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Hydrophysical Evaluation of Wells TW-B, TW-7, UE-6d, U-2gg PSE 3A, U-10L 1, and UE-6e in Yucca Flat

prepared by

Karl Pohlmann, John Healey, Brad Lyles,
Clay Cooper, and Ronald L. Hershey

submitted to

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

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LIST OF ACRONYMS

AMSL	above mean sea level
BLS	below land surface
DOE	Department of Energy
DRI	Desert Research Institute
ft	feet
ft/sec	feet per second
in	inch
gpm	gallons per minute
lb/gal	pound per gallon
LCA	lower carbonate aquifer
LTHMP	Long-term Hydrological Monitoring Program
m/d	meters per day
MDL	method detection limit
μS/cm	microsiemens per centimeter
LTCU	Lower Tuff Confining Unit
NAD	North American Datum
NNSS	Nevada National Security Site
NTS	Nevada Test Site
pCi/L	picocuries per liter of water
REOP	Real Estate/Operation Permit
SC	specific conductance
TD	total depth
TFM	thermal flow meter
TSA	Topopah Spring Aquifer
UGTA	Underground Test Area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator

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INTRODUCTION

This study evaluated six wells in Yucca Flat in support of the Underground Test Area (UGTA) Activity conducted by the U.S. Department of Energy (DOE) at the Nevada National Security Site (NNSS). Accessibility and groundwater sampling conditions were assessed and if conditions permitted, samples were collected for tritium analysis. Four of the wells, TW-B, UE-6d, UE-6e, and TW-7 were sampled in support of UGTA responses to recommendations made by the Yucca Flat/Climax Mine External Peer Review Committee (Navarro, 2016). In addition to its role in support of these responses, TW-7 was included because it is listed in the NNSS Integrated Groundwater Sampling Plan (DOE, 2014) as a required sampling location, although it had not been sampled since 1994. U-2gg PSE 3A and U-10L 1 were evaluated to determine whether deteriorating well conditions can be addressed so that these wells can be used as additional sampling points in Yucca Flat.

The wells evaluated during this project were constructed at various times and for a variety of purposes during the course of NNSS (formerly Nevada Test Site [NTS]) operations. Their current conditions were largely unknown because most had not been accessed for many years. Hydrophysical logging was conducted and groundwater samples were collected for tritium analysis under ambient well flow conditions from May to December 2015.

Desert Research Institute (DRI) deployed one or more of the following logging tools to evaluate the wells: an Idronaut chemtool, thermal flow meter (TFM), discrete groundwater sampler, and a video logging tool. The DRI Idronaut chemtool and the TFM are used to identify zones of natural borehole flow for collecting samples that represent the groundwater with minimal purging. Typically, the Idronaut chemtool determines inflection points in vertical trends in parameters such as temperature, pH, specific conductance (SC), and dissolved oxygen. These inflection points are used to identify intervals of groundwater inflow and outflow. The TFM is then used to measure vertical flow rates and directions at selected depths in the well. The discrete groundwater sampler is used to acquire groundwater samples from zones identified based on evaluations of the chemistry and TFM logs.

Site locations, well construction, and historical tritium activities were reviewed prior to the fieldwork and indicated that the risk of encountering tritium activities above 400,000 picocuries per liter of water (pCi/L) was low in wells TW-7, TW-B, UE-6d, and UE-6e. As a result, operations at these sites followed procedures established for unregulated (far-field) sites described by the UGTA Health and Safety Plan (NSTec, 2015).

U-2gg PSE 3A is a post-shot hole and U-10L 1 had not been sampled prior to this project, so they were both treated as near-field sites (NSTec, 2015). A radiological control technician was provided by Navarro to run a swipe of the wireline as it was retrieved from the well after the first run. This first run tagged the water level and then the probe was lowered 5 to 10 feet (ft) below the water level. The swipe of the wetted wireline or tool was taken as it was retrieved. Logging operations were then suspended until the results of the analyses of these swipes were available. These analyses detected no tritium on the wireline or tools, so logging and sampling operations continued following procedures established for unregulated sites.

All activities were conducted in accordance with the requirements of the UGTA Activity Primary Real Estate/Operation Permit (REOP) NSTec-0075, the DRI secondary REOP DRI-0011, the UGTA Activity Health and Safety Plan (NSTec, 2015), the DRI Site Specific Health and Safety Plan, the DRI Field Activity Work Package, and the UGTA Quality Assurance Plan (DOE, 2012). The locations and elevations of the wells are listed in Table 1 and their locations are mapped in Figure 1.

Table 1. Locations and elevations of wells evaluated in Yucca Flat from 2015 to 2016.

Well Name	Elev. (ft)	UTM NAD 83 Zone 11		Lat./Long. NAD 83	
		Easting (m)	Northing (m)	Lat. (Deg. N)	Long. (Deg. W)
TW-7	4,066	585821.57	4102497.66	37.064809	-116.034646
TW-B	3,929	587701.19	4093012.31	36.979143	-116.014611
UE-6d	3,947	583672.69	4093594.34	36.984756	-116.059804
UE-6e	3,936	586933.23	4093605.74	36.984563	-116.023170
U-2gg PSE 3A	4,298	582,578	4,111,207	37.143602	-116.070165
U-10L 1	4,262	584,843	4,112,466	37.154751	-116.044519

NAD = North American Datum

UTM = Universal Transverse Mercator

Background information included in this report has been compiled from numerous sources. Water-level data and selected well descriptions were obtained from the U.S. Geological Survey (USGS)/DOE Cooperative Studies in Nevada website (http://nevada.usgs.gov/doe_nv). Drilling histories, well construction information, location coordinates, groundwater chemistry, hydrogeology, lithology, and other related data were obtained from the UGTA Borehole Index (Navarro-Intera, 2016a) and the UGTA Chemistry Database (Navarro-Intera, 2016b).

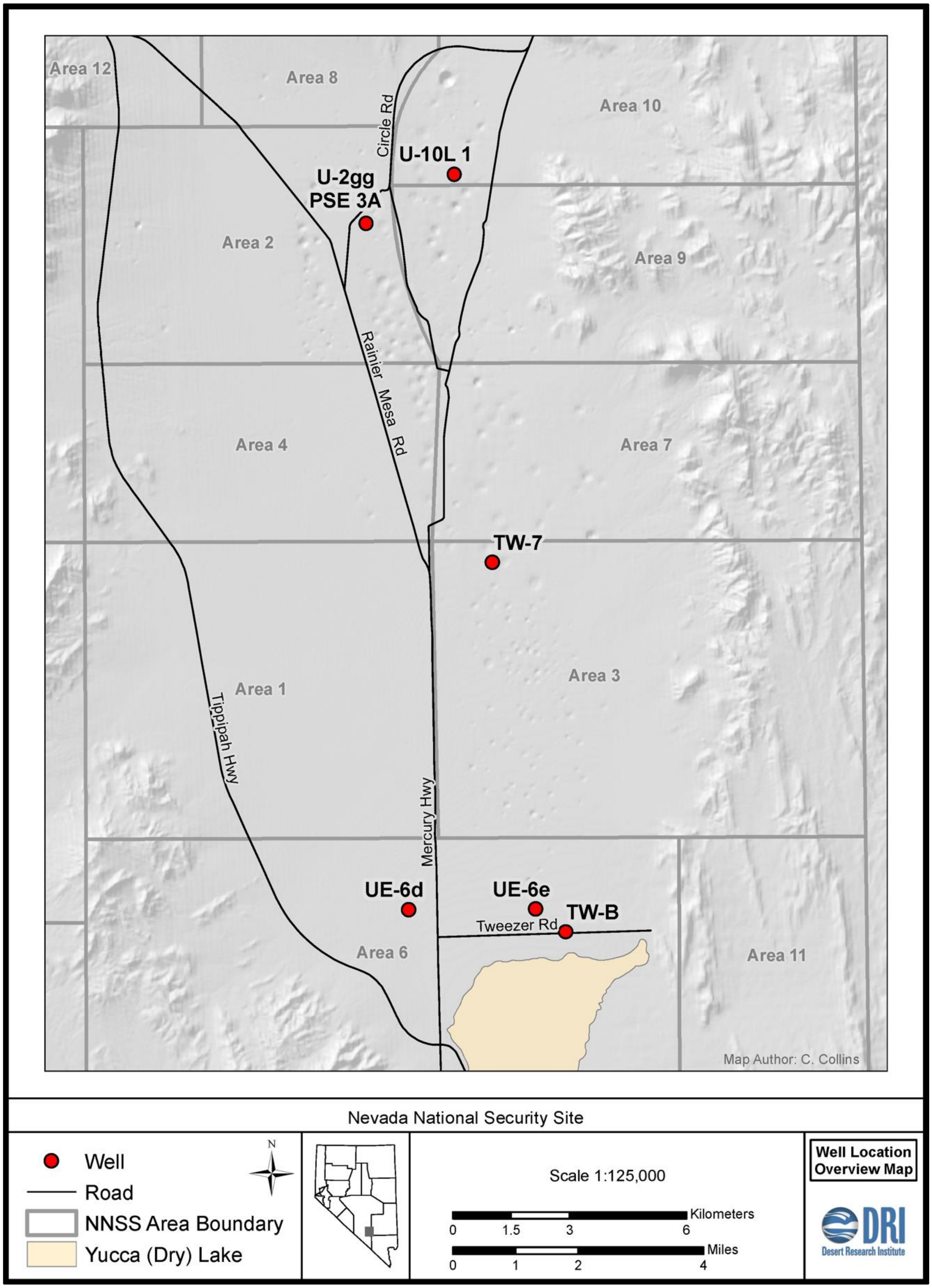

Figure 1. Regional location map showing the six well sites with respect to Yucca Flat, 26.5 miles north of Mercury, Nevada.

TW-B

UGTA ID: Test Well B Ex.

Integrated Groundwater Sampling Plan ID: Test Well B Ex._m1

Integrated Groundwater Sampling Plan Status: Inactive

USGS Site ID: 365849116002101

Coordinates: 587700.6 m North, 4093013 m East, UTM11 NAD83

Elevation: 3,929 ft above mean sea level (AMSL)

Directions

From the intersection of Mercury Highway and Jackass Flats Road in Mercury, follow Mercury Highway north for 30.3 miles to Tweezer Road (Tweezer Road is 1.7 miles north of the intersection of Mercury Highway and Tippipah Highway). Drive east two miles on Tweezer Road. The well is on the north side of Tweezer Road. Figure 2 shows the wellhead.

Figure 2. TW-B wellhead (photo courtesy of NSTec, 2015).

Background for Sampling

TW-B is inactive and has not been regularly sampled since the late 1980s. The well is located in Area 6, south and down hydraulic gradient of the main nuclear testing area in Yucca Flat, so it may be a useful sampling point for monitoring radionuclide migration in the Topopah Spring Aquifer (TSA). TW-B was chosen for evaluation to follow up on detections of tritium in the well from the 1970s through the 1990s. Five nuclear detonations, all above the water table, were conducted within one mile of TW-B (Elliott and Fenelon, 2010), although all of them occurred after elevated tritium activities were first detected in this well (Navarro, 2016).

Well History

TW-B was drilled to a depth of 1,675 ft below land surface (BLS) in 1961. Figure 3 shows a diagram of the completed well. The well is cased with 12.75-inch (in) steel casing from the land surface to 1,539 ft BLS, and 10.75-in steel casing from 1,375 to 1,675 ft BLS. The 10.75-in casing is reported to be slotted from 1,432 to 1,452 ft BLS and from 1,512 to 1,656 ft BLS, although DRI's video shows vertical slots starting at 1,503 ft BLS (see below). The total constructed depth of the well is 1,675 ft BLS.

The perforated interval of TW-B is entirely within the TSA, a welded ash-flow tuff that extends from a depth of 1,411 ft BLS (21 ft above the top of the slotted casing) (Table 2) to below the base of the well. Water levels in TW-B have fluctuated between approximately 1,503 and 1,505 ft BLS since 1989 (USGS, 2016) (Figure 4).

An analysis of recovery data from an aquifer test in 1968 for which TW-B was an observation well (the pumped well is not reported) estimated a hydraulic conductivity of 8×10^{-4} meters per day (m/d). A slug test in 1961 reported a value of 3×10^{-2} m/d (U.S. Department of Energy [DOE], 2016a). Thordarson *et al.* (1967) reported that a drawdown of more than 49 ft was associated with a pumping rate of 15 gallons per minute (gpm; date of test not given), which indicates the relatively low yield of this well.

TW-B was sampled for the Long-term Hydrological Monitoring Program (LTHMP) from 1976 to 1998. Samples were bailed from a depth of 1,644 ft BLS (Navarro-Intera, 2016b). Tritium activities declined steadily from approximately 260 to 100 pCi/L between 1976 and 1981, increased to 150 to 200 pCi/L by 1984, and have declined from 1984 to present (Figure 5). Figure 5 also shows a curve representing theoretical activities that are solely a result of tritium decay over time, using 260 pCi/L as the initial value in 1978. The relationship of observed activities to this decay curve suggests that dilution, presumably from diffusion and dispersion, plays a role in the decline in addition to radioactive decay. However, the source of tritium in TW-B has not been clearly established (Navarro, 2016) given that elevated tritium activities were first measured prior to any underground nuclear detonations within one mile of the well. Suggested origins include infiltration from surface water in Yucca Lake playa (Lyles, 1990) and introduction during drilling of the well (Navarro, 2016). The most recent measurement is 44 pCi/L on June 22, 1998.

Table 2. Hydrostratigraphic units in the lower 355 feet of TW-B (from DOE [2016a]).

Interval (ft BLS)	Hydrostratigraphic Unit
1,320.21 to 1,411.09	Upper Tuff Confining Unit (UTCU), zeolitized bedded tuff
1,411.09 to 1,674.87	Topopah Spring Aquifer (TSA), welded ash-flow tuff

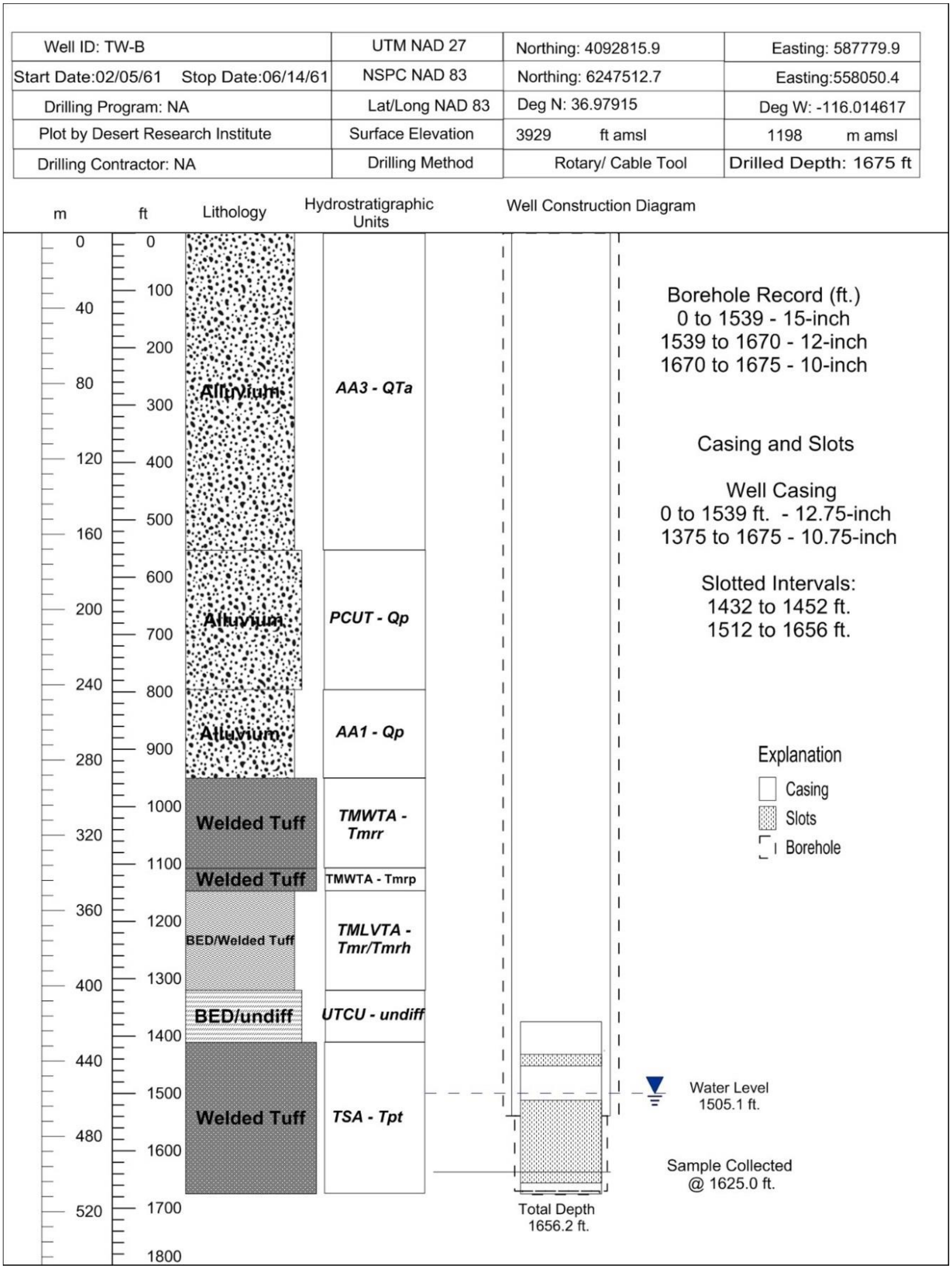

Figure 3. Downhole conditions observed at TW-B. Geologic and as-built well construction information from DOE (2016a).

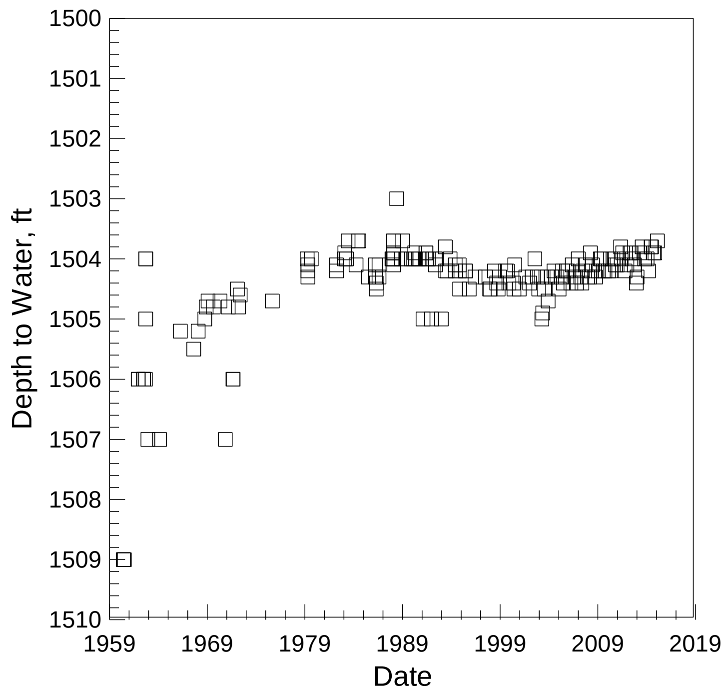

Figure 4. Depth to water in TW-B from 1961 to 2015 (from USGS [2016]).

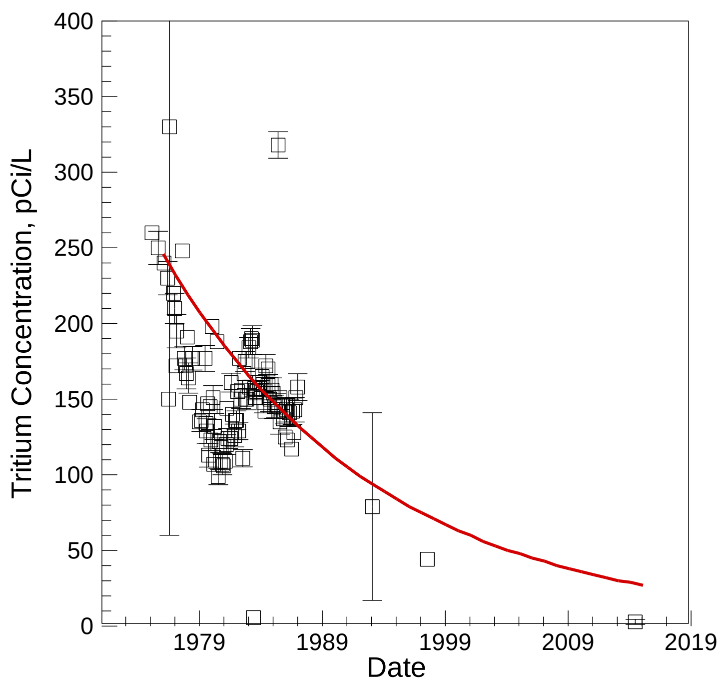

Figure 5. Tritium activities in TW-B. The red line represents tritium decay over time, assuming an initial activity of 260 pCi/L in 1978. For clarity, not all error bars are shown (from DOE [2016b]).

Field Observations

Logging and sampling were conducted on May 20, 2015. The wellhead was found to be in good condition with a padlock securing the hinged access cover. A concrete pad surrounds the well casing. The casing is painted blue and stands approximately 24 inches above grade (Figure 2).

The water level was measured at 1,505.06 ft BLS and the total depth (TD) at 1,656.2 ft on May 20, 2015. The Idronaut chemtool (Figure 6) shows a 16-ft diffusion zone of elevated dissolved oxygen at the top of the water surface. At 1,520 ft BLS, the dissolved oxygen level is at its lowest value (3 percent) and increases downward at a rate of approximately 0.21 percent per foot. The maximum dissolved oxygen value at TD (1,656 ft BLS) is 30 percent. As a result of evaporation, SC is elevated at the water surface, but drops to 470 microsiemens per centimeter (µS/cm) at 1,520 ft BLS (Figure 6). Specific conductance gradually decreases to 425 µS/cm at 1,632 ft BLS, and then increases to 450 µS/cm at TD.

Figure 6 also shows a limited range in temperature, from 24.70 °C at 1,510 ft BLS to 24.78 °C at 1,632 ft BLS, with a significant increase in slope of 1 °C over the lower 25 ft of the well. The linear trend in the temperature profile bounded by inflection points at 1,578 and 1,634 ft represents the primary zone of vertical wellbore flow in TW-B.

Ambient wellbore flow was measured using the TFM at three locations: 1,585, 1,610, and 1,631 ft BLS. Flow was directed downward at a rate greater than 6 gpm (approximately 0.5 feet per second [ft/sec]) (Table 3). The lowermost point of detectable flow (1,631 ft) corresponds to an increase in the temperature profile (Figures 6 and 7). There is also a slight increase in conductivity gradient that corresponds with this point. Despite the low flow rates in and out of the well, the hydraulic head in the well is hydrostatic.

A water sample was collected on May 20, 2015, using a depth-discrete bailer set in the lower slotted interval at a depth of 1,625 ft BLS. The chemistry and TFM logs suggest that this depth integrates all of the downward flow in the well. The low-level tritium result was reported as 2.84 pCi/L at a method detection limit (MDL) of 2.32 pCi/L, but was qualified as a non-detect when laboratory error was included. All tritium analytical results are included in Appendix C.

A video log (Figure 8 shows the tool) was completed on September 16, 2015, to visually inspect the integrity of the well casing and open hole. The log indicates that the casing is intact and shows minimal chemical precipitation. Figure 9 provides a clear image of the milled slots in the casing at 1,424.17 ft (1,424 ft 02 in) BLS. The milled slots appear in the video to a depth of 1,503.17 ft, which is just above the water level. There appear to be twelve to thirteen slots visible along the circumference of the casing. At 1,507.25 ft, the milled slots are clearly visible at the water surface (Figure 10). The video log shows that milled slots continue to a depth of 1,628.17 ft, at which point a vertical torch-cut casing extends from 1,629.08 to 1,644 ft. Figure 10 shows that (1) the slots in the casing were torch-cut in the field before installation, (2) only four slots are present in the casing, and (3) the casing is distorted into an oval shape because the camera deviates off-center, which indicates that the well is not plumb. Figure 11 provides a view of the bottom of the casing string at 1,353 ft and shows what appears to be a single piece of steel strapping.

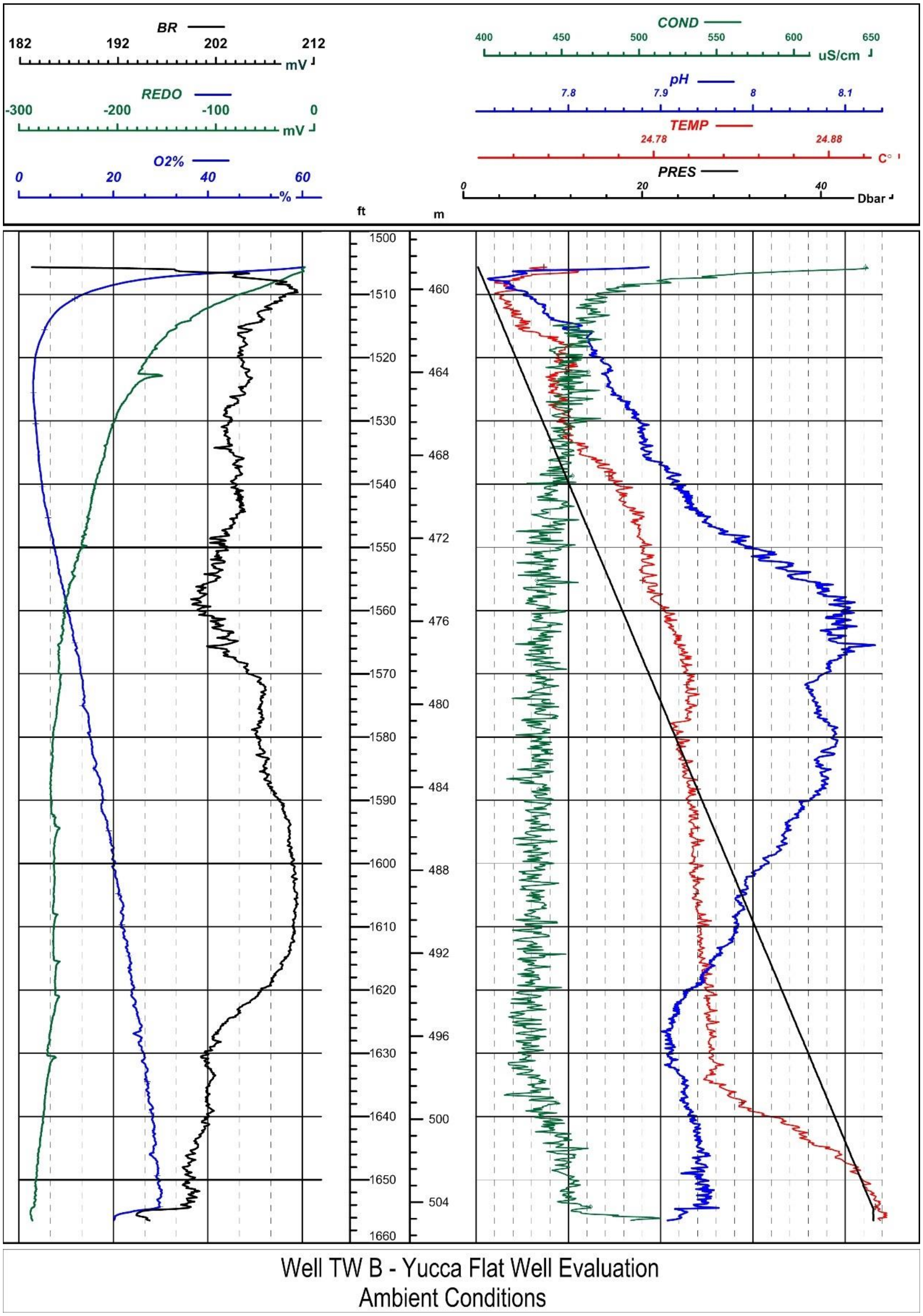

Figure 6. Idronaut chemtool log for in TW-B.

Table 3. Results of the thermal flow meter log in TW-B.

Depth (ft)	Tubing Diameter (in)	Flow Direction	Response Time (sec)		Flow Rate		Velocity		
			Mean	Std. Dev	(GPM)	+/-	(ft/min)	+/-	
1,565	10.75	NO FLOW	31.74	14.55	0.0	0.0	0.0	0.0	
1,585	10.75	DOWN	0.66	0.055	> 6	NA	NA	NA	**
1,610	10.75	DOWN	0.72	0.08	> 6	NA	NA	NA	**
1,631	10.75	DOWN	0.64	0.05	> 6	NA	NA	NA	**
1,640	10.75	NO FLOW	33.74	17.87	0.0	0.0	0.0	0.0	

** Flow rate is greater than the calibration limit.

NA = not applicable.

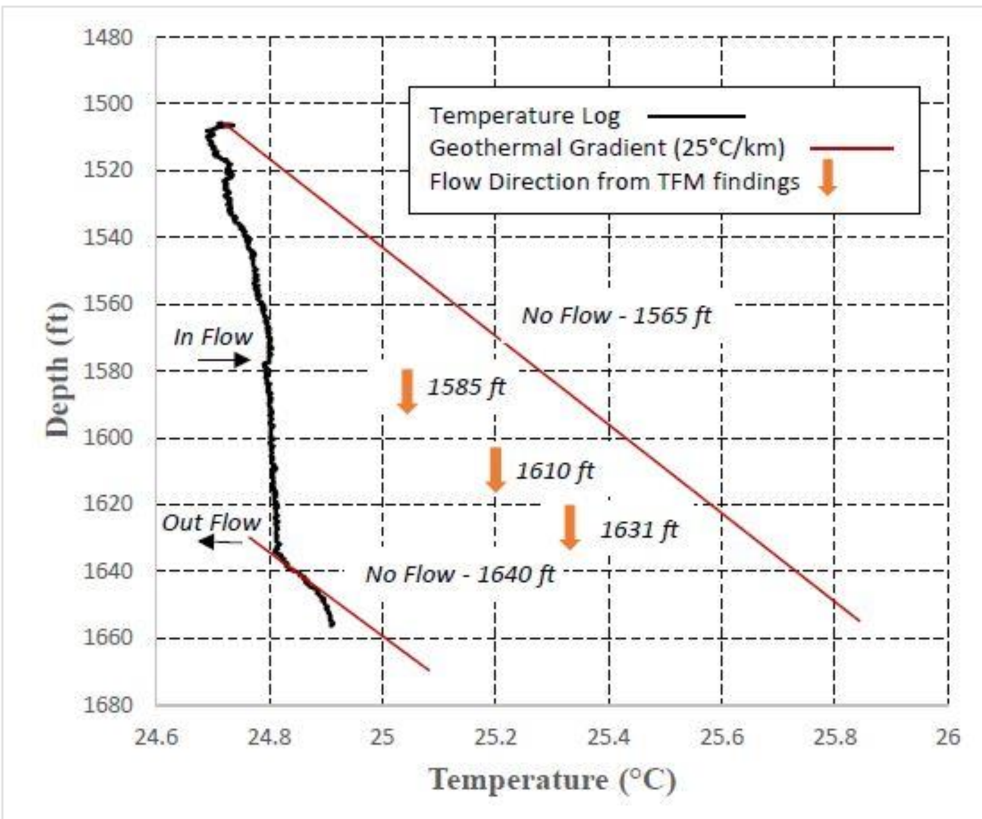

Figure 7. Temperature profile of TW-B with geothermal gradient shown in red. Groundwater flow within the well casing is shown by the orange arrows. This section of the well proved to have a downward flow (> 6 gpm) as verified by TFM results.

Figure 8. Photograph of video camera being lowered into TW-B.

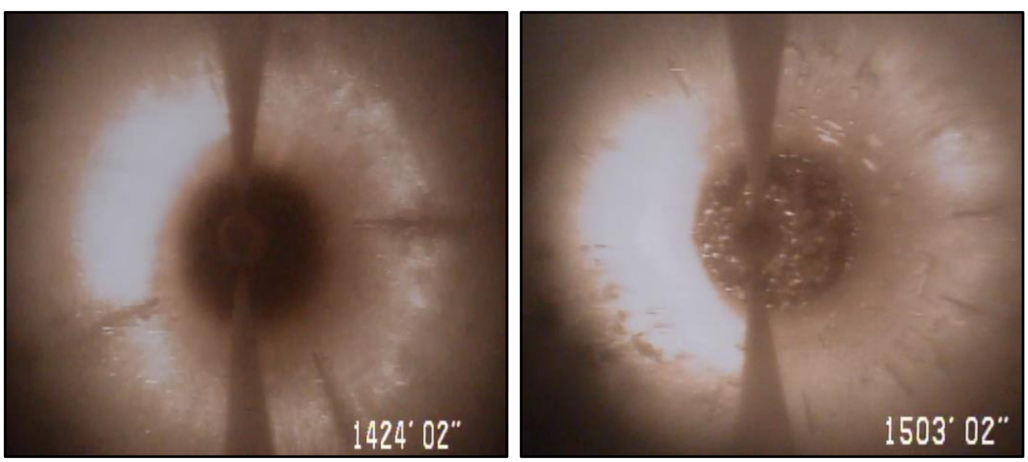

Figure 9. Still images from the borehole video log. The left image shows milled slots above the water level in the well. The right image shows milled slots at the water surface in the well. Depths are shown in feet and inches at the lower right corner of each image.

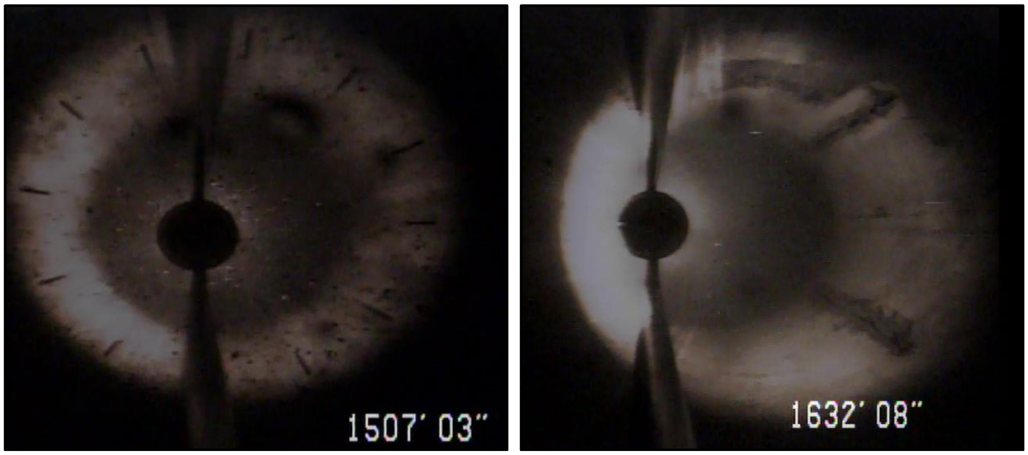

Figure 10. Still images from the borehole video log. The left image shows milled slots. The right image shows four torch-cut slots. The casing is distorted into an oval shape and the camera is positioned off-center, which indicates that the well is deviated off-vertical.

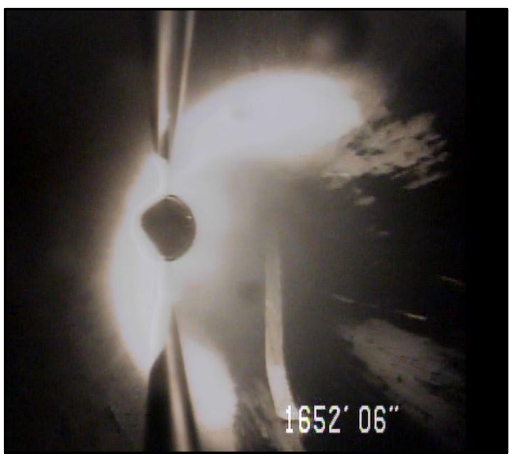

Figure 11. Still image from the borehole video log showing open hole at total depth. The camera lens is approximately three feet above the bottom of the hole. Debris (including what appears to be a piece of steel strapping) can be seen in the lower center of the image.

Summary and Recommendations

TW-B was evaluated and sampled based on its history of tritium observations and because tritium samples had not been collected there since 1994. Results of low-level tritium analysis for this evaluation indicate no detection at an MDL of 2.32 pCi/L when measurement error is considered.

The chemistry and flow logs show that groundwater flow occurs naturally within the wellbore and the video log shows that the casing and slots are generally in good condition. In addition, the chemistry logs and water clarity suggest that the well remains well-developed and is therefore favorable for groundwater sampling with minimal reconditioning.

An electric submersible pump may be used for sample collection in TW-B. However, Thordarson *et al.* (1967) indicated that the yield of this well is very low. Alternatively, observed natural wellbore flow rates above 6 gpm in the interval from 1,578 to 1,634 ft suggest that this well is self-purging, and therefore is a good candidate for sampling using a depth-discrete bailer. A depth of 1,625 ft is recommended for bailing because this depth accounts for all flow contributions through the slotted casing.

The good hydraulic condition of the well, the natural flow observed within the borehole, and its location south and down hydraulic gradient of the main nuclear testing area in Yucca Flat make it a useful sampling point for monitoring radionuclide migration in the Topopah Spring volcanic aquifer.

TW-7

UGTA ID: Test Well 7 (HTH)

Integrated Groundwater Sampling Plan ID: TW-7_m1

Integrated Groundwater Sampling Point Status: Early Detection Well

Sampling Frequency: 5 years

Analytes: ^{3}H

USGS Site ID: 370353116020201

Coordinates: 585821.7 m East, 4102498.4 m North, UTM11 NAD83

Elevation: 4,058 ft AMSL

Directions

From the intersection of Mercury Highway and Jackass Flats Road in Mercury, follow Mercury Highway north for 28.6 miles to Tippipah Highway. Continue on Mercury Highway for 6.53 miles and turn right (east) onto 3-03 Road. Follow 3-03 Road for 1.2 miles, at which point the road curves to the north and becomes 3-05 Road. Follow 3-05 Road north for 0.9 miles and turn left (northwest) on a dirt road. Follow this dirt road for 0.55 miles to the well site. The well is painted light blue and is marked “7” in blue paint (Figure 12).

Figure 12. TW-7 wellhead (photo courtesy of NSTec, 2015).

Background for Sampling

TW-7 is included in the NNSS Integrated Groundwater Sampling Plan (DOE, 2014). However, it had not yet been sampled as part of that plan, so it was evaluated to determine its suitability. TW-7 is known to have been sampled for tritium only once, in 1994, which is described in the Well History section below. Three nuclear tests were detonated near or below the water table within 1,400 ft of TW-7 and 38 nuclear tests, 22 of which were near or below the water table, were detonated within one mile of TW-7 (Elliott and Fenelon, 2010).

Well History

TW-7 was drilled to a depth of 2,272 ft BLS in 1954. The well is cased with blank (no perforations) 12-in steel casing to 2,014 ft BLS. Below this casing is 10 5/8-in open hole from 2,014 to 2,272 ft BLS. Figure 13 shows a diagram of the well as constructed.

Figure 14 shows the history of water levels in TW-7. Since 2005, the water level has remained nearly constant at 1,645 ft BLS. The well penetrates two hydrostratigraphic units: Alluvium from the land surface to 1,660 ft BLS and the Lower Tuff Confining Unit (LTCU) from 1,660 ft BLS to the TD of the well (Table 4). Thordarson *et al.* (1967) report a yield of less than 10 gpm with over 300 ft of drawdown.

A single measurement of tritium is known for TW-7 prior to the present evaluation. Collected in 1994, this sample had a mean activity of 2.2 pCi/L with an MDL of 5.5 pCi/L (Navarro-Intera, 2016b). The sample was apparently collected with a bailer, although the sampling depth is not given. The original results for this sample are listed in the 1994 Annual Site Environmental Report (DOE, 1995) and are attributed to Test Well 7. There is some confusion regarding this sample because Figure 9.2 in DOE (1995) labels the sampling point as Test Hole 7. The UGTA Borehole Index states that Test Hole 7 is a Geologic Information Test Hole that was 520 ft deep before it was plugged to ground surface in September 2000. It is unlikely that Test Hole 7 was sampled because its depth is insufficient to reach the water table at its location in eastern Yucca Flat (SNJV, 2007). Additionally, Figure 9.2 in DOE (1995) shows Test Hole 7 in NNSS Testing Area 7, when in fact both Test Hole 7 and TW-7 are located in Area 3.

Table 4. Hydrostratigraphic units at TW-7 (from DOE [2016a]).

Interval (ft BLS)	**Hydrostratigraphic Unit**
0 to 1,660.10	Alluvium (AA3)
1,660.10 to 2,238.85	Lower Tuff Confining Unit (LTCU), zeolitized bedded tuff.

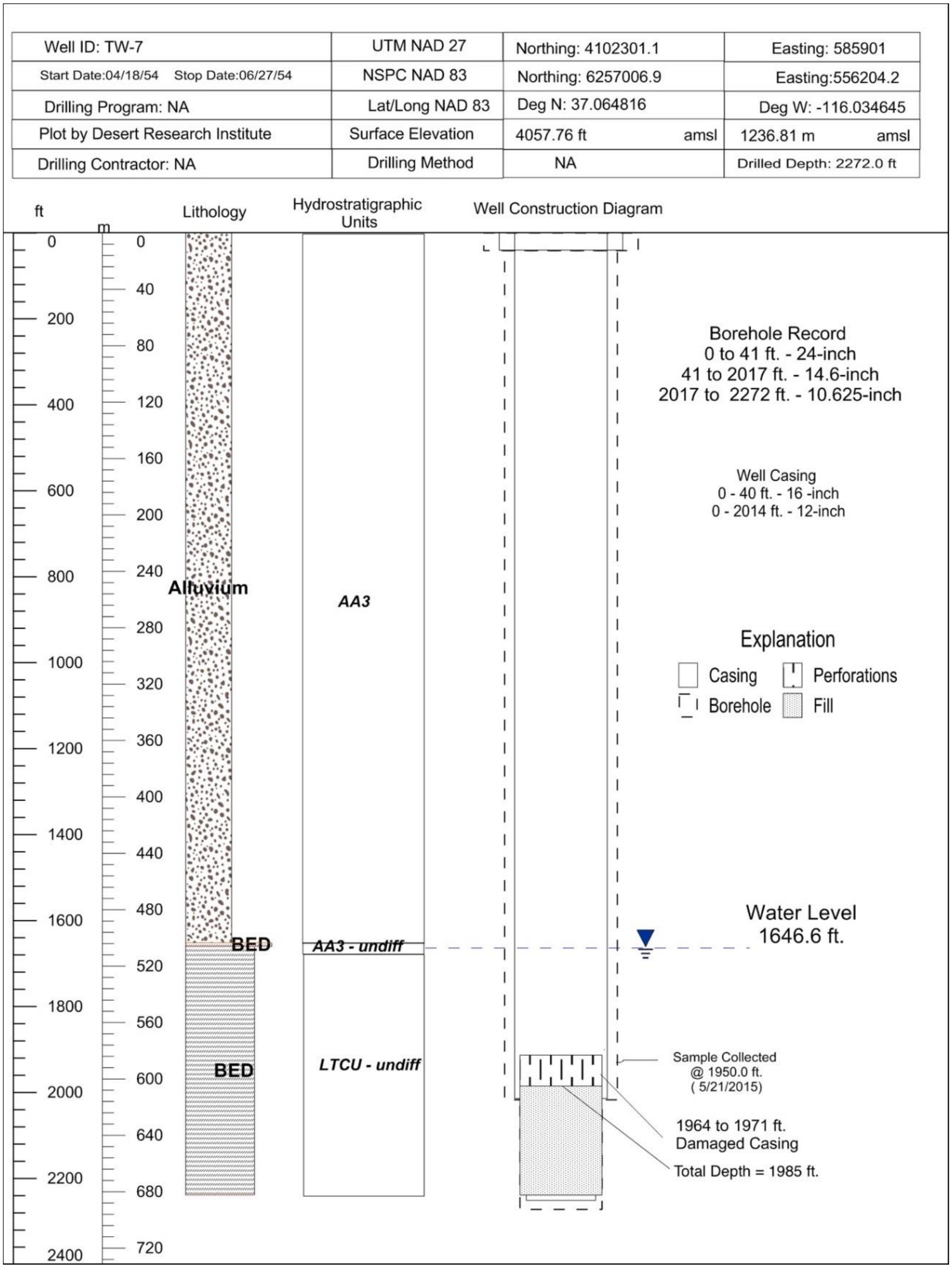

Figure 13. Downhole conditions observed at TW-7. Geologic and as-built well construction information from DOE (2016a).

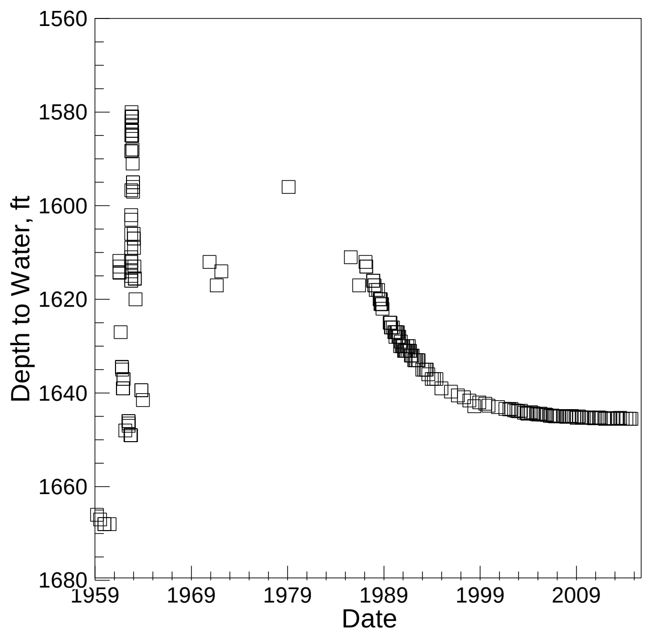

Figure 14. Depth to water in TW-7 from 1959 to 2015 (from USGS [2016]).

Field Observations

TW-7 was logged and sampled on May 21, 2015. The top of the well is painted light blue and is padlocked (Figure 12). The well cap is marked “7” in blue paint. Although the well was constructed to a depth of 2,272 ft, the logging tools met resistance at 1,976 ft, possibly at an uneven casing joint. The video camera was unable to pass below 1,985.11 ft BLS, a depth that is still within the perforated interval (further discussion below). The UGTA Borehole Index reports that a transducer was installed at 1,653 ft BLS in 1988, although it is no longer present.

Results of the Idronaut chemtool log are shown in Figure 15, which shows that the top of the perforated interval is at approximately 1,913 ft BLS. Temperature increases linearly with depth approximately 1 °C from the top of the water level in the well (1,645 ft) to the bottom of the log (1,976 ft), which results in a temperature gradient of 0.003 °C/ft (1 °C/100 m). Specific conductance is nearly constant at 598 μS/cm from the top of the water surface to 1,722 ft BLS. Below this depth, SC declines to 584 μS/cm at 1,976 ft BLS. The pH is in the range of 8.2 to 8.4. Dissolved oxygen is approximately 2.5 percent at the top of the water column and increases steadily to 7 percent at 1,976 ft BLS.

A TFM log was not run because the temperature and chemistry logs showed little evidence of significant flow within the cased interval and the uncased interval (below 1,985 ft BLS) was inaccessible. A video log run on September 15, 2015, revealed that the casing is perforated from 1,913 to 1,924 ft BLS and 1,950 to 1,985 ft BLS, although this is not noted in the UGTA Borehole Index. Water clarity is considered good and the casing is intact to a depth of approximately 1,964 ft. The casing is pinched below this depth (Figure 15), which prevents access with the video camera below 1,985.83 ft BLS (still within the casing). Figure 15 also shows what appears to be a section of rebar at the bottom.

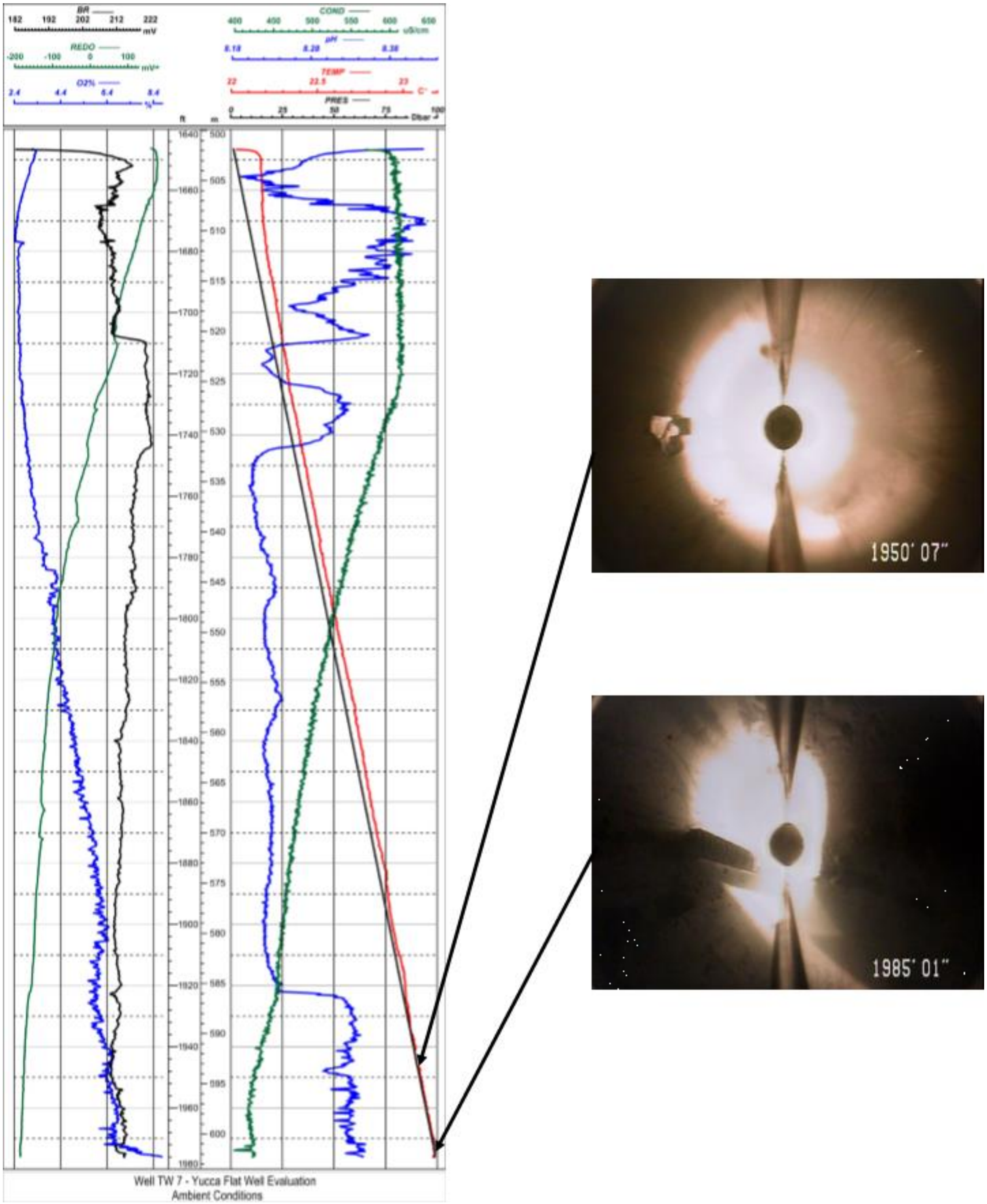

Figure 15. TW-7 Idronaut chemtool log and photos from the video log. The top photo shows the round casing at 1,950 ft, 7 in. The lower photo shows the pinched casing and a possible piece of rebar at 1,985 ft, 1 in.

Two groundwater samples were bailed on May 21, 2015, from the top of the lower perforated interval at a depth of 1,950 ft BLS. Whether these perforations provide hydraulic connection to the adjacent LTCU is unclear, although the pH, conductivity, and temperature profiles do suggest a change in water quality in the perforated section. Tritium activities were below MDLs in both samples (Table 5).

Table 5. Tritium activities in samples collected from TW-7 (from DOE [2016b]).

Date	**Activity (pCi/L)**
1/1/1994	< 5.5
5/21/2015	< 281.41
5/21/2015	< 2.47

Summary and Recommendations

Although TW-7 is in the vicinity of several large detonations, the single known measurement of tritium there indicates a mean activity below the MDL of 5.5 pCi/L in 1994. The 2015 samples indicate tritium activities below the MDL of 2.47 pCi/L.

The casing of TW-7 appears to be pinched below a depth of 1,966 ft and to have collapsed at approximately 1,985 ft. As a result, the lower 287 ft of the well, including the uncased interval, is inaccessible. It is unknown whether the uncased interval also has collapsed.

Water clarity above 1,985 ft is good and there is some indication on the chemistry logs of flow through the casing perforations. It is unknown whether there is a hydraulic connection to the uncased interval below. The conductance of this connection could be tested by pumping the well to induce flow through the obstruction and from the uncased interval and comparing water level drawdown and recovery to earlier testing. Thordarson *et al.* (1967) reported a very low yield in TW-7 so pumping rates should be selected accordingly. Collection of additional tritium samples is recommended if pumping is shown to draw water from below.

Water samples can currently be collected despite the condition of the casing, although whether they would be representative of groundwater in the LTCU is highly uncertain. Bailed samples are likely the best option because of the very low yield of the well.

UE-6d

UGTA ID: UE-6d

Integrated Groundwater Sampling Plan ID: UE-6d_o1

Integrated Groundwater Sampling Plan Status: Inactive

USGS Site ID: 365905116033201

Coordinates: 583672 m East, 4093594.4 m North, UTM11 NAD83

Elevation: 3,947 ft AMSL

Directions

From the intersection of Mercury Highway and Jackass Flats Road in Mercury, follow Mercury Highway north for 28.6 miles to Tippipah Highway. Continue north on Mercury Highway for 2.8 miles and turn left (west) on 6-06 Road at the equipment yard. Follow 6-06 Road through the equipment yard for 0.52 mile and turn left (south) onto a dirt road on the west side of the yard. Follow the dirt road south for approximately 0.5 mile. The unlocked wellhead is covered by an A-frame overhead structure. The casing at land surface is spray-painted with “UE 6D” in blue (Figure 16).

Figure 16. UE-6d wellhead (photo courtesy of NSTec, 2015).

Background for Sampling

UE-6d is not included in the NNSS Integrated Groundwater Sampling Plan (DOE, 2014). The well is located in Area 6, southwest and down hydraulic gradient of the main nuclear testing area in Yucca Flat and near the Topgallant Fault. It is completed in volcanic basin-fill units, so it may be a useful sampling point for monitoring radionuclide migration in these units in southern Yucca Flat, although no nuclear tests have been detonated within one mile of the site (Elliott and Fenelon, 2010). It was chosen for evaluation to follow up on detections of tritium in the well during the 1990s. UE-6d is used for calibrating and/or checking wireline depth control and straightening out spool wraps. The casing shoe depth was calibrated for the weapons testing program.

Well History

Figure 17 shows a diagram of the completed well. UE-6d was drilled in 1968 to a depth of 3,896 ft BLS, but fill in the bottom of the well reduced the depth to 3,864 ft BLS. The well is cased from land surface to 2,125 ft BLS with 7 5/8-in steel casing. The uncased interval is open hole with a diameter of 9.88 in to 2,617 ft BLS and 6.75 in to TD.

The well is open to approximately 1,500 ft of Playa Confining Unit conglomeratic alluvium overlying 86 ft of bedded and ash-fall tuff (Table 6). The well is 0.7 miles south of WW-3, which ceased pumping in 1970. The rising trend in water levels in UE-6d (Figure 18) is primarily attributed to a return to equilibration conditions following the cessation of pumping in WW-3 (Elliott and Fenelon, 2010).

The UGTA Chemistry Database includes results for tritium samples collected from UE-6d in 1994 and 1995, although the collection methods are not stated. The reported tritium activities are 710 and 670 pCi/L, respectively (Figure 19) (Navarro-Intera, 2016b). Assuming that the samples were collected one year apart, the decline in activity from 1994 to 1995 can be entirely attributed to radioactive decay. Based on evaluation of the potential for tritium migration from the underground nuclear tests closest to UE-6d, Navarro (2016) concluded that, although unexplained, these tritium observations are unlikely related to migration from an underground test. It is possible that tritium was introduced to the well through cross-contamination during wireline depth calibration.

Table 6. Hydrostratigraphic units at UE-6d (from DOE [2016a]).

Interval (ft BLS)	Hydrostratigraphic Unit
0 to 290	Alluvial Aquifer (AA3)
290 to 3,810	Playa Confining Unit (PCUT). Alternating units of silt, clay, and fine sand with units of conglomerate with pebble- to boulder-sized clasts.
3,810 to 3,896	Argillic Tuff Confining Unit (ATCU). Argillic bedded and ash-fall tuffs.

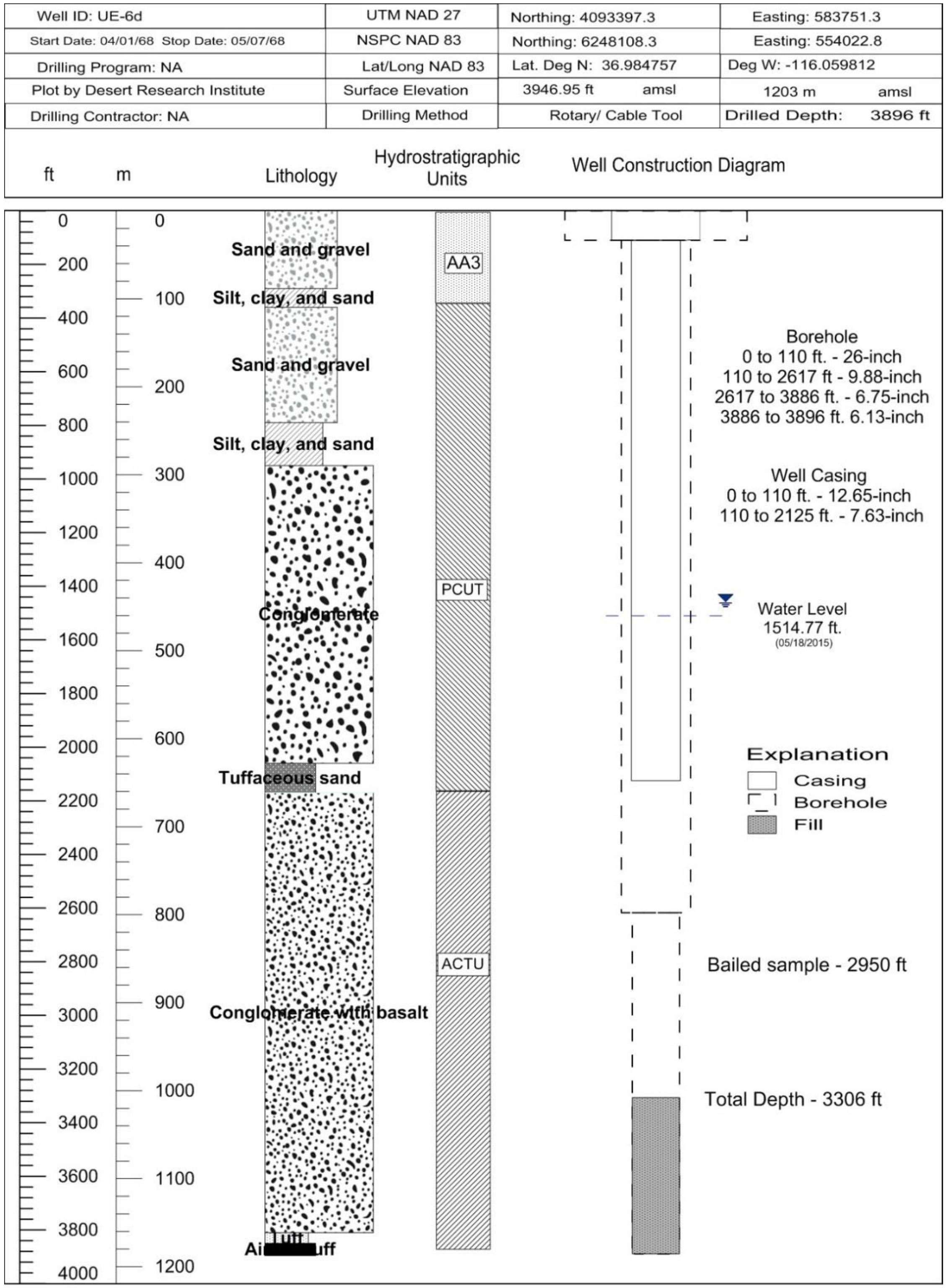

Figure 17. Downhole conditions observed at UE-6d. Groundwater samples were bailed May 18 and 19, 2015. Total depth was measured May 18, 2015. Geologic and as-built well construction information from DOE (2016a).

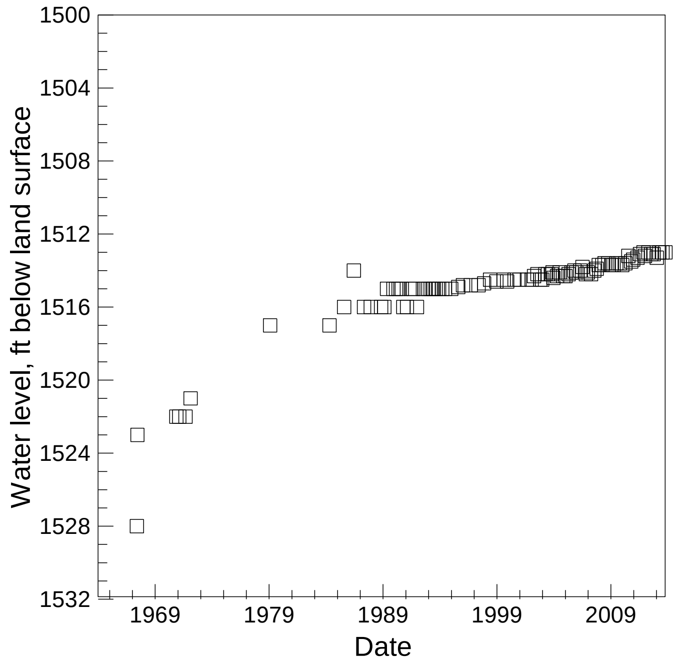

Figure 18. History of water levels in UE-6d. The slow rising trend may be a result of the cessation of pumping at WW-3, located 0.7 miles north (from USGS, 2016).

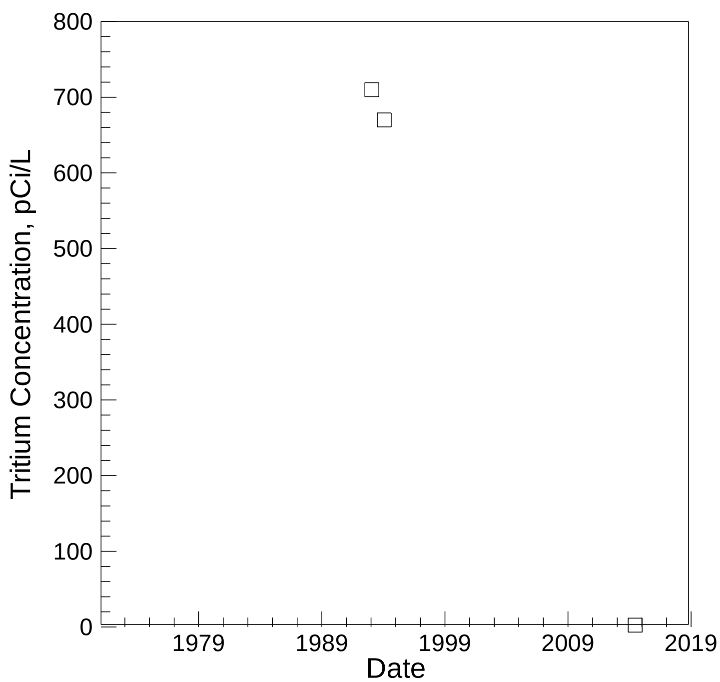

Figure 19. Results of all tritium analyses for UE-6d. The value for the 2015 samples are below the mean MDL of 2.33 pCi/L (from DOE [2016b]).

Field Observations

Logging was performed on May 18, 2015. The depth to water was measured at 1,514.77 ft BLS and TD was tagged using the casing collar locator at 3,306 ft BLS (depth in 1968 was 3,864 ft BLS). The Idronaut chemtool log shows constant pH and temperature increase from the water surface at 1,544.77 ft BLS to the base of the casing at 2,125 ft BLS (Figure 20). Peaks in pH and SC just below the casing suggest that the cement anchoring the base of the casing is affecting water quality, which is possibly exacerbated by a lack of wellbore flow in this interval. Below this zone, pH ranges between 7.6 and 7.8. The nearly constant temperature increase with depth suggests a close correlation to the geothermal gradient and minimal groundwater flow into and vertically within the well. The video log (terminated at 2,841 ft BLS by the video cable length) shows the hole to be round, competent, and in good condition from land surface to 2,841 ft BLS. The water was clear.

Samples were collected May 18 and 19, 2015, using a depth-discrete bailer set in the uncased borehole at a depth of 2,950 ft, which is the vertical midpoint of the uncased interval. The sampled water was very cloudy, which most likely resulted from disturbance of the water column by the previous logging operations. Low-level tritium activities were all below the mean MDL of 2.33 pCi/L (Table 7). Assuming only radioactive decay and the tritium activity of 710 pCi/L observed in 1994, the activity in 2015 would be expected to be approximately 216 pCi/L. The difference may be a result of bailing the samples from a zone that does not contribute groundwater flow to the wellbore, collection of the samples without purging, or changes in the distribution of tritium in the well. The source of tritium in UE-6d remains unexplained (Navarro, 2016).

Table 7. History of tritium activities in UE-6d (from DOE [2016b]).

Date	Activity (pCi/L)	Method Detection Limit (pCi/L)
1/1/1994	710	297
1/1/1995	670	6.1
5/18/2015	< 279.34	279.34
5/18/2015	< 2.44	2.44
5/19/2015	< 280.07	280.07
5/19/2015	< 2.22	2.22

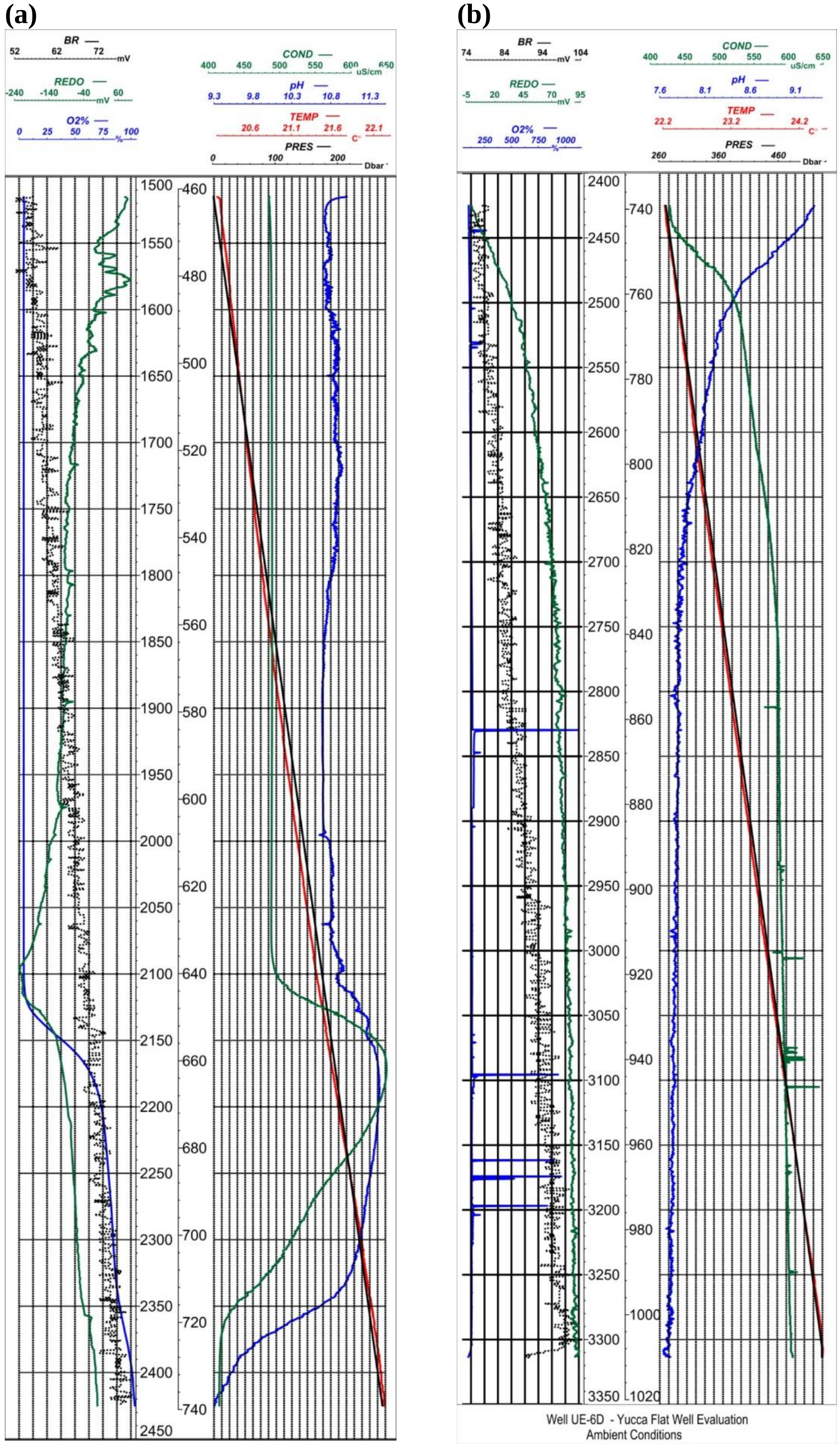

Figure 20. Idronaut chemtool log of UE-6d showing (a) upper section and (b) lower section.

Summary and Recommendations

There is little evidence of borehole flow in UE-6d, although the undisturbed water column was very clear. The groundwater samples contained suspended sediment as a result of disturbance of the water column during logging operations. Tritium results are inconsistent with tritium activities in samples collected in 1994 and 1995, assuming radioactive decay alone, which suggests that differences in the sampling method and/or tritium distribution in the well may play a role. The 2015 samples were bailed from a discrete depth and may not have targeted the same depth interval (which is unreported) as the earlier samples. Although the origin of tritium detections in UE-6d remains unexplained, the 2015 results indicate that the earlier samples were not indicative of a tritium plume (Navarro, 2016).

The lack of borehole flow makes identification of an appropriate sampling interval very difficult. Purging the well may remove some of the suspended sediment and stressed-flow logging may help identify contributing groundwater zones.

U-2gg PSE 3A

UGTA ID: U-2gg PSE 3A

Integrated Groundwater Sampling Plan ID: U-2gg PSE 3A_m1

Integrated Groundwater Sampling Plan Status: Inactive

USGS Site ID: 370837116040901

Coordinates: 582578.1 m East, 4111207.5 m North, UTM11 NAD83

Elevation: 4,311 ft AMSL

Directions

From the intersection of Mercury Highway and Jackass Flats Road in Mercury, follow Mercury Highway north for 28.6 miles to Tippipah Highway. Continue north on Mercury Highway for 7.6 miles to the fork in the road (BJ Wye). Keep left and follow Rainier Mesa Road northwest to 4.7 miles to 2-03 Road. Keep right and follow 2-03 Road north for 1 mile to 2-05 Road. Turn right (northeast) on 2-05 Road and follow for 0.2 miles to a dirt road on the right. Turn right and follow dirt road 0.2 miles southeast to the well site. Figure 21 shows the wellhead.

Figure 21. U-2gg PSE 3A wellhead (photo courtesy of NSTec, 2015).

Background for Sampling

U-2gg PSE 3A is currently inactive. It was selected for evaluation because it may provide monitoring of the near-field conditions in the volcanic aquifer below the INGOT detonation. The INGOT working point is 1,640 ft BLS (DOE, 2015).

Well History

U-2gg PSE 3A is a slant hole drilled in 1994 to within 100 ft of the INGOT detonation cavity in bedded tuffs (Elliot and Fenelon, 2010). Table 8 lists the hydrostratigraphic units identified at U-2gg PSE 3A. Forty-nine nuclear tests, 13 of which were near or below the water table, were detonated within one mile of U-2gg PSE 3A. Unless otherwise noted, all depths given for U-2gg PSE 3A are given as drilled or measured depths along the slanted well. The equation for true vertical depth is $TVD = 0.95106d$, where TVD is the true vertical depth (ft) and d is the measured depth (ft) (P.E. Elliott [USGS], e-mail communication, January 12, 2016).

U-2gg PSE 3A was slant drilled to 2,383 ft. Stainless steel casing (5.5-in diameter) runs from the land surface to 2,060 ft (Figure 22). From 2,060 ft to TD at 2,383 ft, the well is 9.88-in diameter open hole (Navarro-Intera, 2016a). In 2004, the annulus around the 5.5-in casing was cemented from 1,514 to 10 ft. There are no slots in the casing and the well has not been developed. Four water level measurements were made in 1994 and 1995 (Figure 23) and they may be affected by the INGOT detonation near the water table on March 9, 1989 (Elliott and Fenelon, 2010). U-2gg PSE 3A is no longer included in the USGS water level monitoring program.

Prior to this study, three samples were collected from September 21 to 22, 1994. These samples were bailed from depths between 1,927 and 1,960 ft and their tritium activities ranged from 5,450 to 7,500 pCi/L (Navarro-Intera, 2016b) (Figure 24).

Table 8. Hydrostratigraphic units at U-2gg PSE 3A (from DOE [2016a]).

Interval (ft BLS)	Hydrostratigraphic Unit
0 to 1,398	Alluvial Aquifer (AA3), unconsolidated gravelly sand and colluvium
1,397.6 to 1,647	Timber Mountain welded-tuff aquifer (TM-WTA)
1,646.98 to 1,821.19	Timber Mountain lower vitric-tuff aquifer (TM-LVTA)

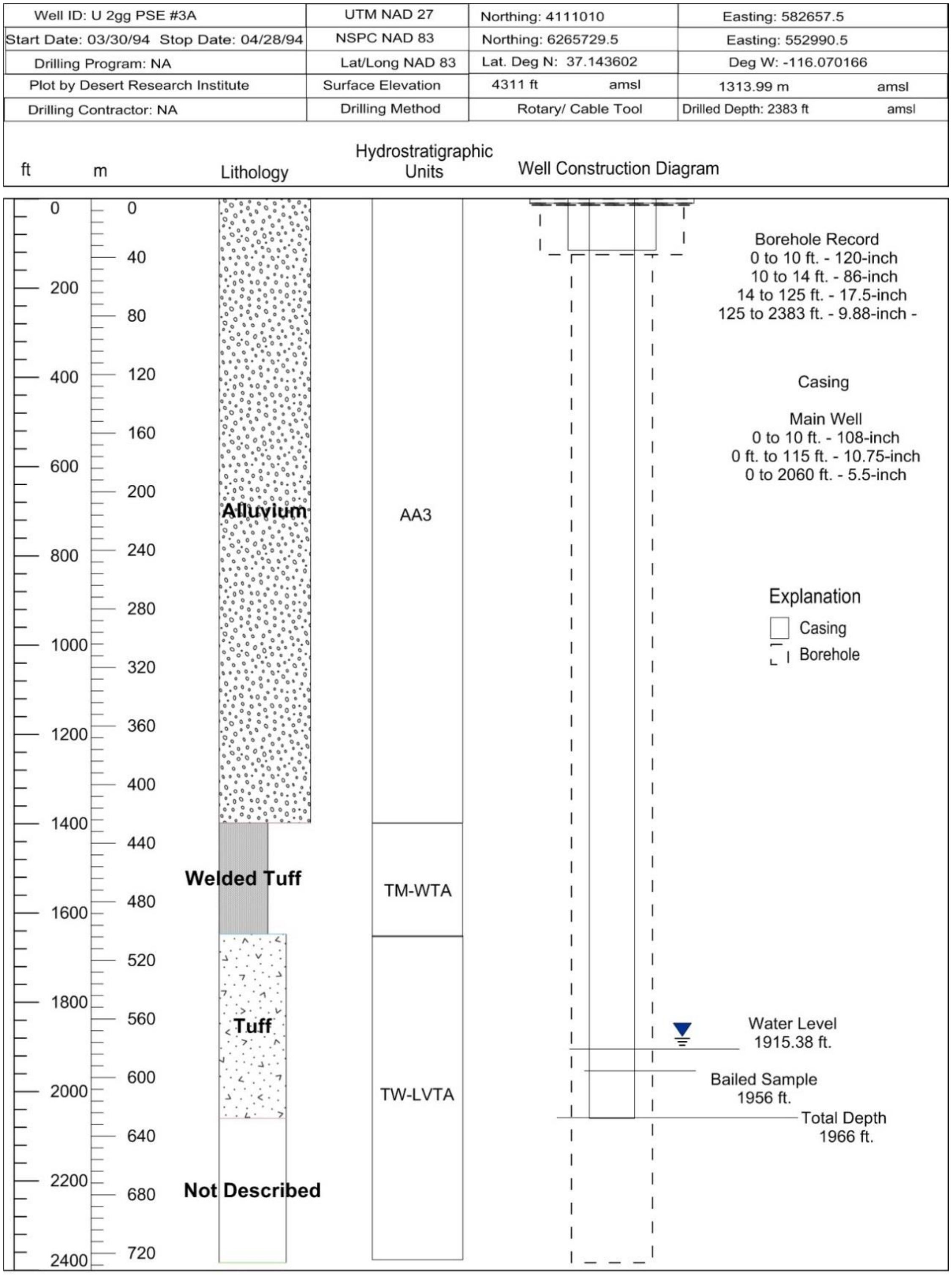

Figure 22. Downhole conditions observed at U-2gg PSE 3A. Depths shown are measured depths along the slanted well. Geologic and as-built well construction information from DOE (2016a).

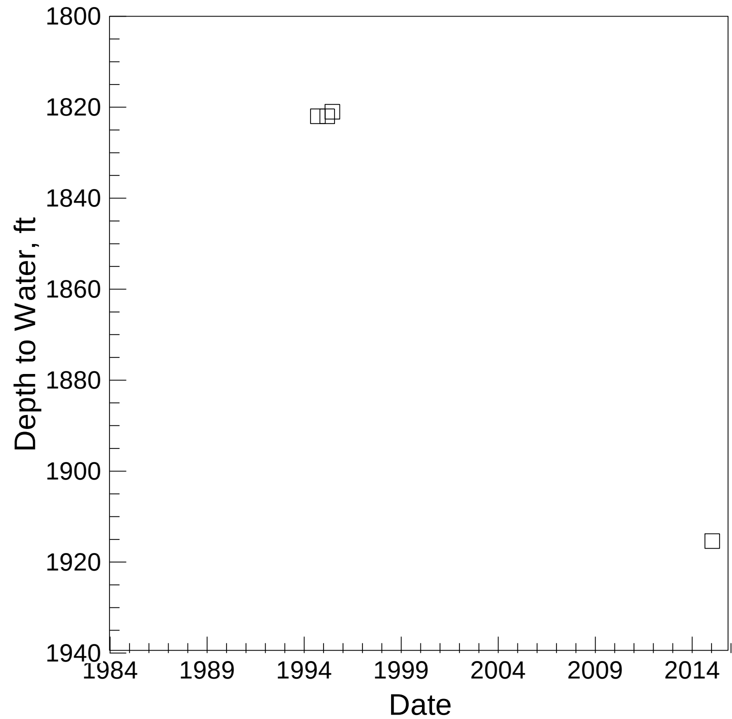

Figure 23. Water level measurements in U-2gg PSE 3A converted to true vertical depths (from USGS [2016]).

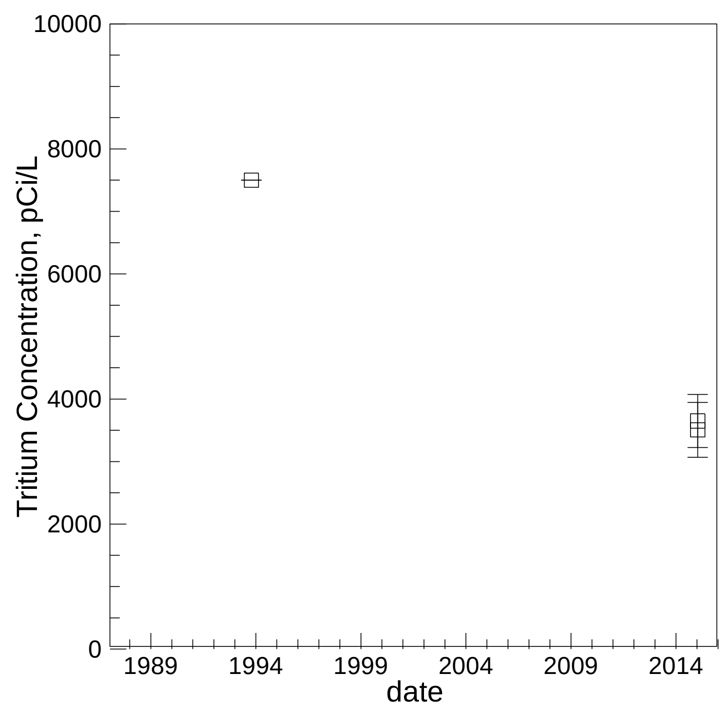

Figure 24. Tritium activities in U-2gg PSE 3A (from DOE [2016b]).

Field Operations

U-2gg PSE 3A was logged and sampled on December 14, 2015. The wellhead was in good condition and consisted of an angled 6-in casing that extended approximately 1 ft above ground surface. The casing is capped, padlocked, and painted light blue (Figure 21).

The water level was measured at 1,915.38 ft (corresponding to a vertical depth of 1,821 ft). During logging operations an obstruction within the casing prevented access below 1,966.2 ft (Figure 25), which is 94 ft above the base of the casing at 2,060 ft. As a result, the logs are entirely within the casing, and therefore do not directly represent hydrochemical conditions in the adjacent hydrostratigraphic units. The 2 °C linear decline in temperature observed with increasing depth below the water level (vertical depth of 1,821.6 ft) is likely an indication of residual heat from the overlying INGOT detonation (vertical depth to working point of 1,640 ft). The other parameters are all significantly affected by the presence of solids in the drilling fluid and are not considered useful for interpreting groundwater conditions or borehole flow.

Two fluid samples were collected using a depth-discrete bailer set at 1,956 ft. The recovered fluid was light brown, nearly opaque, and appeared to have a significant content of drilling fluid. These conditions are commonly encountered in post-shot holes. The mean tritium activity of 3,579 pCi/L is higher than the decayed-corrected mean activity of 1,949 pCi/L for the samples collected in 1994. The cause of the obstruction at 1,966.2 ft is unclear. Unfortunately, the extremely low visibility caused by the remaining drilling fluid prevents effective evaluation by video logging. Swipes of the wireline and equipment by the radiological control technician showed no indication of tritium.

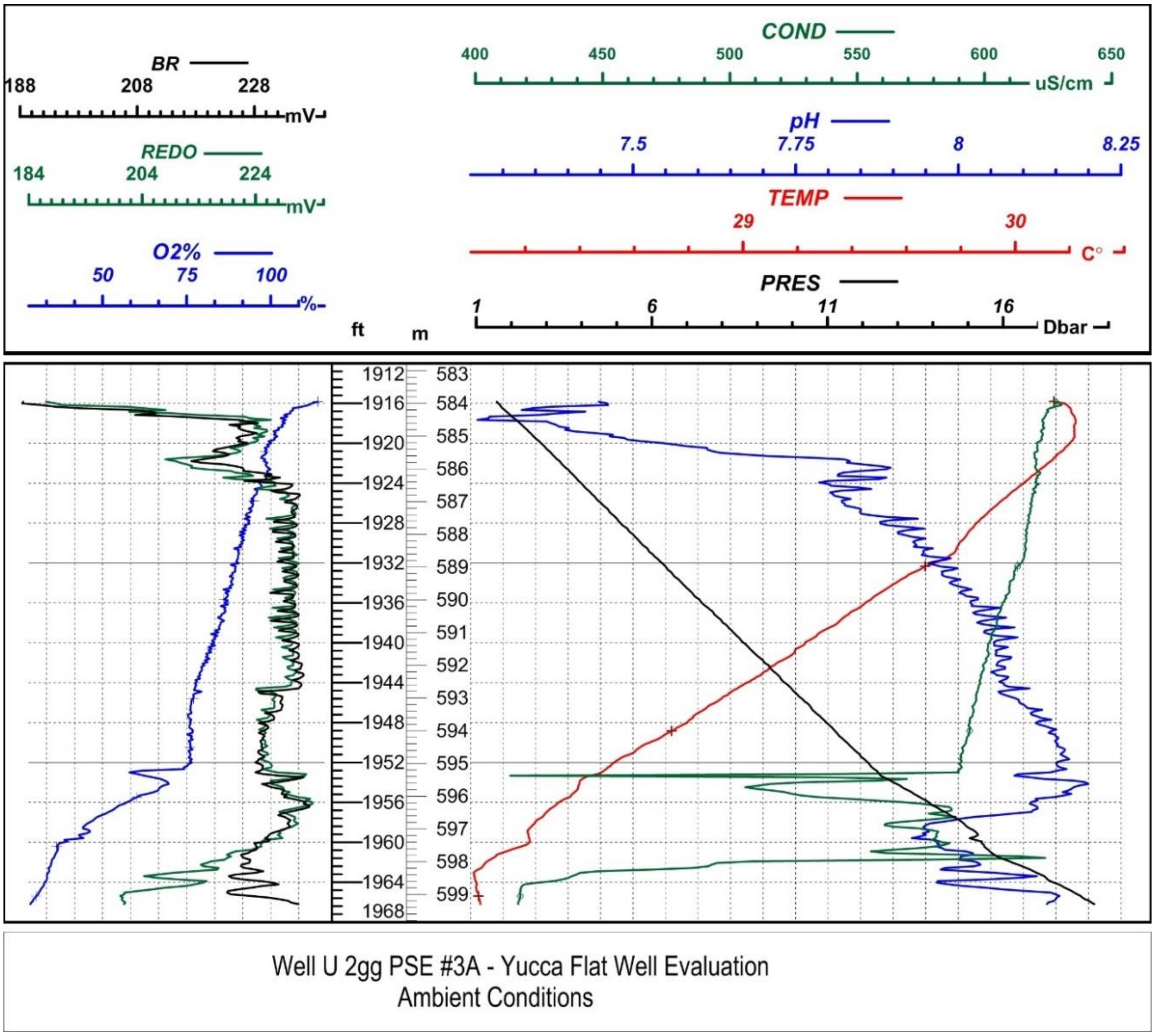

Figure 25. Idronaut chemtool log of U-2gg PSE 3A. The logged interval is inside the casing from the water level at 1,915.38 ft to an obstruction at 1,966.22 ft. Depths shown are measured depths along the slanted well.

Summary and Recommendations

U-2gg PSE 3A remains filled with drilling fluid and access below 1,966.2 ft BLS to the uncased borehole at 2,060 ft BLS is prevented by an obstruction within the casing. The cause of the obstruction is unknown because the opacity of the borehole fluid prevents effective video logging. Tritium activities in the samples collected for this project are higher than the decay-corrected tritium samples collected in 1994, and were collected using similar techniques at approximately the same depths, suggesting that some degree of interaction with the surrounding groundwater is occurring. This interaction may result from circulation of fluids through the obstruction to the uncased borehole below, through breaks in the casing above the obstruction, or through a combination of factors.

Further assessment of the obstruction is necessary to determine whether U-2gg PSE 3A could be used for sampling below INGOT. Unfortunately, low visibility caused by the drilling fluid prevents useful evaluation by video logging. Purging the well of drilling fluids may allow further evaluation through video and chemtool logging and dramatically improve conditions for sampling, although it is also likely to significantly disrupt radionuclide distributions in the vicinity of the well and INGOT cavity.

U-10L 1

UGTA ID: U-10L 1

Integrated Groundwater Sampling Plan ID: Not applicable

Integrated Groundwater Sampling Plan Status: Not included

USGS Site ID: 370917116023701

Coordinates: 584843.4 m East, 4112467 m North, UTM11 NAD83

Elevation: 4,264.6 ft AMSL

Directions

From the intersection of Mercury Highway and Jackass Flats Road in Mercury, follow Mercury Highway north for 28.6 miles to Tippipah Highway. Continue north on Mercury Highway for 7.6 miles to the fork in the road (BJ Wye). Keep left and follow Rainier Mesa Road northwest to 4.7 miles to 2-03 Road. Keep right and follow 2-03 Road north for 1 mile to 2-05 Road. Turn right (northeast) on 2-05 Road and follow it for 0.7 miles to 10-03 Road. Turn right and follow 10-03 east for 1.2 miles to a dirt road on the left. Follow this dirt road north approximately 0.1 miles to the well site. Figure 26 shows the wellhead.

Figure 26. U-10L 1 wellhead (photo courtesy of NSTec, 2015).

Background for Sampling

U-10L 1 is not included in the NNSS Integrated Groundwater Sampling Plan (DOE, 2014). It was constructed in 1964 with 217 ft of uncased borehole in the lower carbonate aquifer (LCA), making it a potentially ideal monitoring well. However, an obstruction encountered in 1997 at a depth of 1,853 ft BLS prevented access to the water level that had last been measured at 1,857 ft BLS in 1980 (Elliott and Fenelon, 2010; USGS, 2016), just four feet below the obstruction.

The objectives of the U-10L 1 evaluation were to determine its current accessible depth, investigate whether the obstruction could be bypassed, and if so, assess the condition of the well and the uncased LCA interval in particular.

Well History

U-10L 1 was completed to a depth of 2,208 ft BLS in 1964. The hole is cased to 1,375 ft BLS with 10 3/4-in steel casing. Below the casing is 833 ft of 9 5/8-in open hole with 217 ft penetrating the LCA. In 1965, caving or an obstruction prevented access to the open interval, although the water level remained measurable and was consistent with levels measured locally in the LCA (Elliott and Fenelon, 2010). In 1997, an obstruction was encountered higher in the hole at a depth of 1,853 ft BLS that prevented access to the water level that had previously been measured in 1980 at 1,857 ft BLS (Elliott and Fenelon, 2010; USGS, 2016). Figure 27 shows a diagram of the completed well. Table 9 lists the hydrostratigraphic units identified at U-10L 1.

Water levels from five measurements made between 1964 and 1980 (USGS, 2016) are shown on Figure 28. The first two levels are thought to reflect transient conditions in the well shortly after drilling and construction were completed (USGS, 2016). There are no records in the UGTA Chemistry Database of samples collected in U-10L 1.

Table 9. Hydrostratigraphic units at U-10L 1 (from DOE [2016a]).

Depth Interval (ft BLS)	Hydrostratigraphic Unit
0 to 928.15	Alluvium (AA3)
928.15 to 1,187.01	Timber Mountain Lower Vitric-tuff Aquifer (TMLVTA). Nonwelded ash-flow and bedded tuff, vitric.
1,187.01 to 1,991.14	Lower Tuff Confining Unit (LTCU). Zeolitized bedded tuff.
1,991.14 to 2,208.01	Lower Carbonate Aquifer (LCA)

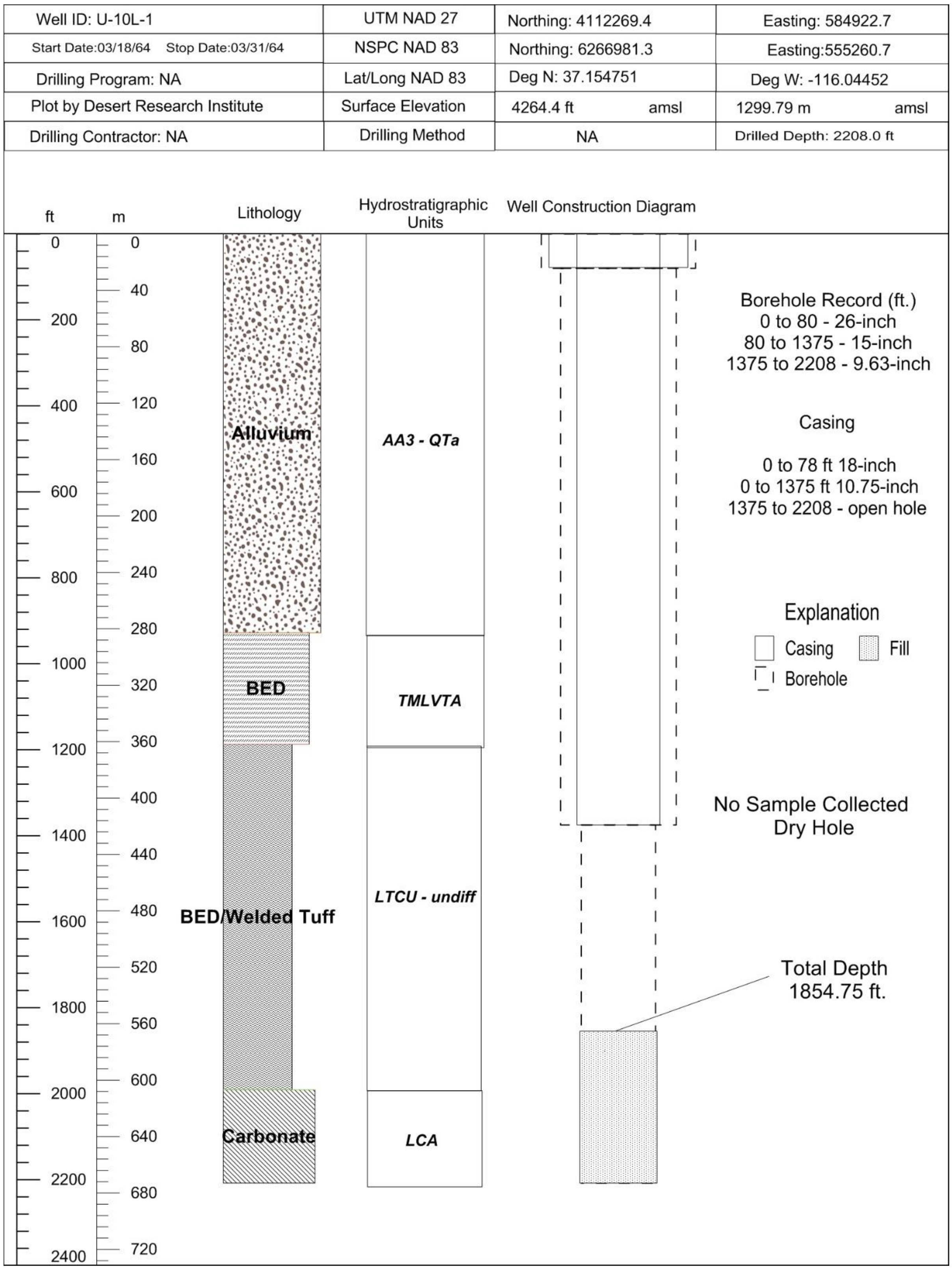

Figure 27. Downhole conditions observed at U-10L 1. Geologic and as-built well construction information from DOE (2016a).

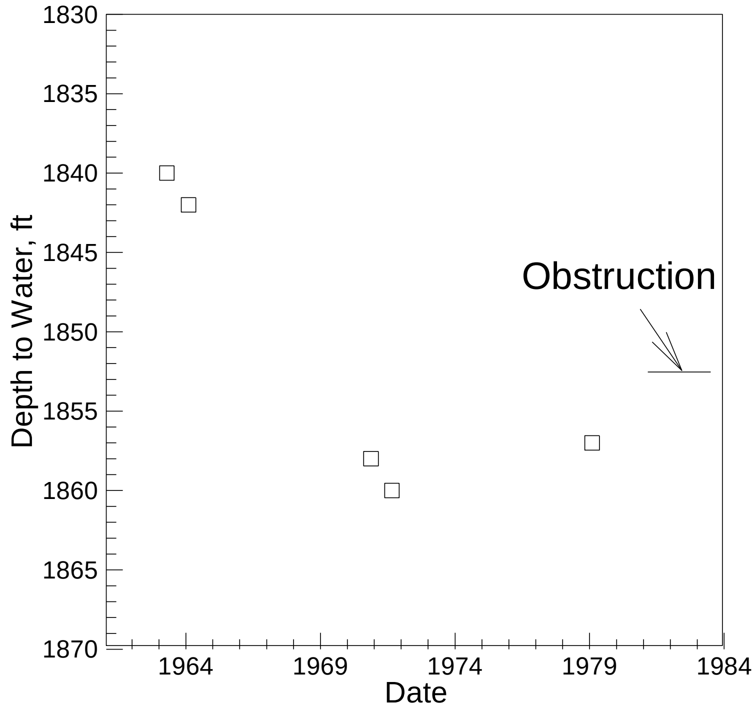

Figure 28. Water level measurements in U-10L 1 (from USGS [2016]). Attempts were made to measure water levels in 1985 and 1997, but an obstruction was encountered at 1,853 ft BLS in both instances, which is above previously measured water levels in the well.

Field Operations

U-10L 1 was evaluated on December 15, 2015. The wellhead was in good condition with a padlock securing the hinged steel cover. The casing extends approximately 24 inches above land surface and is painted light blue.

The video camera was lowered in the hole and encountered an obstruction at 1,854.75 ft BLS (Figure 29). This depth is approximately one foot lower than the depth measured in 1997. Whether this difference is real or related to different measurement methods or reference points is not known. The video log also revealed numerous breakouts and rock ledges along the open borehole wall and rock debris at the bottom. It appears that this debris forms a bridge above the water level, although the thickness of the bridge could not be determined. There was no water detected in the well indicating that the obstruction is above the water level. The chemtool log was not run.

Upon tripping out of the hole with the video camera, the onsite radiological technician stated that the radiation count was above acceptable limits. After a two-hour delay, the radiological technician cleared the equipment for removal, stating that radon had decayed to acceptable limits.

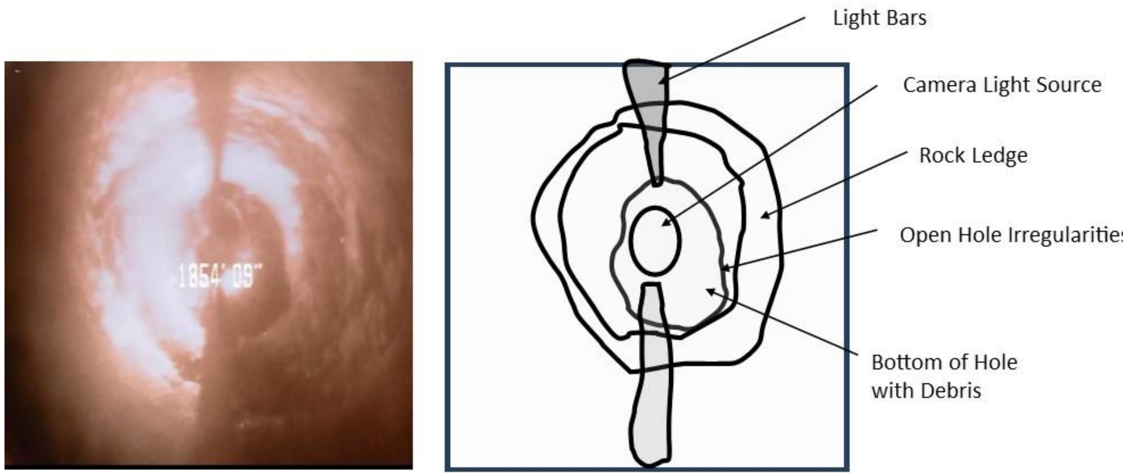

Figure 29. View of the 9 5/8-in open hole just above the obstruction (left) and a description of the features in the photograph (right).

Summary and Recommendations

An obstruction was identified in U-10L 1 at a depth of 1,854.75 ft BGS and approximately 2 ft above the most recent water level measured in 1980. The obstruction appears to be rock debris, although it is not known whether the debris forms a thin bridge or completely fills the wellbore below. To regain the original TD of 2,208 ft and access to the LCA, this debris would require removal, probably through drilling or milling.

UE-6e

UGTA ID: UE-6e

Integrated Groundwater Sampling Plan ID: UE-6e_o1

Integrated Groundwater Sampling Plan Status: Inactive

USGS Site ID: 365905116012002 (2090–2230 ft)

Coordinates: 586933.2 m East, 4093605.9 m North, UTM11 NAD83

Elevation: 3,938 ft AMSL

Directions

From the intersection of Mercury Highway and Jackass Flats Road in Mercury, follow Mercury Highway north for 28.6 miles to Tippipah Highway. Continue north on Mercury Highway for 1.7 miles and turn right (east) on Tweezer Road and follow it for 1.4 miles to 3-12 Road. Turn left (north) and follow 3-13 Road to Emplacement Tower storage area on right (east). Turn right and follow the dirt road east for 0.3 miles through the storage area. The road turns north and then continues east to the well site. The wellhead is spray-painted light blue (Figure 30).

Figure 30. UE-6e wellhead (photo courtesy of NSTec, 2015).

Background for Sampling

UE-6e is not included in the NNSS Integrated Groundwater Sampling Plan (DOE, 2014). The well is located in Area 6, directly south and down hydraulic gradient of the main nuclear testing area in Yucca Flat. It is completed in the Topopah Spring volcanic aquifer, so it may be a useful sampling point for monitoring radionuclide migration in this unit in southern Yucca Flat. UE-6e was selected for evaluation to determine its current condition and to follow up on tritium detections from the 1990s.

Well History

UE-6e was completed in 1973 to a TD of 4,209 ft (Navarro-Intera 2016a). It is cased from land surface to 2,090 ft BLS with 9 5/8-in steel casing. Below the casing, 12 1/2-in open hole originally extended to 2,090 ft BLS and 8 3/4-in open hole originally extended to TD, penetrating 224 ft of the LCA. The well remained full of mud after drilling and logging operations were completed.

In 1992, an effort was made to recomplete the uncased borehole as dual-completion—with independent screen intervals in the LCA and Tertiary volcanic section—to support detailed hydraulic testing and groundwater sampling in the LCA, as well as characterization of the vertical hydraulic gradient. Sloughing in the lower portion of the borehole prevented the installation of casing and screen as planned, and a cement bridge plug was placed at a depth of 2,229 to 2,300 ft BLS, which prevented access to the LCA (DOE, 1996). Casing was not installed above this plug, so the open hole extended 139 ft through the TSA and zeolitized LTCU from the plug to the base of the 9 5/8-in casing at 2,090 ft BLS. Following installation of the bridge plug, the hole was swabbed and operations were suspended. No well development occurred. Figure 31 shows a diagram of the completed well above the bridge plug. Table 10 lists the hydrostratigraphic units penetrated by UE-6e.

Table 10. Hydrostratigraphic units at UE-6e (from DOE [2016a]).

Depth Interval (ft BLS)	Hydrostratigraphic Unit
1,877.95 to 2,209.97	Topopah Spring Aquifer (TSA). Welded ash-flow tuff.
2,209.97 to 2,853.35	Lower Tuff Confining Unit (LTCU). Zeolitized bedded tuff.
2,853.35 to 3,947.83	Oak Springs Butte Confining Unit (OSBCU). Devitrified to zeolitic non- to partially welded tuffs.
3,947.83 to 3,984.91	Argillic Tuff Confining Unit (ATCU). Argillic bedded tuff.
3,984.91 to 4,208.99	Lower Carbonate Aquifer (LCA)

Water levels in the volcanic aquifer appeared to reach equilibrium after recompletion efforts in 1992 (Figure 32). In September 1997, the well was purged causing water levels to drop nearly 4 ft (Elliot and Fenelon, 2010). Since that time, levels have risen to a new equilibrium at an elevation approximately 1.8 ft above pre-1997 levels and approximately the same as those measured in the well prior to recompletion efforts and installation of the bridge plug. Elliott and Fenelon (2010) interpret this response as evidence that the bridge plug is no longer sealing off the lower portion of the well and that water levels now represent conditions over the entire original length of the hole. If this is the case, there is also the possibility that groundwater may move upward through the plug in response to the upward-directed hydraulic gradient.

Samples collected from UE-6e in 1994 and 1995 show tritium activities of 12.5 and 16 pCi/L respectively (Table 11). Another sample collected in 1999 indicated a tritium activity below the detection level of 55.3 pCi/L. These samples were all collected from the volcanic section after the bridge plug was installed, although their depth and sampling method are not described in the UGTA Chemistry Database.

Table 11. Tritium activities in UE-6e (from DOE [2016b]).

Date	**Activity (pCi/L)**	**Detection Limit (pCi/L)**
3/31/1990	< 55.3	55.3
01/01/1994	12.5	4.9
01/01/1995	16	4.2
5/19/2015	< 280.79	280.79
5/19/2015	< 102.48	102.79
5/19/2015	< 2789	2722

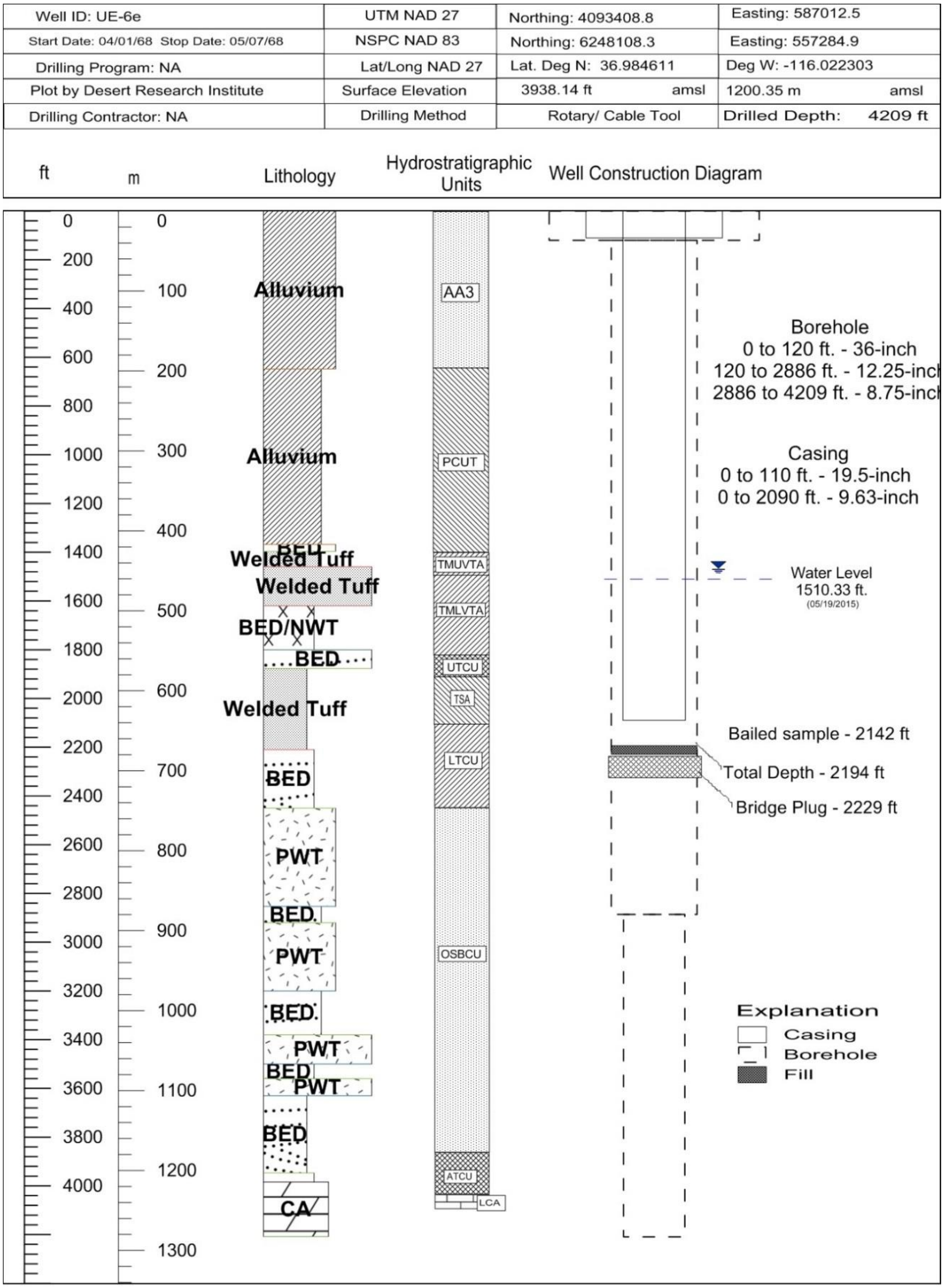

Figure 31. Downhole conditions observed at UE-6e. Geologic and as-built well construction information from DOE (2016a).

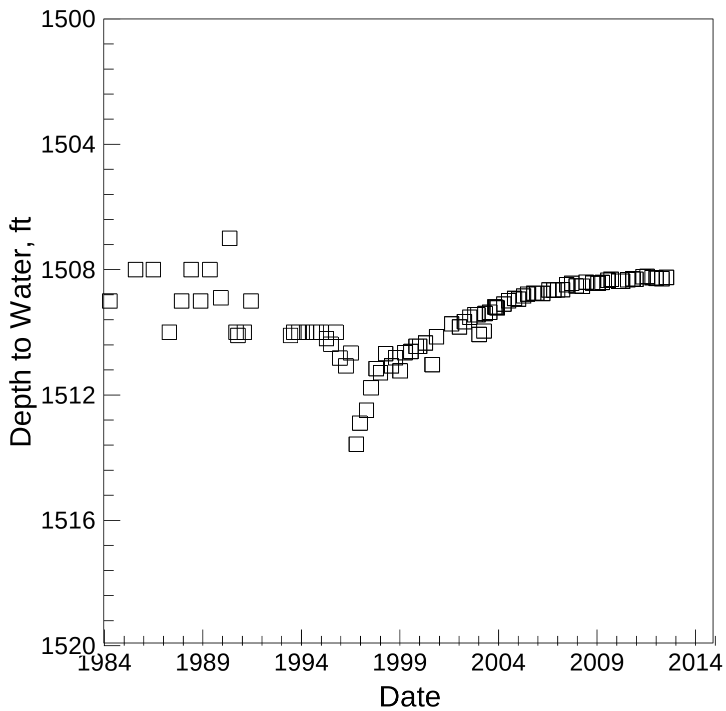

Figure 32. History of water levels in UE-6e (2,090-4,209 ft) (from USGS [2016]).

Field Observations

UE-6e was evaluated on May 19, 2015. The top of the well is painted light blue and is padlocked (Figure 30). The water level was measured at 1,510.33 ft BLS, which is consistent with recent measurements by the USGS (Figure 32). The Idronaut chemtool encountered an obstruction at 2,060 ft BLS and the tool was unable to proceed below 2,194 ft BLS. Upon retrieval, the chemtool was covered with muddy solids and the logs themselves are indicative of a high drilling fluid content that obscured responses to groundwater quality or flow in the open borehole (Figure 33). The TFM was not deployed because of the undeveloped borehole conditions.

The very high drilling fluid content was confirmed by the video log that essentially shows no image once the tool passed below the water level. Based on the pressure gradient log, the mud weight is 8.6 pounds per gallon (lb/gal) (compared to the mass density of water of 8.33 lb/gal). Total depth was measured at 2,194 ft BLS.

The bailer successfully passed the obstruction at 2,060 ft and two samples were collected from 2,142 ft BLS, 147 ft above the bridge plug. Both show tritium activities below their corresponding detection levels (Table 11). The high content of suspended solids in these samples prevented low-level tritium analysis by the commercial lab. The lowest detection level was 102.48 pCi/L.

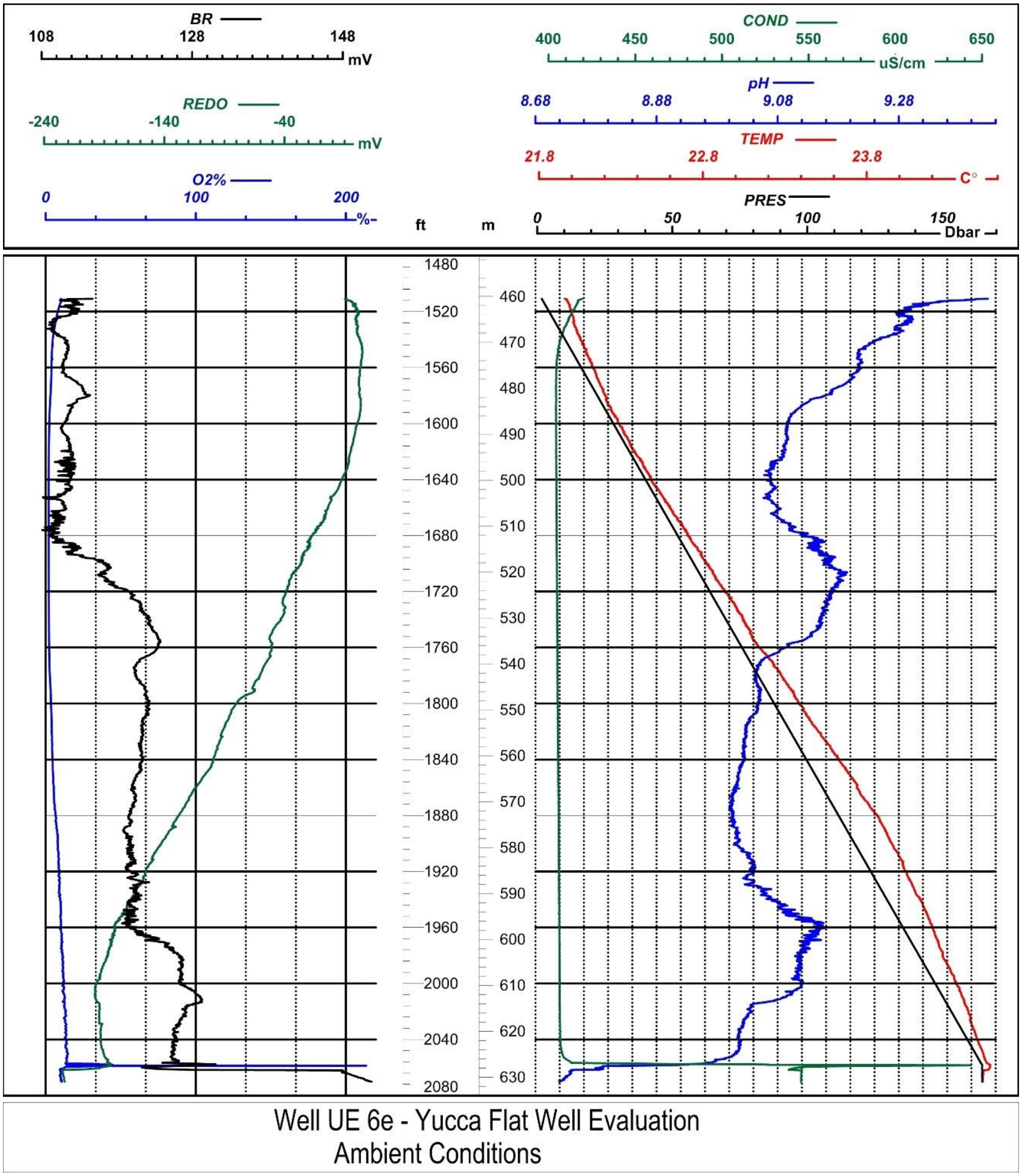

Figure 33. Chemtool log of UE-6e. The logged interval is from the water level at 1,510.33 feet to an obstruction at 2,194 ft BLS.

Summary and Recommendations

Although the location of UE-6e may be useful for monitoring radionuclide migration in the TSA in southern Yucca Flat, its current condition is unsuitable for groundwater sampling. The uncased interval above the bridge plug remains filled with drilling fluid, masking the ambient chemical and borehole flow profiles. The current TD is 2,194 ft BLS. In addition, comparison to the very low tritium activities observed in the mid-1990s could not be made because tritium activity is presently below the lowest detection limit of 102.48 pCi/L (the high content of suspended solids in these samples prevented low-level tritium analysis). Radioactive decay of the earlier tritium occurrences would have reduced those activities to below 5 pCi/L.

SUMMARY OF WELL EVALUATIONS IN YUCCA FLAT

Six wells were evaluated in Yucca Flat during 2015 to 2016 with the goals of assessing their accessibility and suitability for UGTA groundwater sampling and collecting samples if warranted. The evaluation included wellbore access, hydrochemical logging, thermal flow logging, video logging, and collecting water samples for tritium analysis. Key findings from the evaluations are summarized in Table 12. Tritium activities in samples collected from TW-B, TW-7, UE-6d, and UE-6e are below low-level analytical detection levels. The mean tritium activity of two samples collected in post-shot hole U-2gg PSE 3A is 3,578 pCi/L. Water samples could not be collected from U-10L 1 owing to an obstruction in the casing located above the most recently measured water level.

Table 12. Summary of key findings from evaluations of six wells in Yucca Flat.

Well	Constructed Total Depth, ft (date)	Measured Total Depth, ft (date)	Last Known Water level, ft (date) mean	Water Level, ft (date)	Last Known Tritium Activity, pCi/L (sample date)	Tritium Activity, pCi/L (sample date)	Sampling Method	Sample Depth, ft
TW-B	1,675 (1961)	1,656.2 (5/20/2015)	1,504.5 (2013)	1,505.1 (5/20/2015)	44 (6/22/1998)	U 2.84 (5/20/2015)	Depth-discrete Bailer	1,625
TW-7	2,239 (1954)	1,985.11 (9/15/2015)	1,628 (2013)	1,646.6 (5/21/2015)	<5.5 (1/1/1994)	<2.47 (5/21/2015)	Depth-discrete Bailer	1,950
U10L-1	2,208 (1962-1964)	1,854.75 (12/15/2015)	1,851.4 (1997)	NA*	No Data	Not Sampled	Not Sampled	Not Sampled
U-2gg PSE 3A	2,383 (1994)	1,966.2 (12/14/2015)	1,821.7 (1996)	1,915.38 (12/14/2015)	7,500 (9/21/1994)	3,649.13, 3,506.62 (12/14/2015)	Depth-discrete Bailer	1,956
UE-6d	3,896 (1968)	3,306 (5/18/2015)	1,515 (2013)	1,514.77 (5/18/2015)	670 (1/1/1995)	<2.22 (5/18/2015)	Depth-discrete Bailer	2,950
UE-6e	4,209 (1973)	2,194 (5/19/2015)	1,509.6 (2013)	1,510.33 (5/19/2015)	<55 (3/31/1999)	<102.48 (5/19/2015)	Depth-discrete Bailer	2,142

* Obstruction prevented access to the water level.
U Compound was analyzed for, but was not detected ("Non-detect").

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APPENDIX A: ANALYTICAL RESULTS FOR TRITIUM

Table A-1. Results from UGTA Chemistry Database. All samples collected with depth-discrete bailer at depth specified below.

Location	ISPID	Sample Number	Sample Date	Sample Time	Collection Depth (ft)	Parameter	Filtered	Result	Detection Level	Error	Units	QC Level	Reason Code
TW-7	TW-7_m1	427-052115-1	05/21/2015	10:45	1,950	Tritium	N	< 281.41	281.41	--	pCi/L	IV	129
TW-7	TW-7_m1	427-052115-3	05/21/2015	10:45	1,950	Tritium-LL	N	< 2.47	2.47	--	pCi/L	IV	129
UE-6d	UE-6d_o1	428-051815-1	05/18/2015	18:00	2,950	Tritium	N	< 279.34	279.34	--	pCi/L	IV	129
UE-6d	UE-6d_o1	428-051915-2	05/19/2015	09:00	2,950	Tritium	N	< 280.07	280.07	--	pCi/L	IV	129
UE-6d	UE-6d_o1	428-051915-4	05/19/2015	09:00	2,950	Tritium-LL	N	< 2.22	2.22	--	pCi/L	IV	129
UE-6d	UE-6d_o1	428-051815-3	05/18/2015	18:00	2,950	Tritium-LL	N	< 2.44	2.44	--	pCi/L	IV	129
UE-6e	UE-6e_o1	423-051915-3	05/19/2015	17:30	2,142	Tritium	N	< 102.48	102.48	--	pCi/L	IV	129
UE-6e	UE-6e_o1	423-051915-1	05/19/2015	17:30	2,142	Tritium	N	< 280.79	280.79	--	pCi/L	IV	129
UE-6e	UE-6e_o1	423-051915-3	05/19/2015	17:30	2,142	Tritium	N	< 2,789	2,722	--	pCi/L	III	--
TW-B	Test Well B Ex._m1	426-052015-1	05/20/2015	12:15	1,625	Tritium	N	< 281.78	281.78	--	pCi/L	IV	129
TW-B	Test Well B Ex._m1	426-052015-3	05/20/2015	12:15	1,625	Tritium-LL	N	U 2.84	2.32	1.67	pCi/L	IV	129
U-2gg PSE 3A	U-2gg PSE 3A_m1	410-121415-2	12/14/2015	14:05	1,956	Tritium	N	3,506.62	304.29	424.79	pCi/L	IV	--
U-2gg PSE 3A	U-2gg PSE 3A_m1	410-121415-1	12/14/2015	14:00	1,956	Tritium	N	3,649.13	306.51	438.81	pCi/L	IV	--

ISPID — NNSS Integrated Groundwater Sampling Plan ID
Result code U — Compound was analyzed for, but was not detected (“Non-detect”)
Reason Code 129 — Sample result is less than the MDC plus 2-sigma error
LL — Low-level tritium

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Wilhelm Wilborn
UGTA Activity Lead
Nevada Field Office
National Nuclear Security Administration
U.S. Department of Energy
P.O. Box 98518
Las Vegas, NV 89193-8518
Bill.Wilborn@nnsa.doe.gov

Sarah Hammond, Contracting Officer
Office of Acquisition Management
NNSA Service Center
Pennsylvania and H Street, Bldg. 20388
P.O. Box 5400
Albuquerque, NM 87185-5400
Sarah.Hammond@nnsa.doe.gov

Chuck Russell
Division of Hydrologic Sciences
Desert Research Institute
755 E. Flamingo Road
Las Vegas, NV 89119-7363
Chuck.Russell@dri.edu

Jenny Chapman
DOE Program Manager
Division of Hydrologic Sciences
Desert Research Institute
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Kay Birdsell
Los Alamos National Laboratory
P.O. Box 1663 M/S T003
Los Alamos, NM 87544
khb@lanl.gov

P.K. Ortego
National Security Technologies, LLC
P.O. Box 98521
M/S NLV082
Las Vegas, NV 89193-8521
ortegopk@nv.doe.gov

Andy Tompson
Lawrence Livermore National Laboratory
P.O. Box 808, L-231
Livermore, CA 94551-0808
Tompson1@llnl.gov

Jeffrey Sanders
U.S. Geological Survey
Nevada Water Science Center
160 N. Stephanie St.
Henderson, NV 89074-8829
jvsanders@usgs.gov

Ken Rehfeldt
Navarro
P.O. Box 98952
M/S NSF 167
Las Vegas, NV 89193-8952
Ken.Rehfeldt@nv.doe.gov

Brian Haight
Navarro
P.O. Box 98952
M/S NSF 167
Las Vegas, NV 89193-8952
Brian.Haight@nv.doe.gov

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