).

Samples from the third well within a CB (ER-5-5) did not have radionuclide-specific concentrations above MDLs. The hydrologic conceptualization near ER-5-5 in the Northern Testing Area was revised during the model evaluation process from a higher-velocity fractured lava-flow aquifer to that

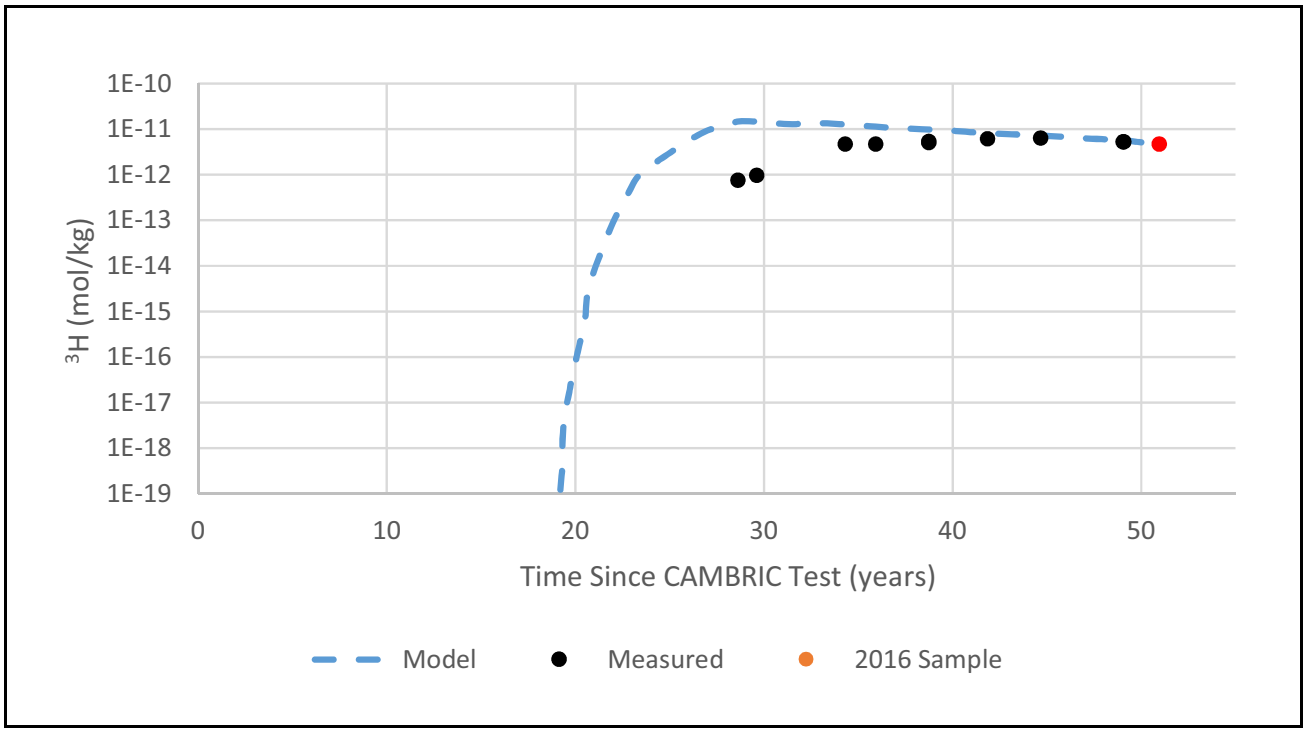

Figure 6-2
Measured ^{3}H Concentrations at UE-5n and Concentrations Forecast by the Groundwater Flow and Transport Model

of a slower-velocity alluvial aquifer. The 2016 analytical results are consistent with this revised conceptualization and indicate that the CB for the MILK SHAKE test is conservative (larger than now expected). The model-evaluation interpretation that ER-5-5 is at the leading edge of a test-derived radiologic plume (N-I, 2014) will continue to be assessed with monitoring data.

6.3 Evaluation of Effectiveness of Institutional Controls and URs, and Identification of Any New Land Use Impacts

Processes are in place to ensure that the Frenchman Flat URs prohibit drilling in the region of possible groundwater contamination. The REOP process for the NNSS screens activities for potential conflict with URs. Construction activities on the NTTR require a USAF Form 813, which triggers an environmental impact review and leads to consultation with the GIS database housing the URs.

As recognized in the CR (NNSA/NFO, 2016b), activities outside the URs have the potential to affect groundwater flow that could alter the CB forecasts. Although the groundwater-level monitoring is a direct sentinel of any such impact on CAU 98, it is paired with monitoring of regional groundwater

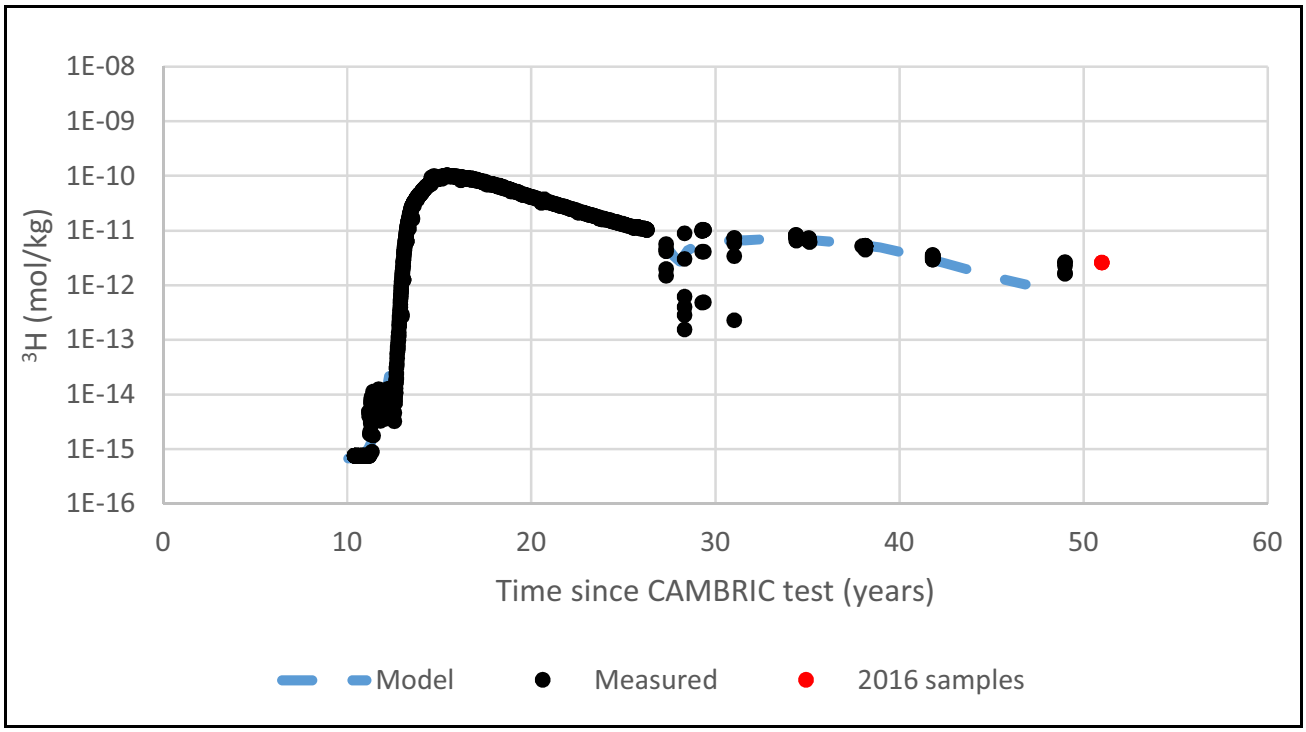

Figure 6-3
Measured ^{3}H Concentrations at RNM-2S and Concentrations Forecast by the Groundwater Flow and Transport Model

Note: The frequency of measurements between 10 and 26 years is so high during the radionuclide migration experiment that the data points appear as a line.

extraction activities, as described below. This allows for early identification of the potential for system changes so that response actions, such as increased monitoring, can be initiated.

The closest wells to CAU 98 that are used for water supply are those operated by NNSA/NFO for NNSS activities. Pumping data are reported by the M&O contractor and are available through USGS (USGS and DOE, 2017). Six wells in the Frenchman Flat area have produced water from the alluvium, two from volcanic units, and three from the LCA (Figure 6-4; SNJV, 2004). During 2016, three of these wells were in production (WW-4, WW-4A, and WW-5B). The production from each well in 2016 is presented in the context of its production history in Figure 6-5. WW-4 and WW-4A pump groundwater from volcanic units and are in the CP sub-basin, separated from the underground testing areas in Frenchman Flat by a hydrologic barrier associated with the Cane Spring fault. Pumping from the alluvial aquifer in the main Frenchman Flat basin is of most importance for the CBs. The production from WW-5B, completed in alluvium, in 2016 totaled 47.43 million gallons, continuing an increasing trend over the last several years. Compared to the period of record

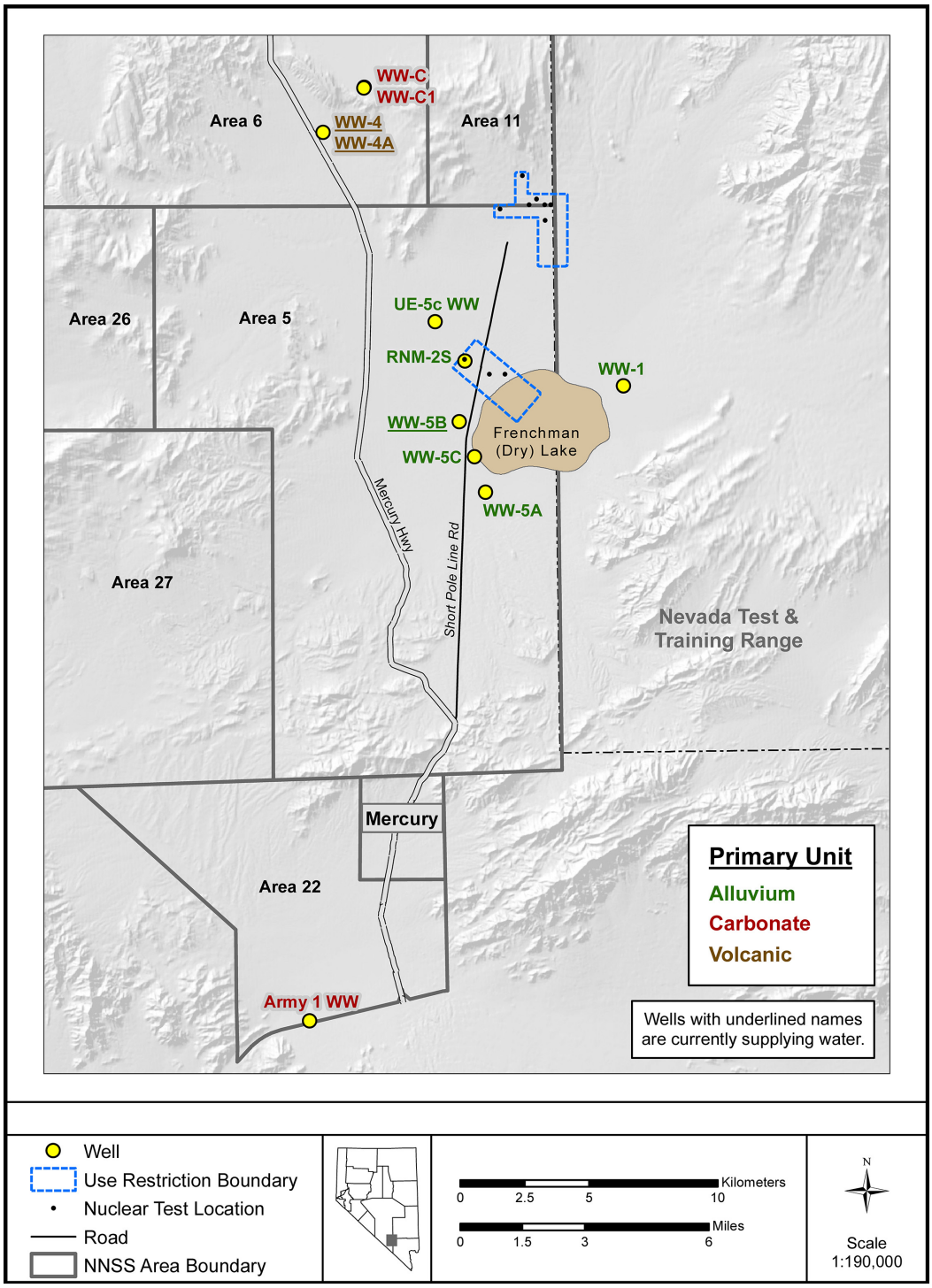

Figure 6-4
Past and Present Groundwater Production Wells in the Frenchman Flat Area

Note: Well RNM-2S was pumped for a radionuclide migration experiment, whereas the others were used for supply.

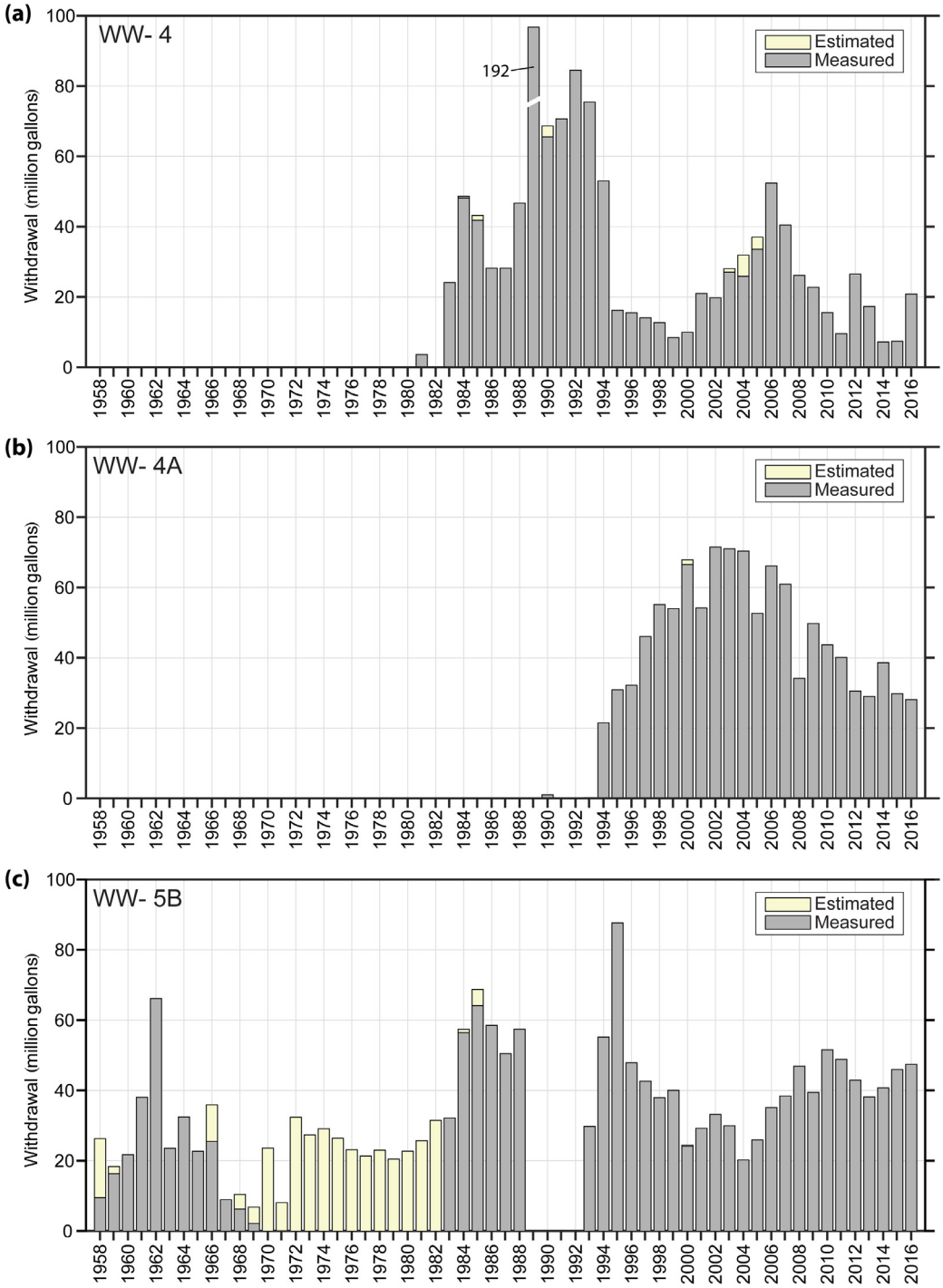

Figure 6-5
Annual Water Production from Wells WW-4, WW-4A, and WW-5B
Note: Data are provisional and from USGS (USGS and DOE, 2017).

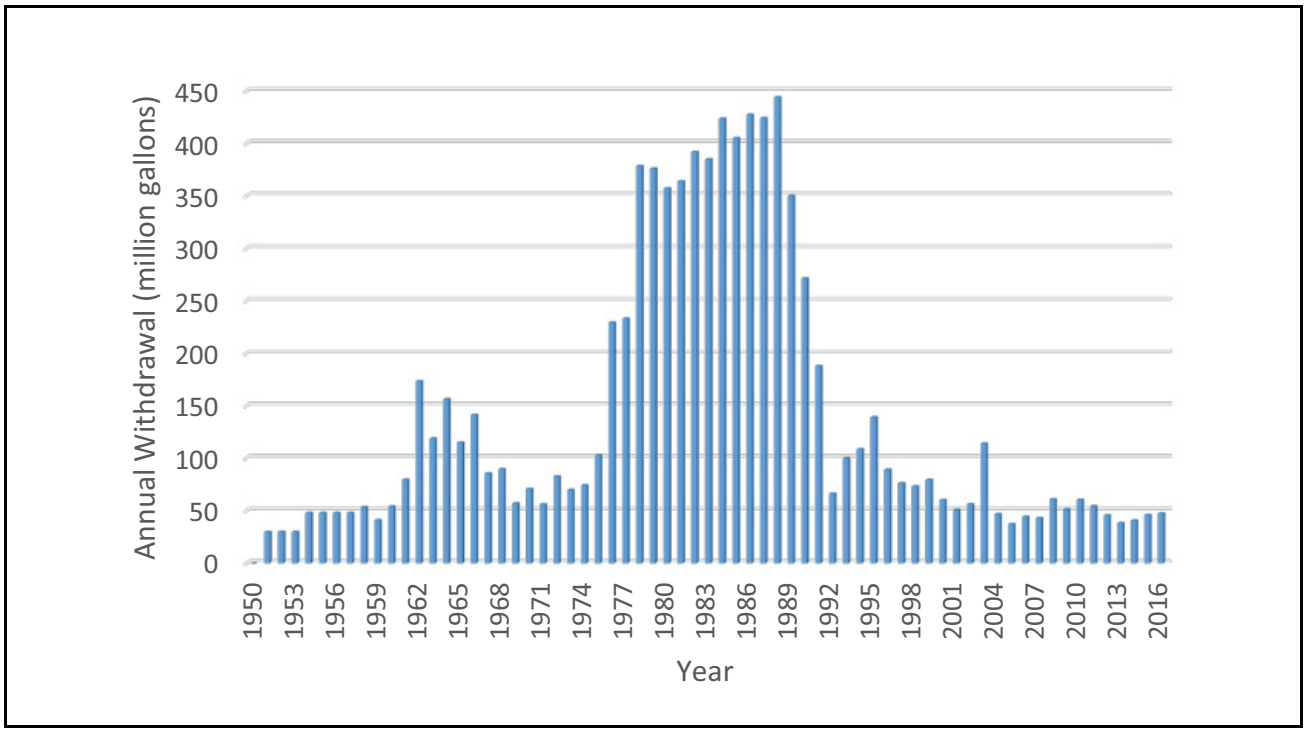

Figure 6-6
Total Annual Withdrawals for Wells Completed in the Alluvial Aquifer of Frenchman Flat

Note: The wells included are WW-1, WW-5A, WW-5B, WW-5C, UE-5C WW, and RNM-2S. Data are provisional and from USGS (USGS and DOE, 2017).

(Figure 6-6), current pumping of groundwater from alluvium in Frenchman Flat is much less than the peak between 1977 and 1991 when RNM-2S was in production for the radionuclide migration experiment (USGS and DOE, 2017).

Regionally, groundwater usage is monitored through data reported by NDWR. Actual usage is reported for the two most actively pumped basins in the region: Indian Springs Valley (Basin 161) and the Amargosa Desert (Basin 230) (Figure 6-7). Pumpage by USAF is included in the Indian Springs Valley data. "Active annual duty" is recorded for all basins and represents the amount of groundwater that can potentially be used, as represented by permits and other legal means. Although the active annual duty does not necessarily coincide with actual groundwater use, changes in the active annual duty reflect interest in a basin's groundwater resources.

The active annual duty for the Frenchman Flat hydrographic basin and eight nearby basins is evaluated each year. A summary of the active annual duty and actual groundwater use for Basins 161

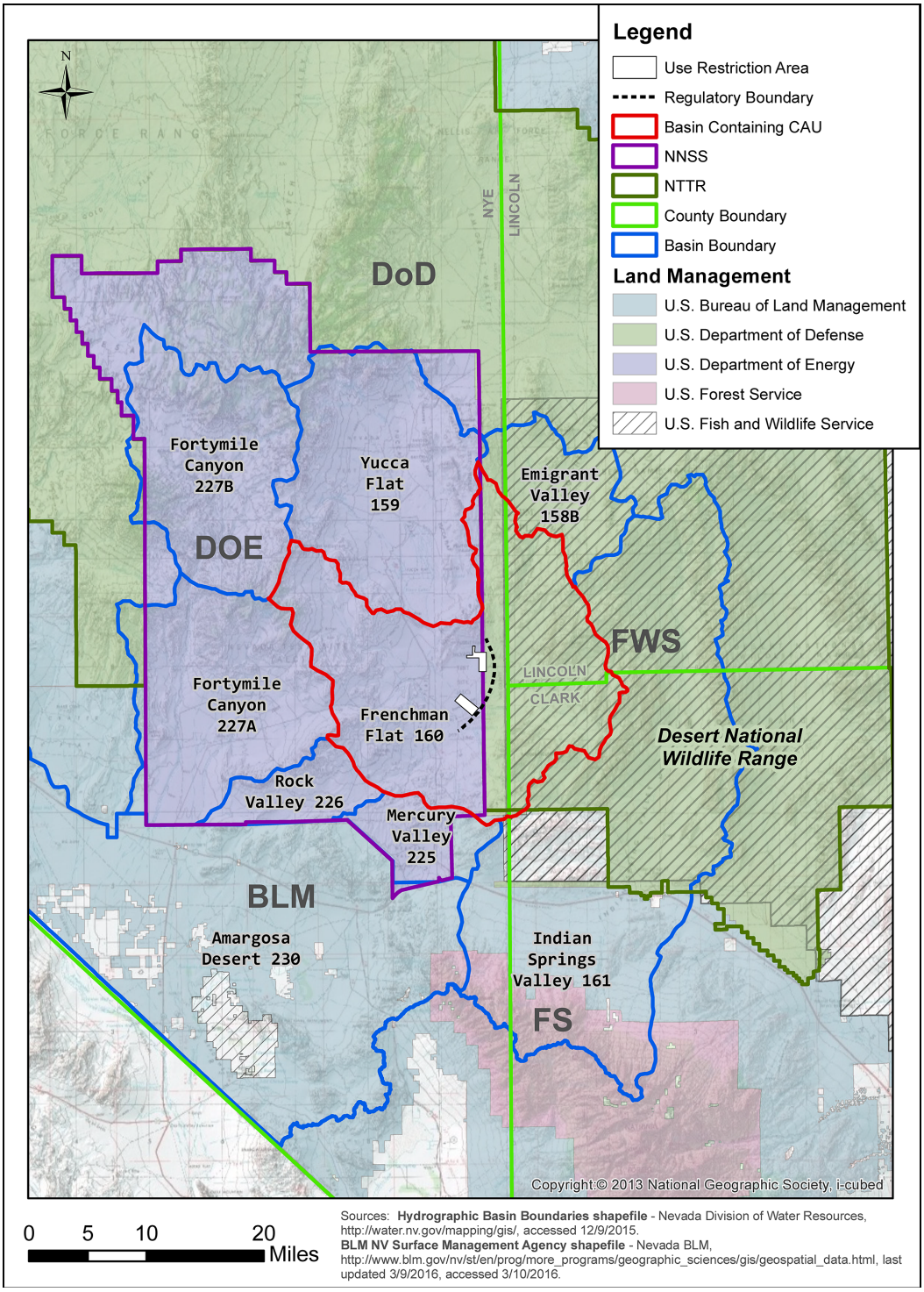

Figure 6-7
Hydrographic Basin Locations, Names, and Numbers in the Vicinity of Frenchman Flat

and 230 is shown in Table 6-3, with the geographic relationship of the basins shown in Figure 6-7. New actions are recorded for two of the basins. Basin 161, Indian Springs Valley, had two applications in 2016, one of which is a change to an earlier application. The total diversion rate requested is 1.071 cubic feet per second (cfs), with the source recorded as a spring. Basin 230, Amargosa Desert, had 20 applications in 2016, one of which was cancelled, four permitted, and the rest waiting for action. All but one are changes to prior applications, requesting changes in existing groundwater rights to support commercial businesses. Four pertained to springs, with a total diversion rate of 1.883 cfs for wildlife use. The total diversion rate for the underground water applications is 8.377 cfs. Direct queries were made in January and February 2017 to the NDWR specialists responsible for the basins of interest, to inquire whether they are aware of any upcoming large-scale projects or other changes that could involve significant increases or decreases in groundwater pumping in the region, but that have not yet reached the application phase. The answer was negative, with a note that the Southern Nevada Water Authority continues to have a number of pending application in Basin 161, Indian Springs Valley (and in adjoining Basin 211, Three Lakes Valley), but there is no timetable of when they will be acted upon to address protests to those applications (Randles et al., 2017).

Table 6-3
Active Annual Duty in 2016 and Actual Groundwater Pumpage in 2015 for Hydrographic Basins near Frenchman Flat[a]

Basin	Active Annual Duty 12/31/2016	Groundwater Pumpage Inventory 2015
158B Emigrant Valley	0.00	NA
159 Yucca Flat	0.00	NA
160 Frenchman Flat	0.00	NA
161 Indian Springs Valley	1,389.97	622
225 Mercury Valley	0.00	NA
226 Rock Valley	0.00	NA
227A Fortymile Canyon (South)	17.22	NA
227B Fortymile Canyon (North)	0.00	NA
230 Amargosa Desert	26,258.46	16,192
Total	**27,665.65**	**16,814**

[a] In acre-feet per year.

Source: NDWR, 2017a and b

6.4 Viability of Closure Strategy for Protecting Human Health and the Environment

The UGTA closure strategy applied to CAU 98 is closure in place with monitoring and institutional controls. The viability of this strategy depends on the forecasted CBs and the institutional controls established around them. The monitoring program is designed to assess both of these factors, and the results from 2016 indicate the closure strategy remains viable.

The water-quality and water-level monitoring activities provide data to assess the continued suitability of the CBs. Whereas water-quality sampling is consistent with model forecasted contaminant transport, water-level data indicate that hydraulic gradients used to calculate the boundaries have uncertainty in terms of local flow directions. Nonetheless, observed gradients are low, supporting the low groundwater velocities in the boundary calculations.

Declining water levels in the aquifer within the alluvium of Frenchman Flat will become a concern to the closure of CAU 98 if the emerging conditions alter flow directions and flow magnitude such that the URs may not be protective of human health and the environment. Several features of the models, boundaries (both contaminant and regulatory), and URs provide assurance of their ability to prevent exposure to COCs:

- Many of the CBs for the tests are relatively small within the larger restricted areas (Figure 6-8). The buffer allows for moderate changes in CB direction or size without extending beyond the UR.

- The regulatory boundary forms an additional buffer for migration to receptors downgradient of the Rock Valley fault system, the expected groundwater pathway out of the Frenchman Flat basin. The regulatory boundary is farther downgradient of the CBs than the URs.

- Contaminant migration from MILK SHAKE is now considered to be more limited than represented by its CB because the simulated fractured basalt aquifer at ER-5-5 was found to be a thin basalt rubble zone during the model evaluation process, which would result in lower simulated groundwater velocities.

- The impact of pumping at WW-5B and WW-5C was examined in a sensitivity analysis for the Central Testing Area, and no significant difference was found in the extent of the ^{3}H plumes.

- The CB associated with the radionuclide migration experiment at CAMBRIC in the Central Testing Area is dominated by ^{3}H, and radioactive decay is an important factor that will limit migration regardless of flow direction.

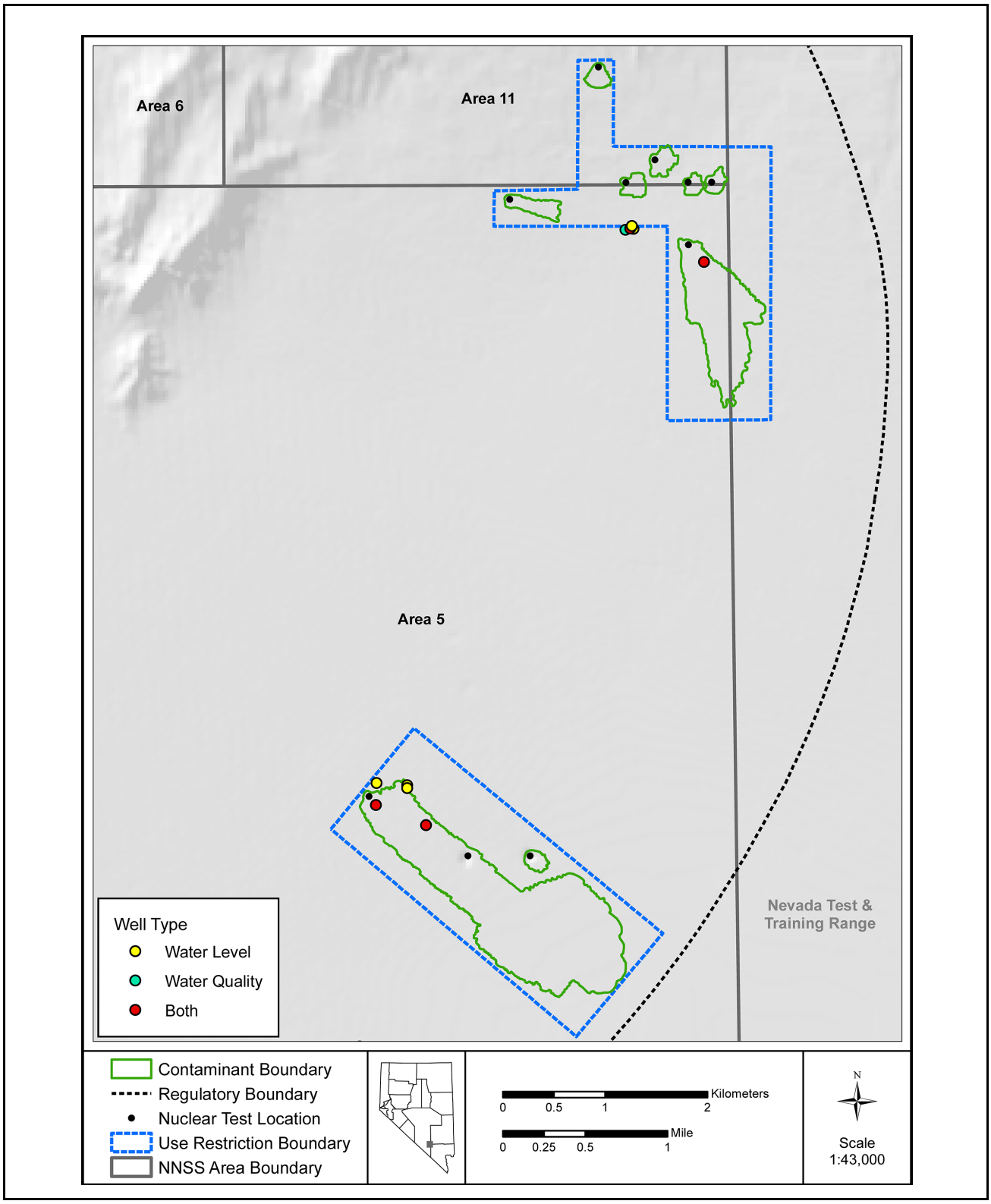

Figure 6-8
Contaminant Boundaries within the UR and Regulatory Boundaries

For these reasons, the URs are considered resilient in protecting human health and the environment. As water-level monitoring continues, trigger levels will be developed to determine whether transient conditions require additional investigation to maintain that protection.

Institutional control monitoring finds the URs implemented and visible in the activity control systems of the NNSS and NTTR. Status checks with cognizant authorities for the NNSS and NTTR, and with NDWR are informative and should provide early warning of any significant increases in groundwater pumping in the region surrounding CAU 98.

7.0 Summary and Recommendations

The regulatory closure of CAU 98 requires annual monitoring for the first five years and an annual report to verify corrective action effectiveness. This report presents the results of monitoring conducted for water quality, water levels, and institutional controls in 2016. COCs were only identified at significant levels in source/plume wells located within known areas of contamination. The ^{3}H concentrations found in the source/plume wells are consistent with trends forecast by the CAU flow and transport models.

Water-level monitoring identified trends in the measured wells. Over the evaluation period (2004–2016), all but one well (WW-5A) completed in the alluvium exhibited a declining water level. More variability in gradient magnitude and direction is observed with the monitoring data than portrayed in the groundwater models. Although observed gradients support low groundwater velocity, local flow directions are sometimes different than those used to calculate the CBs.

The URs were verified as remaining in place and effective at limiting activities near the underground tests. NNSA/NFO, EM Nevada Program, and NTTR managers report no activities during 2016 or activities on the planning horizon that would significantly impact withdrawal of groundwater within Frenchman Flat. Regionally, water-rights records indicate no large increases in groundwater use in basins adjoining Frenchman Flat, and NDWR personnel report no knowledge of pending activities that have yet to reach the formal application stage.

Taken together, the water-quality, water-level, and institutional control monitoring indicate that closure in place with monitoring and institutional controls remains a viable strategy for CAU 98. The monitoring has identified water-level trends that will now be monitored for impact on CB calculations, but the URs remain protective of human health and the environment, and the regulatory boundary objective continues to be met.

Recommendations based on the initial year of monitoring are as follows:

- Water levels from UE-5 PW-1, UE-5 PW-2, and UE-5 PW-3 are important for determining water-level trends and gradients in CAU 98. These wells are currently monitored for the Area 5 RWMC, and their water-level data are used in the 2016 evaluation. Data from these wells should be formally included in CAU 98 monitoring program.

- Although trigger and action levels are not called for during the first five years of post-closure monitoring (NNSA/NFO, 2011), it would be useful to begin the process of developing the conceptual basis for water-level monitoring triggers given observed trends.

- The REOP review required as part of UR verification does not lend itself to identification of potential impacts to groundwater use and thereby identification of impacts to the URs. The M&O contractor identified an improvement to the REOP process, allowing direct identification of possible drilling and increases in groundwater use during REOP approval. It is recommended that the proposed addition to the REOP checklist be accepted and the resulting data used in future years to assess the potential of NNSS activities to impact the URs.

8.0 References

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Appendix A

Additional Analytical Data for 2016 Water Samples

Table A.1-1
Additional Analytical Results for 2016 Water Samples
(Page 1 of 2)

Well	ER-5-3-2	ER-5-3_p2	ER-5-5	ER-5-5	ER-5-5
Sample Date	**05/19/2016**	**06/07/2016**	**05/16/2016**	**05/16/2016**	**05/16/2016**
Sample Number	**202-051916-1**	**201-060716-1**	**206-051616-1**	**206-051616-2**	**206-051616-3**
Water Properties					
pH (SU)	J- 7.1	J- 7.7	J- 8.3	J- 8.3	J- 8.58
Specific Conductance (µS/cm)	1,200	360	440	430	416
Major and Minor Constituents (mg/L)					
Alkalinity as $CaCO_3$	540	160	150	150	145
CO_3	<12	<12	<12	<12	3.1
HCO_3	658.3	195.0	182.9	182.9	170.7
Br	J 0.065	0.47	<0.06	<0.06	J 0.103
Cl	39	19	15	15	13.3
F	1.7	1.4	3.2	3.1	2.79
SO_4	76	3.3	42	41	39.9
Ca	76	14	7.4	7.4	7.16
K	16	8	7.4	7.5	6.42
Mg	27	3	3.4	3.3	3.21
Na	140	53	75	76	J+ 77.9
Al	J- 0.031	U 0.2	U 0.2	U 0.2	<0.068
Fe	0.29	J 1.7	0.34	0.19	0.16
SiO_2	47.1	23.5	44.9	44.9	42.6
Trace Constituents (µg/L)					
Ag	U 10	<1.1	<1.1	<1.1	J 1.25
As	J- 8.4	J 4.3	16	15	J 17.1
Ba	200	UJ 100	U 100	U 100	J 2.31
Cd	<0.21	<0.33	<0.33	<0.33	<1
Cr	U 10	<0.51	J- 1.2	J- 1.3	J 1.69
Li	360	J 24	J 19	J 19	15.1
Mn	52	290	J- 4.7	J- 4.7	J 4.78

Table A.1-1
Additional Analytical Results for 2016 Water Samples
(Page 2 of 2)

Well	ER-5-3-2	ER-5-3_p2	ER-5-5	ER-5-5	ER-5-5
Sample Date	05/19/2016	06/07/2016	05/16/2016	05/16/2016	05/16/2016
Sample Number	202-051916-1	201-060716-1	206-051616-1	206-051616-2	206-051616-3
Pb	7	5.2	<1.3	<1.3	<3.3
Se	<3	<2.7	<2.7	J 3.9	<6
Sr	910	J 60	J 23	J 24	22.7
U	J 12	0.22	J 8.4	J 8.6	9.54
Radionuclides (pCi/L)					
Gross Alpha	9.1	J <1.7	4.1	7.1	J 9.46
Gross Beta	J 14.9	7.4	8.7	8.4	J 7.42
^{26}Al	<12.1	--	<13.1	<7.9	<7.92
^{241}Am	<9.2	--	<340	<250	<39.9
^{243}Am	<590	--	<1,140	<850	<10.5
^{137}Cs	<8.5	--	<9.9	<7.3	<6.05
^{152}Eu	<47	--	<45	<36	<17.2
^{154}Eu	<49	--	<49	<39	<20.8
^{94}Nb	<7.6	--	<9.4	<6.9	<6.02
^{238}Pu	<0.033	--	<0.027	<0.015	<0.0362
$^{239/240}$Pu	<0.024	--	<0.036	<0.033	<0.0362
^{90}Sr	<0.26	--	U 0.26	U 0.39	<0.966
^{235}U	<35	--	<51	<37	<31

µg/L = Micrograms per liter
µS/cm = Microsiemens per centimeter

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 MDL but below the MDL plus error.
-- = Not analyzed.

Appendix B

Water-Level Analyses

B.1.0 Water-Level Analyses

B.1.1 Hydrographs

The following plots show hydrographs from the testing areas in Frenchman Flat to illustrate relationships between water levels within these areas. The plots also identify water levels that were not included in the trend analyses because they were flagged by the USGS as not representing static conditions.

B.1.1.1 ER-5-3 and ER-5-3-3

Figure B.1-1 presents observed water levels at three wells: ER-5-3 main (upper zone), ER-5-3 deep piezometer, and ER-5-3-3. The trend analysis confirms the observation that from 2004 through 2016, ER-5-3 main (upper zone) and ER-5-3-3 show declining trends, while ER-5-3 deep piezometer shows a rising trend.

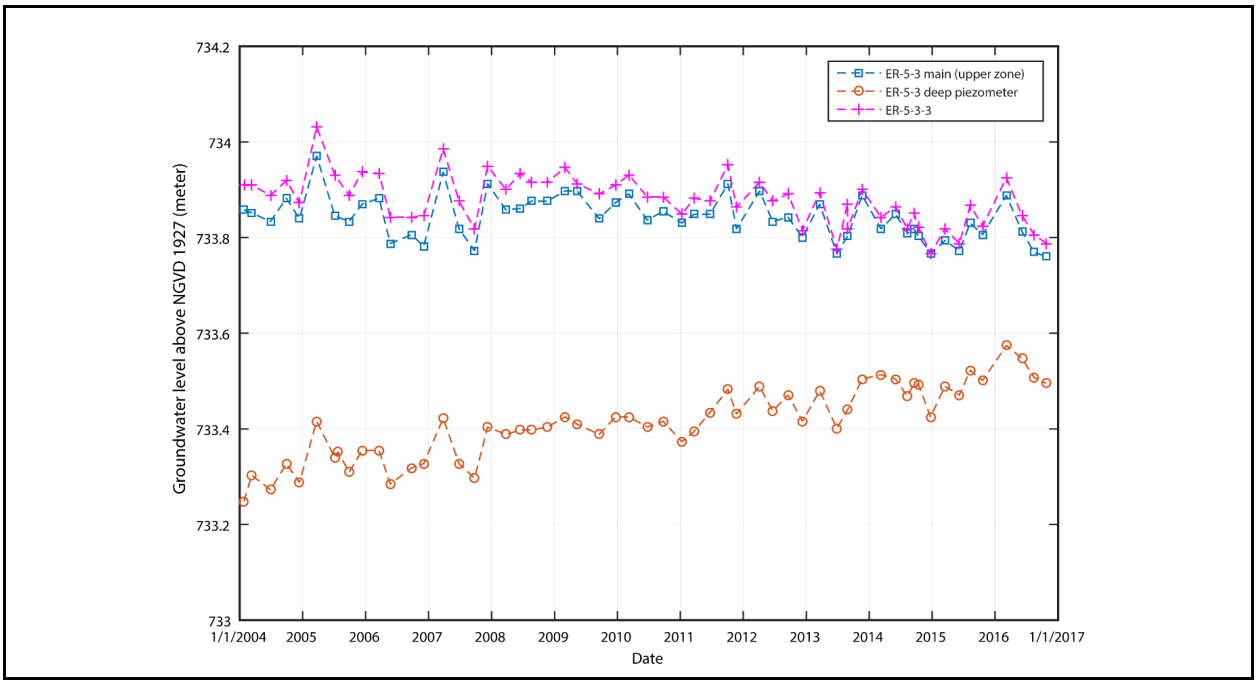


Figure B.1-1
Water Levels in ER-5-3 and ER-5-3-3

Water levels in ER-5-3 main (upper zone) and ER-5-3-3 show similar fluctuations and are both declining over the time period. In contrast, water levels in ER-5-3 deep piezometer are rising—as much as 0.4 m from January 2004 to August 2015. Elliott and Fenelon (2010) attribute this long rising trend to delayed drawdown and slow equilibration of water levels after pumping in the well during aquifer testing.

Second, water levels in ER-5-3 deep piezometer are always lower than water levels in ER-5-3 main (upper zone) and ER-5-3-3, showing a downward hydraulic gradient from the alluvium to the volcanic rocks. However, this downward gradient is decreasing as water levels continue to increase in ER-5-3 deep piezometer.

Third, water levels in ER-5-3 main (upper zone) are always lower than ER-5-3-3. Assuming similar vertical gradients in the alluvium, this suggests groundwater flow toward the southeast. This head difference is decreasing over time, indicating variation in local horizontal gradients.

B.1.1.2 Observation Wells in the Alluvial Aquifer in the Northern Testing Area

Figure B.1-2 shows hydrographs for four wells in the Northern Testing Area. The trend analysis indicates declining trends for all four of these wells. Water levels are higher in the north (ER-5-3-3) as compared to the south (UE-5 PW-1 and UE-5 PW-2). There are strong correlations among water levels in these four wells. For example, water levels are all low on October 21, 2016, and high on March 7, 2016.

After the May 2013 completion of development and testing of new well ER-5-5, the ER-5-5 water levels are visually correlated with levels measured in nearby wells.

B.1.1.3 Observation Wells in the Alluvial Aquifer in the Central Testing Area

Figure B.1-3 presents the hydrographs for five wells in the alluvial aquifer in the Central Testing Area. These wells are ER-5-4 main, ER-5-4 piezometer, UE-5n, RNM-1, and RNM-2S.

The trend analysis indicates declining trends for all five wells. Second, there is a downward-directed gradient from the shallow ER-5-4 piezometer to the deeper ER-5-4 main completion. Also, water levels are always highest at UE-5n and lowest at RNM-1, which produces flow directions in the

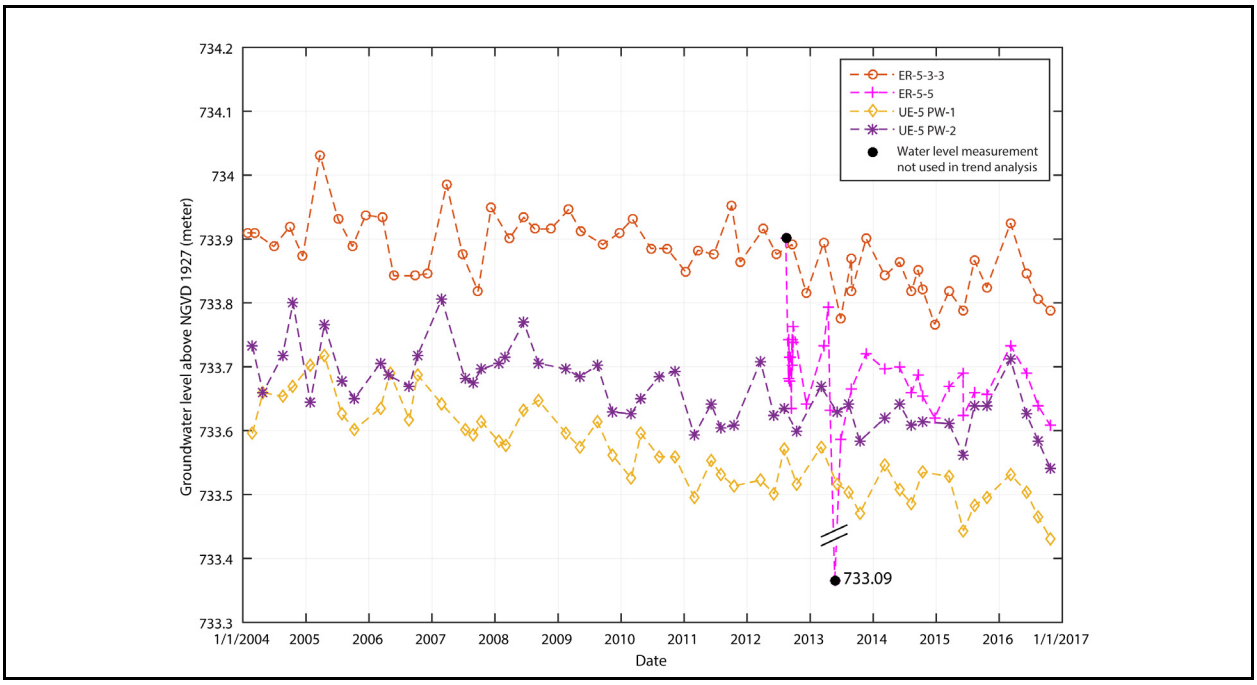


Figure B.1-2
Water Levels in Alluvium Aquifer Wells in the Northern Testing Area

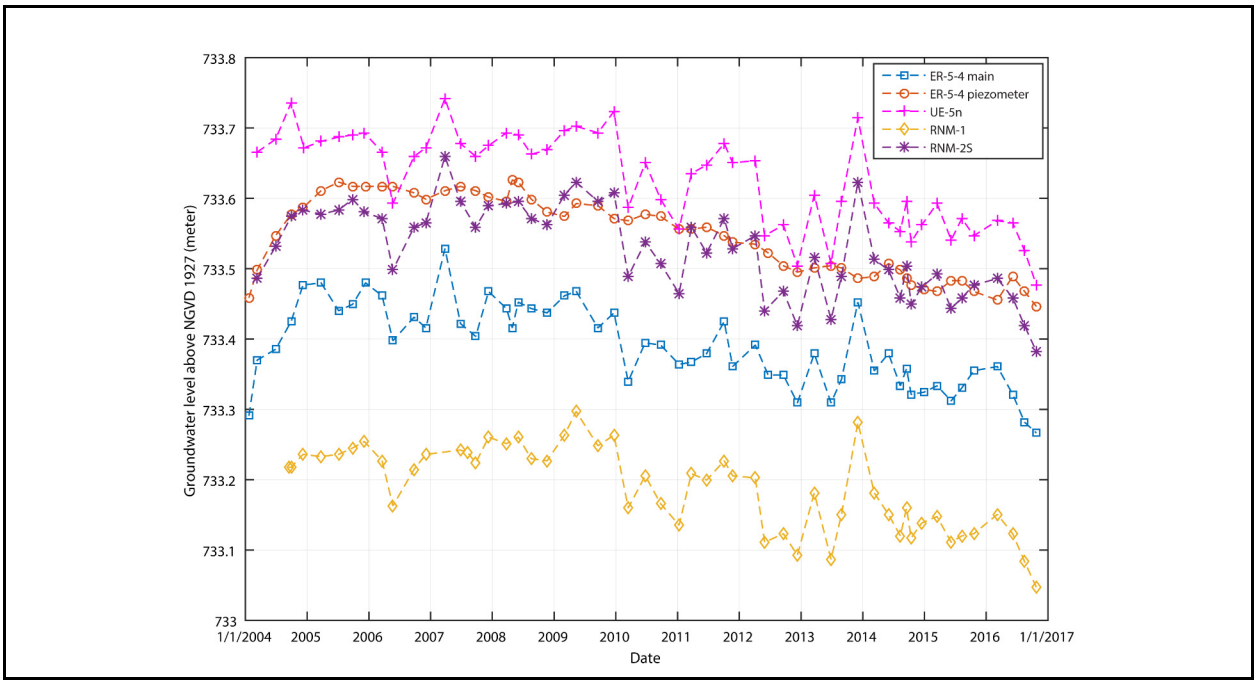


Figure B.1-3
Water Levels in Alluvial Aquifer Wells in the Central Testing Area

Central Testing Area that are inconsistent with basin-wide flow directions. Third, there are strong visual correlations among water levels in ER-5-4 main, UE-5n, RNM-1, and RNM-2S. For example, water levels are all high on December 3, 2013, and low on June 27, 2013, at all four wells. Note that the water-level trend at ER-5-4 piezometer does not show correlation with the other four wells.

B.1.1.4 Water-Supply Wells in the Alluvial Aquifer

Figure B.1-4 presents the hydrographs of two wells in the alluvial aquifer used for water supply. Water levels in WW-5A continue to recover after pumping there ceased in 1970, rising nearly 0.35 m from 2013 through mid-2016. This rise in water levels primarily reflects changes in pumping in WW-5A and nearby wells WW-5B and WW-5C (Elliott and Fenelon, 2010).

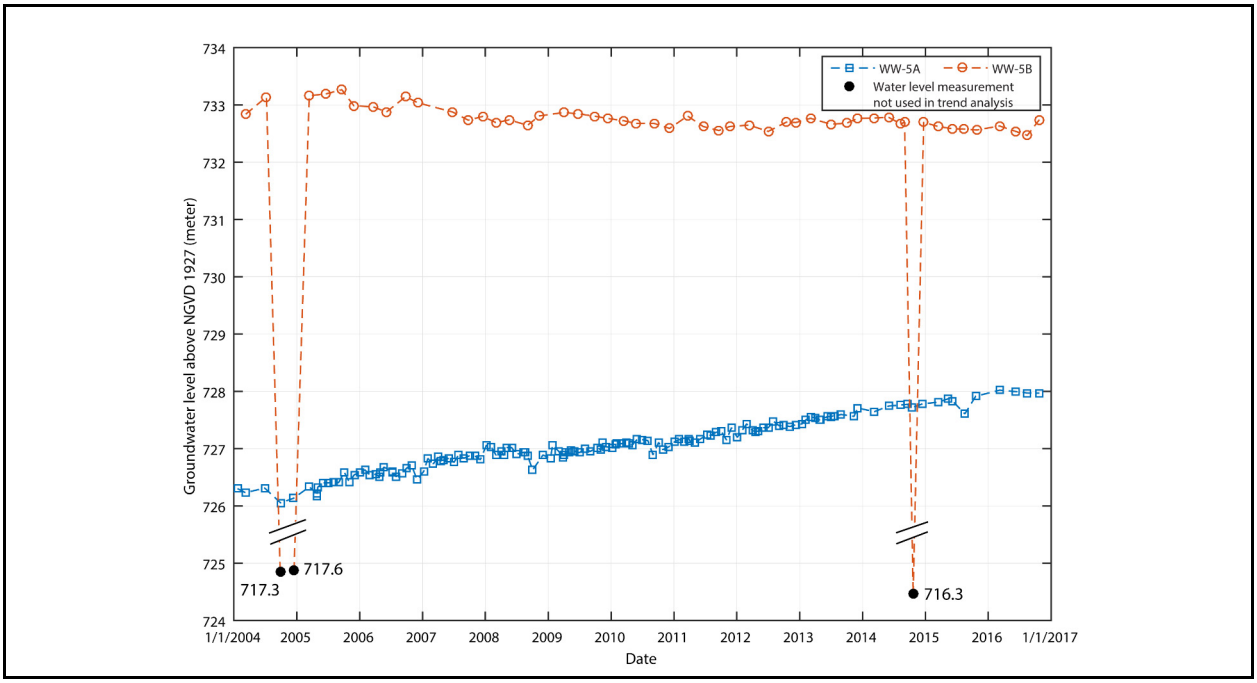


Figure B.1-4
Water Levels at Pumping Wells in the Alluvial Aquifer

B.1.1.5 Wells in the Volcanic Aquifer

Figure B.1-5 presents the hydrographs of five wells that monitor the volcanic aquifer.

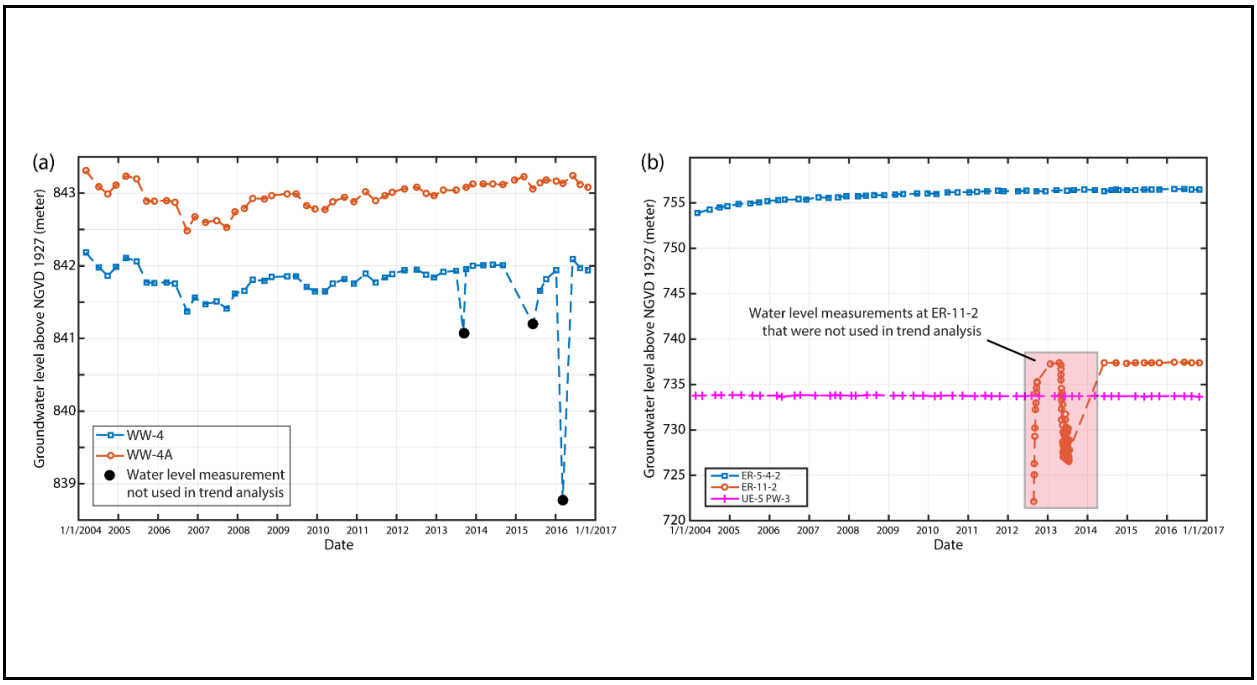


Figure B.1-5
Water Levels in Wells in the Volcanic Aquifer in the (a) Northern Testing Area and (b) Central Testing Area

B.1.1.6 Well in the Carbonate Aquifer

Figure B.1-6 presents the hydrograph of ER-5-3-2, the only observation well in the carbonate aquifer in the monitoring well network. Water levels began declining in 2011 and 2012 after many years of rising.

B.1.2 Groundwater Flow Gradients

Tables B.1-1 through B.1-3 show tabulated results of the determinations of hydraulic gradients using multiple linear regression (Devlin, 2003).

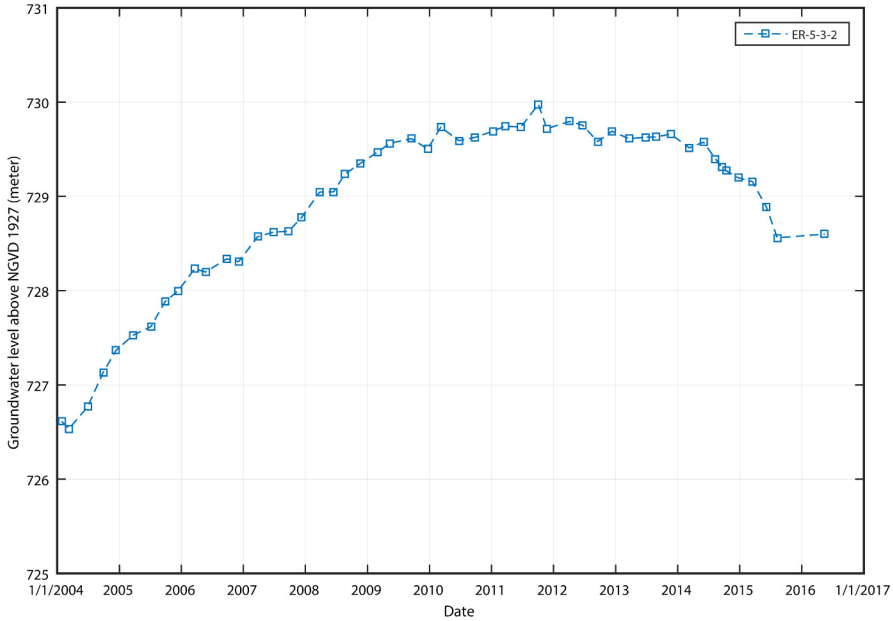


Figure B.1-6
Water Levels in ER-5-3-2 in the Carbonate Aquifer

Table B.1-1
Gradient Analysis for the Entire Testing Area of Frenchman Flat

Well Combination			Combination ID	Observations					BASE-USGSD Alternative Model		NHA Model	
				Number of Synoptic Observations	Direction	SD of Direction	Magnitude [a]	SD of Magnitude	Direction	Magnitude [a]	Direction	Magnitude [a]
ER-5-3-3	RNM-1	UE-5 PW-3	1	11	185	4.2	0.13	0.004	129	0.19	164	0.12
ER-5-3-3	RNM-2S	UE-5 PW-3	2	11	208	7.1	0.06	0.006	130	0.19	164	0.12
ER-5-3-3	UE-5n	UE-5 PW-3	3	11	221	6.8	0.05	0.008	138	0.24	164	0.13
ER-5-5	RNM-1	UE-5 PW-3	4	12	169	1.9	0.12	0.003	129	0.19	168	0.12
ER-5-5	RNM-2S	UE-5 PW-3	5	12	161	4.5	0.05	0.004	130	0.19	168	0.12
ER-5-5	UE-5n	UE-5 PW-3	6	12	152	7.7	0.03	0.004	139	0.23	169	0.13
ER-5-5	WW-5B	UE-5 PW-3	7	10	170	1.5	0.15	0.014	145	0.28	169	0.15
				Min	**152**	**--**	**0.03**	**--**	**129**	**0.19**	**164**	**0.12**
				Mean	**181**	**--**	**0.08**	**--**	**134**	**0.22**	**167**	**0.13**
				Max	**221**	**--**	**0.15**	**--**	**145**	**0.28**	**169**	**0.15**
				SD	**23.4**	**--**	**0.04**	**--**	**6.0**	**0.03**	**2.1**	**0.01**

[a] Magnitudes given as multiples of 10^{-3}.

SD = Standard deviation

Table B.1-2
Gradient Analysis for the Northern Testing Area of Frenchman Flat

Well Combination			Combination ID	Observations					BASE-USGSD Alternative Model		NHA Model	
				Number of Synoptic Observations	Direction	SD of Direction	Magnitude [a]	SD of Magnitude	Direction	Magnitude [a]	Direction	Magnitude [a]
ER-5-3 main (upper zone)	ER-5-5	UE-5 PW-2	1	11	165	2.2	0.29	0.024	128	0.20	157	0.06
ER-5-3 main (upper zone)	UE-5 PW-1	UE-5 PW-2	2	11	233	14.6	0.14	0.009	133	0.43	147	0.12
ER-5-3 main (upper zone)	UE-5 PW-1	UE-5 PW-3	3	11	181	2.7	0.13	0.012	144	0.29	164	0.08
ER-5-3 main (upper zone)	UE-5 PW-2	UE-5 PW-3	4	11	175	3.2	0.22	0.022	128	0.18	162	0.05
ER-5-3-3	ER-5-5	UE-5 PW-2	5	11	165	2.0	0.32	0.026	128	0.19	157	0.06
ER-5-3-3	UE-5 PW-1	UE-5 PW-2	6	11	238	11.7	0.16	0.010	132	0.44	146	0.12
ER-5-3-3	UE-5 PW-1	UE-5 PW-3	7	11	183	2.7	0.14	0.013	143	0.29	163	0.08
ER-5-3-3	UE-5 PW-2	UE-5 PW-3	8	11	176	3.1	0.24	0.018	127	0.18	161	0.05
ER-5-5	UE-5 PW-1	UE-5 PW-2	9	11	182	12.5	0.08	0.024	144	0.37	158	0.11
ER-5-5	UE-5 PW-1	UE-5 PW-3	10	11	167	2.9	0.10	0.009	147	0.29	166	0.09
UE-5 PW-1	UE-5 PW-2	UE-5 PW-3	11	11	154	14.7	0.09	0.016	158	0.32	175	0.10
			Min		**154**	**--**	**0.08**	**--**	**127**	**0.18**	**146**	**0.05**
			Mean		**184**	**--**	**0.17**	**--**	**137**	**0.29**	**160**	**0.08**
			Max		**238**	**--**	**0.32**	**--**	**158**	**0.44**	**175**	**0.12**
			SD		**25.9**	**--**	**0.08**	**--**	**9.8**	**0.09**	**7.8**	**0.03**

[a] Magnitudes given as multiples of 10^{-3}.

Table B.1-3
Gradient Analysis for the Central Testing Area of Frenchman Flat

Well Combination			Combination ID	Observations					BASE-USGSD Alternative Model		NHA Model	
				Number of Synoptic Observations	Direction	SD of Direction	Magnitude [a]	SD of Magnitude	Direction	Magnitude [a]	Direction	Magnitude [a]
ER-5-4 Piezometer	UE-5n	RNM-1	1	12	253	3.8	1.27	0.131	130	0.68	155	0.21
ER-5-4 Piezometer	UE-5n	RNM-2S	2	12	310	25.7	0.20	0.041	123	0.73	147	0.22
ER-5-4 Piezometer	RNM-1	RNM-2S	3	12	326	2.5	1.94	0.058	116	0.58	147	0.17
			Min		**253**	**--**	**0.20**	**--**	**116**	**0.58**	**147**	**0.17**
			Mean		**297**	**--**	**1.14**	**--**	**123**	**0.66**	**150**	**0.20**
			Max		**326**	**--**	**1.94**	**--**	**130**	**0.73**	**155**	**0.22**
			SD		**31.5**	**--**	**0.71**	**--**	**6.0**	**0.06**	**3.9**	**0.02**

[a] Magnitudes given as multiples of 10^{-3}.

B.2.0 References

Devlin, J.F. 2003. "A Spreadsheet Method of Estimating Best-Fit Hydraulic Gradients Using Head Data from Multiple Wells." In *Ground Water,* Vol. 41(3): pp. 316–320.

Elliott, P.E., and J.M. Fenelon. 2010. *Database of Groundwater Levels and Hydrograph Descriptions for the Nevada Test Site Area, Nye County, Nevada*, *1941–2010,* Data Series 533. Reston, VA: U.S. Geological Survey.

Appendix C

Use Restriction and Institutional Control Information

C.1.0 Use Restriction and Institutional Control Information

Correspondence and information regarding the URs and institutional controls in place for CAU 98 are included in this appendix for ready reference. The contents are as follows:

- Letter from Allen to Chapman, dated February 21, 2017, verifying UR records in the NNSS M&O contractor's GIS system and transmitting REOP information for Area 5, with attachments as follows:

  - Current Use Restriction Report
  - List of REOPs

- Email from Kan to Chapman, dated February 7, 2017, describing USAF land control processes and activities pertinent to CAU 98

Attachment C-1

Use Restriction and Institutional Control Information

(11 Pages)

National Security Technologies LLC
Vision • Service • Partnership

G640-BA-17-0001
ADM 16.1.5.A

February 21, 2017

Jeannette Chapman
TREDS Program Manager
Desert Research Institute
755 East Flamingo Road
Las Vegas, NV 89119

Subject: **CONFIRMATION OF FFACO USE RESTRICTIONS FOR CORRECTIVE ACTION UNIT (CAU) 98 FRENCHMAN FLAT**

In response to your letter, dated January 5, 2017, regarding the above subject, the following information is being provided to meet the CAU 98 verification requests:

1. The enclosed Geographic Information System (GIS) report, dated January 9, 2017, verifies the CAU 98 use restrictions were recorded and are being maintained in the Management and Operating Contractor GIS.

2. The enclosed spreadsheet lists all active Real Estate Operating Permits (REOPs) within Areas 5 and 5A as of February 15, 2017. The spreadsheet contains two tabs: the first tab lists all Primary REOPs and the second tab lists all Secondary REOPs. Each record includes a link to the REOP document posted on the Facility Data Warehouse (FDW). A "Description of Change" is included in each REOP document, or the REOP's Change History Log can be accessed via the FDW.

Per our telephone conversation on February 2, 2017, Reed Poderis (National Security Technologies, LLC Environmental Restoration Manager) will be providing additional information, and will be the Point of Contact for these requests in the future.

Please let me know if you have any questions, or would like to discuss the information further. I can be reached at (702) 295-2947.

/s/ Brian M. Allen

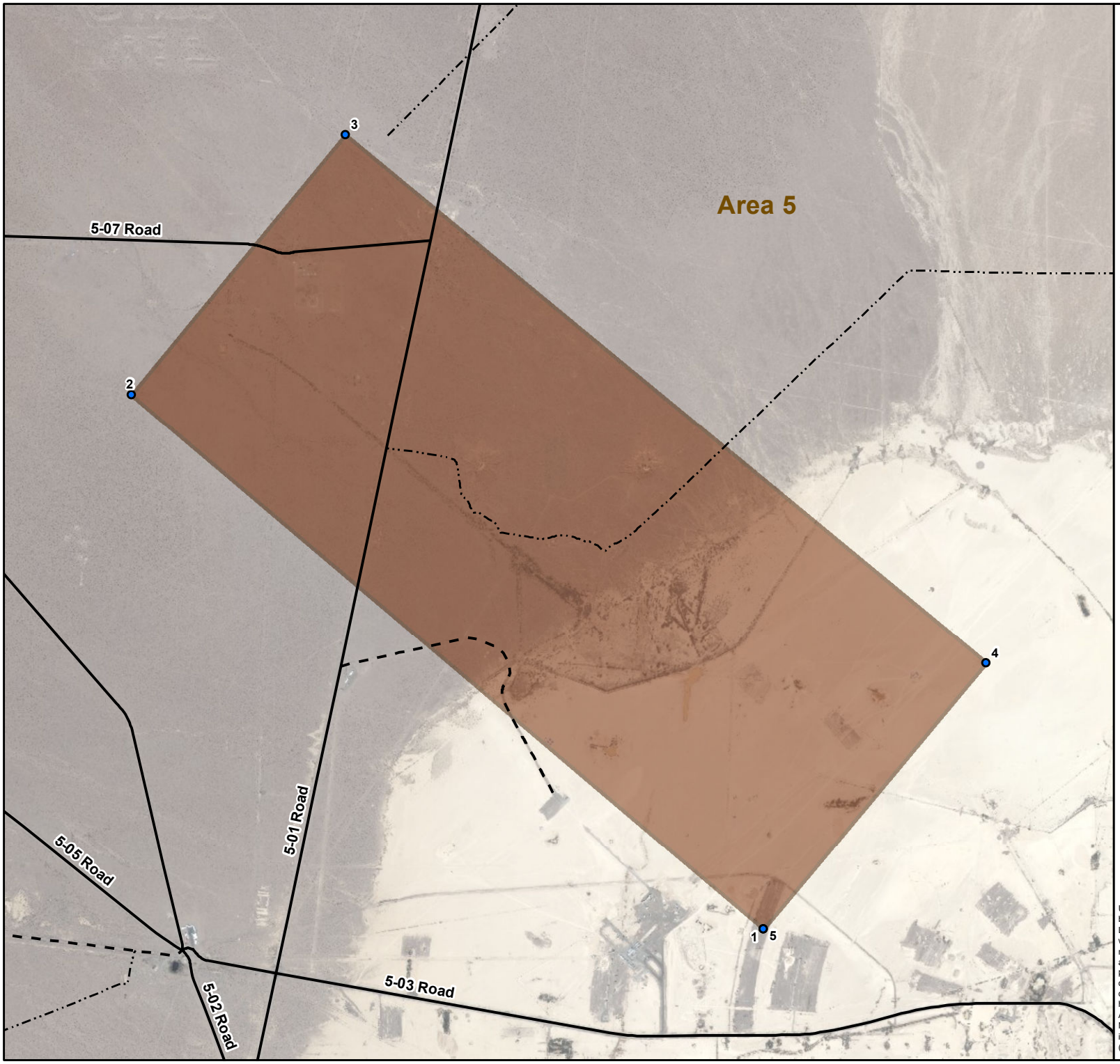
Brian M. Allen, Supervisor
Facility and GIS Services

BMA:mra

Enclosures:
See page 2

Enclosures:
1. Letter from Jeannette Chapman, dated January 5, 2017
2. GIS Report dated January 9, 2017

cc w/encs.
Correspondence Management
B. M. Allen, NSTec
R. F. Boehlecke, NNSA/NFO
R. J. Poderis, NSTec
W. Wilborn, NNSA/NFO



Use Restriction Report

CAU 98

CAS 05-57-001, -002, -003

U-5a, U-5b, and U-5e Cavities

Map Date: January 9, 2017

EXPLANATION

- Use Restriction Point*
- UGTA Subsurface Use Restriction Boundary*
- Secondary Road
- Unimproved Road
- Trail

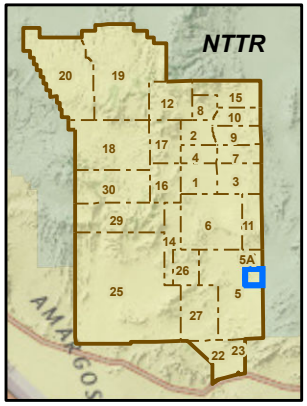
*Source: Underground Test Area (UGTA) Closure Report for Corrective Action Unit 98: Frenchman Flat, Nevada National Security Site (NNSS), Nevada, Revision 1, Record of Technical Change 1, August 2016.

0 250 500 1,000 1,500 Feet

0 100 200 400 600 Meters

N

Map produced by the NSTec GIS Group.
Product ID: 20170109-01-P001-R00



Map Location

Map Projection: UTM (Zone 11, meters) NAD83

Background scene from ESRI World Imagery (ESRI ArcGIS Online: http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9) accessed 9 January 2017 (Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community).

Overview map background scene from National Geographic Map (ESRI ArcGIS Online: http://www.arcgis.com/home/item.html?id=b9b1b422198944fbbd5250b3241691b6) accessed 9 January 2017 (National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC).

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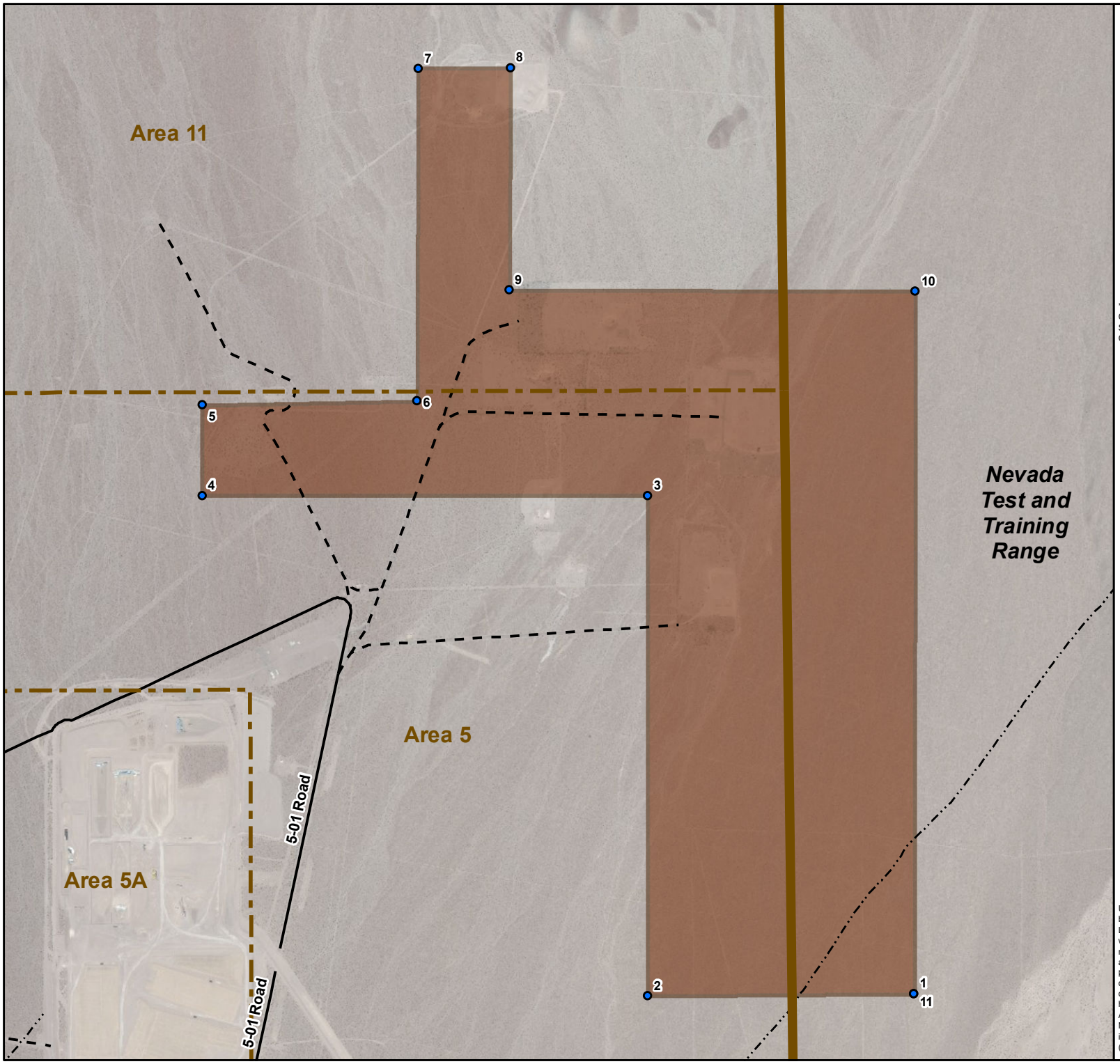
UGTA UR Boundary Points

Description of Site	Point ID	Northing (UTM meters, NAD83)	Easting (UTM meters, NAD83)
U-5a, U-5b, U-5e Cavities	1	4073424	594092
U-5a, U-5b, U-5e Cavities	2	4075453	591693
U-5a, U-5b, U-5e Cavities	3	4076439	592504
U-5a, U-5b, U-5e Cavities	4	4074433	594937
U-5a, U-5b, U-5e Cavities	5	4073424	594092



Use Restriction Report

CAU 98

CAS 05-57-004, -005
CAS 11-57-001, -002, -003,- 004, -005
U-5i, U-5k, U-11b, U-11c, U-11e, U-11f, and U-11g Cavities

Map Date: January 9, 2017

EXPLANATION

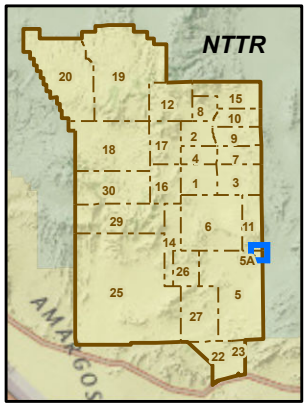
- Use Restriction Point*
- UGTA Subsurface Use Restriction Boundary*
- Secondary Road
- Unimproved Road
- Trail

*Source: Underground Test Area (UGTA) Closure Report for Corrective Action Unit 98: Frenchman Flat, Nevada National Security Site (NNSS), Nevada, Revision 1, Record of Technical Change 1, August 2016.

0 250 500 1,000 1,500 Feet
0 100 200 400 600 Meters

N

Map produced by the NSTec GIS Group.
Product ID: 20160817-01-P002-R01



Map Location

Map Projection: UTM (Zone 11, meters) NAD83

Background scene from ESRI World Imagery (ESRI ArcGIS Online: http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9) accessed 9 January 2017 (Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community).

Overview map background scene from National Geographic Map (ESRI ArcGIS Online: http://www.arcgis.com/home/item.html?id=b9b1b422198944fbbd5250b3241691b6) accessed 9 January 2017 (National Geographic, Esri, DeLorme, NAVTEQ, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, iPC).

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UGTA UR Boundary Points

Description of Site	Point ID	Northing (UTM meters, NAD83)	Easting (UTM meters, NAD83)
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	1	4079457	595991
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	2	4079449	594981
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	3	4081350	594981
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	4	4081350	593287
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	5	4081695	593289
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	6	4081710	594104
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	7	4082971	594109
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	8	4082976	594458
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	9	4082131	594453
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	10	4082126	595997
U-5i,U-5k,U-11b,U-11c, U-11e,U-11f,U-11g Cavities	11	4079457	595991

Active REOPs at Area 5 (as of February 15, 2017)

REOP Number	REOP Name	REOP Description	REOP Document
Primary REOPs			
CNV-0004	CNV-Protective Force Training Complex	CNV Protective Force Training Complex	https://ntsweb.nv.doe.gov/docs/reops/cnv/cnv000400.pdf
CNV-0042	CNV Area 5 Munitions Storage Site	MSM Yankee Area 5	https://ntsweb.nv.doe.gov/docs/reops/cnv/cnv004200.pdf
DOE-0003	Greater Confinement Facility	Greater Confinement Facility	https://ntsweb.nv.doe.gov/docs/reops/doe/doe000300.pdf
DOE-0007	Legacy Sites	Vortex Site 1	https://ntsweb.nv.doe.gov/docs/reops/doe/doe000700.pdf
NAV-0119	Yucca Mountain Permits and Monitoring	UE-5 TR-FF #1	https://ntsweb.nv.doe.gov/docs/reops/nav/nav011900.pdf
		UE-5 TR-FF #2	
NAV-0128	CAU 541 Corrective Action Investigation (AF land)	CAU 541 Air Force Land	https://ntsweb.nv.doe.gov/docs/reops/nav/nav012800.pdf
NSTEC-0016	NNSS Water Systems	05W-ST-5N, Area 5 North Tank	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec001600.pdf
		05W-ST-5S, Area 5 South Tank	
		05-202762, Well 5B	
		Well 5C	
		Booster 5-A	
NSTEC-0033	NOD HiMed Fac	05-ML0027, Parcel 1 Land South of 200 Hill	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec003300.pdf
		05-ML0028, Parcel 2 Land North of 200 Hill	
		05-ML0132, Southwest of NPTEC	
		90-ML0133, Port Gaston Compound	
		90-ML0131, NPTEC Compound	
NSTEC-0039	Fire and Rescue Stations	05-ML0102 - CHECKPOINT PASS TRAINING AREA	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec003900.pdf
NSTEC-0041	Radio Communications Infrastructure	05-14 and 05-15	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec004100.pdf
NSTEC-0055	NNSS Power Distribution Infrastructure	05-S-7, Booster 5-A Substation	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec005500.pdf
		05P-S-FF, 138 kV Frenchman Flat	
NSTEC-0075	NNSS Balance of Plant		https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec007500.pdf
NSTEC-0086	Hazardous Waste Management Area	05-186084 & 05-20 BOUNDARY	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec008600.pdf
NSTEC-0096	Sanitary Waste Disposal	A05 RWMS SEPTIC SYSTEM	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec009600.pdf
		A05 RWMS LAGOON	

Active REOPs at Area 5 (as of February 15, 2017)

REOP Number	REOP Name	REOP Description	REOP Document
NSTEC-0121	Post-Closure Inspections and Maintenance (NNSS)	CAU 005 CAS 05-15-01 [a]	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec012100.pdf
		CAU 005 CAS 05-16-01 East [a]	
		CAU 005 CAS 05-16-01 West [a]	
		CAU 140 CAS 05-23-01	
		CAU 204 CAS 05-18-02	
		CAU 204 CAS 05-33-01	
		CAU 111 CAS 05-21-01 North Covers	
		CAU 111 CAS 05-21-01 South Cover	
		CAU 111 CAS 05-21-01 West Cover	
		Greater Confinement Disposal Borehole - Test	
		CAU 541 - Small Boy	
NSTEC-0145	Underground Test Area Project	ER-5-2	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec014500.pdf
		ER-5-3, ER-5-3 #2, ER-5-3 #3	
		UE-5n	
		ER-5-5	
		U-5a (N1 & N2)	
		ER-5-4, ER-5-4 #2, RNM #1, RNM #2, RNM #2S	
NSTEC-0212	Radioactive Waste Facilities	Area 5 North Pipeline, 05-ML0117	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec021200.pdf
	Radioactive Waste Facilities	05A-ML0120, Area 5 RWMC	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec021200.pdf
NSTEC-0239	NNSS Telecommunications Infrastructure	05-13	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec023900.pdf
	NNSS Telecommunications Infrastructure	05-998653	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec023900.pdf
NSTEC-0269	Base Ops	90-ML0147, Cane Springs Training Area	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec026900.pdf
NSTEC-0279	NNSS Roads and Grounds		https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec027900.pdf
NSTEC-0292	Desert Research FACE Facility	05-ML0070 - NEVADA DESERT FACE FACILITY (NDFF)	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec029200.pdf
		05-ML0071, MGCF	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec029200.pdf
NSTEC-0431	Training and Exercise Venues	05-ML0086, BURMA ROAD	https://ntsweb.nv.doe.gov/docs/reops/nstec/nstec043100.pdf

Active REOPs at Area 5 (as of February 15, 2017)

REOP Number	REOP Name	REOP Description	REOP Document
Secondary REOPs			
ARLSORD-0001	Weather Support for the NNSS	A-05 VERT PRO HSC	https://ntsweb.nv.doe.gov/docs/reops/arlsord/arlsord000100.pdf
		A-05 MEDA 13	
		A-05 MEDA 5	
CHEM-0001	Chemours Fuming Acids Mitigation Workshop	90-ML0131, NPTEC Compound	https://ntsweb.nv.doe.gov/docs/reops/chem/chem000100.pdf
CNV-0028	DAF ESS Training	ESS Training Area	https://ntsweb.nv.doe.gov/docs/reops/cnv/cnv002800.pdf
CNV-0033	CNV-FOF Burma Road	05-ML0086	https://ntsweb.nv.doe.gov/docs/reops/cnv/cnv003300.pdf
CNV-0045	CNV MESH Network	CNV Trailers	https://ntsweb.nv.doe.gov/docs/reops/cnv/cnv004500.pdf
DOD-0010	Base Operations	90-ML0147, Cane Springs Training Area	https://ntsweb.nv.doe.gov/docs/reops/dod/dod001000.pdf
DOD-0019	20th CBRNE	Small Boy	https://ntsweb.nv.doe.gov/docs/reops/dod/dod001900.pdf
DOD-0023	After Charlie	05-ML0086, BURMA ROAD	https://ntsweb.nv.doe.gov/docs/reops/dod/dod002300.pdf
DRI-0004	Nevada Desert Research Center	MGCF	https://ntsweb.nv.doe.gov/docs/reops/dri/dri000400.pdf
		NDFF	
NAV-0026	Navarro UGTA Field Operations	ER-5-2	https://ntsweb.nv.doe.gov/docs/reops/nav/nav002600.pdf
		ER-5-3, ER-5-3 #2, ER-5-3 #3	
		ER-5-4, ER-5-4 #2, RNM #1, RNM #2, RNM #2S	
		ER-5-5	
		U-5a (N1 & N2)	
		UE-5n	
NAV-0127	CAUs 541 and 573 Corrective Action Investigations	CAU 573/541 North	https://ntsweb.nv.doe.gov/docs/reops/nav/nav012700.pdf
		CAU 573/541 South	
NSTEC/S-0005	Hill 200 138 Kv Powerline Reroute	Hill 200 Power Line Reroute	https://ntsweb.nv.doe.gov/docs/reops/nstecs/nstecs000500.pdf
OGA-0004	Tarantula Test Series	05-ML0028, Parcel 2 Land North of 200 Hill	https://ntsweb.nv.doe.gov/docs/reops/oga/oga000400.pdf
		05-ML0027, Parcel 1 Land South of 200 Hill	
		90-ML0133, Port Gaston Compound	
		05-ML0132, Southwest of NPTEC	
		90-ML0131, NPTEC Compound	
SNL-0004	Sandia Seismic Network	Rock Valley - RVFF	https://ntsweb.nv.doe.gov/docs/reops/snl/snl000400.pdf
		200 Hill Infrasound Sites	
		Geophone Sites - A-5	

Active REOPs at Area 5 (as of February 15, 2017)

REOP Number	REOP Name	REOP Description	REOP Document
SNL-0026	UAS (Unmanned Aircraft System) Operations, Sensor Placement and Data Collections	NPTEC Solids Area	https://ntsweb.nv.doe.gov/docs/reops/snl/snl002600.pdf
UNR-0003	UNR Field Tasks - Telemetry and Data Collection	RVFF	https://ntsweb.nv.doe.gov/docs/reops/unr/unr000300.pdf
USGS-0003	USGS Vegetation, Small Mammal and Reptile Studies	Beatley 23, BECAMP FRF001 and FRF004	https://ntsweb.nv.doe.gov/docs/reops/usgs/usgs000300.pdf
		BECAMP FF66	
		BECAMP FRF002	
		BECAMP FRF003	
		BECAMP FRF007	
		Beatley 20	
		Beatley 21	
		Beatley 22	
		Beatley 24	
		Beatley 25	
		Beatley 30	
		Beatley 31	
		Beatley 38	
		BECAMP FRF005	
		BECAMP FRF006	
USGS-0005	Underground Test Area Project (UGTA)	WW-5B	https://ntsweb.nv.doe.gov/docs/reops/usgs/usgs000500.pdf
		WW-5A	
		WW-5C	
		ER-5-5	
		ER-5-3, ER-5-3-2, and ER-5-3-3	
		ER-5-4, ER-5-4-2, RNM-1, RNM-2, and RNM-2S	
		UE-5n	
		UE-5m	

[a] CAU 005 is the same as CAU 5.

From: KAN, MICHAEL K Maj USAF ACC NTTR/SE
To: Jenny Chapman
Cc: CHRISTENSEN, ROGER D GS-12 USAF ACC NTTR/XP
Subject: RE: Institutional Control Monitoring for Frenchman Flat
Date: Tuesday, February 07, 2017 1:32:36 PM

Jenny,

See below for the answers to your questions.

1. What general process control(s) does the USAF use for infrastructure projects that would cause the Use Restrictions (URs) to be recognized in the planning process?
- When the customers' requests require potential construction, an Air Force Form 813 is submitted to request an environmental impact analysis for an undisturbed area. The review process of this 813 would lead to consultation with the newly updated GIS data maps, which would reveal the use restrictions.

2. During 2016, have any new water wells been drilled or are in the planning stages for Frenchman Flat?
- No

3. Are there any USAF activities planned or proposed that may impact groundwater pumping in the Frenchman Flat region?
- Yes, Frenchman Flats spills into Range 65, a live bombing range. Explosives may damage pumping stations and equipment. However, the weapons danger zones are orientated so that fragmentation hazards would not leave the range (and onto the NTS). Therefore, any equipment or facilities for pumping ground water stationed on the NTS side of Frenchman Flats should be safe.

Please feel free to let me know if you need more information.

Mike Kan, Maj, USAF, BSC
Range Radiation Safety Engineer
Nevada Test and Training Range (NTTR), Safety Division
Nellis AFB
DSN: 312 348 4518
Comm: 702 653 4518

-----Original Message-----
From: Jenny Chapman [mailto:Jenny.Chapman@dri.edu]
Sent: Monday, February 06, 2017 1:53 PM
To: KAN, MICHAEL K Maj USAF ACC NTTR/SE <michael.kan@us.af.mil>
Subject: RE: Institutional Control Monitoring for Frenchman Flat

You bet. I appreciate your rapid response.

I am also happy to talk by phone (702-862-5459), and I will be at the DOE Nevada Support Facility for a meeting Thursday and could meet you in person between 7 and 8:30.

Thanks, Jenny

Appendix D

Monitoring Network Inspections and Maintenance

D.1.0 Monitoring Network Inspections and Maintenance

No maintenance activities were conducted on the CAU 98 monitoring wells during 2016.

The water-quality monitoring wells were inspected on January 21, 2016. The general road conditions, well pad conditions, infiltration areas, and surrounding areas were evaluated. Specific conditions are provided in Table D.1-1.

Table D.1-1
Inspection Results in 2016 for Frenchman Flat Water-Quality Monitoring Wells

	ER-5-3_p2	ER-5-3-2	ER-5-5	ER-11-2	RNM-2S	UE-5n
Infiltration area viable?	Yes	Yes	Yes	Yes	Yes	Yes
New roads or facilities constructed?	No	No	No	No	No	No
Changes to drainage pattern or area?	No	No	No	No	No	No

The water-level monitoring wells were inspected in 2016 on March 7, June 6, August 15, and October 24. These inspections considered the well condition (whether locked, marked, or damaged) and condition of the pad and survey point. No compromising conditions were found, as documented in Table D.1-2.

Table D.1-2
Inspection Results for 2016 for Frenchman Flat Water-Level Monitoring Wells

Well	Well Locked?				Well Marked and Undamaged?				Survey Point Marked and Undamaged?				Well Pad in Good Condition (no erosion or standing water)?			
	Mar 7	Jun 6	Aug 15	Oct 24	Mar 7	Jun 6	Aug 15	Oct 24	Mar 7	Jun 6	Aug 15	Oct 24	Mar 7	Jun 6	Aug 15	Oct 24
ER-5-3 deep piez.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ER-5-3 main	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ER-5-3-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ER-5-3-3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ER-5-4 main	X	X	X	X	X	X	X	X	X	X	X	X	See note below			
ER-5-4 piez	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ER-5-4-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ER-5-5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RNM-1	See note below				X	X	X	X	X	X	X	X	X	X	X	X
RNM-2S	See note below				X	X	X	X	X	X	X	X	X	X	X	X
UE-5n	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WW-5A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WW-5B	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WW-4	See note below				X	X	X	X	X	X	X	X	X	X	X	X
WW-4A	See note below				X	X	X	X	X	X	X	X	X	X	X	X
ER-11-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Notes:
ER-5-4 main: Well pad is not clear. Collapsed sediment (2-ft hole) is located at the west side of the well casing. The collapsed sediment area does not appear to provide a flow path for surface water to enter the well.
RNM-1: The well cannot be locked. The well cap is always securely screwed onto the access tube when the field party arrives and is securely screwed onto the access tube before the field party leaves the well.
RNM-2S: The well cannot be locked. The well cap is always securely screwed onto the well when the field party arrives and is securely screwed onto the well before the field party leaves the well.
WW-4: The access tube cannot be locked. The well cap is always securely screwed onto the access tube when the field party arrives and is securely screwed onto the access tube before the field party leaves the well.
WW-4A: The access tube cannot be locked. The well cap is always securely screwed onto the access tube when the field party arrives and is securely screwed onto the access tube before the field party leaves the well.

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