FEDERAL FACILITY AGREEMENT AND CONSENT ORDER (FFACO)
RECORD OF TECHNICAL CHANGE (ROTC)

Corrective Action Unit (CAU) Number: 98
CAU Description: Frenchman Flat
CAU Owner: Underground Test Area (UGTA) - Environmental Restoration (ER)

ROTC No. DOE/EMNV--0035-ROTC 1 **Page** 1 of 2

Document Type Frenchman Flat Five-Year Evaluation **Date** 05/24/2023

The following technical changes (including justification) are requested by:

Kenneth Rehfeldt	Navarro UGTA Project Manager
Requestor Name	Requestor Title

Description of Change:	**Justification:**
1. Section 4.2 Page 39, 1st full paragraph, 12th bullet: Change well name from “WW-4_m1” to “WW-4A_m1”	1. The incorrect well name was listed; change to correct well name.

Schedule Impacts:

No impacts to schedule.

ROTC applies to the following document(s):

- Corrective Action Unit 98: Frenchman Flat Five-Year Evaluation, Nevada National Security Site, Nevada, Revision No. 1, May 2022, DOE/EMNV--0035.

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Nevada Program

DOE/EMNV--0035

Corrective Action Unit 98: Frenchman Flat Five-Year Evaluation Nevada National Security Site, Nevada

Controlled Copy No.: UNCONTROLLED
Revision No.: 1

May 2022

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U.S. Department of Energy
Environmental Management Nevada Program

CORRECTIVE ACTION UNIT 98: FRENCHMAN FLAT FIVE-YEAR EVALUATION NEVADA NATIONAL SECURITY SITE, NEVADA

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

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Revision No.: 1

May 2022

CORRECTIVE ACTION UNIT 98:
FRENCHMAN FLAT FIVE-YEAR EVALUATION
NEVADA NATIONAL SECURITY SITE, NEVADA

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List of Acronyms and Abbreviations

General Acronyms and Abbreviations

AA	Alluvial aquifer
CAU	Corrective action unit
CP	Control Point
CR	Closure report
DOE	U.S. Department of Energy
EM	Environmental Management
FF	Frenchman Flat
ft	Foot
gal/min	Gallons per minute
in.	Inch
ISPID	Integrated Sampling Plan Identifier
LCA	Lower carbonate aquifer
MDC	Minimum detectable concentration
mi	Mile
MWAT	Multiple-well aquifer test
NAD	North American Datum
NGVD	National Geodetic Vertical Datum
NNSS	Nevada National Security Site
NTTR	Nevada Test and Training Range
pCi/L	Picocuries per liter
RN	Radionuclide
ROTC	Record of Technical Change
RWMC	Radioactive Waste Management Complex

List of Acronyms and Abbreviations *(Continued)*

UGTA	Underground Test Area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VA	Volcanic aquifer
µg/L	Micrograms per liter

Symbols for Elements and Compounds

C	Carbon
Cl	Chlorine
^3H	Tritium
I	Iodine
Tc	Technetium

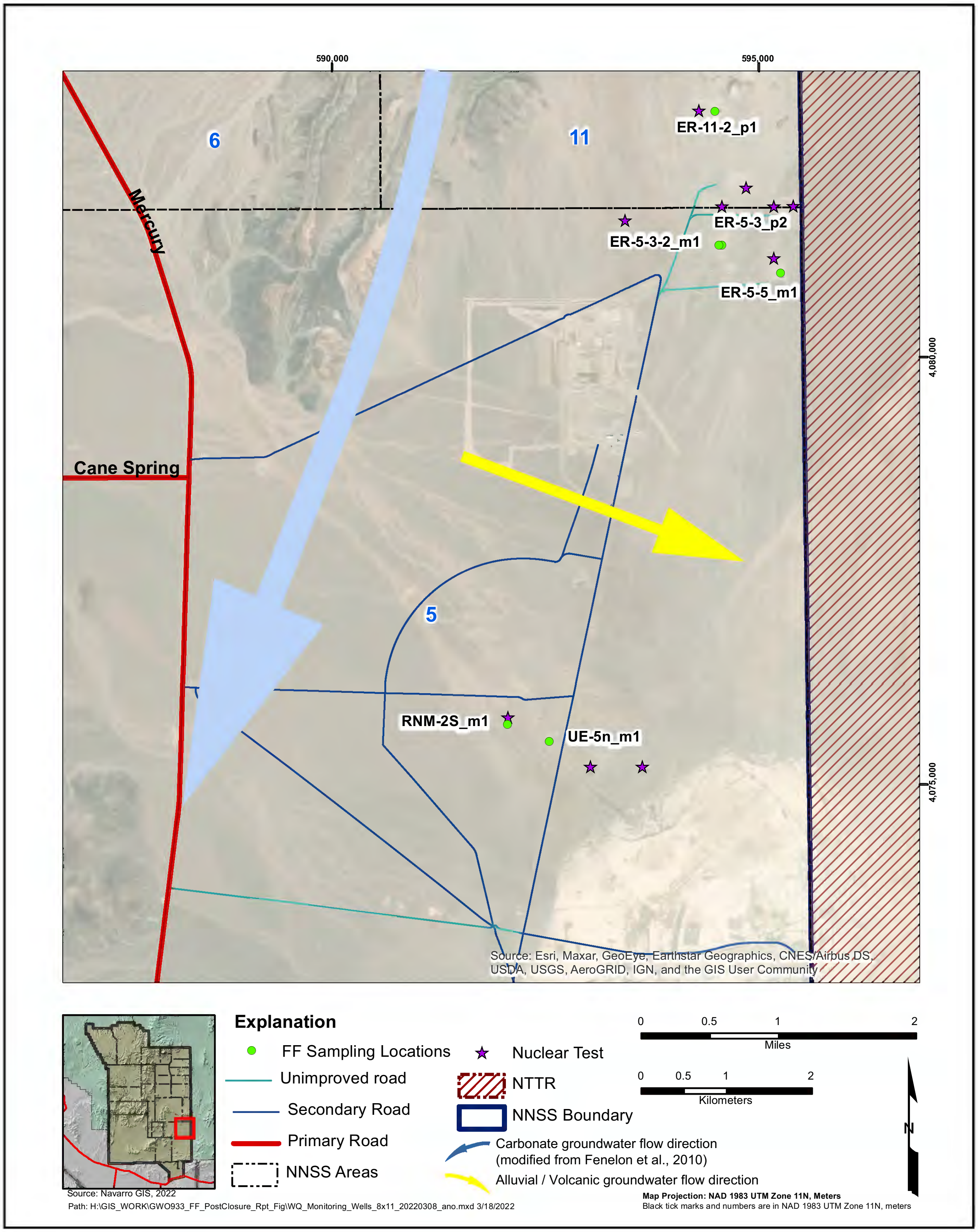
1.0 Frenchman Flat Five-Year Evaluation

The Corrective Action Unit (CAU) 98, Frenchman Flat (FF) Closure Report (CR) (NNSA/NFO, 2016) and its ensuing Records of Technical Change (ROTCs) (compiled in DOE/EMNV, 2019) required the U.S. Department of Energy (DOE), Environmental Management (EM) Nevada Program's Underground Test Area (UGTA) Activity to collect data for five years to establish triggers for the monitoring network and analyze the monitoring points for viability in long-term monitoring. This document provides the results of the five-year evaluation and presents recommendations for future monitoring of CAU 98.

The existing network consists of six long-term monitoring wells that were sampled for water-quality monitoring annually from 2016 through 2020 (Figure 1-1), and 19 water-level monitoring wells (14 wells with 16 completions in the FF post-closure monitoring network, plus three pilot wells at the Area 5 Radioactive Waste Management Complex [RWMC]) that were measured quarterly for the same time period (Figure 1-2).

The five-year evaluation results presented in Sections 2.0 and 3.0 of this report are based on the radionuclide (RN) sampling results and water-level measurements specified in the FF CR (NNSA/NFO, 2016). The FF CR, Section 4.1.1.2 (NNSA/NFO, 2016), states the following: "Groundwater samples from the six long-term monitoring wells will be collected once a year for five consecutive years to establish the initial post-closure conditions." Additionally, the FF CR, Section 4.1.2 states the following: "The objective of measuring water levels is to verify groundwater conditions have not changed—in particular, due to pumping, seismic events, or climate change. Water-level data will be collected in and around the FF CAU to support long-term monitoring activities for the UGTA Activity. For the first five years, water levels will be measured in 16 completions on a quarterly basis."

The five-year data collection presented in this report provides a baseline that was used to make recommendations in Section 4.0 for ongoing monitoring in the FF CAU. The FF CR, Section 4.1.5 states the following: "The initial five years of data will provide a baseline to evaluate future data and make recommendations regarding the monitoring strategy. The evaluation will consider the method and frequency of groundwater sampling, laboratory analyses, frequency of water-level measurements, and number of wells requiring monitoring."



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Source: Navarro GIS, 2022

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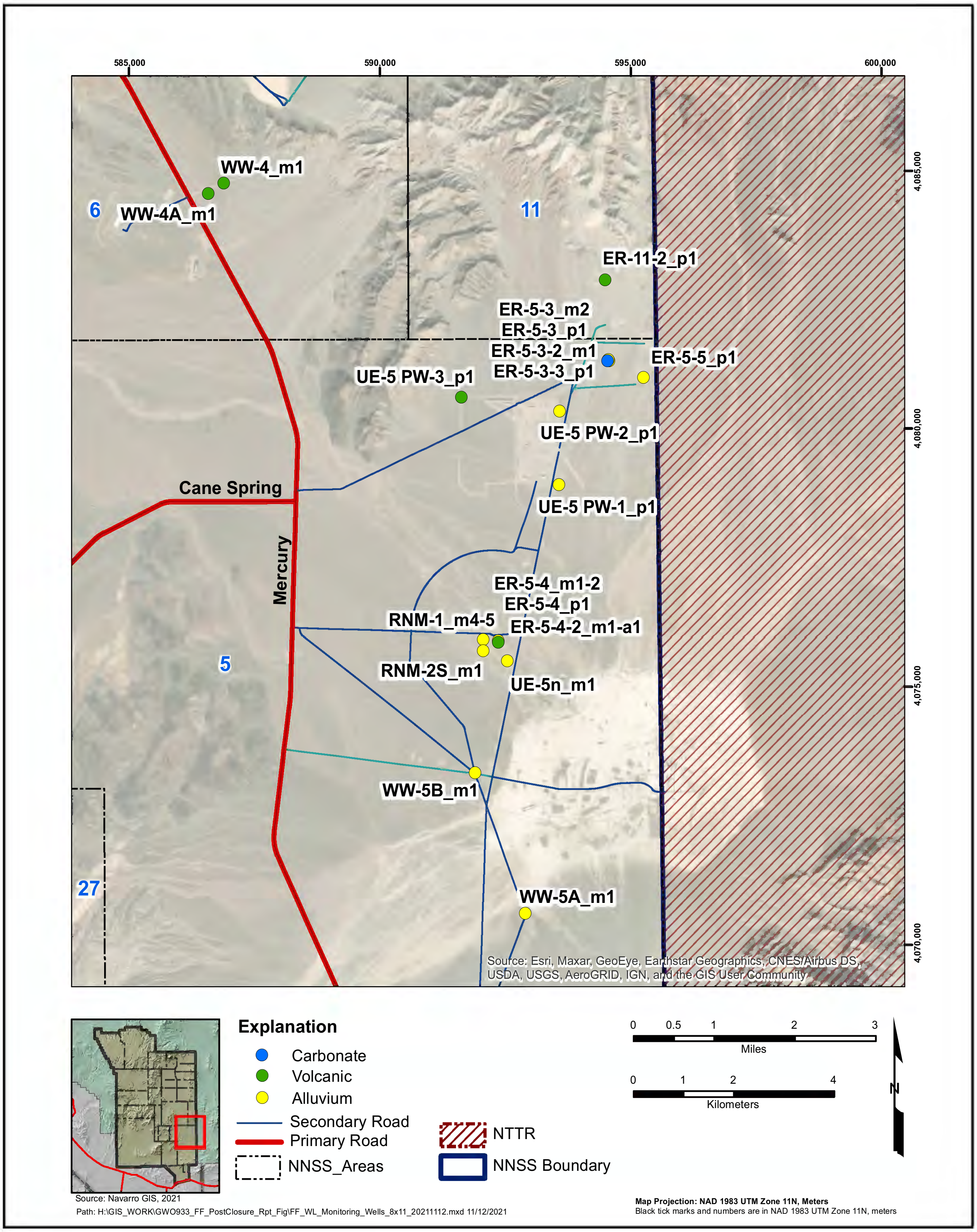
Map Projection: NAD 1983 UTM Zone 11N, Meters
Black tick marks and numbers are in NAD 1983 UTM Zone 11N, meters

Figure 1-1
FF Groundwater Sampling Locations



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Map Projection: NAD 1983 UTM Zone 11N, Meters
Black tick marks and numbers are in NAD 1983 UTM Zone 11N, meters

Figure 1-2
FF Water-Level Measurement Locations

2.0 Evaluation of Water-Quality Sampling Data

The evaluation of the water-quality samples is divided into the northern wells (ER-5-3_p2, ER-5-3-2_m1, ER-5-5_m1, and ER-11-2_p1) and the southern wells (RNM-2s_m1 and UE-5n_m1). Table 2-1 presents the RN sample results from the first five years of long-term monitoring in FF (2016 through 2020).

Table 2-1
RN Sampling Results from Long-Term Monitoring (2016–2020)
(Page 1 of 3)

Well and ISPID	Sample Date	^{3}H	Low-Level ^{3}H	^{14}C	^{36}Cl	^{99}Tc	^{129}I
	pCi/L						
ER-5-3_p2	06/07/2016 [a]	<360	<3.73	<420	--	--	--
	04/06/2017 [a]	--	<2.67	--	--	--	--
	01/31/2018 [a]	--	<2.91	--	--	--	--
	01/29/2019 [a]	--	<2.41	--	--	--	--
	02/06/2020 [a]	--	<2.54 | <3.16	--	--	--	--
ER-5-3-2_m1	05/19/2016 [b]	<340	<3.71	J <400	<3.1	<7.4	<0.93
	03/14/2017 [b]	<247	<2.82	<2.91	<2.69	<8.48	<0.749
	01/30/2018 [b]	--	<3.14 | <2.83	--	--	--	--
	01/23/2019 [b]	--	<3.1	--	--	--	--
	02/04/2020 [b]	--	<3.01	--	--	--	--
ER-5-5_m1	05/16/2016 [b]	<350 | <350	--	J <410 | J <410	<2.8 | <2.6	<7.0 | <7.2	<0.76 | <0.75
	05/16/2016 [b, c]	<249	<3.65	<3.09	<2.97	<5.93	<0.836
	03/08/2017 [b]	<246 | <248	<2.81 | <2.77	<3.14 | <2.83	<2.69 | <2.85	<8.27 | <9.07	<1.15 | <0.243
	01/24/2018 [b]	--	<2.66 | <2.97	--	--	--	--
	01/16/2019 [b]	--	<2.79	--	--	--	--
	01/30/2020 [b]	--	<3.28	--	--	--	--

Table 2-1
RN Sampling Results from Long-Term Monitoring (2016–2020)
(Page 2 of 3)

Well and ISPID	Sample Date	^{3}H	Low-Level ^{3}H	^{14}C	^{36}Cl	^{99}Tc	^{129}I
	pCi/L						
ER-11-2_p1	04/19/2016 [a]	--	J 17.48	--	--	--	--
	06/29/2016 [a]	--	<2.99	--	--	--	--
	04/01/2017 [a]	--	<3.03 | <2.88	--	--	--	--
	02/05/2018 [a]	--	<3.03 | <2.47	--	--	--	--
	02/05/2019 [a]	--	<2.61 | <2.75	--	--	--	--
	02/11/2020 [a]	--	<2.91	--	--	--	--
RNM-2s_m1	05/10/2016 [b]	76,000 | 75,000	--	J <400 | J <410	<3.3 | <3.2	<6.9 | <6.8	<0.69 | <0.69
	03/06/2017 [b]	86,000 | 85,000	--	<410 | <400	<3.6 | <2.9	<7.8 | <8.0	<0.74 | <0.71
	01/22/2018 [b]	82,000 | 80,000	--	<380 | <370	<3.2 | <2.9	<7.3 | <7.7	<0.81 | <0.86
	01/14/2019 [b]	65,000 | 74,800	--	<648 | <626	J <21 | <21.1	<8.15 | <8.23	<0.512 | <0.296
	01/27/2020 [b]	65,100 | 65,000	--	<635 | <649	<2.99 | <4.01	<8.98 | <7.09	<0.949 | <0.833
UE-5n_m1	05/05/2016 [b]	135,000	--	J <420	<2.6	<7.0	<0.73
	03/01/2017 [b]	132,000	--	<400	<2.8	<7.4	<0.69
	01/18/2018 [b]	123,000	--	<380	<2.7	<7.5	<0.82
	01/10/2019 [b]	120,000	--	<645	<21.3	<8.26	<0.498
	01/22/2020 [b]	116,000	--	<153	<2.7	<6.1	<0.77

Table 2-1
RN Sampling Results from Long-Term Monitoring (2016–2020)
(Page 3 of 3)

Well and ISPID	Sample Date	^3H	Low-Level ^3H	^{14}C	^{36}Cl	^{99}Tc	^{129}I
	pCi/L						

Source: Navarro, 2021

[a] Sample collected using a depth-discrete bailer.
[b] Sample collected using an electric submersible pump.
[c] Sample was analyzed by a different laboratory.

C = Carbon
Cl = Chlorine
^3H = Tritium
I = Iodine

MDC = Minimum detectable concentration
pCi/L = Picocuries per liter
Tc = Technetium

J = Estimated value.
-- = Not analyzed.

Notes:
(1) The symbol “|” reports the sample and field duplicate results.
(2) The numeric values reported in the table represent the MDC for that analysis; the “<” symbol indicates a sample result less than the MDC.
(3) Detection limits are evaluated on a periodic basis (typically, yearly). Each laboratory performs a detection limit study using blanks and spiked samples analyzed on different dates. Seven repetitions are analyzed, and a statistical calculation is performed based on a student-t distribution. They are calculated to measure and report with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. The limits change based on instrument performance, detector sensitivity, background analyte concentrations in the laboratory, type of instrument used, analyst experience spiking materials used, and laboratory performing the work.

For the northern wells, RN sampling has not identified low-level ^3H above the MDC in any well during the five-year evaluation period. The consistent nondetects for low-level ^3H in the northern wells indicate the ^3H in those wells has remained stable during for the five-year evaluation period, suggests no RN plumes at the monitoring wells at this time, and agrees with flow and transport modeling in FF (N-I, 2014, Figure A-7) that forecasts minimal contaminant movement.

Two wells in the southern portion of the basin, RNM-2s_m1 and UE-5n_m1, have detectable ^3H concentrations as a result of the CAMBRIC forced gradient tracer experiment and the discharge of pumped water into the Cambric Ditch (Travis et al., 1983; Tompson et al., 2005). Figures 2-1 and 2-2 show the ^3H concentration measured in samples collected during the five-year evaluation period (plotted as data for years 2016 through 2020) and from previously collected samples taken from RNM-2s_m1 and UE-5n_m1, respectively. The figures allow the five-year evaluation data to be viewed in the context of longer trends in ^3H concentration. In both wells, data show a consistent

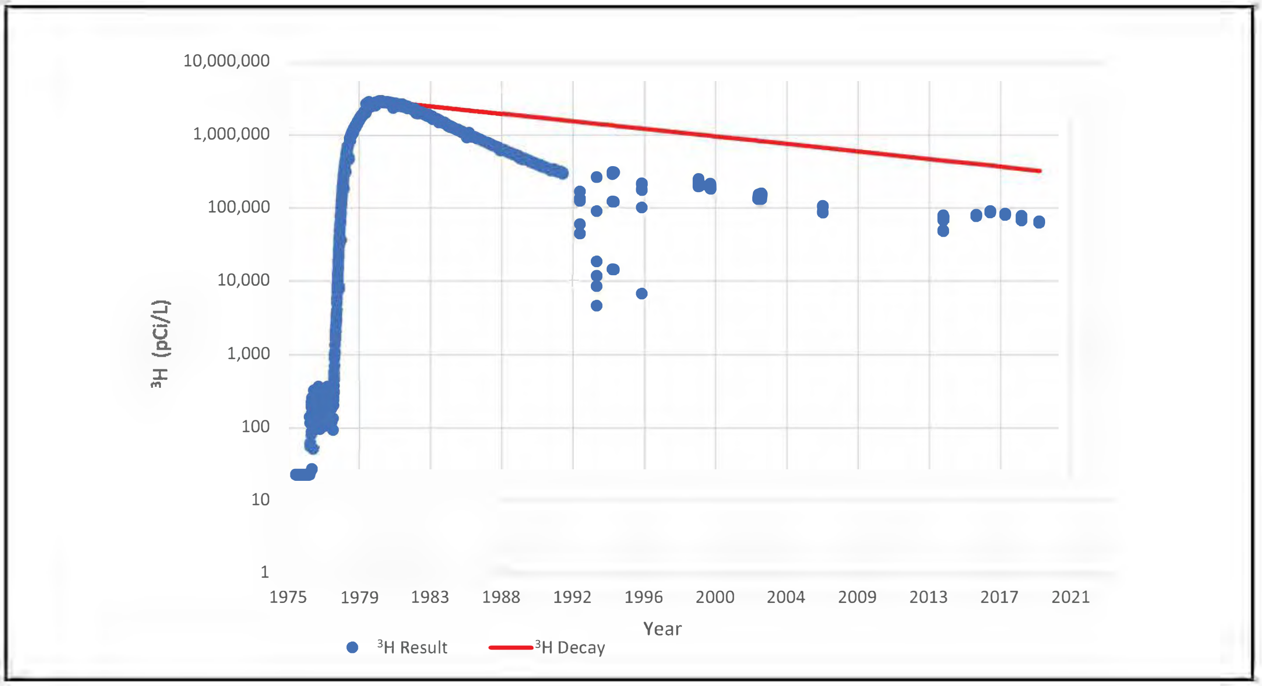

Figure 2-1

Trend in ^{3}H Concentration Measured in Samples from RNM-2s_m1

Source: Navarro, 2021

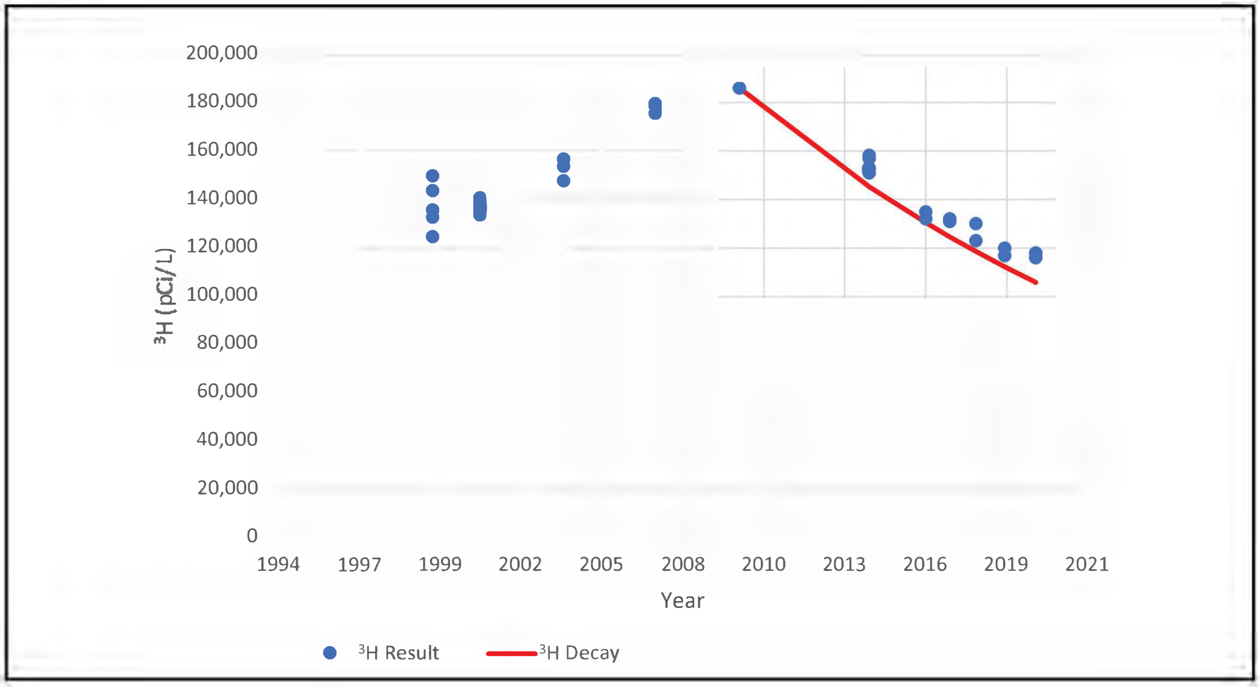

Figure 2-2

Trend in ^{3}H Concentration Measured in Samples from UE-5n_m1

Source: Navarro, 2021

downward trend in ^{3}H concentrations for the five-year evaluation period. In both figures, a decay curve has been added to show how ^{3}H concentrations would have changed over time when considering only radioactive decay.

In Figure 2-1 for RNM-2s, the ^{3}H concentration rose rapidly during the CAMBRIC experiment and reached a peak concentration in about 1980. As the experiment continued, the ^{3}H concentration continued to decline until the test was terminated in late 1991. The peak ^{3}H value decreased faster than simple radioactive decay from a peak in about 1980 until late 1991 when the pumping ceased (Tompson et al., 2005). That more rapid decline in ^{3}H concentration was the result of pumping from RNM-2s during the experiment. From 1992 to the present, the trend in ^{3}H concentrations in RNM-2s has generally followed a trend parallel to the simple ^{3}H radioactive decay curve. This supports the idea that groundwater in the vicinity of RNM-2s is now moving very slowly under a natural gradient, and the primary mechanism reducing the ^{3}H concentration is radioactive decay.

For UE-5n (Figure 2-2) the ^{3}H concentration shows the impact of the infiltration of water pumped from RNM-2s into the Cambric Ditch. Tritium concentrations in UE-5n continued to rise after the cessation of pumping in late 1991 until about 2010. After 2010 the rate of infiltration to the water table slowed sufficiently that ^{3}H concentrations began to decline. Shortly after 2010, the rate of ^{3}H concentration decrease was slightly slower than pure radioactive decay. During the five-year evaluation period, the trend in ^{3}H concentration in UE-5n also parallels the ^{3}H decay curve. This also supports the expectation that groundwater flow under natural gradient conditions is slow. Other RNs (^{14}C, ^{129}I, ^{36}Cl, and ^{99}Tc) sampled in these two wells (Table 2-1) all have been below the MDCs.

3.0 Evaluation of Water-Level Measurement Data

Water-level hydrographs provide the necessary data to evaluate whether groundwater conditions have changed. The water-level data are evaluated in five groups: (1) alluvial aquifers (AAs) and volcanic aquifers (VAs) in the northern portion of the FF Basin, (2) AAs and VAs in the central portion of the FF Basin, (3) lower carbonate aquifer (LCA), (4) southern portion of the FF Basin, and (5) Control Point (CP) Basin.

The northern FF Basin AA and VA water-level measurements come from ER-5-3_p1 (Figures 3-1 and 3-2), ER-5-3_m2 (Figures 3-1 and 3-3), ER-5-3-3_p1 (Figures 3-1 and 3-4), ER-5-5_p1 and ER-5-5_m1 (Figures 3-5 through 3-7), and ER-11-2_p1 (Figures 3-8 and 3-9). Two of the pilot wells, UE-5 PW-1_p1 (Figures 3-5 and 3-10) and UE-5 PW-2_p1 (Figures 3-5 and 3-11), are also considered to be located in the northern portion of the basin. Water-level data are reported from ER-5-5 in both the m1 and p1 completions; these two completions measure nearly identical intervals. The m1 completion contains the pump string, which is used to sample the well for water quality. Water-level measurements are also made in the pump string before pumping and quarterly by the U.S. Geological Survey (USGS). The p1 completion contains a downhole transducer used to obtain continuous water-level records. Data from both completions are reported in this document. The water-level measurements in the wells located in the northern portion of the FF Basin have shown consistent trends over extended periods of time (Figures 3-1 and 3-5). Consistent trends indicate that these water-level monitoring locations provide useful long-term data to assess changes to the FF groundwater flow system. The water levels in ER-5-3_m2 and ER-5-3-3_p1 are very similar and have trended downward for the past 14 years. Both wells are completed in the same geologic interval and appear to provide duplicate information. The deep piezometer, ER-5-3_p1, completed in the older alluvium, has shown an increasing water-level trend over the past 18 years. These contrasting trends may indicate the magnitude of the vertical gradient in the alluvium at the ER-5-3 location has been decreasing with time. The water level at ER-11-2_p1 appears to be steady over the past five years. ER-5-5_m1 has a consistent downward trend of water level since 2013. The water levels in the two pilot wells, UE-5 PW-1_p1 and UE-5 PW-2_p1, have both shown a consistent downward trend since 1998.

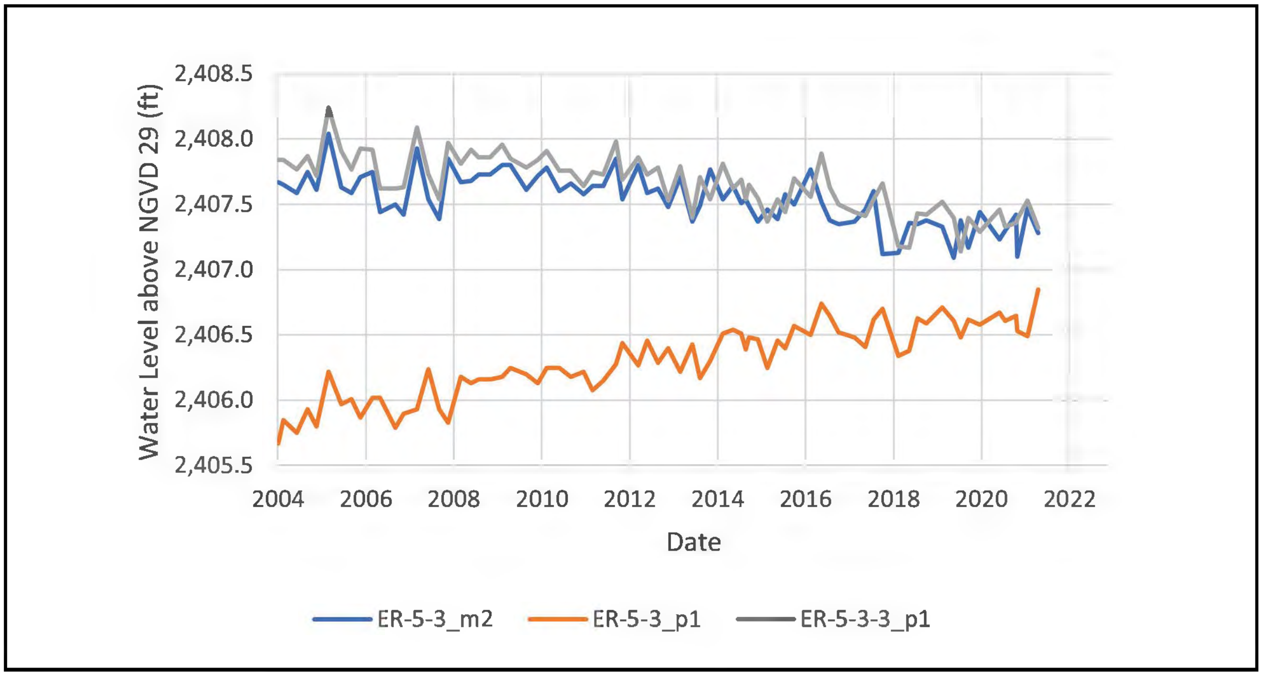

Figure 3-1
Long-Term Water-Level Trends in the AA Wells ER-5-3_m2 and ER-5-3-3_p1, and the AA/VA Well ER-5-3_p1
Source: USGS, 2021

The water-level measurements in many of the wells located in the central portion of the FF Basin have shown consistent trends over extended over periods of time (Figures 3-8 and 3-12.). Consistent trends indicate that these water-level monitoring locations provide useful long-term data to assess changes to the FF groundwater flow system. The water levels in the central portion of the basin come from a number of wells, including ER-5-4_m1-2 (Figures 3-12 and 3-13), ER-5-4_p1 (Figures 3-12 and 3-14), ER-5-4-2_m1-a1 (Figures 3-8 and 3-15), RNM-1_m4-5 (Figures 3-12 and 3-16), RNM-2s_m1 (Figures 3-12 and 3-17), UE-5n_m1 (Figures 3-12 and 3-18), and pilot well UE-5 PW-3_p1 (Figures 3-8 and 3-19). With the exception of ER-5-4-2_m1-a1, these wells have shown a consistent downward trend in water levels since about 2006. The ER-5-4-2 location also has had consistent water levels since at least 2006, but it appears the water levels have not decreased. The water-level trend at ER-5-4-2_m1-a1 (Figure 3-15) shows an increasing trend that differs from other nearby wells. It appears the well is recovering slowly from a drawdown event in 2003. The rate of recovery has decreased consistently over time, but water levels in the well have been following a consistent trend for nearly two decades.

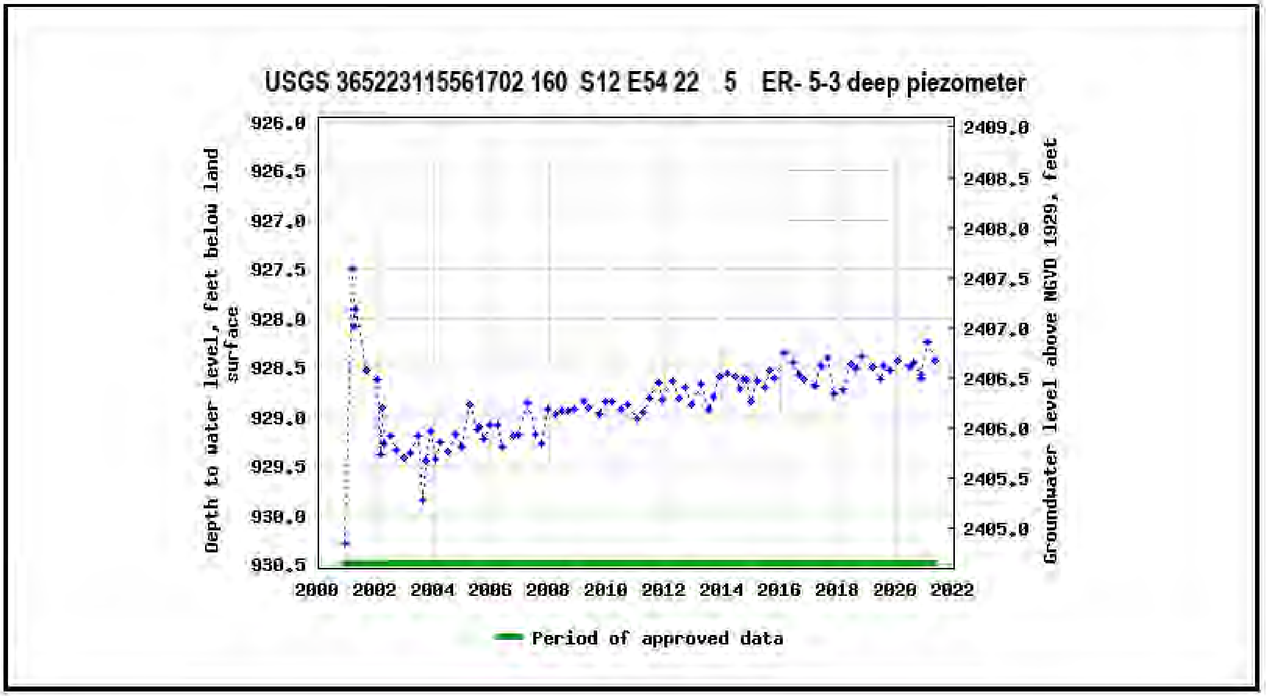

Figure 3-2
Water Levels in ER-5-3_p1
Source: USGS/DOE, 2021

ER-5-3_p1 (deep piezometer): Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. Water levels show about a 2-foot (ft) declining trend from March 2001 to February 2002 followed by a rising trend of about 1.1 ft through the middle of 2021. The initial declining trend followed by the long rising trend through early 2021 may be due to be delayed drawdown and slow equilibration of water levels after withdrawals from the main completion zones in 2001. Water levels are consistent and considered representative of steady-state conditions in the AAs and VAs open to the well. Currently, water levels in ER-5-3_p1 (deep piezometer) are about 0.5 ft lower in altitude than water levels ER-5-3_p2 (shallow piezometer), indicating a downward hydraulic gradient from the alluvium to the volcanic rocks.

ER-5-3-2_m1 is the only well in the FF Basin completed in the regional LCA (Figures 3-20 and 3-21). This well experienced a rapid drop in water level in 2016 after pumping, and the water-level trend has continued at the now steady value since 2016. The cause of the sudden drop in water level is unknown but does not appear to be related to natural changes in LCA water levels. An investigation of the potential cause or causes of the water-level changes in ER-5-3-2_m1 was conducted by USGS. Their findings are documented in a draft report that was undergoing internal USGS and UGTA Activity subject matter expert reviews at the time this five-year evaluation report was prepared. Specific findings will be released when the USGS investigation report is published, but a general conclusion of the USGS investigation is that ER-5-3-2_m1 is a viable sampling location for the LCA in FF based on the similarity of the water chemistry to other LCA water samples in the vicinity.

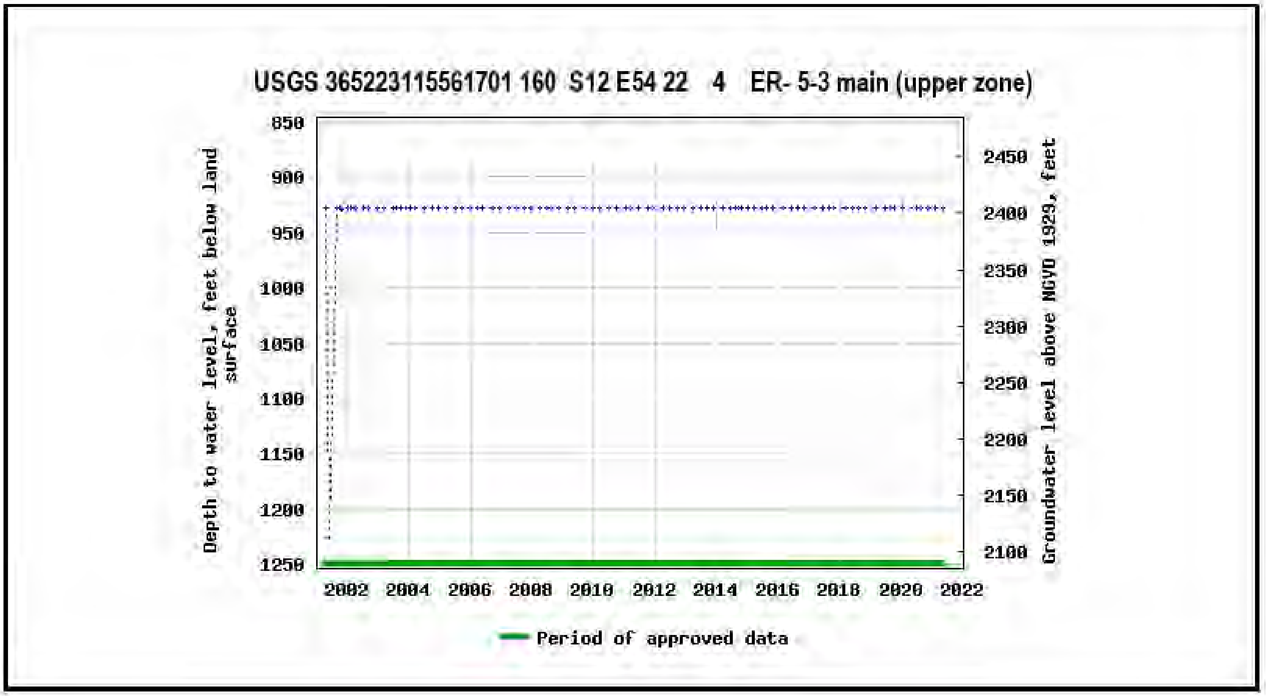

Figure 3-3
Water Levels in ER-5-3_m2
Source: USGS/DOE, 2021

ER-5-3_m2 (main completion – upper): Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. The water levels show a slight declining trend beginning in September 2009 with an overall change of less than 1 ft and are considered representative of steady-state conditions in the AA open to the well. Two anomalous water levels are the result of activity in the well: (1) a water level on May 23, 2001, affected by pumping in the well; and (2) a water level on October 15, 2001 that may be affected by installation of a permanent bridge plug.

The southern portion of the basin is represented by water-level measurements in WW-5A (Figures 3-22 and 3-23) and WW-5B (Figures 3-22 and 3-24). Both these locations show long-term water-level trends directly related to pumping. At WW-5B, continued groundwater withdrawals have resulted in a long-term declining water-level trend. At WW-5A, the cessation of pumping about 40 years ago and decreased pumping in the vicinity of WW-5A since 1995 has resulted in a long-term water-level rise as the groundwater level recovers from the historic pumpage.

The water levels in CP Basin, as represented by water-level records from WW-4 (Figures 3-25 and 3-26) and WW-4A (Figures 3-25 and 3-27), show the impact of water production from those wells. The conceptual model of the groundwater flow systems in the vicinity of CP Basin suggests that the withdrawals of water in WW-4 and WW-4A are not likely to impact the water levels around the

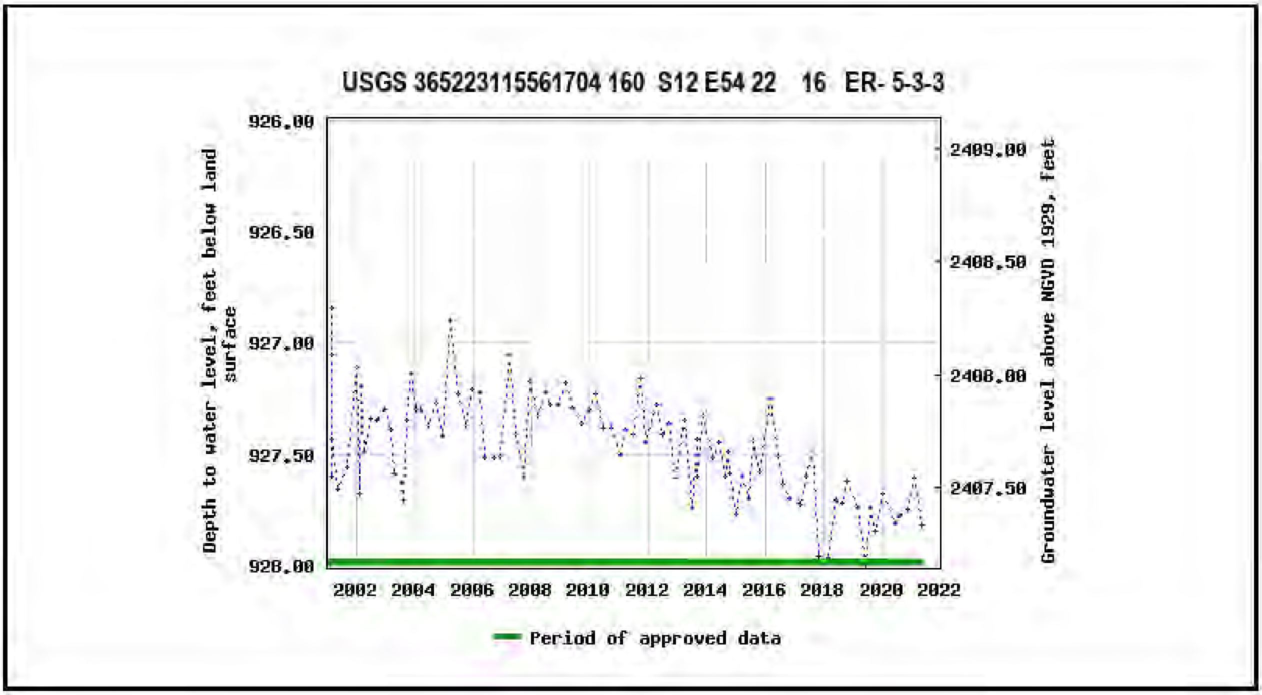

Figure 3-4
Water Levels in ER-5-3-3_p1
Source: USGS/DOE, 2021

ER-5-3-3_p1: Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. Water levels are consistent through March 2009, followed by a slight declining trend through the present (2021). Overall, water levels vary by about 0.5 ft and are considered representative of steady-state conditions in the AA.

underground tests in FF. As shown in Figure 3-25, the water-level hydrographs from WW-4 and WW-4a show similar trends and appear to provide duplicate trend information.

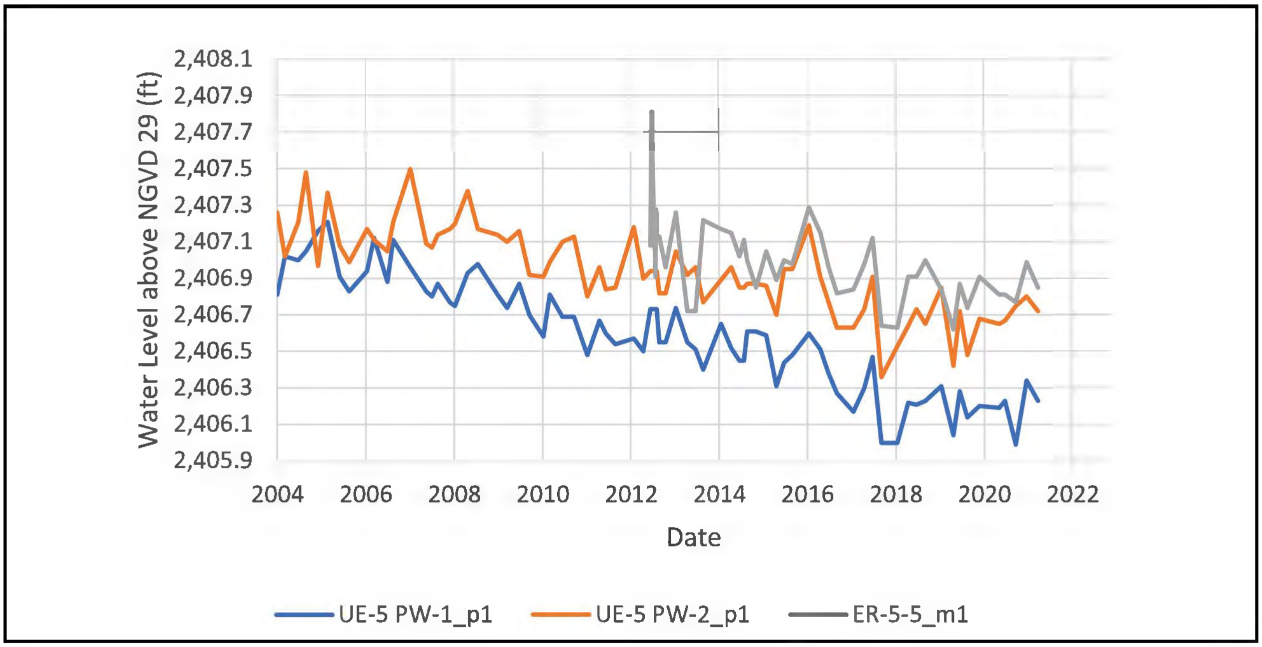

Figure 3-5
Long-Term Water-Level Trends in the AA Wells ER-5-5_m1, UE-5 PW-1_p1, and UE-5 PW-2_p1
Source: USGS, 2021

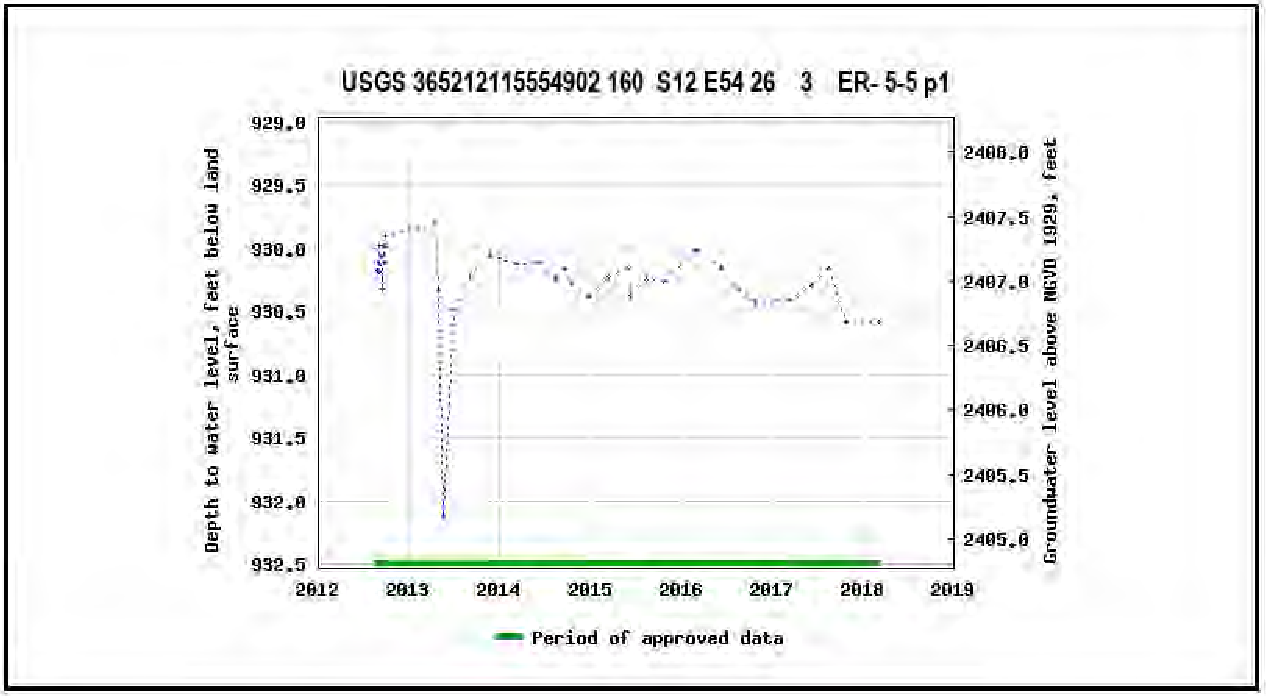

Figure 3-6
Water Levels in ER-5-5_p1
Source: USGS/DOE, 2021

ER-5-5_p1: Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. This piezometer monitors the same completion zone as the main completion casing (ER-5-5_m1), and water-level altitudes in both wells are nearly identical. Two water levels measured in ER-5-5_p1 are anomalous due to pumping from well development and testing activities in May and June 2013.

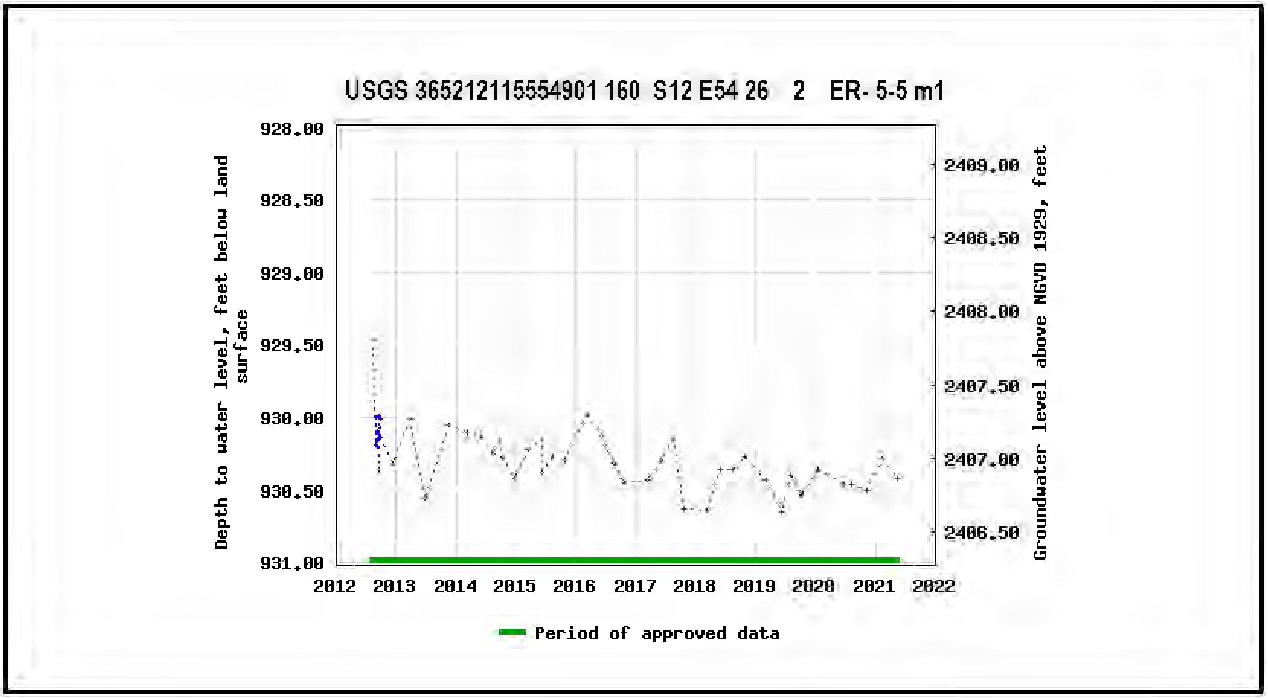

Figure 3-7
Water Levels in ER-5-5_m1
Source: USGS/DOE, 2021

ER-5-5_m1: Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. This casing monitors the same completion zone as the piezometer string (ER-5-5 p1), and water-level altitudes in both wells are nearly identical. The initial water level in ER-5-5_m1, measured on the same day well construction was completed, may have been affected by construction activities. With the exception of one measurement in June 2013 (caused by pumping), all subsequent water levels are consistent with water-level altitudes measured in nearby wells completed in the alluvium and are considered representative of steady-state conditions in the AA open to the well.

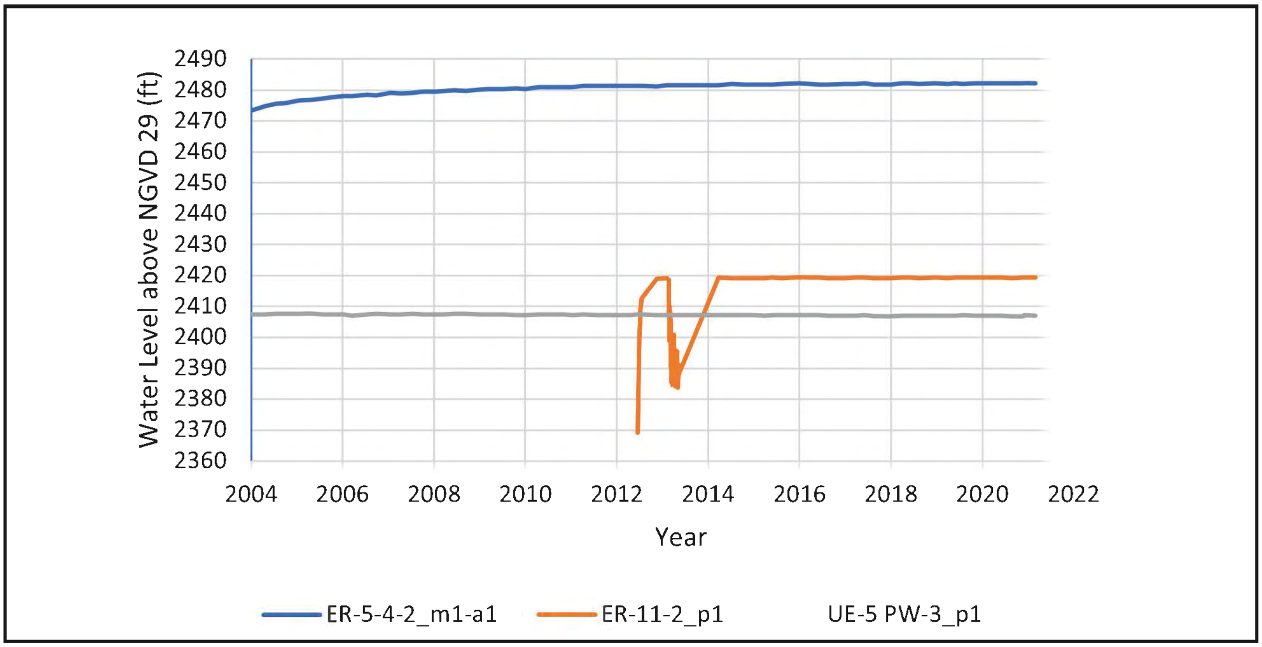

Figure 3-8
Long-Term Water-Level Trends in the VA Wells ER-5-4-2_m1-a1, ER-11-2_p1, and UE-5 PW-3_p1
Source: USGS, 2021

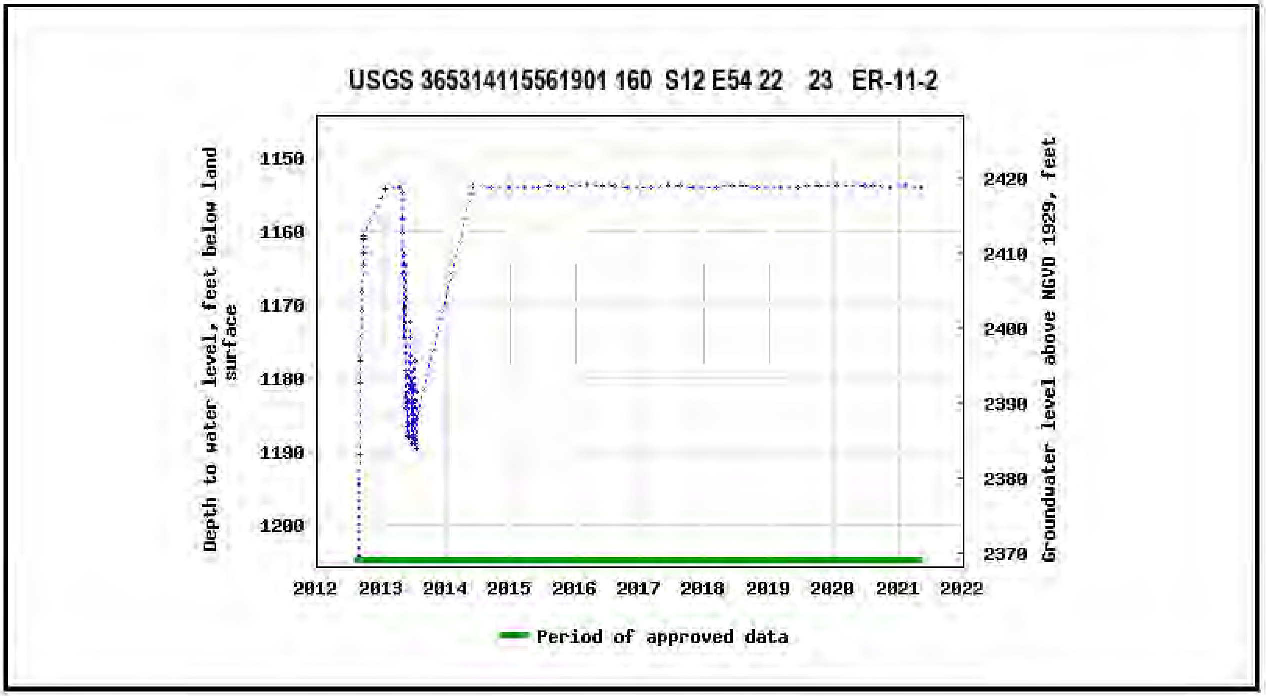

Figure 3-9
Water Levels in ER-11-2_p1
Source: USGS/DOE, 2021

ER-11-2_p1: Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. Water levels before 2014 are impacted by well construction and development and testing activities. The remaining water levels to the present are consistent and considered representative of steady-state conditions in the volcanic confining unit open to the well.

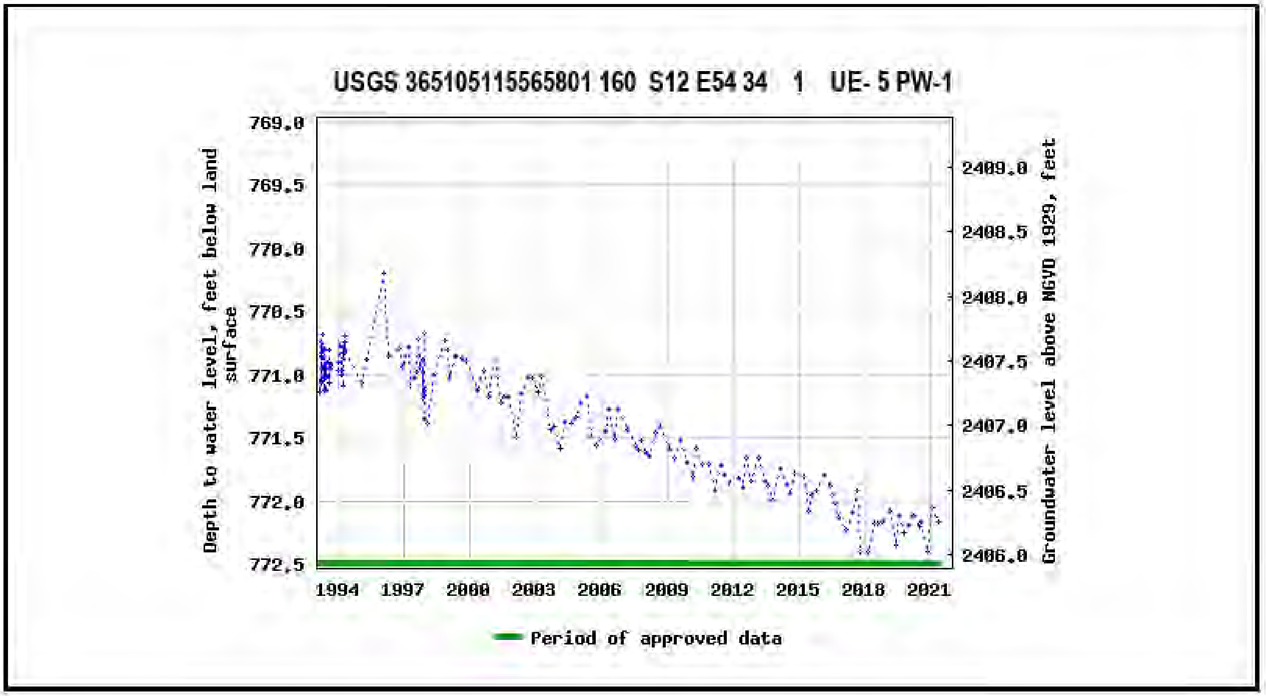

Figure 3-10
Water Levels in UE-5 PW-1_p1
Source: USGS/DOE, 2021

UE-5 PW-1_p1: Elliott and Fenelon (2010) provide an expanded description of the water-level records, a summary of which is provided here. UE-5 PW-1 is open below the water table to alluvium. This well is one of three pilot wells constructed to monitor the Area 5 RWMC. Water levels in UE-5 PW-1 show a downward trend beginning in 1996 but, overall, have remained consistent from 1993 to 2021. During the period of record, UE-5 PW-1 water levels varied by about 1 ft. The declining trends are interpreted to be the result of pumping from wells to the south of UE-5 PW-1. Since 1951, five wells have had large amounts of water withdrawn from them: RMN-2s, UE-5c WW, WW-5A, WW-5B, and WW-5C. Only two of these wells, WW-5B and WW-5C, have been used significantly since 2000. However, the declining trend in UE-5 PW-1 may in part, or entirely, be the result of past pluvial conditions in the AA. If this is the case, then the declining water-level trend is attributed to dissipation of pluvial heads in the AA as water levels equilibrate to heads in underlying units. All three pilot wells have shown a consistent trend for more than 20 years.

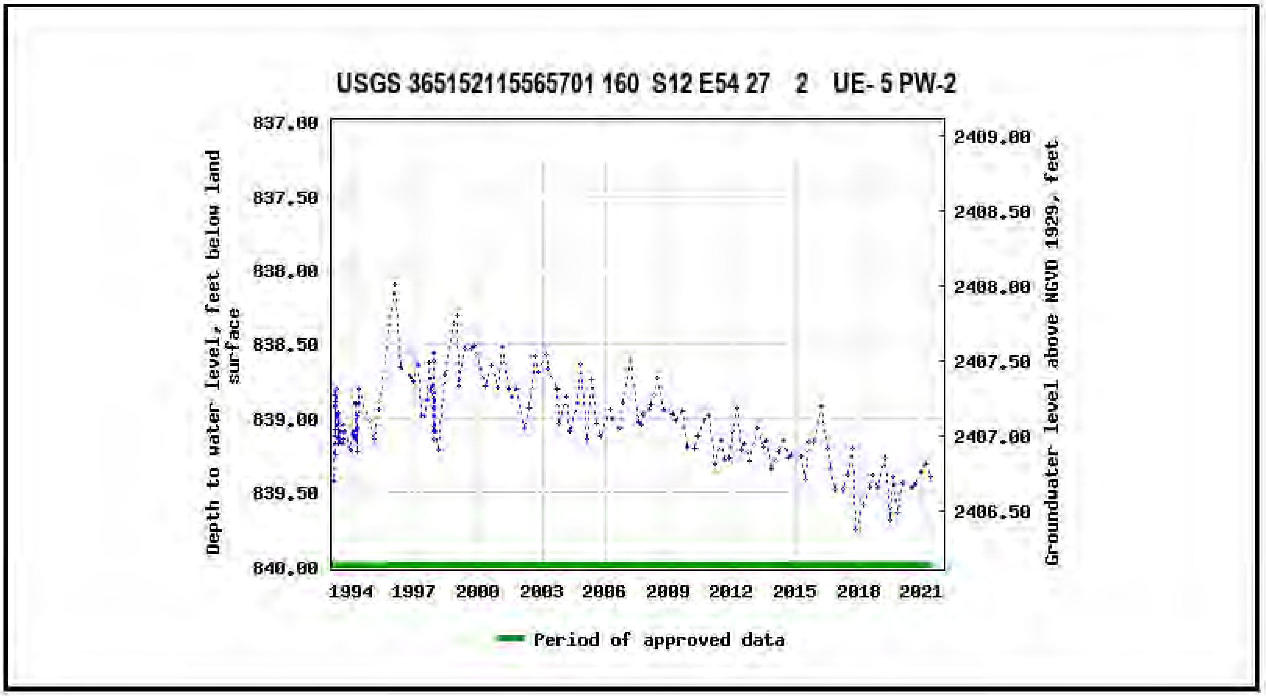

Figure 3-11
Water Levels in UE-5 PW-2_p1
Source: USGS/DOE, 2021

UE-5 PW-2-p1: Elliott and Fenelon (2010) provide an expanded description of the water-level records, a summary of which is provided here. UE-5 PW-2 is open below the water table to alluvium. This well is one of three pilot wells constructed to monitor the Area 5 RWMC. Water levels in UE-5 PW-2 show a noisy but slight rising trend followed by a clearly defined downward trend beginning in about 2000. The UE-5 PW-2 water-level trend is similar to the trend in UE-5 PW-3, 1.2 miles (mi) to the northwest. Water levels in UE-5 PW-2 through 1998 are considered representative of steady-state conditions in the AA. The transient water levels in UE-5 PW-2 are interpreted to be declining at a slower rate than in UE-5 PW-1 because UE-5 PW-2 is further away from the pumping wells. Since 1951, five wells have had large amounts of water withdrawn from them: RMN-2s, UE-5c WW, WW-5A, WW-5B, and WW-5C. Only two of these wells, WW-5B and WW-5C, have been used significantly since 2000. However, the declining trend in UE-5 PW-2 may in part, or entirely, be the result of past pluvial conditions in the AA. If this is the case, then the declining water-level trend is attributed to dissipation of pluvial heads in the AA as water levels equilibrate to heads in underlying units. All three pilot wells have shown a consistent trend for more than 20 years.

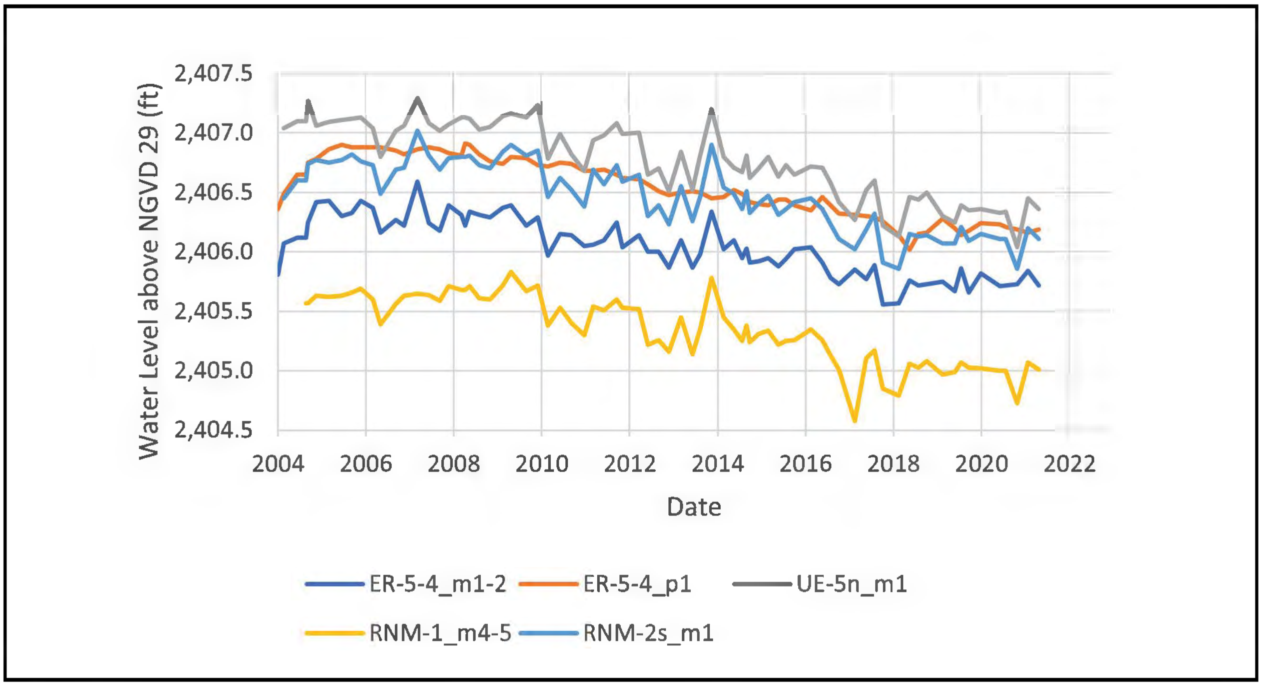

Figure 3-12
Long-Term Water-Level Trends in the AA Wells ER-5-4_p1, UE-5n_m1, RNM-1_m4-5, and RNM-2s_m1; and in the AA/VA Well ER-5-4_m1-2
Source: USGS, 2021

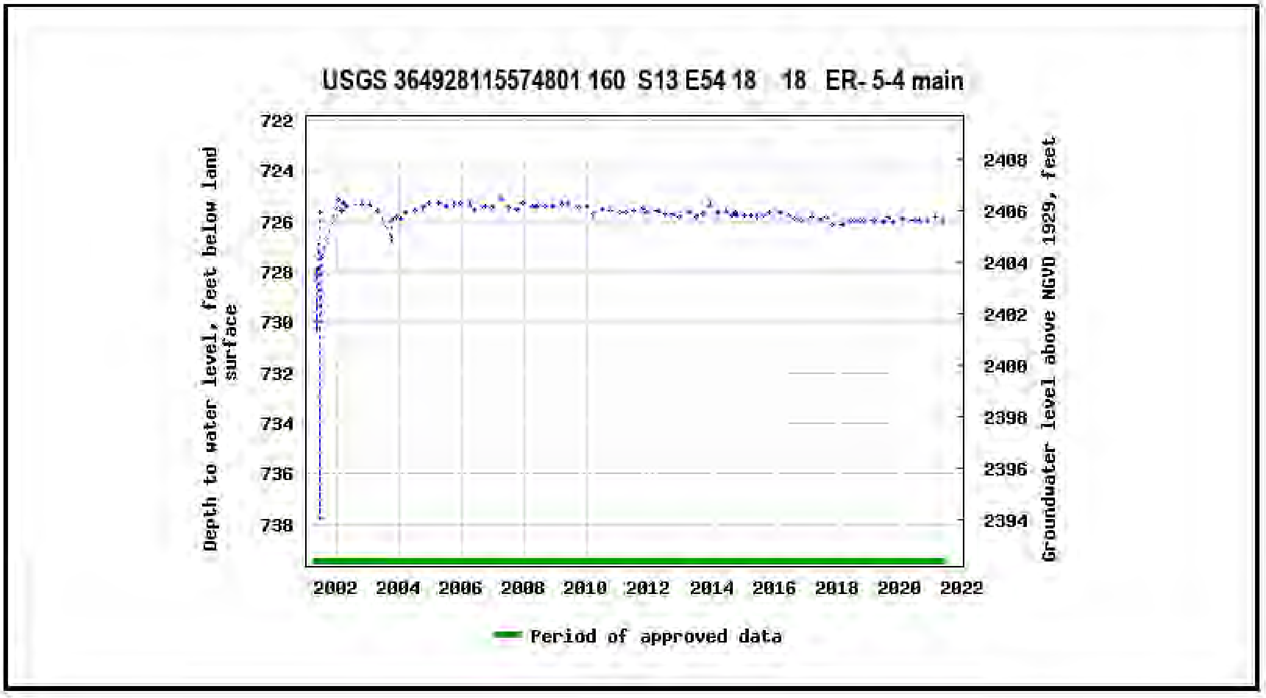

Figure 3-13
Water Levels in ER-5-4_m1-2
Source: USGS/DOE, 2021

ER-5-4_m1-2 (main): Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. ER-5-4_m1-2 (main) is the larger diameter of two well strings in hole ER-5-4. The well string has two completion zones, both of which are open. Water levels before 2005 show effects from development and testing at the well and pumping from nearby wells (RNM-2s). Subsequent water levels show an overall declining trend and are about 4 to 5 ft lower than pre-pumping levels measured in nearby wells open to the AA. These declining water levels are assumed to represent transient conditions in the AA-VA as a result of incomplete recovery from historic pumping in RNM-2s because of limited recharge to the alluvium and a large cone of depression from pumping of other wells in FF.

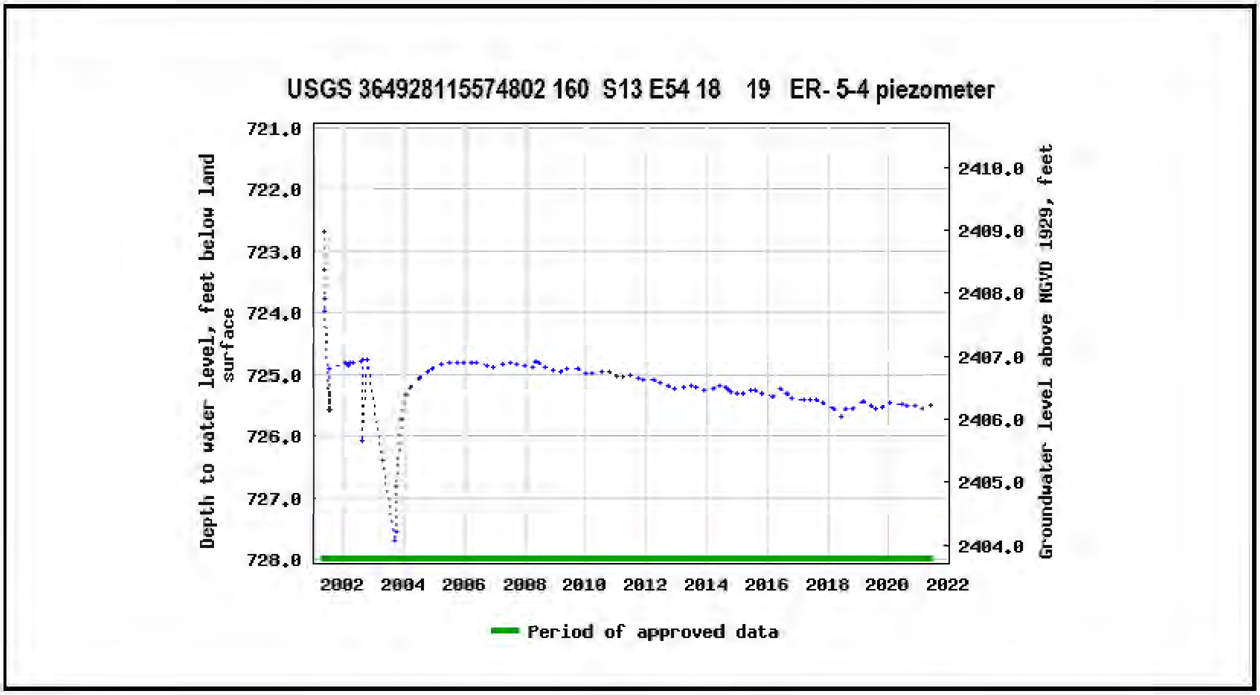

Figure 3-14

Water Levels in ER-5-4_p1

Source: USGS/DOE, 2021

ER-5-4_p1 (piezometer): Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. ER-5-4_p1 (piezometer) is the smaller diameter of two well strings in hole ER-5-4. Water levels before 2005 show effects from development and testing at ER-5-4_m1 and pumping from nearby wells (RNM-2s). The water levels after recovery from the test (beginning mid-2005) show an overall declining trend and are about 3 to 5 ft lower than pre-pumping levels measured in nearby wells open to the AA. These declining water levels are assumed to represent transient conditions in the AA as a result of active and historic pumping from wells in FF. These transient levels are assumed to reflect incomplete recovery from historic pumping in RNM-2s because of limited recharge to the alluvium and a large cone of depression from pumping of other wells in FF.

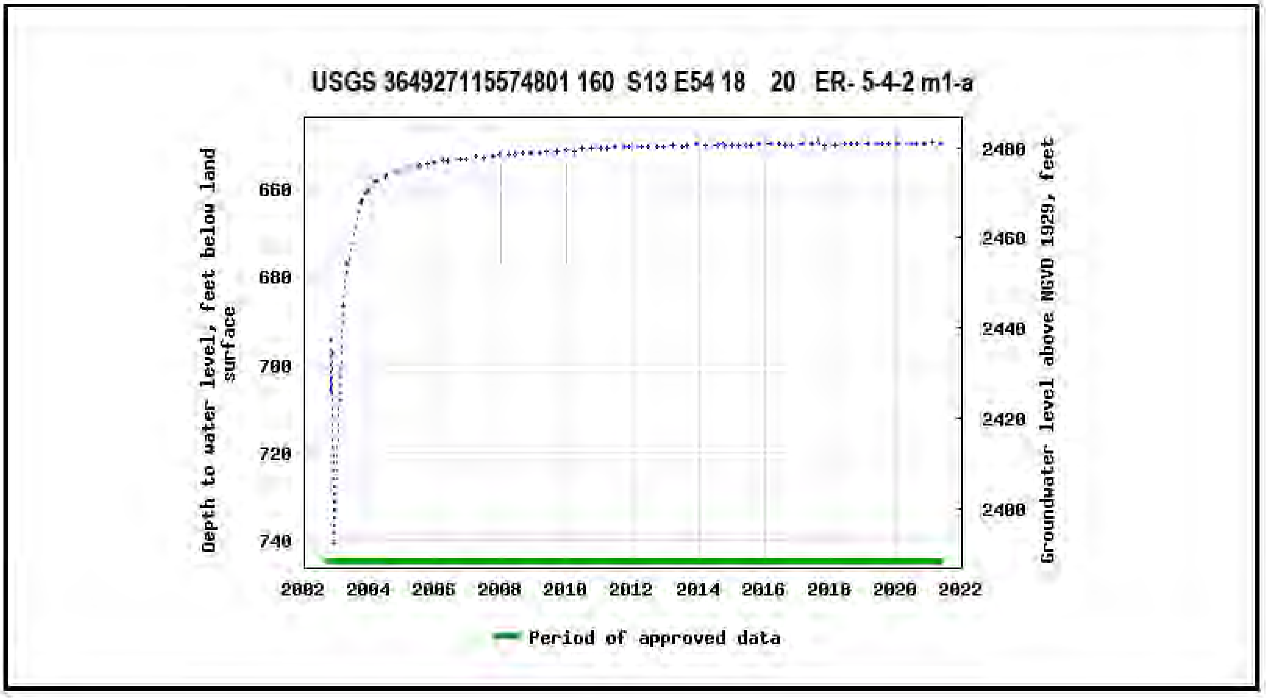

Figure 3-15
Water Levels in ER-5-4-2_m1-a
Source: USGS/DOE, 2021

ER-5-4-2_m1 and ER-5-4-2_m1-a: There two completions represent the represent the 2.875-inch (in.) tubing and 2.375-in. access tubing in the main completion of hole ER-5-4-2, respectively. Elliott and Fenelon (2010) provide an expanded description of the water-level records, a summary of which is provided here. The two completions monitor the same completion zone, and water-level altitudes in both wells are nearly identical (average difference is 0.08 ft since 2009). Only the data from ER-5-4-2_m1-a are presented in the report. Water levels through 2015 show long-term recovery from well construction and a 10-day constant-rate test that ended on November 23, 2002. The first 13 years of water levels are flagged as localized conditions, where drawdown occurred locally from pumping of the well. Water levels since 2016 have equilibrated at an altitude of 2,482 ft above sea level and are considered representative of steady-state conditions in the volcanic confining unit open to the well. Interestingly, this steady-state estimate is at least 70 ft higher than the water-level altitudes in the overlying AA-VA and the underlying regional carbonate aquifer. It is possible that this high water-level altitude may be a remnant of past pluvial conditions in this intervening and isolated confining unit. If this is the case, then a very slow declining trend would be expected. This declining trend would occur as the mound in the confining unit dissipates over the next thousands of years and water levels equilibrate with the overlying and underlying aquifers. The slow recovery of water levels in this well indicates that the well is completed in low-permeability formations and does not represent conditions in more permeable units where RNs are more likely to migrate.

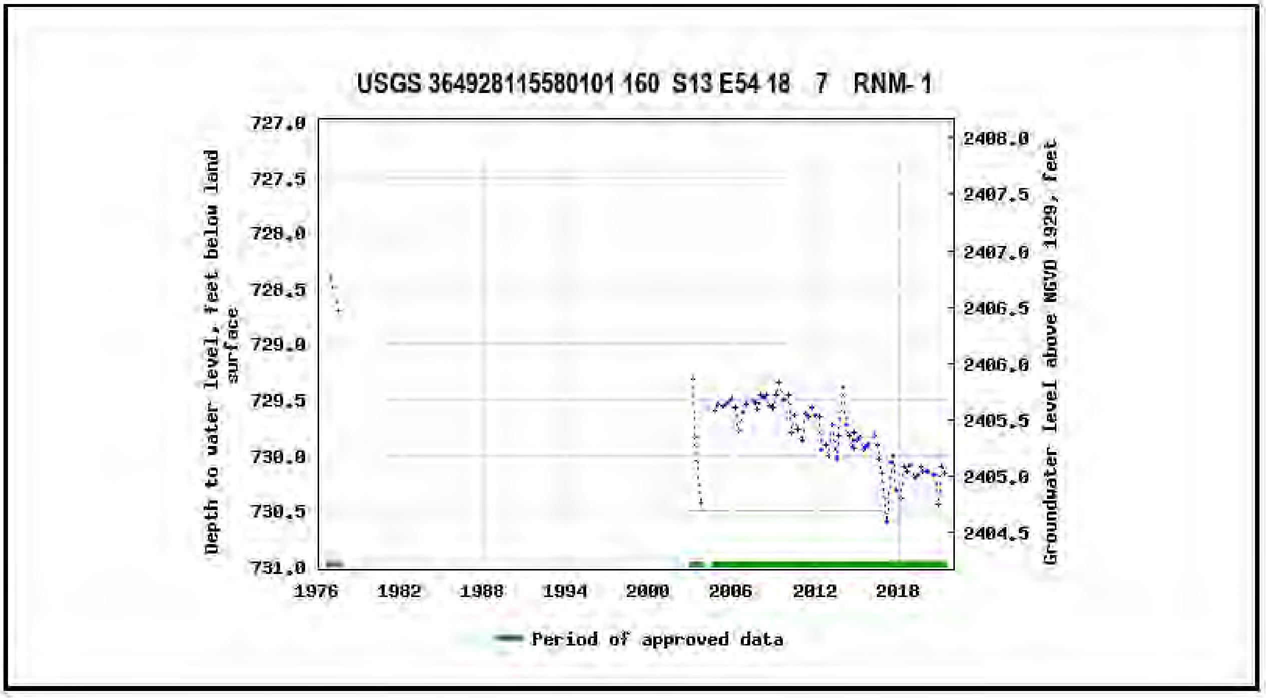

Figure 3-16
Water Levels in RNM-1_m4-5
Source: USGS/DOE, 2021

RNM-1_m4-5: Elliott and Fenelon (2010) provide an expanded description of the water-level record, a summary of which is provided here. The water levels in RNM-1 are impacted by pumping in RNM-2s during the RN migration experiment (October 1975 to August 1991) and multiple-well aquifer tests (MWATs) (April through July 2003). By late 2004, water levels stabilized to within 4 to 5 ft of pre-pumping levels. These water levels are assumed to represent transient conditions in the AA as a result of active and historic pumping from wells in FF. The lower stabilized water levels are assumed to reflect incomplete recovery from pumping in RNM-2s because of limited recharge to the alluvium and a large cone of depression from pumping of other wells in FF.

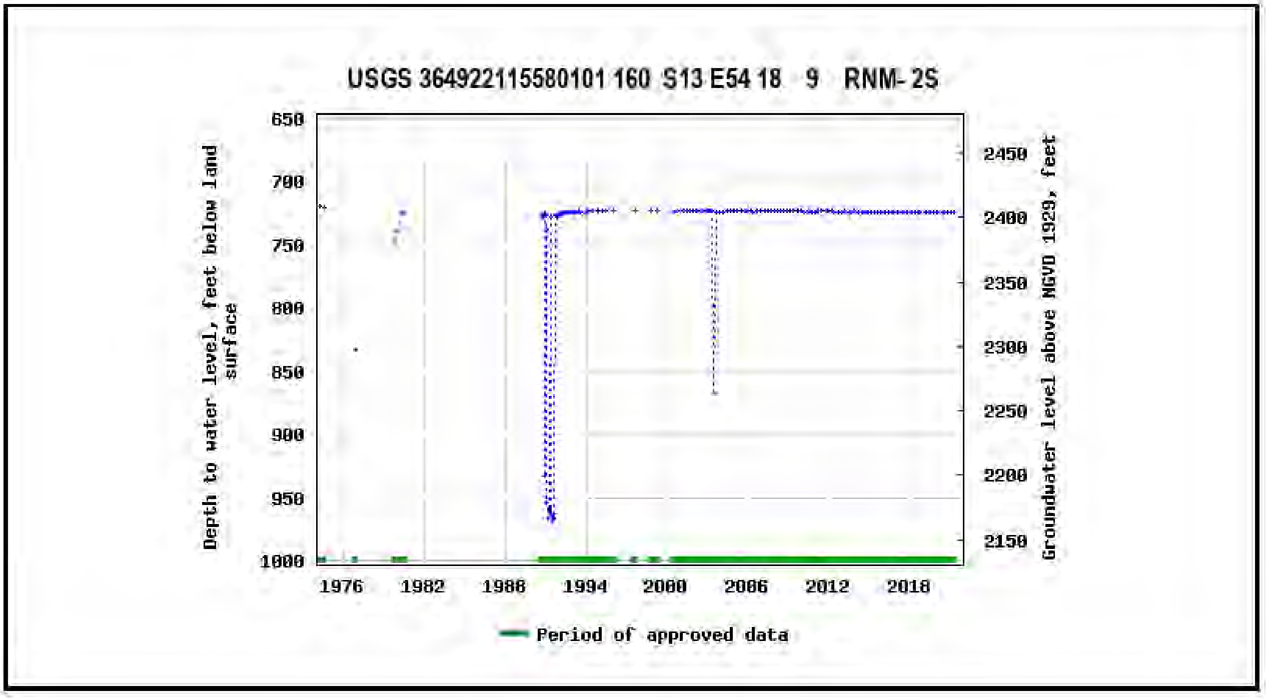

Figure 3-17
Water Levels in RNM-2s_m1
Source: USGS/DOE, 2021

RNM-2s_m1: Elliott and Fenelon (2010) provide an expanded description of the water-level records, a summary of which is provided here. Water levels in RNM-2s are impacted by the RN migration experiment (October 1975 and August 1991) and an MWAT (2003). Water levels since 1994 (with the exception of the 2003 aquifer test) are assumed to represent transient conditions in the AA as a result of active and historic pumping in RNM-2s, UE-5c WW, WW-5A, WW-5B, and WW-5C. The stabilized water levels are 3 to 4 ft lower than pre-1974 levels and are assumed to reflect incomplete recovery from pumping in RNM-2s because of limited recharge to the alluvium and a large cone of depression from pumping of other wells in FF.

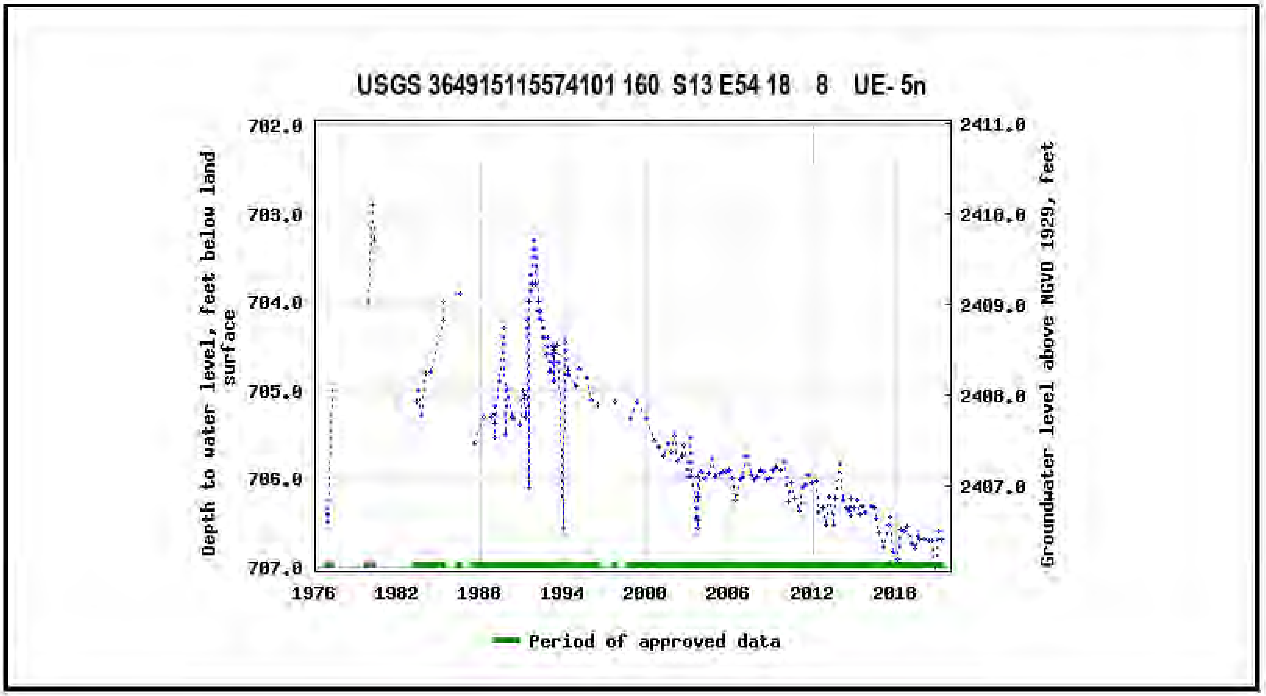

Figure 3-18
Water Levels in UE-5n_m1
Source: USGS/DOE, 2021

UE-5n_m1: Elliott and Fenelon (2010) provide an expanded description of the water-level records, a summary of which is provided here. The water levels in UE-5n are impacted by the pumping of RNM-2s during the RN migration experiment (October 1975 and August 1991) and an MWAT (2003). During the RN migration experiment, the water discharged into the Cambric Ditch infiltrated to the water table and created a recharge mound that caused water levels in UE-5n to rise. The declining water levels since 1992 are the result of the dissipation of the recharge mound, impact of RNM-2s pumping, and pumping of wells to the south. It is assumed that later water levels did not rise as high as the 1980 water levels because the rise in the water table from infiltration of discharge water was partially offset by the drawdown cone from pumping in RNM-2s. Several months after pumping in RNM-2s and discharge to the ditch ceased, water levels stopped rising in UE-5n and began a long-term decline as the mound dissipated. Water levels appear to have stabilized between late 2003 and 2010. Water levels continued to decline after 2010 and are assumed to represent transient conditions in the AA as a result of active and historic pumping in RNM-2s, UE-5c WW, WW-5A, WW-5B, and WW-5C.

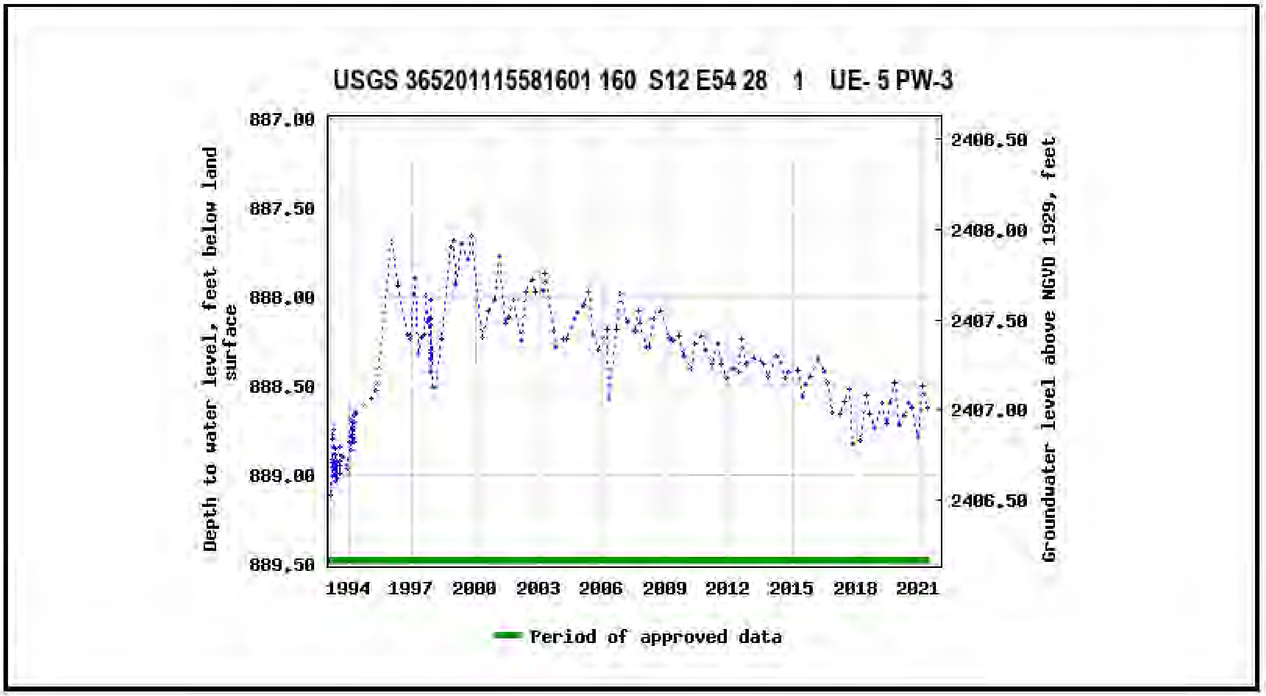

Figure 3-19
Water Levels in UE-5 PW-3_p1
Source: USGS/DOE, 2021

UE-5 PW-3_p1: Elliott and Fenelon (2010) provide an expanded description of the water-level records, a summary of which is provided here. UE-5 PW-3 is open below the water table to 30 ft of welded tuff overlying about 40 ft of bedded tuff. The well is one of three pilot wells constructed to monitor the Area 5 RWMC. Water levels show a noisy rising trend followed by a clearly defined downward trend. This water-level trend is similar to the trend in UE-5 PW-2, 1.2 mi to the southeast. The overall change in water levels for the period of record is about 1.5 ft (with the exception of one suspect water level). Water levels through 1999 are considered representative of steady-state conditions in the VA. Subsequent water levels show a declining trend of about 1 ft, which is interpreted to be the result of pumping from wells to the south. These transient water levels in UE-5 PW-3 are interpreted to be declining at a slower rate than in UE-5 PW-1 because UE-5 PW-3 is further away from the pumping wells. However, the declining trend in UE-5 PW-3 may in part, or entirely, be the result of past pluvial conditions in the VA. If this is the case, then the declining water-level trend is attributed to dissipation of pluvial heads in the VA as water levels equilibrate to heads in underlying units. The water-level trend in UE-5 PW-3 has been consistent for more than 20 years.

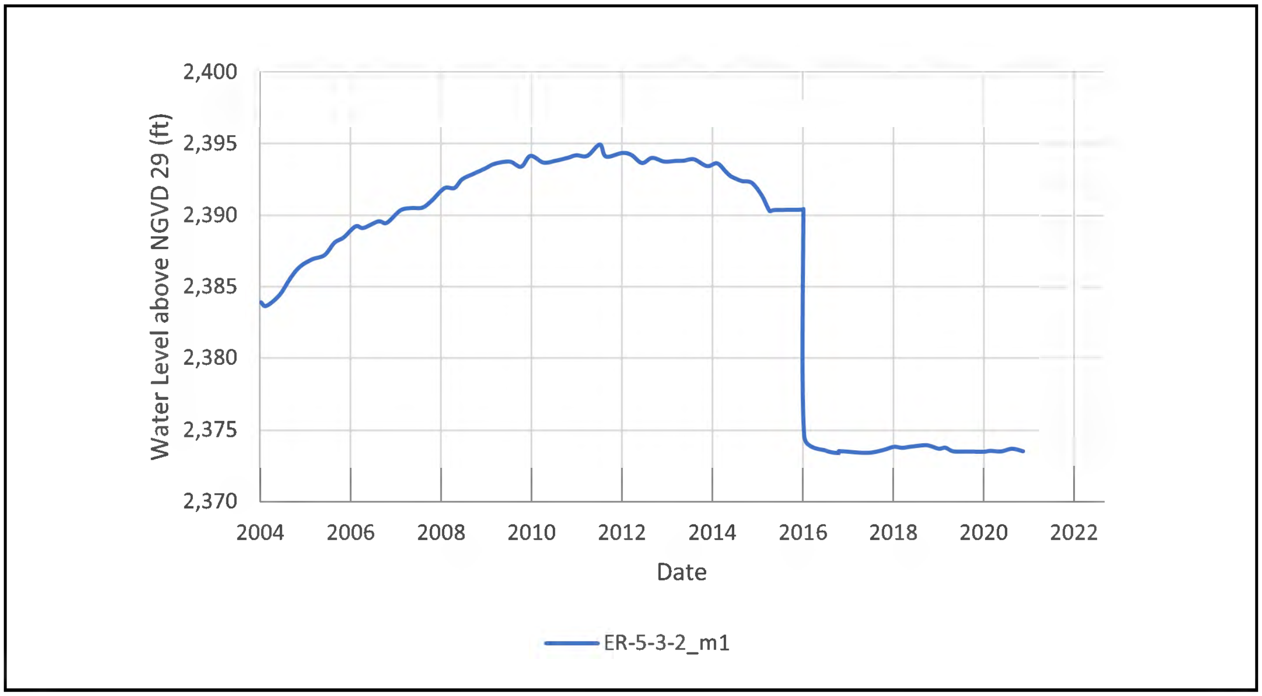

Figure 3-20
Long-Term Water-Level Trends in the LCA in ER-5-3-2_m1
Source: USGS, 2021

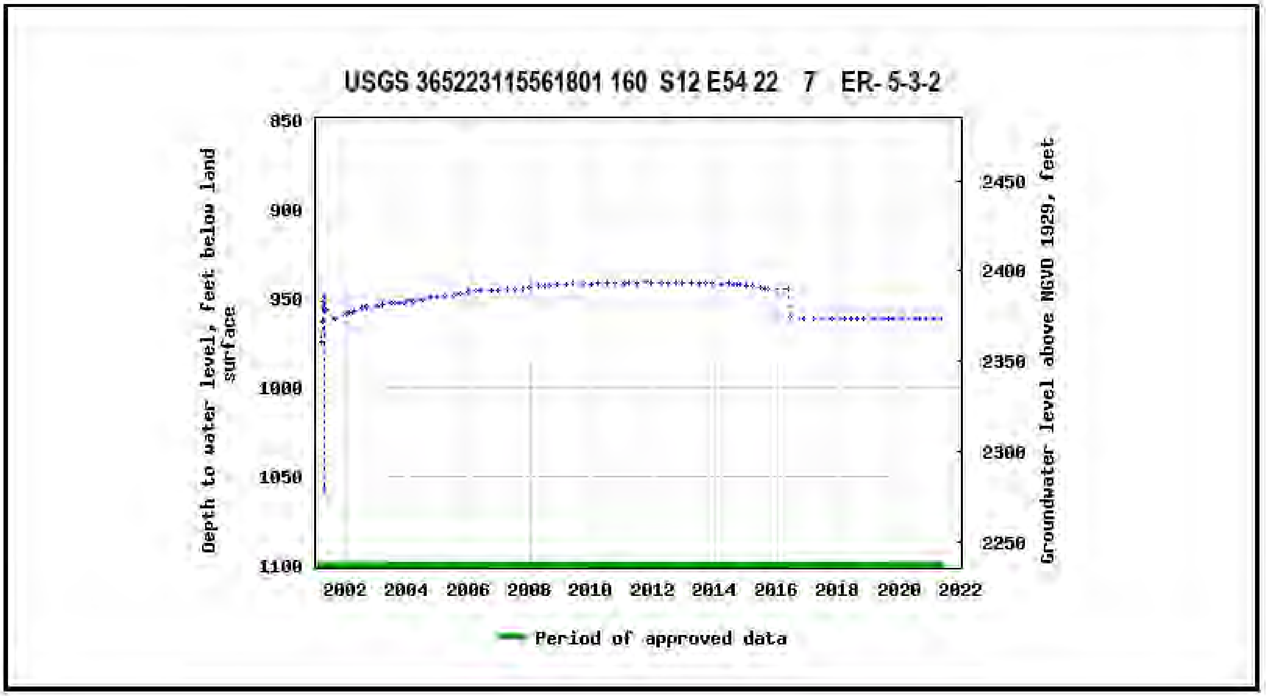

Figure 3-21
Water Levels in ER-5-3-2_m1
Source: USGS/DOE, 2021

ER-5-3-2_m1: Elliott and Fenelon (2010) provide a thorough description of the water-level record in ER-5-3-2, a summary of which is provided here. ER-5-3-2 is open to about 1,010 ft of Paleozoic dolomite. The entire length of this open interval contains fill from sloughing of the hole. ER-5-3-2 initially was completed in 2000, but water was believed to be unintentionally entering the slotted interval from above the cement seal. In March 2001, the well was recompleted and the open hole above, and part of, the slotted interval was sealed off. Initial water levels are interpreted to be recovering from well construction. The well was developed between April and September 2001 and water levels through September 2001 show the effects of development. Following development, water levels show a long and steady rise of about 21.5 ft in 10 years followed by a decline of about 4.5 ft through 2015. The cause of the rise and decline is unknown. The shape of the trend (rise followed by decline) is similar to climatically induced water-level trends in nearby wells open to carbonate rocks. However, the magnitude of the water-level changes are unreasonably large and do not appear natural. Water levels dropped abruptly in May 2016 after the well was pumped and sampled. ER-5-3-2 has been pumped and sampled annually since 2016, with between 29,000 and 45,000 gallons of water removed during each event. Water levels have remained relatively stable and depressed at an altitude of about 2,374 ft since 2016. It is unknown why water levels have remained consistently low after these pumping episodes instead of recovering to levels prior to pumping. Because of the anomalous nature of the water-level changes in ER-5-3-2 throughout the period of record, all water levels are flagged as nonstatic.

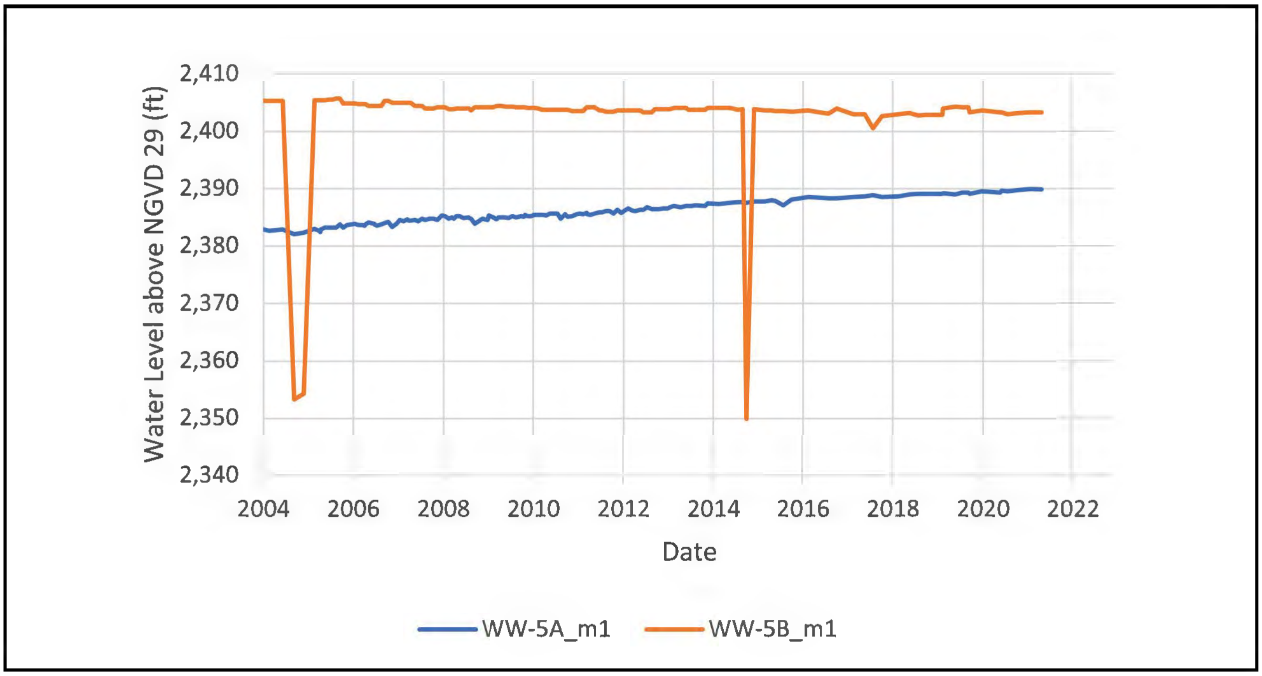

Figure 3-22
Long-Term Water-Level Trends in the AA Production Wells WW-5A_m1 and WW-5B_m1
Source: USGS, 2021

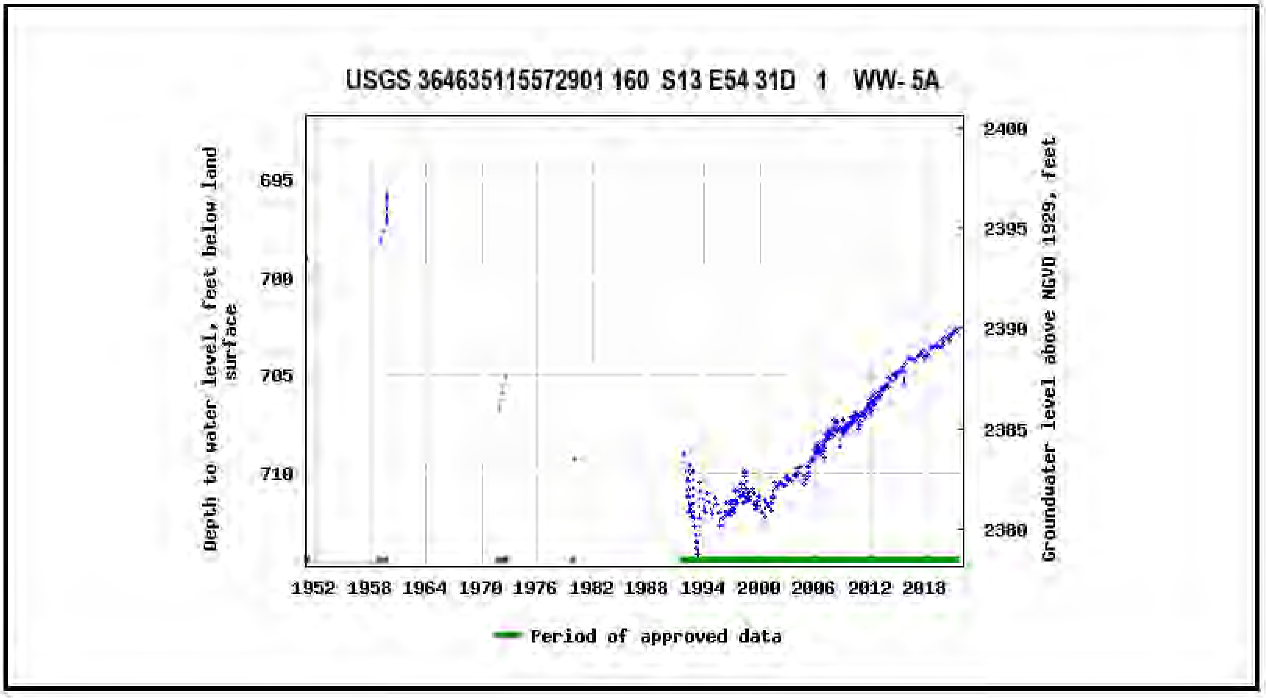

Figure 3-23
Water Levels in WW-5A_m1
Source: USGS/DOE, 2021

WW-5A_m1: Elliott and Fenelon (2010) provide a thorough description of the water-level record, a summary of which is provided here. WW-5A is open below the water table to about 210 ft of alluvium consisting of tuffaceous conglomerate. All post-1951 water levels represent transient conditions in the AA. Water levels declined 10 to 15 ft from 1951 to 1995 and then rose almost 10 ft through the present (2022). This decline and rise in water levels primarily reflects changes in pumpage in this well and nearby WW-5B and WW-5C. Pumping was discontinued at WW-5A in 1970.

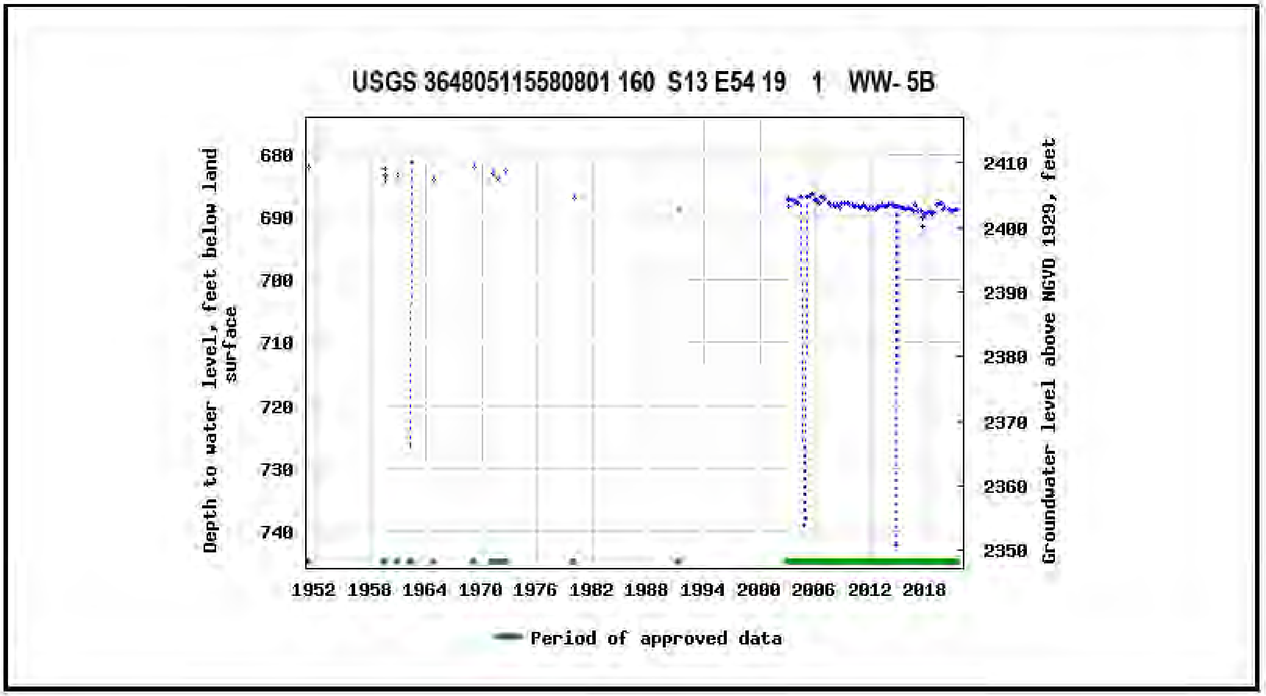

Figure 3-24
Water Levels in WW-5B_m1
Source: USGS/DOE, 2021

WW-5B_m1: Elliott and Fenelon (2010) provide a thorough description of the water-level record, a summary of which is provided here. WW-5B is open below the water table to about 220 ft of alluvium consisting of lightly cemented sand and gravel. The well was completed for water supply, and about 2.2 billion gallons of water have been withdrawn from the well from 1951 to 2019. Two nearby wells, WW-5A and WW-5C, are about 9,600 and 4,800 ft, respectively, south–southeast of WW-5B. WW-5A was pumped from 1951 to 1970, and WW-5C was pumped nearly continuously from 1954 to 2012 and sporadically from 2012 to the present (2022). Overall, transient water levels show a declining trend of about 6 ft from 1972 to 2020. The lowest transient water level in WW-5B was measured in 1991, despite no pumping in the well from 1989 to 1992. However, WW-5C was pumping in 1991 at relatively low rates. The fluctuations in water levels likely are attributable to a drawdown cone from pumpage in WW-5B and WW-5C. Water levels in WW-5B were lowered about 50 ft when the well was actively pumping at a rate of about 610 gallons per minute (gal/min) for example in late 2004. The long-term declining trend in the water level in WW-5B is the result of the combined pumping of WW-5B, WW-5A, and WW-5C.

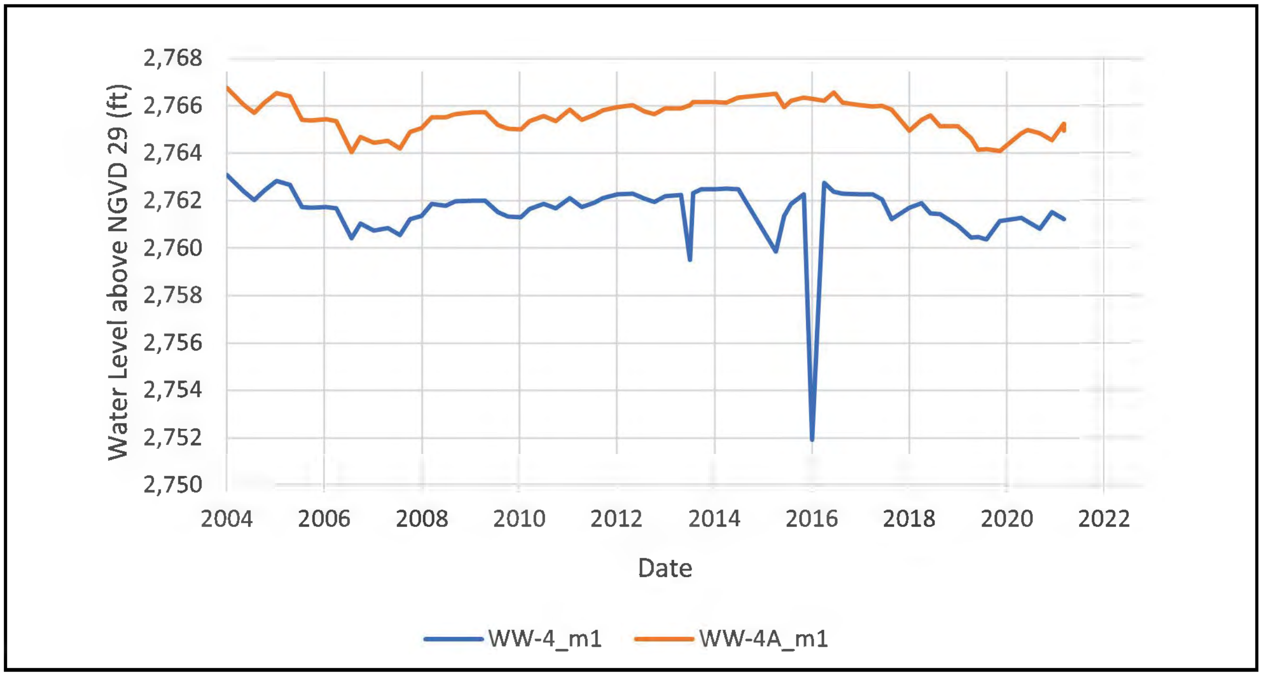

Figure 3-25

Long-Term Water-Level Trends in the VA Wells WW-4_m1 and WW-4A_m1

Source: USGS, 2021

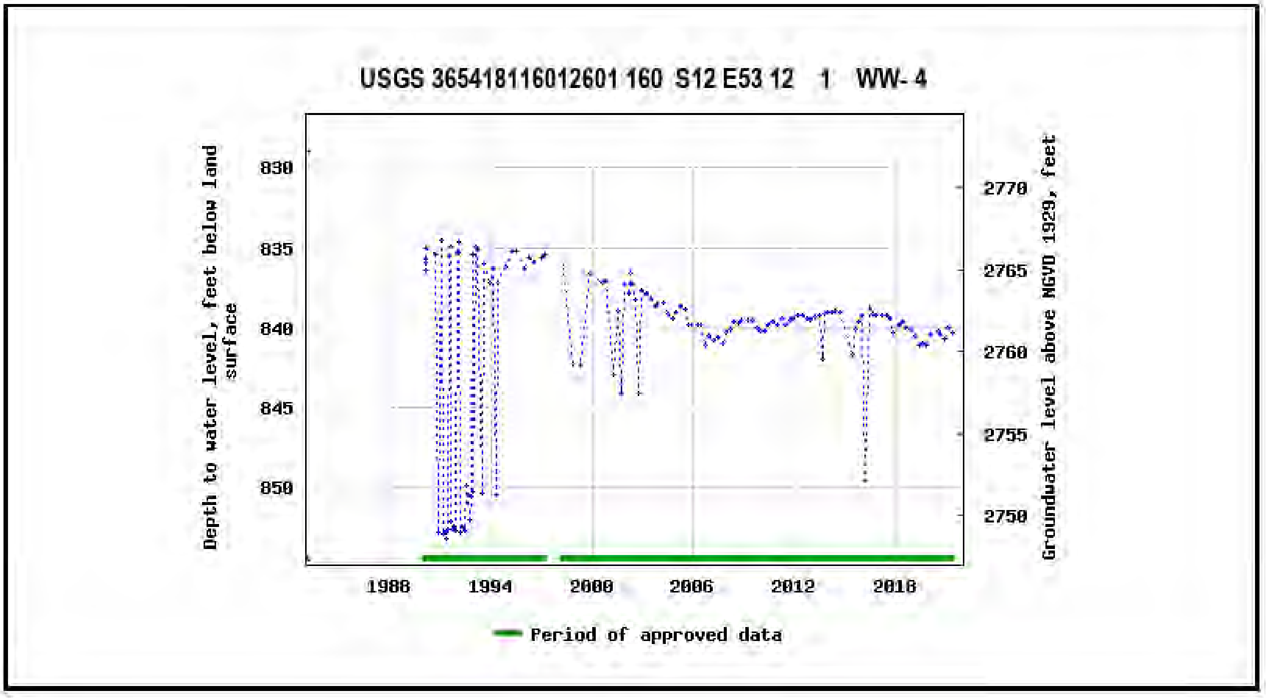

Figure 3-26
Water Levels in WW-4_m1
Source: USGS/DOE, 2021

WW-4_m1: Elliott and Fenelon (2010) provide a thorough description of the water-level record, a summary of which is provided here. WW-4 is open below the saturated zone to about 630 ft of primarily ash-flow tuffs with thinner layers of reworked bedded tuffs. The well has been used continuously for water supply since April 1983. WW-4A, about 1,200 ft southwest of WW-4, began pumping continuously for water supply in July 1994. Subsequent withdrawals from WW-4 through 2004 decreased to about one-half of the amount withdrawn prior to when WW-4A came online. Withdrawals from both wells steadily decreased from 2006 to 2015, then show a small increase through the present (2020). The change in water-level trend beginning in about 2007 reflects the change is withdrawals. The downward spikes represent measurements taken when the well was pumping. Drawdowns during pumping in WW-4 were about 15 to 20 ft when pumping rates were about 580 gal/min, and about 5 to 6 ft at pumping rates of 360 gal/min. Nonpumping transient water levels show an overall decline of about 5 ft from 1990 to 2020, followed by a slight increase in water level to the present likely due to decreased pumpage. The initial water level in 1983 is assumed to represent steady-state conditions in the VA. All other nonpumping levels (i.e., the well was not pumping during the measurement) are considered representative of transient conditions in the VA resulting from pumping in WW-4 and WW-4A.

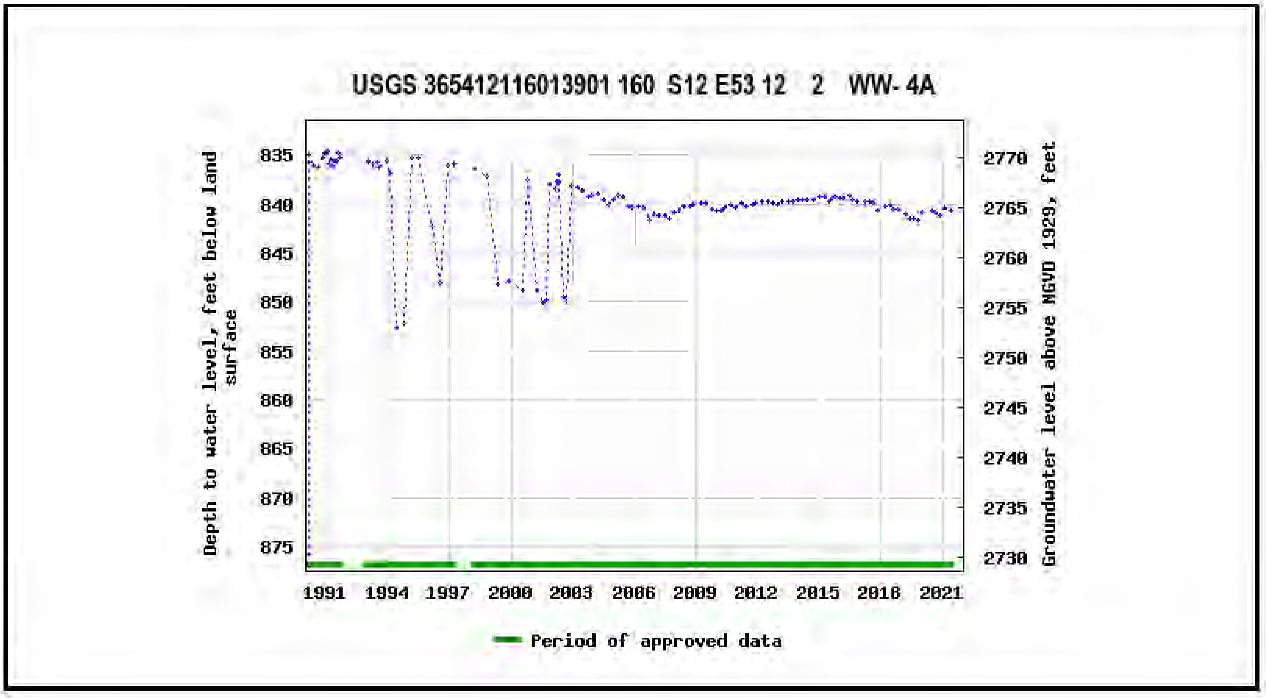

Figure 3-27
Water Levels in WW-4A_m1
Source: USGS/DOE, 2021

WW-4A_m1: Elliott and Fenelon (2010) provide a thorough description of the water-level record, a summary of which is provided here. WW-4A is open below the saturated zone to about 680 ft of primarily ash-flow tuffs with thinner layers of bedded tuffs. The principal aquifer zone, consisting mostly of moderately to densely welded tuffs, is from 1,050 to 1,450 ft below land surface. The well has been used continuously for water supply since July 1994. WW-4, about 1,200 ft northeast of WW-4A, began pumping continuously for water supply in April 1983, but withdrawals have decreased since WW-4A came online. Withdrawals from both wells steadily decreased from 2006 to 2015, then show a small increase through the present. The change in water-level trend beginning in about 2007 reflects the change is withdrawals. The downward spikes represent measurements taken when the well was pumping. At pumping rates of 600-650 gal/min, drawdowns in WW-4A are about 10 to 16 ft during active pumping. Nonpumping transient water levels show an overall declining trend of about 6 ft from 1990 through the present (2020). All nonpumping levels (that is, the well was not pumping during the measurement) are considered representative of transient conditions in the VA resulting from pumping in WW-4 and WW-4A.

4.0 Recommendations for Post-Closure Monitoring in FF

4.1 Groundwater Sampling

The wells in the northern portion of the basin have shown only nondetects for low-level ^{3}H over the past five years, consistent with forecast slow rates of RN migration (N-I, 2014, Figure A-7). The recommendation is to transition to standard ^{3}H measurement in ER-5-3_p2, ER-5-5_m1, ER-11-2_p1, and ER-5-3-2_m1; and to continue sampling at these locations to provide monitoring for potential future RN migration. Based on discussion in the FF CR (NNSA/NFO, 2016, Section 2.2, Table 2-1, and Section 4.1.1.1), the two other monitoring well locations in FF (ER-11-2_p1 and ER-5-3-2_m1) are also recommended for continued groundwater sampling, but as noted below, the unique location of each well is an important consideration for continued sampling. ER-11-2_p1 is not believed to be on a flow path downgradient of an underground test, but provides a monitoring location between the test location and the Nevada National Security Site (NNSS) boundary to the east. Sampling of ER-11-2_p1 provides additional confidence that RNs are not migrating directly to the east toward the NNSS boundary. The water-level changes in ER-5-3-2_m1, as noted in Section 3.0, are not fully understood at this time. An ongoing investigation by the USGS will provide insights into the observed water-level changes in this well. The ability of the well to produce moderate amounts of water when pumped and the similarity of water chemistry to other LCA samples in the vicinity suggest this well provides a viable sample of the LCA in this location. ER-5-3-2_m1 is a key monitoring location as the only well completed in the LCA. Continued sampling of this location is recommended because of its unique access to the LCA.

In the south, sampling for standard ^{3}H should continue at RNM-2s_m1 and UE-5n_m1. The recommendation is to also continue measurement of ^{129}I and ^{14}C because the ^{3}H concentrations exceed 1,000 pCi/L. The other RNs have consistently been measured (Table 2-1) at below the MDCs, which are well below the *Safe Drinking Water Act* standard (CFR, 2021). As shown in Figures 2-1 and 2-2 the trend of ^{3}H concentrations at both locations has followed a simple RN decay curve during the five-year evaluation period. This is indicative of a slow-moving RN plume for which RN concentrations are not expected to change much with time, except for radioactive decay. Nonetheless, sampling for ^{3}H, ^{129}I, and ^{14}C will provide increased confidence that the monitoring is protective.

It is recommended to sample at the current six wells every six years starting in 2026, following the same practice as at the Yucca Flat/Climax Mine and Rainier Mesa/Shoshone Mountain CAUs:

- ER-11-2_p1
- ER-5-3_p2
- ER-5-5_m1
- RNM-2s_m1
- UE-5n_m1
- ER-5-3-2_m1

The recommended RN trigger is measured ^{3}H at or above 1,000 pCi/L. If ^{3}H in a monitoring well sample is observed above the recommended trigger, additional analytes (^{129}I and ^{14}C) will be measured and evaluated for trends. Every 12 years, an evaluation of the monitoring network will be performed.

4.2 Water-Level Measurements

The consistent water-level trends observed across most of the measurement locations leads to the recommendation to perform yearly water-level measurements. Of the 19 water-level measurements reported (16 completions and the three pilot wells), the recommendation is to continue measurements in 14 of the existing locations, plus the three pilot wells, on an annual basis. For each well, these measurements should be made as close to the same time each year, and all the well measurements should be made within as short a period of time as possible.

Some of the water-level measurement wells appear to provide redundant information. For example, ER-5-3_m2 and ER-5-3-3_p1 are located on the same well pad and are screened in the same interval. The similarity of water-level measurements (Figures 3-1, 3-3, and 3-4) suggest that one of these wells could be eliminated from the network with no loss of data. It is recommended that water-level measurements continue to be made in ER-5-3_m2, as this is the location that is measured manually to be consistent with most of the other locations in the network.

Water-level measurements from WW-4 and WW-4A do not appear to be relevant to the changes in the groundwater system in FF. The recommendation is to eliminate one of the wells from the water-level network, as the measurements in Figure 3-25 suggest they provide redundant information. Although either well would be acceptable, the recommendation is to continue to report water-level measurements from WW-4A for two reasons: (1) WW-4A has a longer period of record, and (2) recent water-level measurements from WW-4A are not as noisy as the WW-4 water-level measurements.

It is recommended to measure water levels annually at the following 17 (14 water-level measurement locations and three pilot wells) points:

- ER-5-3_p1
- ER-5-3_m2
- ER-5-3-2_m1
- ER-5-4_m1-2
- ER-5-4_p1
- ER-5-4-2_m1-a1
- ER-5-5_m1
- ER-11-2_p1
- RNM-1_m4-5
- RNM-2s_m1
- UE-5n_m1
- WW-4_m1
- WW-5A_m1
- WW-5B_m1
- UE-5 PW-1_p1
- UE-5 PW-2_p1
- UE-5 PW-3_p1

5.0 References

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N-I, see Navarro-Intera, LLC.

Navarro GIS, see Navarro Geographic Information Systems.

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

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USGS, see U.S. Geological Survey.

USGS and DOE, see U.S. Geological Survey and U.S. Department of Energy.

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U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016. *Underground Test Area (UGTA) Closure Report for Corrective Action Unit 98: Frenchman Flat, Nevada National Security Site, Nevada,* Rev. 1, DOE/NV--1538-Rev. 1. Las Vegas, NV.

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U.S. Geological Survey and U.S. Department of Energy. 2021. "USGS/U.S. Department of Energy Cooperative Studies in Nevada" web page. As accessed at https://nevada.usgs.gov/doe_nv/ on 14 September.

Appendix A

Nevada Division of Environmental Protection Comments

(5 Pages)

NEVADA ENVIRONMENTAL MANAGEMENT OPERATIONS ACTIVITY
DOCUMENT REVIEW SHEET

1. Document Title/Number: Draft Corrective Action Unit 98: Frenchman Flat Five-Year Evaluation, Nevada national Security Site, Nevada, Revision 0, February 2022	2. Document Date: February 2022
3. Revision Number: 0	4. Originator/Organization: Navarro
5. Responsible EM Nevada Program Activity Lead: John Myers	6. Date Comments Due: March 2022
7. Review Criteria: Full	
8. Reviewer/Organization Phone No.: Chris Andres, (702) 668-3911, Nikita Lingenfelter (702) 668-3924, or Justin Costa Rica (702) 668-3913	9. Reviewer's Signature:

10. Comment Number/Location		11. Type[a]	12. Comment	13. Comment Response
1.	Section 1, Page 1, 3rd, and 4th Paragraphs		Please add introductions to these paragraphs to add context and/or more background information, such as how the quotes of these paragraphs connect to the information that follows in the Evaluation.	The following introduction was added to Paragraph 3: "The five-year evaluation results presented in Sections 2.0 and 3.0 of this report are based on the radionuclide (RN) sampling results and water-level measurements specified in the FF CR (NNSA/NFO, 2016)." The following introduction was added to Paragraph 4: "The five-year data collection presented in this report provides a baseline that was used to make recommendations in Section 4.0 for ongoing monitoring in the FF CAU."
2.	Section 1.0		Please include a Figure showing the groundwater flow direction(s), the locations of underground detonations, and the sampling/water level monitoring locations.	Figure 1-1 has been revised to show the sampling locations, underground detonations, and groundwater flow paths (carbonate and volcanic/alluvial) as requested. Figure 1-2 shows the water-level monitoring locations.
3.	Section 2.0, Page 4, Table 2-1		Please indicate on the Table whether samples were taken using a discrete bailer or pumping (after 3 well volumes).	Footnotes for bailed or pumped wells have been added to the table.
4.	Table 2-1, Page 5		Please explain why the MDCs for ^{14}C, ^{36}CL, ^{99}Tc and ^{129}I increased/changed for each year of sampling.	The following explanation has been added to the footnotes of the table, per Navarro Analytical Services: "Detection limits are evaluated on a periodic basis (typically, yearly). Each laboratory performs a detection limit study using blanks and spiked samples analyzed on different dates. Seven repetitions are analyzed, and a statistical calculation is performed based on a student-t distribution. They are calculated to measure and report with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. The limits change based on instrument performance, detector sensitivity, background analyte concentrations in the laboratory, type of instrument used, analyst experience spiking materials used, and laboratory performing the work."

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10. Comment Number/Location		11. Type[a]	12. Comment	13. Comment Response
5.	Section 3.0, Page 9, General Comment		It is unclear whether this is the raw or processed data being presented. There are several occasions where the data will deeply dip and/or rise (e.g., Figure 3-6 Water Levels in ER-5-5_p1). Are these dips and rises due to recent sampling and/or nearby sampling or are these due to equipment failure? As such, the Figures in Section 3.0 should indicate whether these are erroneous data or due to something like pumping/sampling.	The measurements reported were made by USGS quarterly with a steel tape, unless otherwise noted. All data reported by USGS are approved values as indicated by the green bar at the bottom of the graph. Fluctuations represent natural or human induced water-level changes. Descriptions of the water-level records from the USGS/DOE website have been added to the hydrograph figures.

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10. Comment Number/Location		11. Type[a]	12. Comment	13. Comment Response
6.	Section 3.0, Page 20, 1st Paragraph and Section 4.1, Page 25, 1st Paragraph		In regard to Well ER-5-3-2_ml, it is stated on Page 20 that "This well experienced a rapid drop in water level in 2016 after pumping, and the water-level trend has continued at the now steady value since 2016. The cause of the sudden drop in water level is unknown but does not appear to be related to natural changes in LCA water levels." In the Calendar Year 2020 Annual Closure Monitoring Report for Corrective Action Unit 98: Frenchman Flat, Underground Test Area, Nevada National Security Site, Nevada (January 2020-December 2020, Revision 0, June 2021 (ACM) in regard to the same well, it was stated in Section 6.2 that, "This well experienced a mechanical problem in 2016 following pumping…This change in water level is believed to be the result of a well construction problem…" The ACM also stated in Section 6.3.1 that the mechanical failure called into question the integrity of the well. What investigation has been done to date or why has the cause of the rapid drop in water level in 2016 not been investigated during the ensuring six (6) years to attempt to determine with certainty any problems with this very important, key monitoring well given that it is the sole monitoring well in the regional carbonate aquifer? What is planned for the future and why is the EM NP confident that this is not related to natural changes in the LCA?	The description in the draft report was revised following SME input that suggested more investigation was needed to understand the change in water level. EM Nevada Program initiated a study by USGS to further investigate the water-level changes. The draft study is in SME review (submitted to internal reviewers on 03/04/2022) with publication in late CY2022 or CY2023. The investigation evaluated multiple hydrologic, geochemical, and geologic data using several scenarios to explain the abrupt change in water level. While no clear explanation was identified to explain the water-level change, the study confirmed the completion is producing water from the LCA (based on water chemistry) and concludes that the well is a viable LCA sampling location. The report will be updated to recommend continued sampling of ER-5-3-2. As the investigation report is not yet published, the update to this report will not produce details at this time but will acknowledge the investigation. The drop in water level in 2016 was not investigated because the project was at the beginning of the 5-year data collection period, and it was deemed appropriate to complete the data collection to identify any trends. The investigation undertaken by USGS, while not conclusive as to the cause for the water-level change, does support continued sampling of ER-5-3-2 as an LCA monitoring location. No additional investigations are planned at this time. The following was added to the text: "An investigation of the potential cause or causes of the water-level changes in ER-5-3-2_m1 was conducted by USGS. Their findings are documented in a draft report that was undergoing internal USGS and UGTA Activity subject matter expert reviews at the time this five-year evaluation report was prepared. Specific findings will be released when the USGS investigation report is published, but a general conclusion of the USGS investigation is that ER-5-3-2_m1 is a viable sampling location for the LCA in FF based on the similarity of the water chemistry to other LCA water samples in the vicinity."

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10. Comment Number/Location		11. Type[a]	12. Comment	13. Comment Response
7.	Section 4.1, Page 25		It is not clear why it is being recommended to discontinue the measurement of radionuclides other than tritium in the south where tritium has been measured above Safe Drinking Water Standards during the five-year post-closure monitoring period, yet nothing is said about the sampling for other radionuclides in the north where tritium levels have been below the minimum detectable concentration. ^{129}I and ^{14}C should be sampled for in all wells every 12 years and evaluated for trends.	Referring to sampling at RNM-2s and UE-5n, the five-year trend for radionuclides other than ^{3}H is nondetect each time. While it is expected that the trend of nondetect values will continue, the report has been updated to reinstate sampling at those two wells for ^{129}I and ^{14}C to be consistent with the recommendation that ^{129}I and ^{14}C be evaluated for any well where ^{3}H values exceed 1,000 pCi/L. Referring to sampling of wells in the northern portion of the basin, the evidence from more than 25 years of characterization sampling across the NNSS is that elevated ^{3}H values are a precursor for elevated concentrations of other test-related radionuclides. Unless elevated ^{3}H is detected, no other test-related radionuclide will be detected. Setting a trigger value of 1,000 pCi/L for ^{3}H to initiate other radionuclide sampling, as was done for RM and YF, is conservative and provides protection for downgradient water users. We disagree that ^{129}I and ^{14}C should be sampled in all wells every 12 years. The setting of a trigger value for ^{3}H at 1,000 pCi/L to initiate sampling for ^{129}I and ^{14}C is protective of human health and provides consistency with recent closures for the RM and YF CAUs.

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10. Comment Number/Location		11. Type[a]	12. Comment	13. Comment Response
8.	Section 4.2, Page 26, 2nd Paragraph		Is this water level monitoring continuous (e.g., pressure transducer) or performed on a quarterly basis? Additionally, it appears that the USGS collects this data. As such, is the request for USGS to discontinue this monitoring or to simply not present the data?	The water-level monitoring has been performed quarterly by USGS with one exception: Only ER-5-5_p1 has a pressure transducer (PXD) installed (since 03/22/2018). The PXD failed and was replaced 09/28/2020. The recommendation for annual water-level measurements is consistent with the CR requirements for YF and RM. Annual water levels, if taken at the same time of year each time, provide for an analysis of trends to determine whether the groundwater system is changing. The forecast slow rate of radionuclide migration in Frenchman Flat of about 1 meter per year suggests the time frame of concern for trends in the groundwater system is on the order of decades. Quarterly water-level changes will have no measurable impact on radionuclide migration. DOE will provide annual measurements obtained at the same time of year annually as proposed for the closure monitoring. Quarterly measurements would not be planned.
9.	Section 4.2, Page 26, 3rd Paragraph		Please state why Well WW-4A is being recommended for continuation of water level measuring over Well WW-4.	WW-4A was chosen for two reasons: first, because it has a longer period record; and second, recent measurements are not as noisy as the WW-4 record. Added to paragraph: "Although either well would be acceptable, the recommendation is to continue to report water-level measurements from WW-4A for two reasons: (1) WW-4A has a longer period of record, and (2) recent water-level measurements from WW-4A are not as noisy as the WW-4 water-level measurements."

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