N/0002653--046

Pahute Mesa Phase II Well ER-20-12 Well Development, Testing, and Sampling Data and Analysis Report

Revision No.: 0

April 2018

Prepared for U.S. Department of Energy under Contract No.DE-NA0002653.

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PAHUTE MESA PHASE II WELL ER-20-12 WELL DEVELOPMENT, TESTING, AND SAMPLING DATA AND ANALYSIS REPORT

Revision No.: 0
April 2018
Navarro
c/o U.S. DOE
P.O. Box 98952
Las Vegas, NV 89193-8952

Prepared for U.S. Department of Energy under Contract No.DE-NA0002653..

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LIST OF ACRONYMS AND ABBREVIATIONS

General Acronyms and Abbreviations

amsl	Above mean sea level
ANC	Acid-neutralizing capacity
bgs	Below ground surface
BNC	Base-neutralizing capacity
CAIP	Corrective action investigation plan
cm	Centimeter
CS	Carbon steel
D	Deep
DOE	U.S. Department of Energy
DRI	Desert Research Institute
DTW	Depth to water
DVD	Digital versatile disc
EERF	Eastern Environmental Radiation Facility
EOI	Effective open interval
EPA	U.S. Environmental Protection Agency
e-tape	Electric tape
FAWP	Field Activity Work Package
FFACO	*Federal Facility Agreement and Consent Order*
FI	Field Instruction
FMI	Formation MicroImager
FMP	Fluid management plan
ft	Foot
ft/s	Feet per second
gal	Gallon
GEL	General Engineering Laboratories
g/L	Grams per liter
GMWL	Global meteoric water line
gpm	Gallons per minute
GWC	Groundwater characterization
HASL	Health and Safety Laboratory
HFM	Hydrostratigraphic framework model

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

HGU	Hydrogeologic unit
HSU	Hydrostratigraphic unit
Hz	Hertz
I	Intermediate
I-CHEM	Idronaut Ocean Seven 303*Plus*
ID	Identification
id	Inside diameter
in.	Inch
INW	Instrumentation Northwest, Inc.
ISPID	Integrated Sampling Plan Identifier
km	Kilometer
LANL	Los Alamos National Laboratory
Lat	Latitude
LLNL	Lawrence Livermore National Laboratory
LMWL	Local meteoric water line
Long	Longitude
LSC	Liquid scintillation counter
LTWLM	Long-term water-level monitoring
LVF	Load Verification Form
m	Meter
m^2/day	Square meters per day
m^3	Cubic meter
Ma	Million years ago
mBar	Millibar
MCL	Maximum contaminant level
MDA	Minimum detectable activity
MDC	Minimum detectable concentration
mg/L	Milligrams per liter
mm	Millimeter
MWAT	Multiple-well aquifer test
N/A	Not applicable
NA	Not available
NAD	North American Datum

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

ND	No data
NDEP	Nevada Division of Environmental Protection
N-I	Navarro-Intera, LLC
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
NSPC	Nevada State Plane Coordinates
NSTec	National Security Technologies, LLC
NTTR	Nevada Test and Training Range
NTU	Nephelometric turbidity unit
NWAS	Northwestern Air Services
od	Outside diameter
pCi/L	Picocuries per liter
PM	Pahute Mesa
PM-OV	Pahute Mesa-Oasis Valley
ppm	Parts per million
psi	Pounds per square inch
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
PST	Pacific Standard Time
PXD	Pressure transducer
QC	Quality control
REOP	Real Estate/Operations Permit
RN	Radionuclide
S	Shallow
SBMS	Standards-Based Management System
SDWA	*Safe Drinking Water Act*
sec	Second
SEC	Specific electrical conductivity
SN	Serial number
SOP	Standard Operating Procedure
SS	Stainless steel
SU	Standard unit
SWL	Static water level

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

TD	Total depth
TDS	Total dissolved solids
TFM	Thermal flowmeter
TWG	Technical Working Group
UDI	United Drilling, LLC
UGT	Underground test
UGTA	Underground Test Area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VSC	Variable speed controller
WDT	Well development and testing
WLM	Water Level Model
WRL/TOC	Wireline depth from top of casing
XRD	X-ray diffraction
XRF	X-ray fluorescence
°C	Degrees Celsius
µg/L	Micrograms per liter
µmhos/cm	Micromhos per centimeter
µS/cm	Microsiemens per centimeter
%meq/L	Milliequivalents per liter
‰	Per mil

List of Stratigraphic and Hydrostratigraphic Abbreviations and Symbols

Note: Some figures in this document include terminology taken from legacy documents. In these instances, both acronyms and/or definitions have been included on the following list.

AA	Alluvial aquifer
BFCU	Bullfrog confining unit
BRA	Belted Range aquifer
CHZCM	Calico Hills zeolitic composite unit
LFA	Lava-flow aquifer
LPCU	Lower Paintbrush confining unit

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

NTMMSZ	Northern Timber Mountain Moat structural zone
PBRCM	Pre-Belted Range composite unit
Pz	Paleozoic Rocks
Qal	Quaternary alluvial deposits
Qay	Quaternary young alluvial deposits
QTa	Quaternary old alluvial deposits
QTc	Quaternary/Tertiary colluvium
RCSZ	Ribbon Cliff structural zone
SCCC	Silent Canyon caldera complex
Tac	Calico Hills Formation
Tas	Andesite of Sarcobatus Flat
Tb	Belted Range Group
Tbdc	Comendite of Chartreuse
Tbg	Grouse Canyon Tuff
Tbgb	Grouse Canyon bedded tuff
Tbq	Comendite of Quartet Dome
Tc	Crater Flat bedded tuff
Tc	Crater Flat Group
TCA	Tiva Canyon aquifer
Tcb	Bullfrog Tuff
Tcbs	Stockade Wash lobe of Bullfrog Tuff
Tct	Tram Tuff
TCVA	Thirsty Canyon volcanic aquifer
Tf	Volcanics of Fortymile Canyon
Tfb	Beatty Wash Formation
Tfbw	Rhyolite of Beatty Wash
Tgc	Caldera moat-filling sediments
Tgfc	Furnace Creek formation
Tgy	Basin-fill sediments, undivided
Th	Calico Hills
Th	Calico Hills bedded tuff
Th	Calico Hills bedded/nonwelded tuff
Th	Calico Hills Formation

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

Th	Calico Hills lithic-rich Tuff
Thr	Calico Hills mafic-rich Tuff
Thrl	Calico Hills rhyolitic lava
Tm	Timber Mountain Group
Tma	Ammonia Tanks Tuff
Tma	Timber Mountain Ammonia Tanks Tuff
Tmab	Ammonia Tanks bedded tuff
Tmab	Timber Mountain Ammonia Tanks bedded tuff
Tmar	Ammonia Tanks mafic-rich Tuff
Tmar	Timber Mountain Ammonia Tanks mafic-rich Tuff
Tmat	Rhyolite of Tannenbaum Hill
TMCC	Timber Mountain caldera complex
TMLVTA	Timber Mountain lower vitric-tuff aquifer
Tmr	Rainier Mesa Tuff
Tmr	Timber Mountain Rainier Mesa Tuff
Tmrb	Rainier Mountain bedded tuff
Tmrb	Timber Mountain Rainier Mountain bedded tuff
Tmrf	Rhyolite of Fluorspar Canyon
Tmrp	Rainier Mesa mafic-poor Tuff
Tmrp	Timber Mountain Rainier Mesa mafic-poor Tuff
Tmrr	Rainier Mesa mafic-rich Tuff
Tmrr	Timber Mountain Rainier Mesa mafic-rich Tuff
Tmt	Basalt of Bullfrog Hills
TMWTA	Timber Mountain welded-tuff aquifer
Tp	Paintbrush Group
Tpcm	Tiva Canyon Pahute Mesa Lobe
Tpcx	Tiva Canyon landslide breccia
Tpr	Rhyolite of Silent Canyon
Tpy	Yucca Mountain Tuff
Tq	Volcanics of Quartz Mountain
Tqh	Middle rhyolite
Tqj	Rhyolite of Handley
Tsp	Spearhead member of Stonewall Flat Tuff

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

Tt	Thirsty Canyon Group
Ttb	Basalt of Black Mountain
Ttc	Comendite of Ribbon Cliff
Ttg	Gold Flat Tuff
Tth	Trachyte of Hidden Cliff
Ttp	Pahute Mesa Tuff
Ttr	Rocket Wash Tuff
Tts	Trachytic rocks of Pillar Spring and Yellow Cleft
Ttt	Trail Ridge Tuff
Typ	Basalt of Thirsty Mountain and other areas
UPCU	Upper Paintbrush confining unit
WTA	Welded-tuff aquifer

Symbols for Elements and Compounds

Am	Americium
Bi	Bismuth
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
Cl	Chloride
C/O	Carbon/oxygen
CO_2	Carbon dioxide
CO_3	Carbonate
Cs	Cesium
DIC	Dissolved inorganic carbon
DO	Dissolved oxygen
Eu	Europium
H	Hydrogen
^2H	Deuterium
^3H	Tritium
H_2CO_3	Carbonic acid
HCO_3	Bicarbonate

LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

Ho	Holmium
I	Iodine
K	Potassium
Mg	Magnesium
Na	Sodium
Nb	Niobium
Np	Neptunium
O	Oxygen
O_2	Oxygen gas
PCO_2	Partial pressure of carbon dioxide
Pu	Plutonium
S	Sulfur
Sn	Tin
SO_4	Sulfate
Sr	Strontium
Tc	Technetium
Th	Thorium
U	Uranium
$\delta^{13}C$	Delta carbon-13
δD	Delta deuterium
$\delta^{18}O$	Delta oxygen-18

1.0 INTRODUCTION

Underground Test Area (UGTA) Well ER-20-12 was drilled and completed for the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO) in support of the Nevada Environmental Management Operations UGTA Activity. This report summarizes the data and analysis of well development and testing (WDT) activities for the well in the context of ongoing hydrogeological studies and long-term groundwater monitoring of the Pahute Mesa area within, and in the vicinity of, the Nevada National Security Site (NNSS) in Nye County, Nevada (Figure 1-1). The well was constructed between September 30, 2015, and January 17, 2016, as a part of the Pahute Mesa Phase II drilling program in accordance with the *Phase II Corrective Action Investigation Plan* (CAIP) *for Corrective Action Units 101 and 102: Central and Western Pahute Mesa, Nevada Test Site, Nye County, Nevada* (NNSA/NSO, 2009a). The CAIP is a requirement of the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended), agreed to by the State of Nevada; DOE, Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. WDT activities were conducted at Well ER-20-12 from July 27 to September 1, 2016.

Well ER-20-12 was constructed to evaluate possible sources and groundwater pathways to explain anomalous tritium (^3H) detections first observed in 2011 and 2013 in groundwater samples from an offsite well, UGTA Well PM-3 (N-I, 2014). (***Note:*** In this document, references to PM-3-1 and PM-3-2 historical names are equivalent to the ISPID designations for these wells: PM-3_p1 and PM-3_p2, respectively.) The well was intended to enhance the understanding of the hydrogeology of the area that includes the northwest portion of the NNSS and offsite locations that are down both physiographic and groundwater gradients from the site. Figure 1-1 is a physical relief map showing the location of Well ER-20-12 relative to Well PM-3, as well as the NNSS boundary, former test locations, other existing wells and boreholes, Thirsty Canyon, and the town of Beatty in Oasis Valley. The WDT activities were to define hydraulic properties in saturated Tertiary volcanic rocks.

Well ER-20-12 is within operational Area 20 of the NNSS; Well PM-3 is located off site to the southwest. A topographic map, Figure 1-2, shows Well ER-20-12 is located approximately 305 meters (m) (1,000 feet [ft]) east of the Nevada Test and Training Range (NTTR). Well ER-20-12

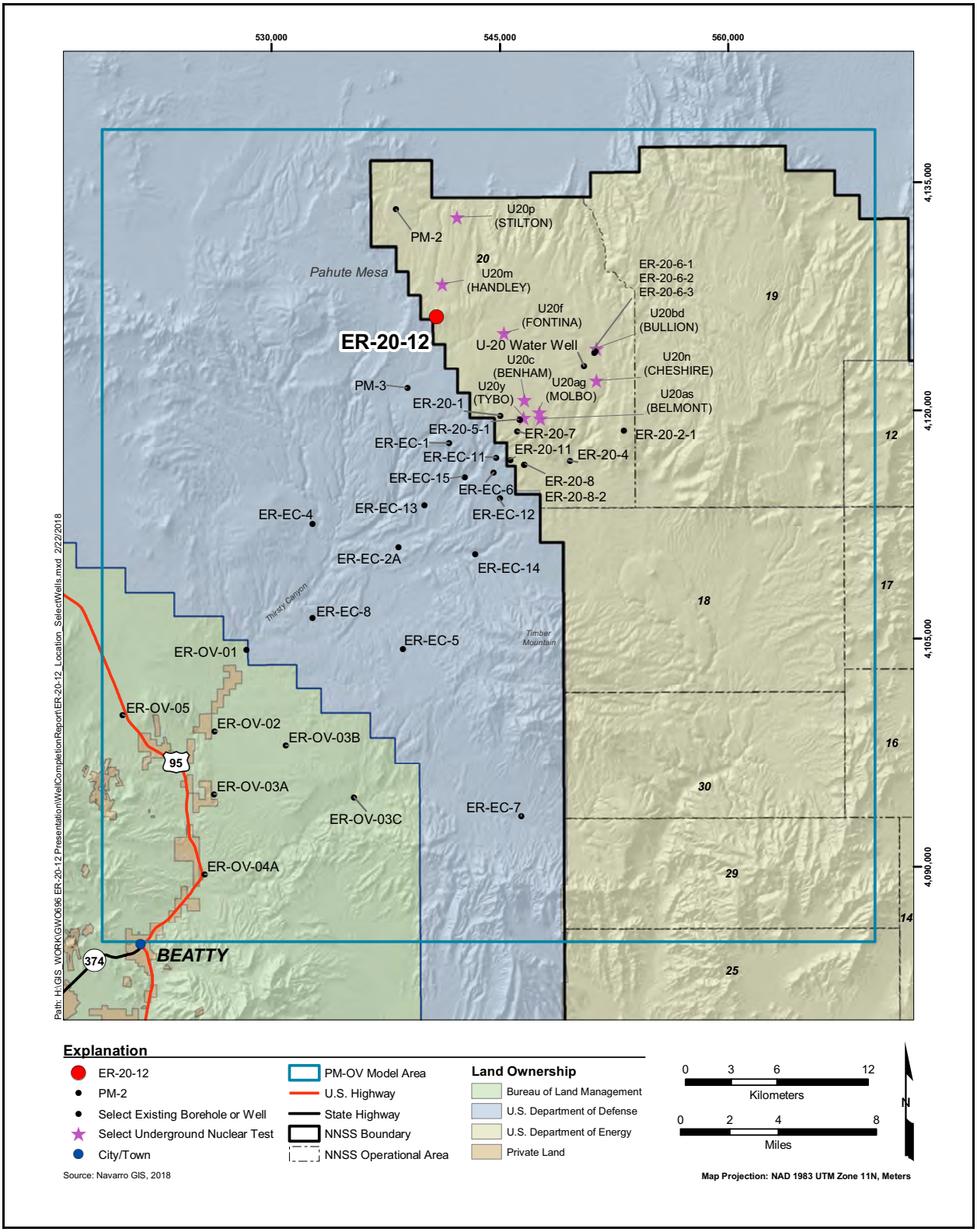

Figure 1-1
Location of Well ER-20-12 and Select Wells

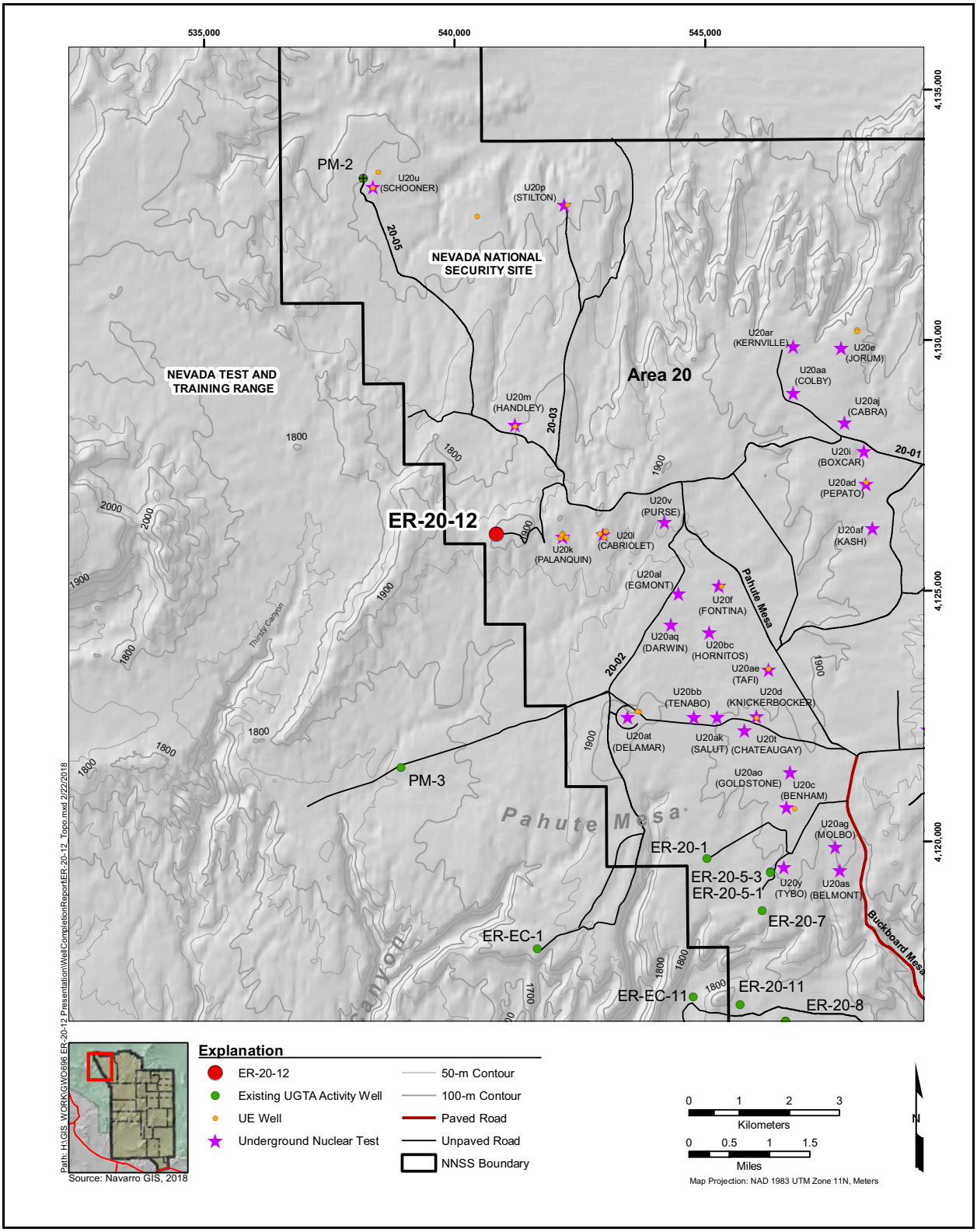

Figure 1-2
Topographic Map of the Well ER-20-12 Area

was sited between Well PM-3, approximately 5 kilometers (km) to the southwest off site, and the locations of the 1970 HANDLEY (with post-shot borehole U-20m PS 1D) and 1975 STILTON (with post-shot borehole U20p PS 1D) underground tests (UGTs), approximately 2 km and 7 km to the northeast, respectively. The well drilling and data collection activities were designed, in part, to test hypotheses of radionuclide (RN) sourcing for the contamination observed in Well PM-3. A north–northeast-to-south–southwest groundwater flow path, deduced from local water levels, would likely transport RNs from either the HANDLEY and/or STILTON potential sources, through the ER-20-12 location, along the way to PM-3. In addition, the ER-20-12 location could detect contamination from another possible source: the 1969 PURSE test (with post-shot borehole U20v PS 1D), located 4 km east of ER-20-12 and about 7 km northeast of PM-3, which could yield RN contamination to PM-3 along a southwest groundwater flow path (Figure 1-2).

The drilling and completion activities followed the guidelines presented in the *Field Instruction* (FI) *for the Underground Test Area Activity Drilling and Well Completion Operations, Nevada National Security Site, Nevada* (Navarro, 2015b); with an addendum to the drilling and completion criteria specifically for Well ER-20-12 (Navarro, 2015a). The *Pahute Mesa ER-20-12 Well Data Package* (Navarro, 2016f) and *Completion Report for Well ER-20-12, Corrective Action Units 101 and 102: Central and Western Pahute Mesa* (NNSA/NFO, 2016) provide the drilling and completion information. ER-20-12 well development, testing, and sampling activities followed the guidelines presented in the *Phase II Testing Plan: Central and Western Pahute Mesa, Nevada Test Site, Nye County, Nevada* (NNES, 2010a). The summary of analytes and additional guidelines for chemistry sampling were provided by the *Nevada National Security Site Integrated Groundwater Sampling Plan* (NNSA/NSO, 2014) and the updated *NNSS Integrated Sampling Plan and Water-Level Monitoring Implementation Strategy* (Navarro, 2016b). Specific well development, testing, and sampling details were provided by the Field Activity Work Package (FAWP) for Well ER-20-12 (Navarro, 2016e).

The main completion of Well ER-20-12 (ER-20-12_m1) was finished in the Pre-Belted Range composite unit (PBRCM). In addition, four piezometers were completed and numbered sequentially from depth as follows: ER-20-12_p1, completed in the Belted Range aquifer (BRA); ER-20-12_p2, completed in the non-welded ash-flow tuff portion of the Calico Hills zeolitic composite unit (CHZCM); ER-20-12_p3, completed in the rhyolite lava portion of the CHZCM; and ER-20-12_p4,

completed in the Timber Mountain welded-tuff aquifer (TMWTA) and Timber Mountain lower vitric-tuff aquifer (TMLVTA).

The piezometer and main completions in Well ER-20-12 were developed between June 27 and August 19, 2016. Piezometer p1 was developed with a rod pump from June 27 to July 7, 2016. The main completion (m1) was developed along with testing from August 12 through August 19, 2016, following a pump function test on August 11.Well development objectives included removing residual drilling and completion fluids to improve the hydraulic connection of the well with transmissive horizons within the completed intervals. Well development was attempted by pumping the well, but low, unsustainable pump rates limited the effectiveness of development. The WDT activities included well development; cyclic-rate testing; and groundwater characterization (GWC) sampling for hydrogeologic, geochemical, and radiochemistry data. A more detailed discussion of the WDT program is provided in Section 1.3.

1.1 Project Organization

Well ER-20-12 was constructed, developed, and tested by several UGTA participants. Environmental and hydrogeologic field support services were provided by Navarro. Engineering, inspection, geotechnical, and field support were provided by National Security Technologies, LLC (NSTec). Drilling and casing operation services were provided by United Drilling, LLC (UDI); Northwestern Air Services (NWAS); and B&L Casing. Geophysical logging was conducted by Schlumberger and COLOG. Navarro and NSTec (the NNSS management and operating [M&O] contractor) were the prime contractors to NNSA/NFO. Schlumberger, UDI, NWAS, B&L Casing, and COLOG performed work as service subcontractors to NSTec.

NSTec provided site supervision, engineering, construction, inspection, geologic support, and onsite radiological monitoring. Navarro was the principal environmental contractor for the project and was responsible for environmental compliance and waste management on site. Navarro collected and analyzed fluid samples for water quality and chemistry, and for monitoring and documenting disposition of fluids and drill cuttings produced from the borehole. In addition, Navarro personnel collected geologic, hydrologic, and drilling parameter data as described in the ER-20-12 drilling data report (Navarro, 2016f). Guidelines for managing fluids used and generated during drilling, completion, and testing of UGTA wells are discussed in Section 6.0.

The Technical Working Group (TWG) is a group of scientists and engineers from NNSA/NFO, the Nevada Division of Environmental Protection (NDEP), Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Desert Research Institute (DRI), U.S. Geological Survey (USGS), NSTec, and Navarro. The TWG provided technical advice during drilling, design, construction, development, and testing of the well to ensure that the scientific and technical objectives were achieved.

1.2 Well ER-20-12 Site Background

As specified in the drilling and completion criteria addendum (Navarro, 2015a), Well ER-20-12 was intended to be a "near-field hydrogeological investigation well (to provide) detailed hydrogeological information in the shallow-to-intermediate-depth Tertiary volcanic section." The term "near-field well" is a classification for a well with water measured, or anticipated to be, above a ^{3}H level of 400,000 picocuries per liter (pCi/L), a threshold level negotiated between NDEP and DOE for the purposes of fluid management and health-and-safety planning. Well ER-20-12 was anticipated to show "near-field" levels of ^{3}H based on its proximity to the HANDLEY test, as well as possible impacts from the STILTON and PURSE tests.

Hydrostratigraphically, the HANDLEY (U20m) and STILTON (U20p) tests were conducted in lavas of the PBRCM hydrostratigraphic units (HSUs), and the PURSE (U20v) test was conducted in the Upper Paintbrush confining unit (UPCU) HSU. Low levels of ^{3}H (below the *Safe Drinking Water Act* [SDWA] standard of 20,000 pCi/L [CFR, 2016]) were measured in Wells PM-3-1 and PM-3-2 in the Tiva Canyon aquifer (TCA) and UPCU, respectively. Higher levels of ^{3}H were anticipated for these HSUs in Well ER-20-12 due to the shorter distance of groundwater transport from the suspected source HANDLEY (U20m) (Navarro, 2015a). The ^{3}H levels encountered in Well ER-20-12 are discussed in Section 5.2 of this report.

The HSUs of known or suspected contamination were predicted to be in the subsurface at the location of Well ER-20-12 based on interpretations of pre-existing information (see Figure 4-6, left), with a plan conceived to complete ER-20-12 in the deepest unit, the PBRCM. Prior information along with field observations of the actual hydrogeology and contamination encountered during drilling (see Figure 4-6, right) were used to make decisions on additional completions, including the installation of piezometers in (1) the BRA, (2) a non-welded ash-flow tuff within the CHZCM, (3) a rhyolite lava within the CHZCM, and (4) the TMWTA and TMLVTA.

The site for Well ER-20-12 is located within a structural block that lies between the Black Canyon Caldera to the west and the margin of the buried Area 20 caldera to the east. The structural block in which the well is located is defined by a number of prominent high-angle normal faults. Two prominent faults (the Handley fault and the Purse fault) form, respectively, the west and east boundaries of the block; and the buried Ribbon Cliff structural zone and the West Silent Canyon structural zone, respectively, form the southern and northern boundaries of the structural block (Figure 1-3). In general, the surrounding area consists of relatively flat-lying Miocene-age volcanic rocks, predominately non- to densely welded ash-flow tuff and bedded tuffs.

The well completion criteria (Navarro, 2015a) listed specific objectives of drilling, completion, and initial sampling at Well ER-20-12, including the following:

- Obtain geologic information to reduce uncertainties in the Pahute Mesa hydrogeologic framework model (HFM), and to improve subsequent groundwater flow and transport modeling for the area of Western Pahute Mesa and specifically between the Handley and Purse faults in the potentially near-field environment downgradient of the HANDLEY (U20m) UGT:
    - To provide detailed hydrogeologic information in the shallow-to-intermediate-depth Tertiary volcanic section.
    - To provide information regarding the presence and extent of aquifer-like units (welded-tuff aquifers [WTAs] and lava-flow aquifers [LFAs]).
    - To provide information that may help characterize structural features such as the Handley, Purse, and Ribbon Cliff structural zones/faults, and investigate what effect they may have on groundwater flow.
    - To provide detailed information on the hydrogeology and nature of aquifer units in the upper portion of the saturated section where contaminant transport may be most likely.
- Obtain information on the potential distribution of ^{3}H:
    - Determine the nature of the distribution of ^{3}H in groundwater and vertical extent of ^{3}H in the hydrostratigraphic section at Well ER-20-12.
- Obtain petrophysical and secondary physical properties of saturated hydrogeologic units (HGUs) including detailed fracture data, hydrothermal alteration, and hydrologic information.
- Obtain aqueous geochemistry samples from the TCA, BRA, and PBRCM to help better define possible groundwater flow paths based on water chemistry.

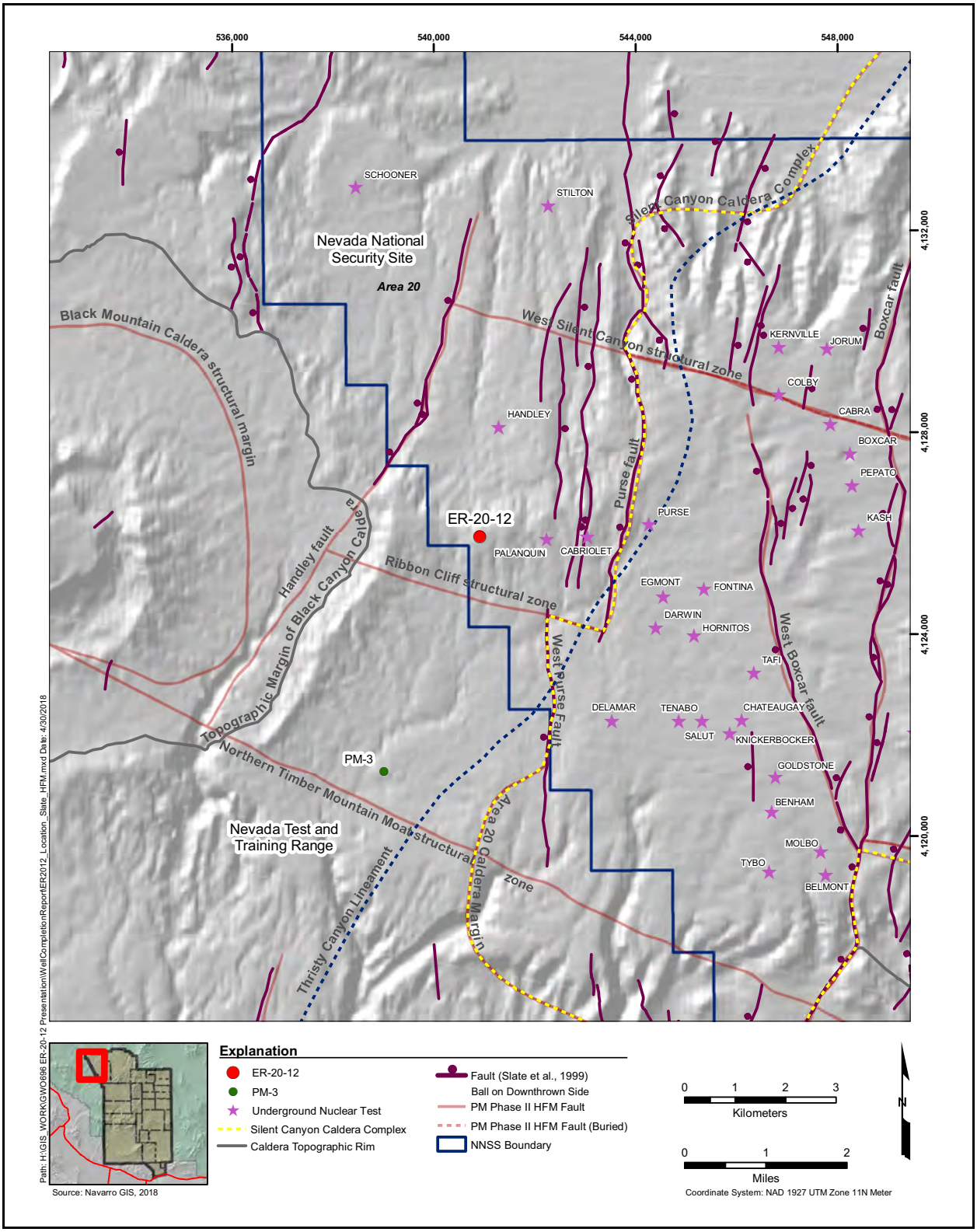

Figure 1-3
Structure Map of the Well ER-20-12 Site

- Obtain detailed water-level data to determine the regional water level and vertical heads within units to better understand local groundwater flow.
- Investigate the possibility that perched water zones may be present above the regional water level.
- Obtain geologic samples for detailed mineralogical analyses to help define the assignment of geologic units and the potential distribution of reactive minerals in the volcanic section.

The objectives of this study is to further characterize the hydrology of Pahute Mesa from information obtained in the hydraulic testing at Well ER-20-12, including the following:

- Data to determine the vertical hydraulic gradient
- Data to determine vertical and horizontal hydraulic conductivity

The analysis of the data was expected to provide the following:

- Hydraulic properties of the saturated HSUs for the purposes of modeling
- Hydraulic influence of production from HSUs tested at surrounding observation wells

The completed well could only accommodate single-well hydraulic testing, but could be a potential pumping location or observation well for subsequent multiple-well aquifer tests (MWATs).

1.3 Well ER-20-12 Specifications

Well ER-20-12 was drilled to a total depth (TD) of 1,384.81 m (4,543.33 ft) below ground surface (bgs). The surface elevation is 1,907.56 m (6,258.40 ft) above mean sea level (amsl). The abridged borehole statistics are provided in Table 1-1, and Figure 1-4 shows the current wellhead configuration (NNSA/NFO, 2016). Figure 1-5 shows the well completions as configured for the WDT (NNSA/NFO, 2016). Borehole, casing, tubing, and screen diameter dimensions are reported.

The main well completion (m1) provides monitoring access to a single HSU, the PBRCM, provided by 5.5-inch (in.) stainless-steel (SS) slotted tubing, attached to 5.5-in. SS blank tubing, extended through the bottom of 9.625-in. carbon-steel (CS) well completion casing. In addition, four piezometers were installed in the annular space between the well completion casing and the borehole wall: piezometers p1 and p3, completed with 2.875-in. SS slotted tubing attached to 2.375-in. CS blank tubing; and piezometers p2 and p4, completed with 1.9-in. CS slotted tubing attached to 1.9-in. CS blank tubing. Piezometers p1 through p3 were completed between 9.625-in. CS casing and an

Table 1-1
Abridged Drill-Hole Statistics for Well ER-20-12
(Page 1 of 2)

LOCATION DATA: Coordinates:	Nevada State Plane (NAD 27)	N 921,330.73 ft E 537,330.92 ft
	Nevada State Plane (NAD 83)	N 6,280,822.82 m E 511,298.95 m
	Universal Transverse Mercator (NAD 27, Zone 11)	N 4,125,952.84 m E 540,925.06 m
	Latitude/Longitude (NAD 83)	37.281047 decimal degrees N 116.5392 decimal degrees W
Collar Elevation:	1,907.56 m (6,258.40 ft) amsl	
DRILLING DATA: Spud Date: Date TD Reached: Date Well Completed: TD:	10/08/2015 01/02/2016 01/06/2016 1,384.81 m (4,543.33 ft) bgs	
Hole Diameters:	137.16 cm (54 in.) from surface to 2.17 m (7.13 ft); 91.44 cm (36 in.) from 2.01 m (6.6 ft) to 19.35 m (63.5 ft); 66.04 cm (26 in.) from 19.35 m (63.5 ft) to 765.14 m (2,510.3 ft); 46.99 cm (18.5 in.) from 765.14 m (2,510.3 ft) to 1,326.48 m (4,352 ft); 21.59 cm (8.5 in.) from 1,326.48 m (4,352 ft) to 1,384.8 m (4,543.33 ft).	
Drilling Techniques:	Dry auger drilling using a 137.16-cm (54-in.) diameter bucket style auger bit from surface to 2.17 m (7.13 ft); drilling using a 91.44-cm (36-in.) bit to 19.35 m (63.5 ft); to rotary drilling with air-foam and conventional circulation using a 46.99-cm (18.5-in.) chisel tooth tricone button bit to 765.14 m (2,510.3 ft); rotary drilling with air-foam and conventional circulation using a 66.04-cm (26-in.) chisel tooth tricone button bit to 765.96 m (2,513 ft); rotary drilling with air-foam and conventional circulation using a 46.99-cm (18.5-in.) chisel tooth tricone button bit to 1,326.53 m (4,352.16 ft); rotary drilling with air-foam and conventional circulation using a 21.59-cm (8.5-in.) chisel tooth tricone button bit to 1,384.8 m (4,543.33 ft).	
CASING DATA:[a]	106.68-cm (42-in.) CS conductor casing from ground surface to 2.01 m (6.6 ft); 76.2-cm (30-in.) CS conductor casing from ground surface to 19.05 m (62.5 ft); 50.8-cm (20-in.) CS surface casing from ground surface to 762.85 m (2,502.8 ft); 24.44-cm (9.625-in.) CS intermediate casing from ground surface to 1,188.72 m (3,900 ft); 13.97-cm (5.5-in.) CS blank casing from ground surface to 540.29 m (1,772.63 ft); 13.97-cm (5.5-in.) SS completion casing from 540.29 m (1,772.63 ft) to 1,216.7 m (3,991.81 ft).	
WELL COMPLETION DATA: Description of Completion Casing: (m1)	The lower portion of the well within the saturated zone from 540.29 m (1,772.63 ft) to 1,349.94 m (4,428.95 ft) was completed with nominally 12.19-m (40-ft) lengths of 13.97-cm (5.5-in.) od by 12.57-cm (4.95-in.) id blank and slotted SS casing. A bullnose termination was installed on the bottom of the completion string from 1,349.94 m (4,428.95 ft) to 1,350.61 m (4,431.15 ft). The slotted 13.97-cm (5.5-in.) casing has 6.985-cm (2.75-in.) by 0.317-cm (0.125-in.) machine-cut slots. From 1,216.7 m (3,991.81 ft) bgs to 1.349.94 m (4,428.95 ft) bgs, nominally 12.19-m (40-ft) lengths of 13.97-cm (5.5-in.) od by 12.57-cm (4.95-in.) id, of threaded SS slotted casing was installed. From 539.93 m (1,771.43 ft) to 0.966 m (3.17 ft) above ground surface was completed with nominally 12.80 m (42 ft) lengths of 13.97-cm (5.5-in.) CS blank casing was installed above a crossover. Depth intervals for the CS tubing and SS blank and slotted tubing are tabulated below.	
Description of Piezometer Strings:	The deep piezometer (p1) consists of nominally 9.45-m (31-ft) lengths of 6.03-cm (2.375-in.) od by 5.07-cm (1.995-in.) id CS Hydril tubing with upset couplings extending from 0.86 m (2.84 ft) above ground surface to 1,043.43 m (3,423.34 ft). The crossover, from 6.03-cm (2.375-in.) CS tubing to 7.30-cm (2.875-in.) SS tubing, extends from 1,043.43 m (3,423.34 ft) to 1,043.69 m (3,424.18 ft). The slotted SS tubing consists of nominally 9.45-m (31-ft) lengths of 7.30-cm (2.875-in.) od by 5.99-cm (2.36-in.) id tubing with flush joint couplings and a bullnosed termination, extending to 1,117.35 m (3,665.85 ft). Depth intervals for the CS tubing and SS blank and slotted tubing are tabulated below. The intermediate piezometer (p2) consists of nominally 9.45-m (31-ft) lengths of 4.82-cm (1.9-in.) od by 3.83-cm (1.51-in.) id CS Hydril tubing with upset couplings extending from 0.80 m (2.64 ft) above ground surface to 938.65 m (3,079.52 ft). Depth intervals for the Hydril blank and slotted tubing are tabulated below. The intermediate piezometer (p3) consists of nominally 9.45-m (31-ft) lengths of 6.03-cm (2.375-in.) od by 5.07-cm (1.995-in.) id CS Hydril tubing with upset couplings extending from 0.89 m (2.94 ft) above ground surface to 888.51 m (2,915.08 ft). The crossover, from 6.03-cm (2.375-in.) CS tubing to 7.30-cm (2.875-in.) SS tubing, extends from 777.67 m (2,551.42 ft) to 777.93 m (2,552.26 ft). The slotted SS tubing consists of nominally 9.45-m (31-ft) lengths of 7.30-cm (2.875-in.) od by 5.99-cm (2.36-in.) id tubing with flush joint couplings and a bullnosed termination, extending to 888.51 m (2,915.08 ft). Depth intervals for the CS tubing and SS blank and slotted tubing are tabulated below.	

Table 1-1
Abridged Drill-Hole Statistics for Well ER-20-12
(Page 2 of 2)

	The shallow piezometer (p4) consists of nominally 9.45-m (31-ft) lengths of 4.82-cm (1.9-in.) od by 3.83-cm (1.51-in.) id CS Hydril tubing with upset couplings extending from 0.53 m (1.73 ft) above ground surface to 513.78 m (1,685.65 ft). Depth intervals for the Hydril blank and slotted tubing are tabulated below.	
	Slots for SS piezometers are machine-cut, 0.15-cm (0.06-in.) by 6.67-cm (2.625-in.), 8 vertical slots per row, 108 rows per joint on 7.62-cm (3.00-in.) centers, each row offset by 22.5 degrees from the next.	
	Slots for the CS piezometers are machine-cut, 0.20-cm (0.08-in.) by 5.58-cm (2.2-in.), 4 vertical slots per row, 108 rows per joint (432 slots).	
WELL COMPLETION DATA:	Description	Depth Interval
Detail of Surface Casing:	Blank 50.8-cm (20-in.) CS casing:	+0.61 - 762.85 m (+2.01 - 2,502.80 ft)
Detail of Intermediate Casing:	Blank 24.44-cm (9.625-in.) CS casing:	+0.76 - 1,188.72 m (+2.51 - 3,900 ft)
Detail of Completion Casing:	Blank 13.97-cm (5.5-in.) CS casing:	+0.97 - 539.93 m (+3.17 - 1,771.43 ft)
	13.97-cm (5.5-in.) crossover to SS	539.93 - 540.29 m (1,771.43 - 1,772.63 ft)
	Blank 13.97-cm (5.5-in.) SS casing:	540.29 - 1,216.70 m (1,772.63 - 3,991.81 ft)
	Slotted 13.97-cm (5.5-in.) SS casing:	1,216.70 m - 1,349.94 m (3,991.81 - 4,428.95 ft)
	with bullnosed termination:	1,349.94 m - 1,350.61 m (4,428.95 - 4,431.15 ft)
Detail of Shallow Piezometer (p4):	Blank 4.82-cm (1.9-in.) Hydril tubing:	+0.53 - 513.78 m (+1.73 - 1,685.65 ft)
	Slotted 4.82-cm (1.9-in.) Hydril tubing with orange peeled termination:	513.78- 579.66 m (1,685.65 - 1,901.79 ft)
Detail of Intermediate Piezometer (p3):	Blank 6.03-cm (2.375-in.) CS tubing:	+0.90 m - 777.67 m (+2.94 - 2,551.42 ft)
	7.30-cm (2.875-in.) CS crossover:	777.67 - 777.93 m (2,551.42 - 2,552.26 ft)
	Slotted 7.30-cm (2.875-in.) SS tubing	777.93 - 887.87 m (2,552.26 - 2,912.96 ft)
	bullnosed termination:	887.87 - 888.51 m (2,912.96 - 2,915.08 ft)
Detail of Intermediate Piezometer (p2):	Blank 4.82-cm (1.9-in.) Hydril tubing:	+0.82 - 938.63 m (+2.64 - 3,079.52 ft)
	Slotted 4.82-cm (1.9-in.) Hydril tubing with orange peeled termination:	938.63 - 957.72 m (3,079.52 - 3,142.13 ft)
Detail of Deep Piezometer (p1):	Blank 6.03-cm (2.375-in.) CS tubing:	+0.86 m - 1,043.43 m (+2.84 - 3,423.34 ft)
	7.30-cm (2.875-in.) CS crossover:	1,043.43 - 1,043.69 m (3,423.34 - 3,424.18 ft)
	Slotted 7.30-cm (2.875-in.) SS tubing	1,043.69 - 1,116.70 m (3,424.18 - 3,663.73 ft)
	bullnosed termination:	1,116.70 - 1,117.35 m (3,663.73 - 3,665.85 ft)
Detail of Completion Materials:	3/8-in. Gravel pack:	936 - 962.55 m (3,071 - 3,157 ft) 1,029 - 1,135 m (3,376 - 3,725 ft)
	20/40 Sand pack:	962.55 - 936 m (3,053 - 3,071 ft) 1,018.95 - 1,029 m (3,343 - 3,376 ft)
	Type II neat cement:	898.24 - 930.55 m (2,946.93 - 3,053 ft) 962.25 - 1,018.95 m (3,157 - 3,343 ft) 1,135.38 - 1,193.59 m (3,725 - 3,916 ft)
FLUID-LEVEL DATA:	Fluid Depth [b]	Fluid Elevation
Main Completion (m1):	563.79 m (1,849.73 ft)	1,345.76 m (4,408.67 ft)
Shallow Piezometer (p4):	492.17 m (1,614.74 ft)	1,415.39 m (4,643.66 ft)
Intermediate Piezometer (p3):	571.90 m (1,876.32 ft)	1,335.66 m (4,382.08 ft)
Intermediate Piezometer (p2):	572.00 m (1,876.65 ft)	1,335.56 m (4,381.75 ft)
Deep Piezometer (p1):	566.93 m (1,860.02 ft)	1,340.63 m (4,398.38 ft)
DRILLING CONTRACTOR:	United Drilling, LLC	
GEOPHYSICAL LOGS BY:	Schlumberger, COLOG	

[a] Casing lengths referenced to ground level. For stick-up heights, see Figure 1-4.
[b] Measurements by Navarro using a calibrated Solinst e-tape on 05/11/2016.

cm = Centimeter
e-tape = Electric tape
id = Inside diameter
NAD 27 = North American Datum, 1927
NAD 83 = North American Datum, 1983
od = Outside diameter

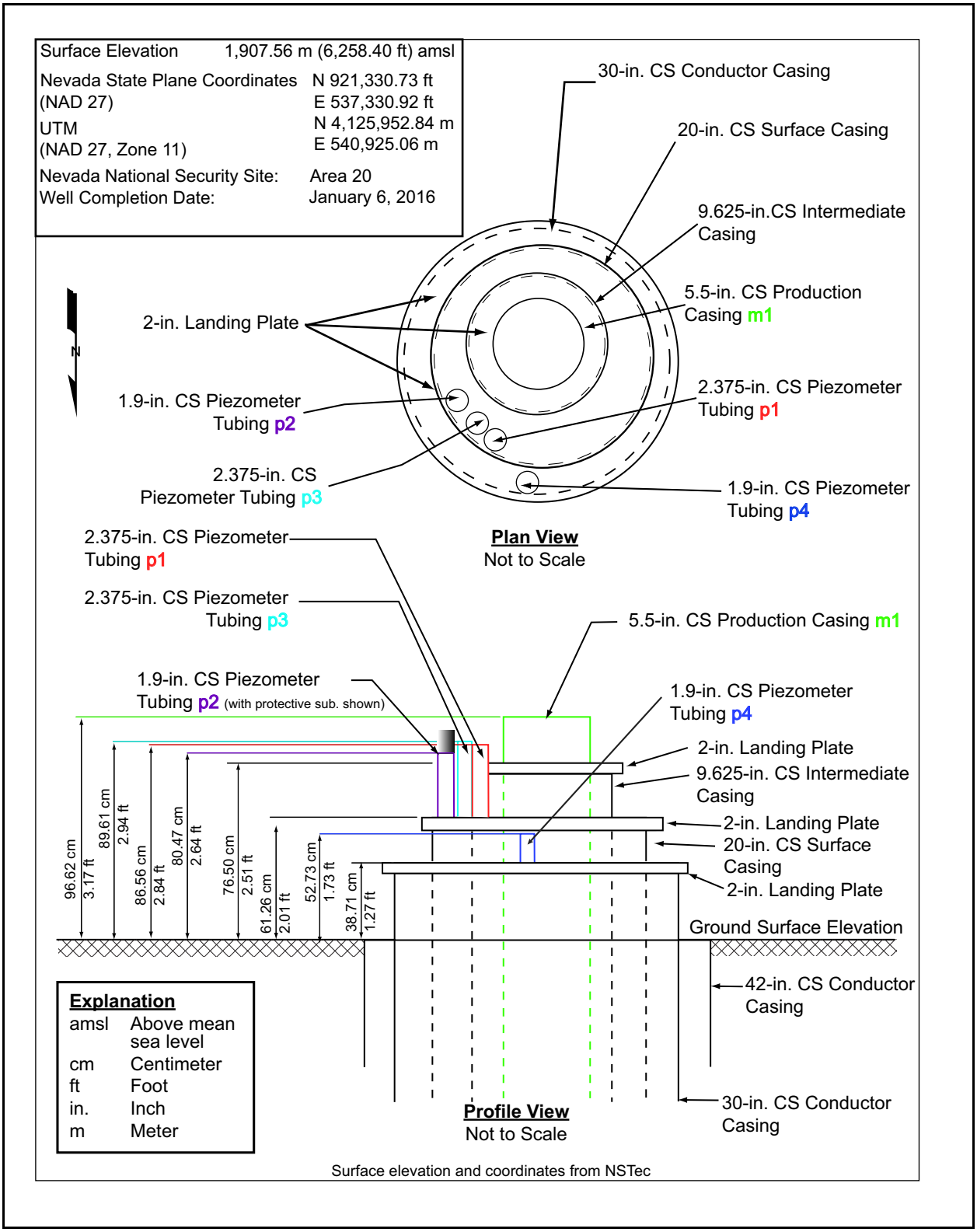

Figure 1-4
Wellhead Diagram for Well ER-20-12

18.5-in. borehole wall; piezometer p4 was completed between 20-in. CS casing and a 26-in. borehole wall. Piezometers p1, p2, and p3 access the BRA, an ash-flow lithology of the CHZCM, and a lava lithology of the CHZCM HSUs, respectively. Piezometer p4 accesses both the TMLVTA and TMWTA HSUs.

Static water levels (SWLs) were measured in the main completion (m1) and piezometers p1 and p2 on August 11 and 12, 2016, before installation of pressure transducers (PXDs) for monitoring head during groundwater pumping, including for WDT. The SWL for the main completion (m1) in the PBRCM was 1,849.62 ft bgs measured on August 11. The SWL for piezometer p1 in the BRA was 1,859.48 ft bgs, and was 1,875.51 ft bgs for p2 in the ash-flow tuff unit of the CHZCM, both measured on August 12. SWLs were also measured in piezometers p3 and p4 when long-term water-level monitoring (LTWLM) PXDs were removed on July 20, 2016. A SWL of 1,876.20 ft bgs was measured for piezometer p3, completed in the lava unit of the CHZCM. The SWL for piezometer p4, completed across both TMLVTA and TMWTA, was 1,614.78 ft bgs, significantly different than the SWLs in the other piezometers and the main completion.

Active testing began August 11 and was completed August 19, 2016. The post-constant-rate test recovery monitoring ended on August 23, 2016, with the removal of the PXDs and the testing pump. A dedicated sampling pump was installed August 25 to 26, 2016, as shown in Figure 1-5. The sampling pump is installed from 2,150 to 2,176 ft bgs. The intake is at 2,159.50 ft bgs, approximately 300 ft below the water level. Demobilization activities were completed on September 1, 2016.

Complete details on drilling, completion, geophysical logging, and geology are presented in the *Pahute Mesa ER-20-12 Well Data Package* (Navarro, 2016f), and the *Completion Report for Well ER-20-12, Corrective Action Units 101 and 102: Central and Western Pahute Mesa* (NNSA/NFO, 2016).

1.4 Well Development, Testing, and Sampling

The Pahute Mesa Phase II Testing Plan (NNES, 2010a) presents the overall WDT approach. Specific objectives for WDT operations included the following:

- Improve the hydraulic efficiency of the well by removing residual drilling fluids and sediment.

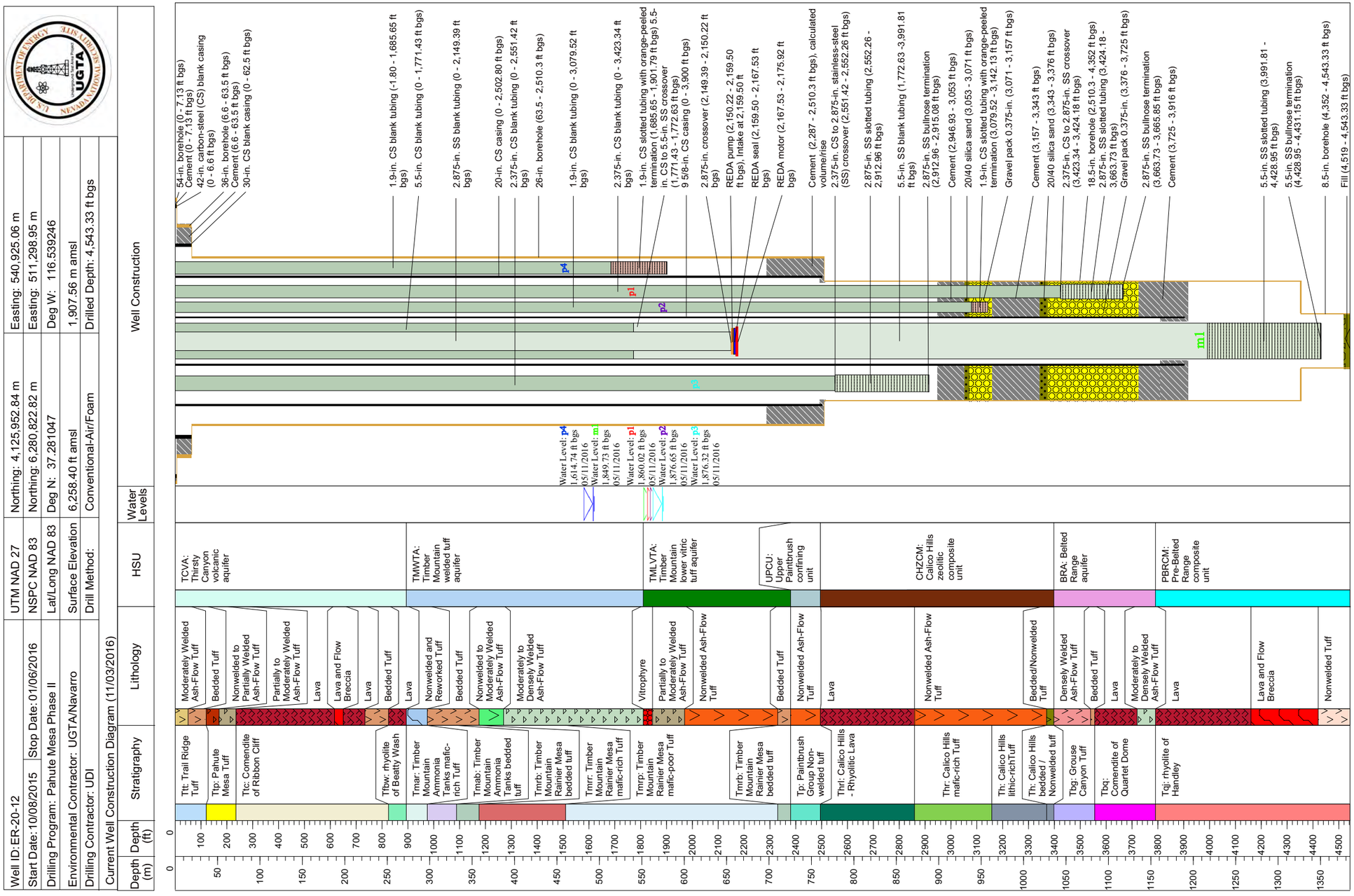

Figure 1-5
Well Completion Diagram for Well ER-20-12

- Acquire data to estimate the hydraulic parameters of specific HSUs.
- Restore the natural chemistry of groundwater in the well.
- Characterize spatial variability in downhole groundwater chemistry.
- Characterize HSU composite groundwater chemistry.

The WDT program was designed to achieve these objectives through the collection of hydrologic data during both pumping and static (nonpumping) conditions and the collection of water-chemistry samples. The planned activities included the following:

- Monitor water levels before WDT activities to estimate barometric efficiency.
- Monitor water levels during pumping to determine the hydraulic response.
- Conduct flow and temperature logging under static and pumping conditions to determine the distribution of water production across completed intervals.
- Conduct water-quality chemistry logging under static and pumping conditions to characterize chemical variability.
- Collect depth-discrete bailer and composite groundwater samples to determine geochemistry and radiochemistry.
- Conduct step-drawdown and constant-rate testing to determine well losses and hydraulic parameters.
- Monitor water levels in background wells to determine regional trends during Well ER-20-12 WDT operations and to observe any response to the pumping.

1.5 Background Head Monitoring

The Pahute Mesa Phase II CAIP (NNSA/NSO, 2009a) established a regional head-monitoring program to monitor water-level fluctuations and trends as well as any hydraulic responses caused by drilling or testing of wells within and adjacent to Pahute Mesa. Many of the wells monitored have multiple completions [e.g., shallow (S), intermediate (I), and deep (D)] and provide HSU-specific monitoring intervals for more than one HSU. Responses to Well ER-20-12 groundwater production in these wells during drilling and WDT operations provided important information on the hydraulic connectivity across structural blocks and along faults in Pahute Mesa. Details of the head-monitoring

program are discussed in the *Central and Western Pahute Mesa Phase II Head Monitoring during Drilling, Nevada Test Site, Nye County, Nevada* (NNES, 2010b).

During WDT at Well ER-20-12, hydraulic heads were monitored in the following locations: (1) the main completion (m1), completed in the PBRCM; (2) the four piezometers (p1, completed in the BRA; p2, completed in a non-welded ash-flow tuff of the CHZCM; p3, completed in a rhyolite lava of the CHZCM; and p4, completed in the TMWTA and TMLVTA); and (3) in Wells PM-3-1, completed in the TCA; PM-3-2, completed in the UPCU; and U-20m PS 1D, the HANDLEY post-shot well completed in the PBRCM. Detailed information on the completion intervals and HSUs monitored is presented in Section 2.5. Long-term monitoring results and other data collected from these wells are documented and discussed in the *Long-Term Head Monitoring Data Report, Fiscal Year 2016* (Navarro, 2017).

1.6 Well Development, Testing, and Sampling Schedule

The generic schedule for WDT activities at Well ER-20-12 is outlined below:

- Conduct predevelopment water-level monitoring in testing and observation wells (30 or more days).

For each completion interval/HSU to be tested:

- Mobilize equipment; configure the well; and install the testing pump and monitoring equipment (3 to 5 days).
- Conduct well development, step-drawdown testing, and flow and chemistry logging under pumping conditions (5 days).
- Monitor post-development and water-level recovery (minimum of 5 days).
- Conduct constant-rate pump test and GWC sampling (up to 20 days).
- Monitor post-test water-level recovery (up to 20 days).
- Perform flow and chemistry logging under ambient conditions (3 days).
- Remove the testing pump and instrumentation (2 days).

After completing WDT activities:

- Install dedicated sampling pump and LTWLM instrumentation (2 days).
- Complete demobilization (5 days).

Table 1-2 summarizes the WDT activities conducted at Well ER-20-12. A detailed schedule of daily activities is provided in Section 2.1.

Table 1-2
Summary of WDT Activities at Well ER-20-12

Dates	Activities
05/11/2016	Initial LTWLM water levels recorded
05/25 to 07/20/2016	Installation of PXDs and LTWLM.
06/07 to 06/10/2016	DRI well logging.
06/27 to 07/07/2016	Rod pumping and sampling of piezometer p1.
07/21 to 07/26/2016	No activity on site.
07/27 to 07/28/2016	Mobilization of equipment to the site and began equipment setup.
07/29 to 07/31/2016	No activity on site.
08/01 to 08/03/2016	Equipment setup and servicing of the pump motors.
08/04 to 08/07/2016	No activity on site.
08/08 to 08/10/2016	Tripped in the pump assembly and moved equipment away from the wellhead.
08/11/2016	Installed a PXD in the m1 completion and performed a function test of the pump.
08/12/2016	Installed PXDs in the p1 and p2 piezometers and pumped the well.
08/13 to 08/18/2016	Continued pumping the well in cycles with the pump being shut off overnight.
08/19/2016	Collected GWC and FMP samples. Pumping ended.
08/20 to 08/21/2016	No activity on site.
08/22 to 08/26/2016	Removal of the PXDs and testing pump. Dedicated electric-submersible-sampling pump installed and function tested.
08/27 to 08/28/2016	No activity on site.
08/29/2016	Demobilization activities.
08/30 to 08/31/2016	Demobilization activities. Depth-discrete bailer samples collected from piezometers p2 and p4.
09/01/2016	Completed demobilization of equipment and facilities.

FMP = Fluid management plan

1.7 Governing Documents

In addition to the Pahute Mesa Phase II CAIP (NNSA/NSO, 2009a) and related documents referenced in the preceding subsections, the following documents identify WDT requirements for UGTA Activity field operations:

- *Navarro Field Activity Work Package (FAWP) for Underground Test Area (UGTA) Activity Well Development, Testing, and Sampling at Well ER-20-12* (Navarro, 2016e)
- *Field Instruction for the Underground Test Area Activity Well Development and Testing, and Groundwater Sampling* (Navarro, 2016a)
- *Final Well Specific Fluid Management Strategy for UGTA Well ER-20-12, Nevada National Security Site,* Rev. 1 (NNSA/NFO, 2015a [hereafter referred to as the Strategy Letter])
- *Navarro UGTA Field Operations Secondary Real Estate/Operations Permit* (REOP) (REOP No. NAV-0026, Rev. 01) (Navarro, 2015c)
- *Underground Test Area (UGTA) Health & Safety Plan,* Rev. 3. (NNSA/NFO, 2015c)
- *Underground Test Area Project Waste Management Plan*, with *Attachment 1 Fluid Management Plan for the Underground Test Area Project* (NNSA/NSO, 2009b)
- *Underground Test Area Activity Quality Assurance Plan, Nevada National Security Site, Nevada* (NNSA/NFO, 2015b)

1.8 Report Organization

This report is organized into the following sections:

- Section 1.0 is an introduction and summary of the WDT activities.
- Section 2.0 provides the schedule of field activities, data collection details, and the raw data collected.
- Section 3.0 presents hydraulic data evaluation and analysis of the WDT for Well ER-20-12.
- Section 4.0 presents an overview of the geology and hydrogeology of the Pahute Mesa region in the area of Well ER-20-12.
- Section 5.0 presents an overview of the geochemistry of the Pahute Mesa region in the area of Well ER-20-12.
- Section 6.0 provides information and data regarding environmental compliance requirements.

- Section 7.0 provides observations and conclusions.
- Section 8.0 provides references cited.
- Appendix A presents current lithologic logs for Well ER-20-12.
- Appendix B presents descriptions of the measurement equipment used and the submersible pump performance curves.
- Appendix C provides PXD installation/removal and water-level measurement data forms.
- Appendix D presents grab sample water-quality and bromide concentration data during production.
- Appendix E presents descriptions of the electronic data files included on the accompanying digital versatile disc (DVD).

2.0 WELL DEVELOPMENT, HYDRAULIC TESTING, AND GROUNDWATER SAMPLING ACTIVITIES

This section provides a detailed history of activities, descriptions of the equipment and methods used, water-level measurements and monitoring data, results of flow and chemistry logging, water-quality monitoring data, and analytical results from the GWC samples collected.

The Pahute Mesa LTWLM program was in operation during both drilling and WDT activities at Well ER-20-12. Data from this program are provided in the *Long-Term Head Monitoring Data Report, Fiscal Year 2016* (Navarro, 2017). However, information on the monitored wells is included in this section. A preliminary analysis of the hydraulic influence of water production during drilling of Well ER-20-12 on LTWLM Well PM-3 is provided in Section 3.6.

2.1 Schedule of Activities

WDT scheduled activities for Well ER-20-12 included LTWLM; well logging by DRI; a period of pre-WDT well sampling, including rod pumping of piezometer p1; and a period intended for well development pumping, step-rate pump testing, and constant-rate pump testing. Water production from the well was considerably less than anticipated. Related complications (such as well de-watering) prevented continuous step-rate and constant-rate pump testing. Instead, during the field time allotted, cycled pump testing was conducted, where the pump was completely shut off to allow water recovery, then turned on again in repeated cycles. Though cyclic testing is somewhat analogous to a step-rate test by increasing the stress to an aquifer in increasing increments, a step-rate test is able to sustain each given pump rate as the rate is increased.

LTWLM records from nearby wells were reviewed for potential impacts by both the well drilling/well completion and WDT activities at ER-20-12. Continuous water-level records were available from 30-pounds-per-square-inch-absolute (psia) PXDs installed before ER-20-12 well drilling—including Wells PM-3-1, PM-3-2, and U-20m PS 1D–with installation dates of June 2, June 3, and July 23, 2015, respectively. Water levels were measured in the main completion and all of the piezometers of Well ER-20-12 using an e-tape on May 11, 2016. PXDs (30 psia) were installed in Well ER-20-12 at piezometers p1 and p3 on May 25, 2016; and at the main completion (m1) and piezometers p2 and p4

on May 26, 2016. LTWLM (pre-WDT) for ER-20-12 ended with the removal of the 30-psia PXDs, including removals from piezometer p1 on June 27, 2016, in preparation for rod pumping and sampling; piezometers p3 and p4 on July 20, 2016; the main completion (m1) on July 20, 2016, in preparation for WDT activities; and piezometer p2 on July 27, 2016, in preparation for WDT activities.

PXDs rated for 1,000 psia were installed in the main completion (m1) and piezometers p1 and p2 for pump-test water-level monitoring.

DRI mobilized equipment and met Navarro personnel at Well ER-20-12 to conduct hydrophysical and geochemical logging from June 7 to June 10, 2016.

Navarro personnel mobilized equipment for rod pumping and sampling of piezometer p1 from June 27 to July 7, 2016. Production flow rate, temperature, water-quality parameters, and ^{3}H were monitored with field equipment during production. Chemistry sampling was conducted at the end of the production period. The GWC samples were collected July 6, 2016, and sent to General Engineering Laboratories (GEL) on July 11, 2016. Samples were collected and shipped on the same dates to USGS for sulfur isotope analysis, and to LLNL for analysis of stable isotopes and radiometric isotopes.

Mobilization of equipment to the Well ER-20-12 site and preparation for WDT operations began on July 27, 2016. WDT activities consisted of two function tests and 18 additional cyclic-drawdown tests over a period of nine days (August 11 to 19, 2016). During this time period of stressed (pumping) conditions, water from the pumped main completion (m1) was monitored for production flow rate, temperature, water-quality parameters, and ^{3}H, using field equipment. GWC and FMP samples were collected August 19, 2016, and sent to GEL on August 22, 2016, for analysis. Samples were collected and shipped on the same dates to USGS for sulfur isotope analysis, and to LLNL for stable isotopes and radiometric isotopes analysis. In addition, GWC samples from depth-discrete bailers were collected from piezometers p2 and p4 on August 30 and 31, 2016, respectively, and sent to GEL on September 15, 2016. The well was unable to sustain a constant pumping rate; thus, a constant-rate test was not performed. Alternatively, the well was cycle tested by turning the pump on until the well was de-watered, then shutting the pump off to allow the well to recover. After 20 pumping cycles were completed, the well was allowed to recover for four days before the PXDs were removed from the piezometers on August 22, 2016.

GWC samples were collected during the testing on August 19, 2016. Water-level monitoring and hydrophysical/geochemical logging under post-pumping ambient conditions were not conducted.

2.2 Measurement Equipment

This section identifies and describes the measurement equipment used during the WDT. More detailed descriptions are provided in Appendix B.

Formal depth-to-water (DTW) measurements are made with calibrated e-tapes equipped with conductivity sensors. The e-tapes are calibrated every two years against a reference steel tape maintained by USGS. A calibration factor is determined to correct all measurements to a common reference for comparability.

Navarro has a variety of Comprobe, Mt. Sopris, and Century wireline winch units available with varying cable lengths to set and retrieve equipment including PXDs. Although the wirelines provide accurate measurements over short lengths, the e-tape measurements are used as the formal DTW measurement data.

Barometric pressure was measured using Viasala model PTB110 barometers. The barometers are housed with the datalogger near the wellhead in a weatherproof enclosure, which is vented to the atmosphere. The pressure sensor outputs an analog millivolt signal and is accurate to ± 0.5 millibar (mBar) at 20 degrees Celsius (ºC).

Instrumentation Northwest, Inc. (INW) model PT12 and PT2X PXDs were used below the water level for automated recording of total pressure in wells and the groundwater temperature at the PXD. The INW PT12 PXDs are digital with an accuracy to ± 0.05 percent of full-scale pressure. The PXDs are factory-calibrated every two years. The pressure values for the PXDs are pounds per square inch absolute (psia). The groundwater temperature at the PXD is recorded in ºC with an accuracy of ± 0.5 ºC.

The production rate was measured using a Foxboro IMT25 Transmitter and Foxboro 8004A Magnetic Flow Tube (4 in.). The meter is accurate to 0.25 percent of the flow rate being measured at flow velocities greater than or equal to 2.0 feet per second (ft/s). The meter is factory-calibrated every two years.

Campbell Scientific CR1000 dataloggers were used to record data (e.g., PXD pressure data, groundwater temperature, barometric pressure, and flow rates). The CR1000 is a fully programmable datalogger that uses digital communication (e.g., RS485, SDI12 protocol) with digital sensors or makes analog measurements (precision voltage measurement, pulse counter) for analog sensors. A description of the datalogger data is provided in Appendix B.

Measurement of temperature, pH, dissolved oxygen (DO), specific electrical conductivity (SEC), and turbidity of grab samples was accomplished using a Hydrolab Quanta Multiprobe. A Horiba F-53 pH/ION meter (pH + bromide) was used to measure bromide in the grab samples. Water-chemistry parameters (pH, DO, SEC, temperature, and turbidity) were also measured continuously on a side stream from the wellhead discharge using a Hydrolab Quanta Multiprobe with a flow-through cell. The equipment used to analyze the grab samples was calibrated daily. Due to the daily calibrations, the grab sample data are taken as the formal water-quality data. The inline measurement equipment was calibrated less frequently, and was used to identify trends and to monitor water quality when grab samples were not being collected.

The distribution of various parameters (i.e., vertical flow, temperature, pressure, and water chemistry) with depth was logged using downhole tools during both well drilling/completion and WDT. The tools included an Idronaut Ocean Seven 303*Plus* (I-CHEM) chemistry tool and a thermal flowmeter (TFM). Measurements were made under ambient conditions.

Tritium activities were evaluated against background, analytical error, and the FMP Attachment 1 discharge criteria (NNSA/NSO, 2009b). The samples were analyzed using a Packard liquid scintillation counter (LSC).

2.3 Depth-to-Water Measurements

DTW measurements were made with calibrated e-tapes on select dates as well as before installation and after removal of PXDs. The first LTWLM water levels were measured on May 11, 2016, approximately four months after completion of well drilling and construction activities on January 17, 2016. The May 11 levels are reported on the finalized well completion diagram in the ER-20-12 well completion report (NNSA/NFO, 2016, Figure 8-1). Water levels measured on May 25 and May 26, 2016, were taken before the first installation of PXDs for the LTWLM program. Other LTWLM water levels were measured after PXDs were removed or before they were reinstalled on June 6, June 13

and 14, and June 28, 2016. PXD recorded water levels indicate levels were disturbed by rod pumping of piezometer p1 from June 27 to July 7, 2016. Water levels were measured July 20 and July 27, 2016, after the LTWLM PXDs were removed from the piezometers in preparation for WDT activities. These levels are assumed to represent the ambient, pre-pumping (pre-WDT) equilibrium head. This assumption can be evaluated based on the PXD pressures recorded at the times at which stresses were applied to the well, as identified in the activity schedule in Table 1-2. DTW measurements are listed in Table 2-1.

Table 2-1
Well ER-20-12 Water-Level Measurements during LTWLM and WDT
(Page 1 of 2)

Date	Time	Depth to Water		SWL Elevation	
		(m)	(ft)	(m)	(ft)
5.5-in. Main Completion (m1)					
05/11/2016	13:15	563.80	1,849.73	1,343.77	4,408.68
05/26/2016	13:10	563.82	1,849.81	1,343.74	4,408.60
06/06/2016	14:10	563.80	1,849.75	1,343.76	4,408.66
06/14/2016	12:35	563.75	1,849.57	1,343.81	4,408.84
07/20/2016	13:15	563.77	1,849.65	1,343.79	4,408.76
08/11/2016	09:10	563.76	1,849.62	1,343.80	4,408.79
08/22/2016	12:20	563.52	1,848.82	1,344.04	4,409.59
2.375-in. Piezometer (p1)					
05/11/2016	14:20	566.93	1,860.02	1,340.63	4,398.39
05/25/2016	10:40	566.91	1,859.94	1,340.65	4,398.47
06/06/2016	15:56	566.88	1,859.84	1,340.68	4,398.57
06/13/2016	13:00	567.06	1,860.44	1,340.50	4,397.97
06/27/2016	14:10	566.97	1,860.15	1,340.59	4,398.26
08/12/2016	09:30	566.77	1,859.48	1,340.79	4,398.93
08/23/2016	09:30	566.69	1,859.23	1,340.87	4,399.18
1.9-in. Piezometer (p2)					
05/11/2016	12:45	572.00	1,876.65	1,335.56	4,381.76
05/26/2016	09:35	571.89	1,876.27	1,335.68	4,382.14
06/09/2016	13:30	571.88	1,876.26	1,335.68	4,382.15
06/13/2016	11:15	571.91	1,876.36	1,335.65	4,382.05
07/27/2016	10:50	571.85	1,876.14	1,335.72	4,382.27
08/06/2016	11:09	571.50	1,874.99	1,336.07	4,383.42
08/12/2016	10:05	571.66	1,875.51	1,335.91	4,382.90
08/22/2016	12:55	571.55	1,875.17	1,336.01	4,383.24
08/30/2016	09:45	571.69	1,875.61	1,335.88	4,382.80

Table 2-1
Well ER-20-12 Water-Level Measurements during LTWLM and WDT
(Page 2 of 2)

Date	Time	Depth to Water		SWL Elevation	
		(m)	(ft)	(m)	(ft)
2.375-in. Piezometer (p3)					
05/11/2016	14:45	571.90	1,876.32	1,335.66	4,382.09
05/25/2016	13:00	571.91	1,876.35	1,335.65	4,382.06
06/06/2019	13:47	571.90	1,876.30	1,335.67	4,382.11
06/13/2016	14:50	571.94	1,876.45	1,335.62	4,381.96
07/20/2016	15:10	571.87	1,876.20	1,335.70	4,382.21
1.9-in. Piezometer (p4)					
05/11/2016	12:15	492.17	1,614.74	1,415.39	4,643.67
05/26/2016	11:25	492.16	1,614.71	1,415.40	4,643.70
06/09/2016	12:50	492.15	1,614.67	1,415.41	4,643.74
06/13/2016	09:35	492.18	1,614.78	1,415.38	4,643.63
07/20/2016	11:00	492.19	1,614.79	1,415.38	4,643.62
08/30/2016	10:10	492.09	1,614.48	1,415.47	4,643.93

Blue = LTWLM PXD removal
Green = WDT PXD installation
Gray = LTWLM PXD installation

2.4 Pressure Transducer Installation

A PXD was installed in each of the piezometers of Well ER-20-12 for data collection as part of the LTWLM program. Water pressures and groundwater temperatures at the PXD were recorded continuously by a datalogger for the period from May 25 and 26 to July 20 through 27, 2016, after which LTWLM PXDs were removed and eventually replaced with higher-rated psia PXDs for WDT activities.

Typically during pump testing, the monitored interval is a substantial vertical distance below the top of the water column. During pumping, the temperature distribution in the well may change during the monitoring period. To eliminate the potential temperature effects on the pressures monitored, an INW PT12 PXD rated for 0 to 2,000 psia was used to monitor the water level in the main completion and piezometers p1 and p2 for the WDT activities. The PXD was set to near the base of the screened interval in the well tubing/screen assembly.

The PXD installation depth is calculated by the use of the DTW measurement and the PXD pressure at the installation depth attributable to water pressure. The PXD pressure at the set depth minus the PXD pressure in air above the water surface is multiplied by a calculated density conversion factor to give the PXD depth below the SWL. The PXD depth below SWL is then added to the measured DTW to determine the PXD installation depth.

The PXD installation depth is calculated rather than measured because of two uncertainties associated with the direct depth measurement provided by the wireline unit: (1) the hanging length of the cable is not as accurately known, as the length of the e-tape cannot be measured directly; and (2) when the PXD is removed, the wireline counter may not return to zero. The counter reading at the top of the casing during removal is recorded as the wireline offset value. The wireline offset value provides an indication of the uncertainty of the depth measurements from differences in wireline diameters and slippage in the wireline counter.

2.5 Background PXD and DTW Head Monitoring

As discussed in Section 1.5, PXDs were installed in the existing piezometers of Well ER-20-12, and in Wells PM-3-1, PM-3-2, and U-20m PS 1D (near HANDLEY) for head monitoring during pump testing at Well ER-20-12. Monitoring information for these wells is provided in Table 2-2. The table provides spatial and water-level information, including the distance to Well ER-20-12, surface elevation at the wellhead, and the DTW on May 11, 2016, as well as details of the specific HSUs that intersect with the effective open intervals (EOIs) of the wells. Details on the PXD installation status for wells monitored by Navarro (including the pressure ranges of the PXDs, the dates monitoring began, PXD set depths, and depths to groundwater measured at the time of installation) are provided in Table 2-3. The data files containing PXD pressure, barometric pressure, and PXD temperature are on the DVD that accompanies Appendix E.

2.6 Pre-development LTWLM Monitoring at PM-3-1, PM-3-2, and ER-20-12

LTWLM data were collected and reviewed for PM-3 for the duration of both well completion and WDT activities at Well ER-20-12. The criteria for siting ER-20-12 included that the well be close enough to induce hydraulic effects in surrounding observation wells, including Well PM-3, during the WDT. Following a general protocol, the LTWLM monitoring program was initiated before drilling in anticipation that water production during the drilling of Well ER-20-12 might induce drawdown at

Table 2-2
Well Construction, Location, Water-Level, and Hydrostratigraphic Information

Well	Distance from ER-20-12 (ft)	Surface Elevation (ft amsl)	DTW on May 11, 2016 (from DTW or PXD) (ft bgs)	SWL Elevation (ft amsl)	Completion Top and Bottom of EOI			EOI		HSU Elevations		HSU Thickness		HSU Depths	
					Top (ft amsl)	Bottom (ft amsl)	EOI Length (ft)	HSU	% (ft)	Top (ft amsl)	Bottom (ft amsl)	Total Thickness (ft)	Thickness of HSU across EOI (ft)	Top Depth (ft bgs)	Bottom Depth (ft bgs)
PM-3_p2	5,048	5,823.2	1,454.66	4,368.51	4,350.2	4,136.2	214.0	UPCU	100%	4,588	3,938	650	214.0	1,235	1,885
PM-3_p1	5,048	5,823.2	1,456.77	4,366.39	3,951.2	3,631.2	320.0	UPCU	4%	4,588	3,938	650	12.8	1,235	1885
								TCA	80%	3,938	3,683	255	255.2	1,885	2,140
								LPCU	16%	3,683	3,123	560	51.9	2,140	2,700
								--	total 100%	--	--	--	total 320.0	--	--
U-20m PS 1D	1,996	5,959.5	--	--	1,666.0	1,215.0	451.0	PBRCM	100%	3,593	1,803	1,790	Unknown [a]	2,372	4,162
UE-20j	2,160	5,902.8	(1,270 in October 1964)	4,633	4,162.8	212.8	3,950	Undiff.	--	--	--	--	--	--	--
ER-20-12_p4	0.0	6,258.40	1,614.74	4,643.66	4,572.75 Top of screen	3,971.4	601.4 Top to bottom EOI	TMWTA	21%	5,364	4,448	916	124.4	894	1,810
								TMLVTA	79%	4,448	3,878	570	477.0	1,810	2,380
								--	total 100%			--	total 601.4		
ER-20-12_p4	0.0	6,258.40	1,614.74	4,643.66	4,643.66 Water table	3,971.4	672.3 Saturated thickness	TMWTA	29%	5,364	4,448	916	195.3	894	1,810
								TMLVTA	71%	4,448	3,878	570	477.0	1,810	2,380
								--	total 100%			--	total 672.3		
ER-20-12_p3	0.0	6,258.40	1,876.32	4,382.08	3,748.1	3,311.5	436.6	CHZCM	100%	3,763	2,860	903	436.6	2,495	3,398
ER-20-12_p2	0.0	6,258.40	1,876.65	4,381.75	3,205.4	3,101.4	104.0	CHZCM	100%	3,763	2,860	903	104.0	2,495	3,398
ER-20-12_p1	0.0	6,258.40	1,860.02	4,398.38	2,915.4	2,533.4	382.0	CHZCM	14%	3,763	2,860	903	55.0	2,495	3,398
								BRA	86%	2,860	2,467	393	327.0	3,398	3,791
								--	total 100%	--	--	--	total 382.0	--	--
ER-20-12_m1	0.0	6,258.4	1,849.73	4,408.67	2,342.4	1,715.1	627.3	PBRCM	100%	2,467	1,715	752	627.3	3,791	4,543

[a] EOI extends beyond logged HSUs.

LPCU = Lower Paintbrush confining unit

-- = Not applicable

Table 2-3
PXD Readings for LTWLM and May 11, 2016, Pre-pumping Water Levels

Well Name	HSU Monitored	Date and Time of Installation	PXD Range (psia)	PXD Set Depth (ft bgs)	DTW Measurement and PXD Reading (ft bgs)	SWL Elevation (ft amsl)
LTWLM PXD Reading						
PM-3_p1	UPCU, TCA, LPCU	06/02/2015, 15:10	0-30	1,476.43	1,456.57	4,366.59
PM-3_p2	UPCU	06/03/2015, 11:40		1,474.27	1,454.51	4,368.65
U-20m PS 1D	PBRCM[a]	07/23/2016, 11:20		NA	NA	NA
ER-20-12_m1	PBRCM	05/26/2016, 13:20		1,870.91	1,849.81	4,408.59
ER-20-12_m1	PBRCM	07/20/2016, 09:00		NA (removal)	1,849.65	4,408.75
ER-20-12_p1	CHZCM, BRA	05/25/2016, 13:40		1,879.08	1,859.94	4,398.46
ER-20-12_p1	CHZCM, BRA	06/27/2016, 11:10		NA (removal)	1,860.15	4,398.25
ER-20-12_p2	CHZCM	05/28/2016, 06:30		1,895.44	1,876.27	4,382.13
ER-20-12_p2	CHZCM	07/22/2016, 07:10		NA (removal)	1,876.14	4,382.26
ER-20-12_p3	CHZCM	05/25/2016, 14:10		1,893.07	1,876.35	4,382.05
ER-20-12_p3	CHZCM	07/20/2016, 12:30		NA (removal)	1,876.20	4,382.20
ER-20-12_p4	TMWTA, TMLVTA	05/26/2016, 13:20		1,637.00	1,614.71	4,643.69
ER-20-12_p4	TMWTA, TMLVTA	05/29/2016, 10:40		NA (removal)	1,614.79	4,643.61
Pre-pumping Water Levels DTW or PXD Reading						
Well Name	**HSU Monitored**	**Date and Time of Measurement or Reading**	**PXD Range (psia)**	**PXD Reading (ft bgs)**	**DTW Measurement (ft bgs)**	**SWL Elevation (ft amsl)**
PM-3_p1	UPCU, TCA, LPCU	05/11/2016, 19:20	0-30	1,456.77	NA	4,366.39
PM-3_p2	UPCU	05/11/2016, 19:20		1,454.66	NA	4,368.51
U-20m PS 1D	PBRCM[a]	05/11/2016, 19:20		NA	NA	NA
ER-20-12_m1	PBRCM	05/11/2016, NA		NA	1,849.73	4,408.67
ER-20-12_p1	CHZCM, BRA	05/11/2016, NA		NA	1,860.02	4,398.38
ER-20-12_p2	CHZCM	05/11/2016, NA		NA	1,876.65	4,381.75
ER-20-12_p3	CHZCM	05/11/2016, NA		NA	1,876.32	4,382.08
ER-20-12_p4	TMWTA, TMLVTA	05/11/2016, NA		NA	1,614.74	4,643.66

[a]Open intervals extend below logged hydrostratigraphy.

NA = Not available

PM-3. Figures 2-1 and 2-2 are plots of the LTWLM water levels in piezometer p1 (PM-3-1) and piezometer p2 (PM-3-2), respectively, recorded for the 2016 fiscal year from October 1, 2015, to September 12, 2016. The time period includes the time periods of ER-20-12 well completion activities—from the initiation of well drilling October 8, 2015, to final well completion January 6, 2016—as well as the activities of LTWLM, pre-WDT logging and sampling, and WDT from May through August 2016.

The borehole for Well ER-20-12 was drilled using an air-foam drilling fluid in conventional circulation without reuse of the drilling fluid. The air foam was mixed at the surface; pumped down the drill stem; returned up the annulus, lifting both formation water and drill cuttings; and discharged to the sump. The net result is that formation water is allowed to flow naturally to the borehole, and the removal of the water by air-foam lift is effectively a pumping-related aquifer stress.

A period of lowered heads, most likely a drawdown effect from the drilling of Well ER-20-12, is present in both the record for piezometers PM-3-1 (Figure 2-1) and PM-3-2 (Figure 2-2). An abrupt drawdown of about 1.5 ft approximately December 1, 2015, followed by a period of stabilized lowered heads until approximately February 1, 2016, corresponds to the time-frame of the ER-20-12 well drilling and completion. This is followed by a recovery period lasting until approximately April 1, 2016. A period of lowered heads of about 0.25 ft is present on both records during August 2016, corresponding to the time-frame of WDT activities, but variation is not much greater than the fluctuations observed during the entire fiscal year.

The continuous LTWLM record for the main completion (m1) and four piezometers of Well ER-20-12 is shown on Figure 2-3 from the initial late May installation to final late July removal of the LTWLM (30 psia) PXDs. For the two months of record available, the water levels were very stable with the exception of a period corresponding to the rod pumping of piezometer p1 from July 1 to July 7, 2016, for sampling purposes. The temperature record for the same period showed the same pattern, with stable temperatures except for the pumping period (Figure 2-4).

2.7 Pre-development ER-20-12 Well Logging

Table 2-4 lists the geophysical logs that were conducted during the drilling of ER-20-12, and are summarized in the well completion reports. The logs were used to determine screening intervals based on structures thought to enhance hydrologic flow, namely fractures, joints, and faults. The

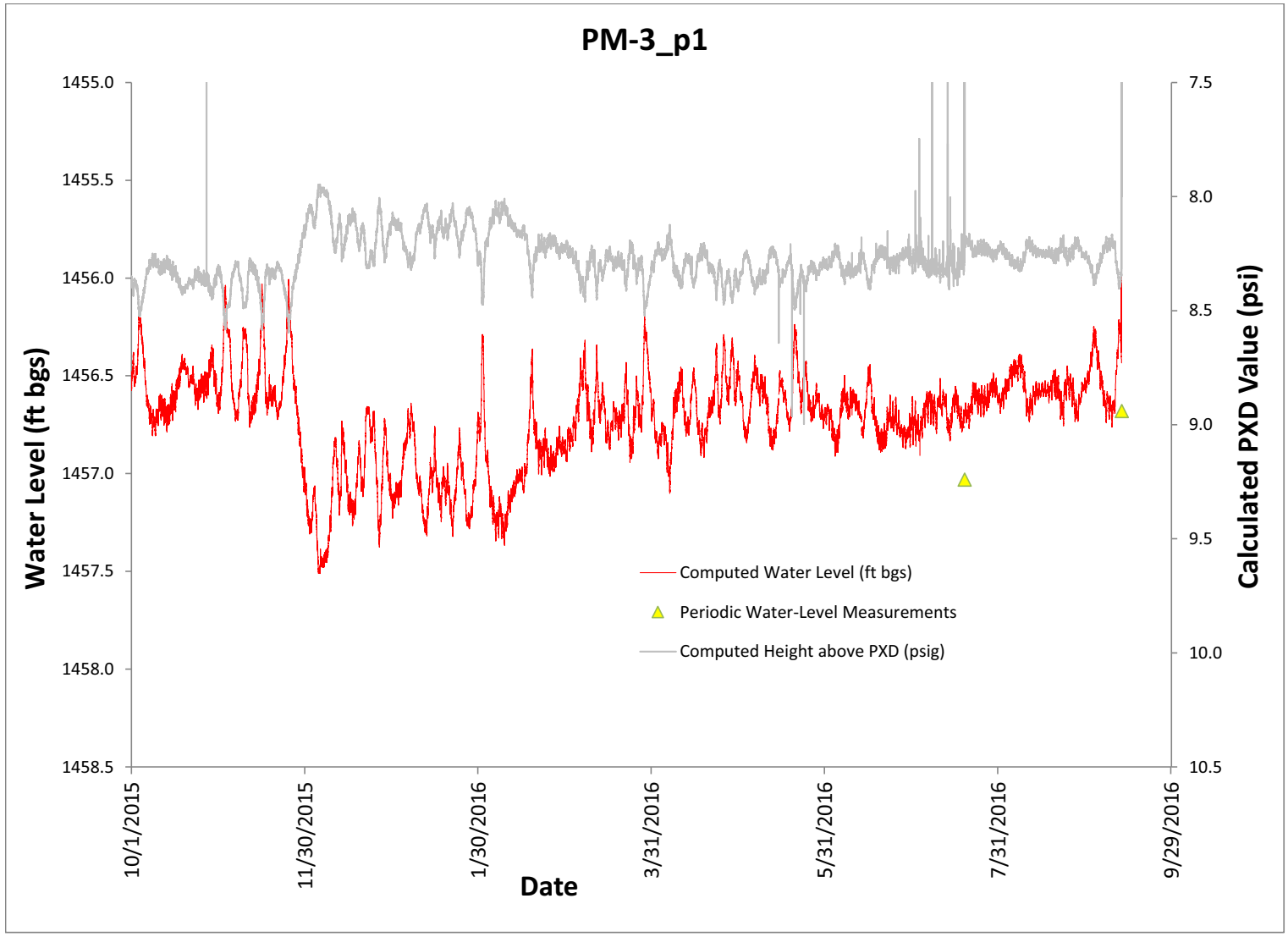

Figure 2-1
Long-Term Water-Level Monitoring of Piezometer PM-3-1

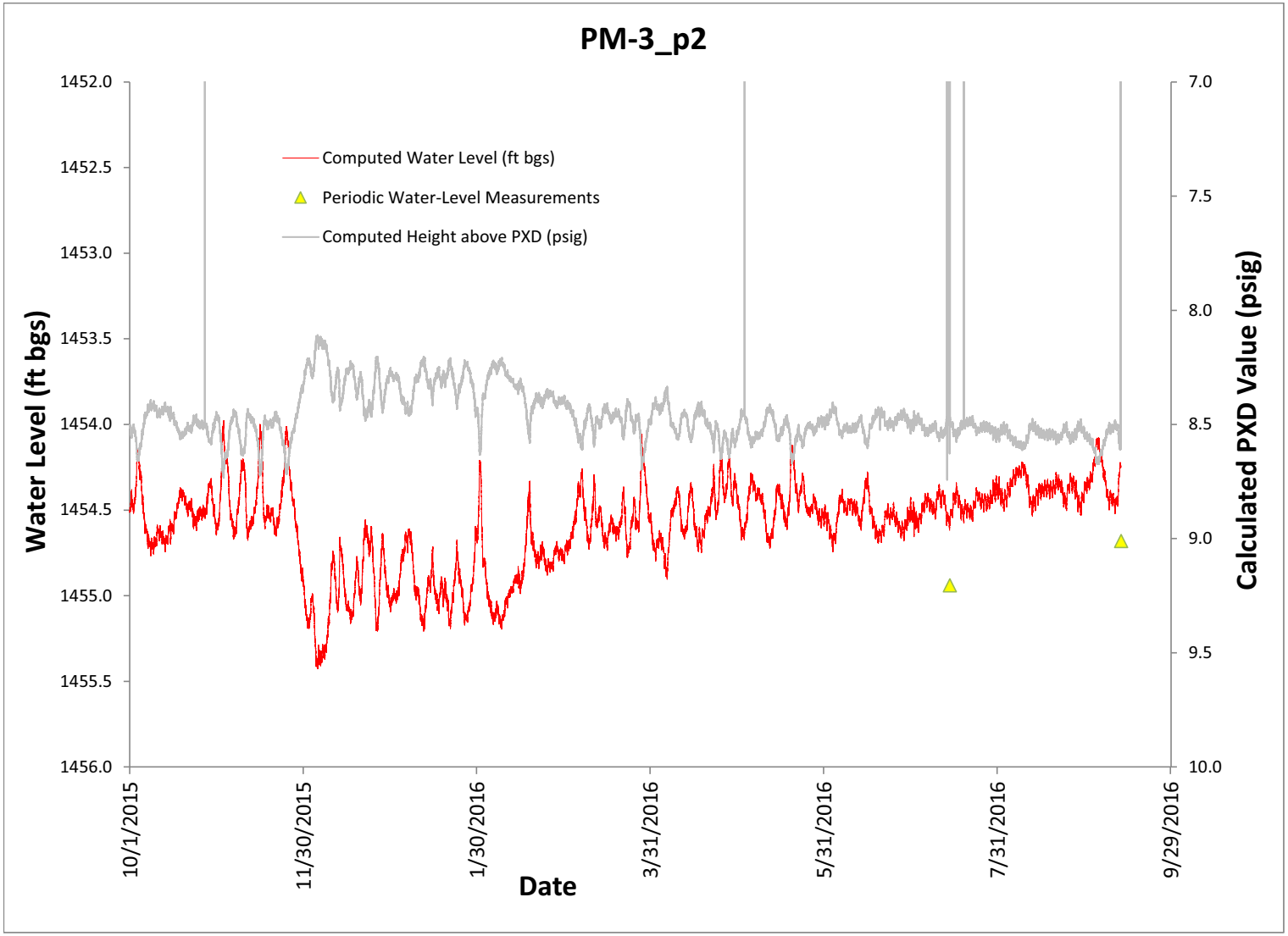

Figure 2-2
Long-Term Water-Level Monitoring of Piezometer PM-3-2

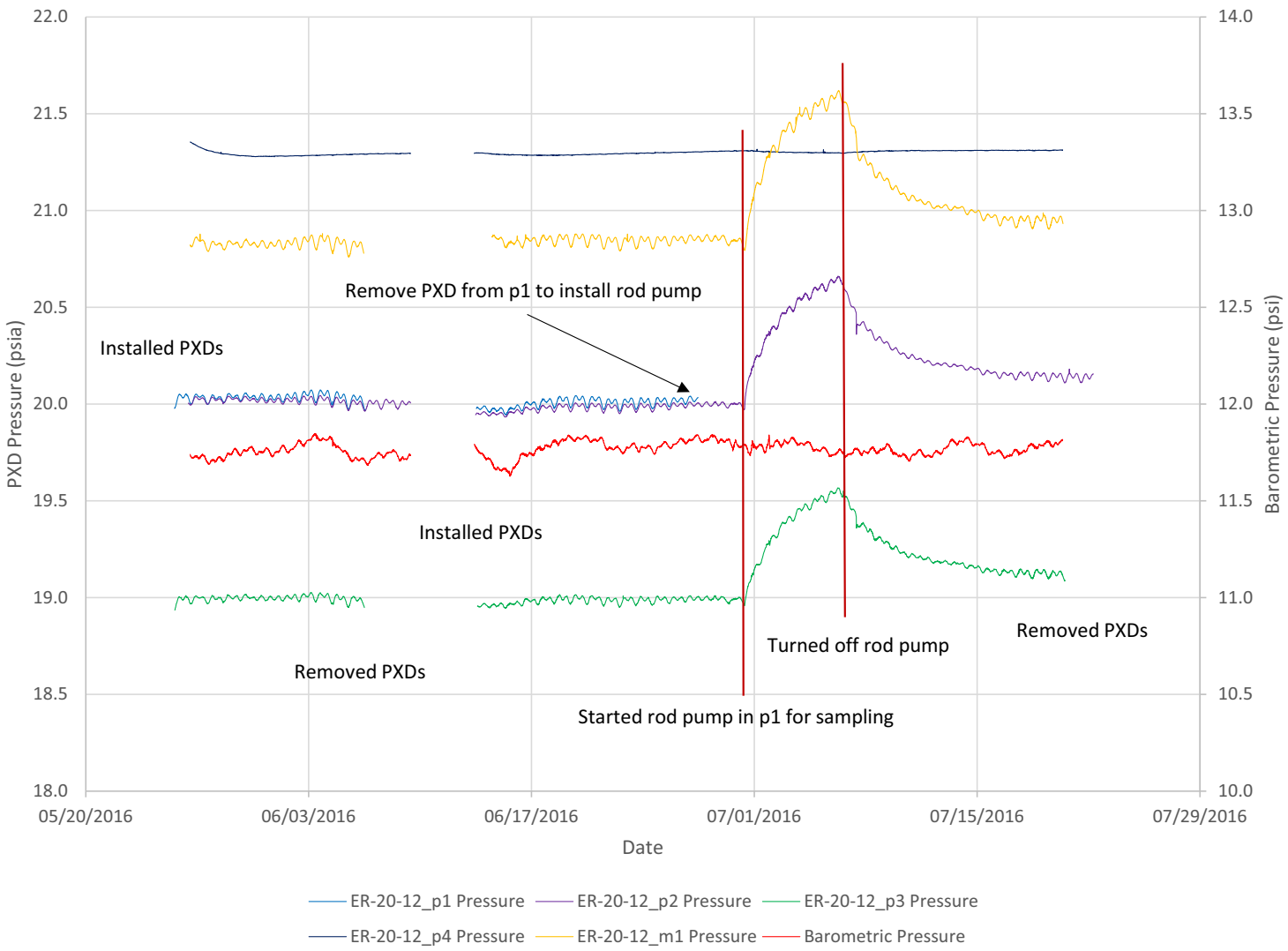

Figure 2-3
Barometric Pressure and Pressure Responses in Piezometers and Main Completion during Rod Pumping and Sampling of Piezometer p1 in Well ER-20-12

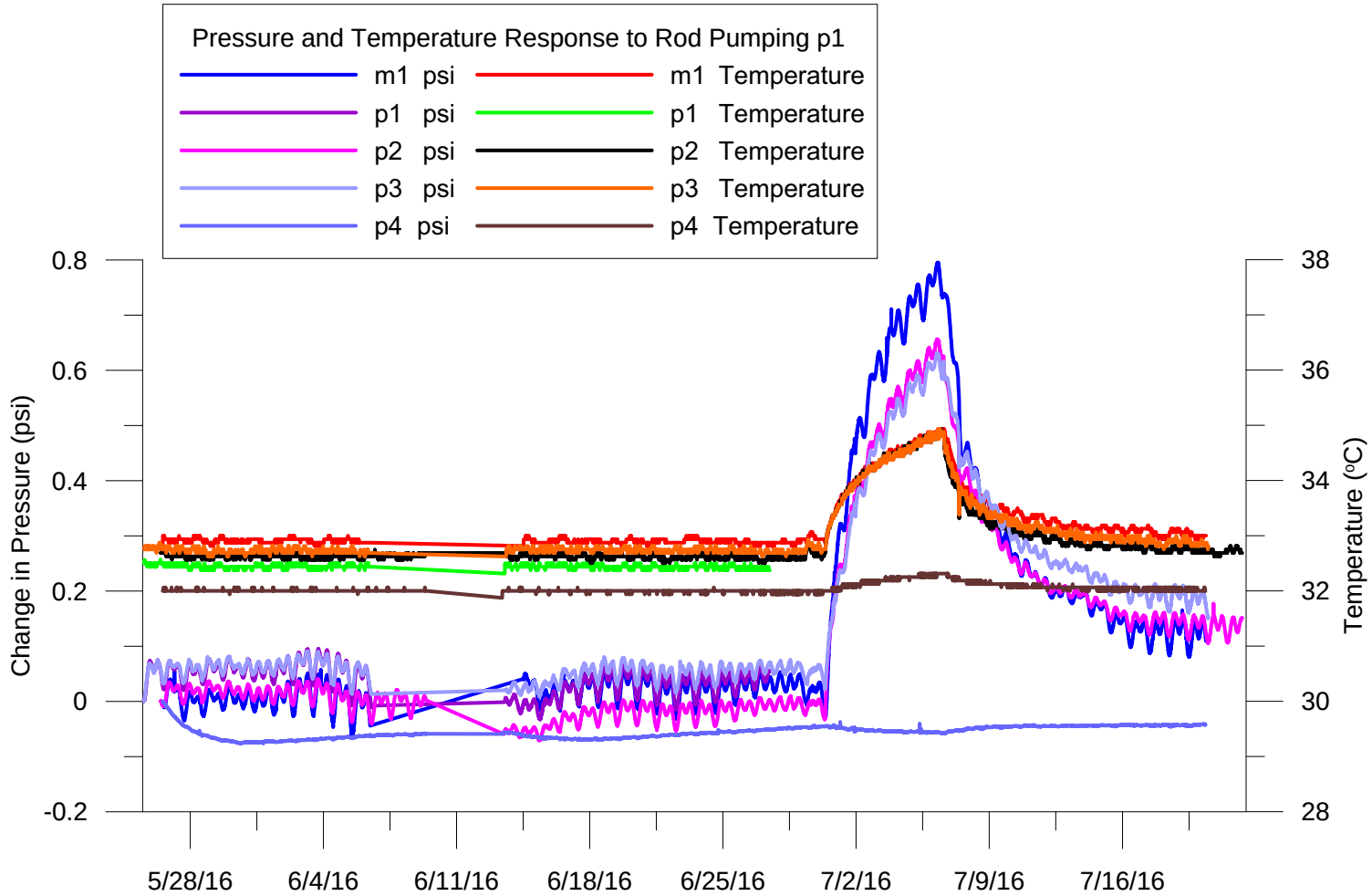

Figure 2-4
Pressure and Temperature Responses in Piezometers and Main Completion during Rod Pumping and Sampling of Piezometer p1 in Well ER-20-12 in July 2016

Table 2-4
LogPlot File Names of Geophysical Logs from Drilling

NSTec_ER-20-12_Fluid Check.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_Run4_ConPr_R05_L002Up.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_Density_Neutron_ConPr_Composite.las
CP17-00217_NNSS-NFO_NNSS_ER-20-12_Density_Neutron_Laterolog_ConPr_R04_L002Up.las
CP17-00217_NNSS-NFO_NNSS_ER-20-12_SGR_Sonic_Caliper_Imager_Survey_ConPr_R03_L003Up_Rev1.las
CP17-00217_NNSS-NFO_NNSS_ER-20-12_SGR_Sonic_Caliper_Imager_Survey_ConPr_R03_L003Up.las
CP17-00217_NNSS-NFO_NNSS_ER-20-12_Temperature_ConPr_R02_L001Down_PSTP.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_AIT_HRLA_ConPr_R02_L002Up.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_AIT_HRLA_ConPr_R02_L002Up.las
NSTec_UGTA_ER-20-12_Chem.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_Run4_ConPr_R05_L002Up.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_Density_Neutron_ConPr_Composite.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_Temperature_ConPr_R01_L001Down.las
CP17-00214_NNSS-NFO_NNSS_ER-20-12_Temperature_ConPr_R01_L001Down.las
ER-20-12 CDFM 2500-4350'.las
ER-20-12_3900-4350 Ambient_CDFM.las
ER-20-12_3900-4350 Ambient_CDFM.las
ER-20-12_3900-4350_Chemistry.las
ER-20-12_3900-4350_Chemistry.las
CP17-00224_NNSA-NFO_NNSS_ER-20-12_Temperature_ConPr_Merge_Composite.las
CP17-00224_NNSA-NFO_NNSS_ER-20-12_Laterolog_ConPr_R05_L002Up.las
CP17-00224_NNSA-NFO_NNSS_ER-20-12_Laterolog_ConPr_R05_L002Up.las
CP17-00224_NNSA-NFO_NNSS_ER-20-12_Density_Neutron_ConPr_R05_L002Up.las
CP17-00224_NNSA-NFO_NNSS_ER-20-12_Density_Neutron_ConPr_R05_L002Up.las
CP17-00224_NNSA-NFO_NNSS_ER-20-12_SGR_Sonic_Caliper_Imager_Survey_ConPr_R04_L005Up.las
NSTec_ER-20-12_Fluid Chemistry.las

LTWLM period, before WDT, provided a time window to conduct hydrophysical and hydrochemical logging under ambient (undisturbed and equilibrated) conditions in the effective open intervals of the piezometers and main completion of ER-20-12. DRI conducted the logging from June 7 to June 10, 2016, initiating the work five months after the completion of drilling activities, and finishing approximately two weeks before the rod pumping and sampling of piezometer p1.

I-CHEM hydrochemical logs were conducted in the main completion (m1) on June 7, 2016, and in piezometers p1 and p3 on June 8, 2016. A TFM hydrophysical log was completed in piezometer p1

on June 8, 2016. A TFM log was conducted in the main completion (m1) on June 10, 2016, after an unsuccessful attempt on June 9. A TFM logging attempt on June 10, 2016, in piezometer p3 was unsuccessful.

The I-CHEM tool recorded a continuous reading over the logging interval for (1) ambient borehole temperature, (2) pressure, (3) pH, (4) SEC, (5) bromide, and (6) oxygen gas (O_2) concentration as the percentage of the O_2 atmospheric equilibrium concentration. The TFM tool recorded at set stations measurements of borehole upward (+) or downward (-) flows in gallons per minute (gpm). The temperature profile and TFM station results are plotted alongside the well completion diagram, as well as the water production encountered during drilling, for m1, p1, and p3 in Figures 2-5 through 2-7, respectively.

2.8 Pre-development Rod Pumping and Sampling

During ER-20-12 well drilling and completion activities, water was tagged with a lithium bromide tracer introduced in the well. However, there was no pre-completion or open-hole well development conducted, and thus fluids used during completion remained in the hole. Because of the small size of the piezometers, it was not feasible to install an electric submersible pump to remove the completion fluids. Piezometers p2 and p4 were constructed with 1.9-in. diameter CS tubing, which could be sampled only by bailers. Piezometers p1 and p3 were constructed with 2.375-in. diameter CS tubing, the minimum diameter needed to host an insert rod pump.

To meet well-purging and groundwater sampling objectives for piezometer p1, a 1.9-in. insert rod pump operated by a surface deployed pump jack was installed. Before installation, a water level was obtained to determine set depths. Piezometer p1 was partially developed using a 1.9-in. swabbing assembly inserted into the piezometer tubing. The limited pre-sampling development removed approximately 23,575 gallons (gal) of water, swabbed from piezometer p1. All produced fluids were routed through a wellhead manifold and into a 1-in. flexible hose and flowmeter for monitored discharge into Sump #1. The wellhead manifold was equipped with necessary valves for sampling, a calibrated pressure gauge, and a pressure relief valve leading to a bypass hose.

GWC, including water-quality parameters to gauge well development, and FMP samples were collected in accordance with the well development, testing, and sampling FI (Navarro, 2016a).

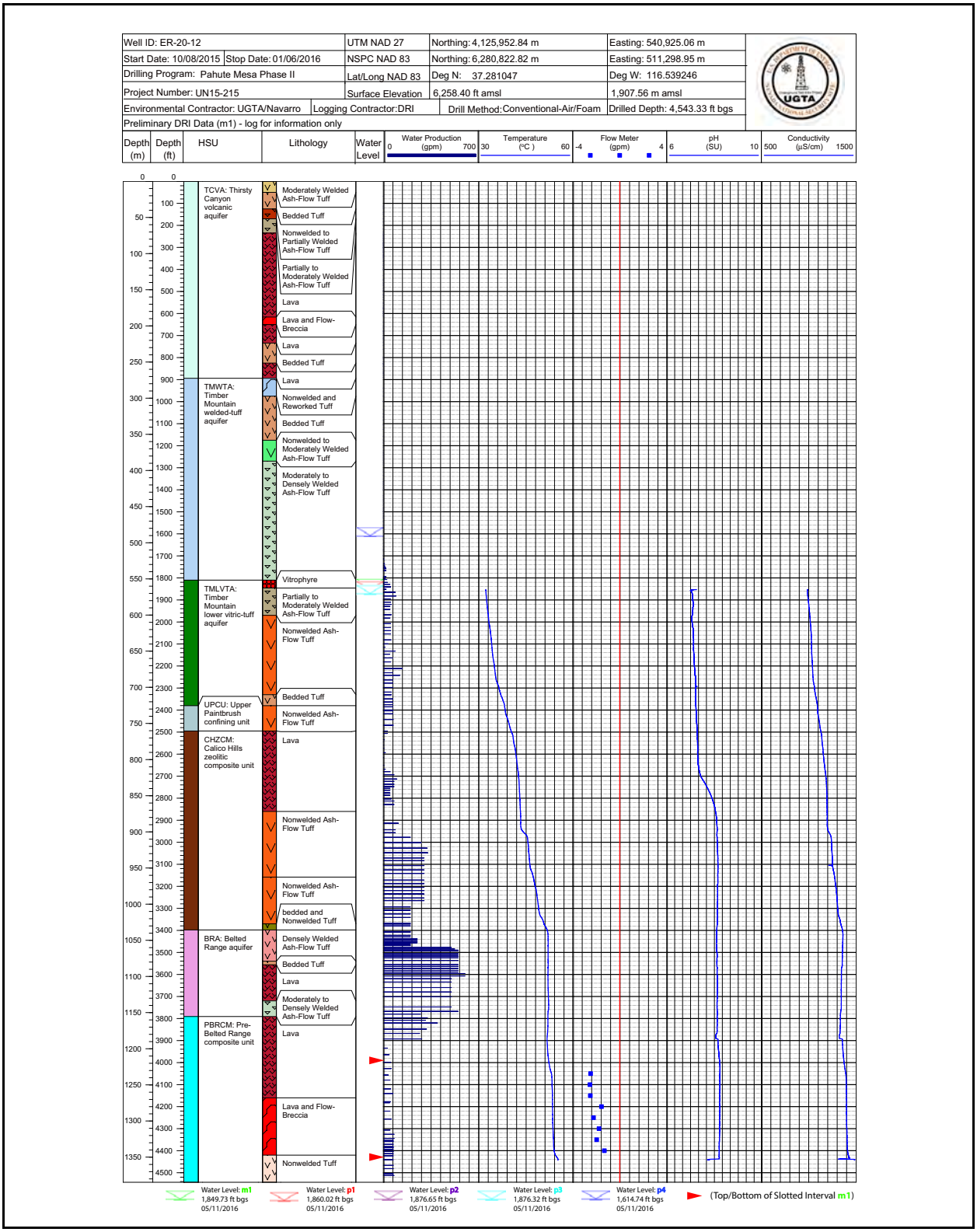

Figure 2-5
Geohydrologic Logging of the ER-20-12 Main Completion (m1) Conducted by DRI in June 2016

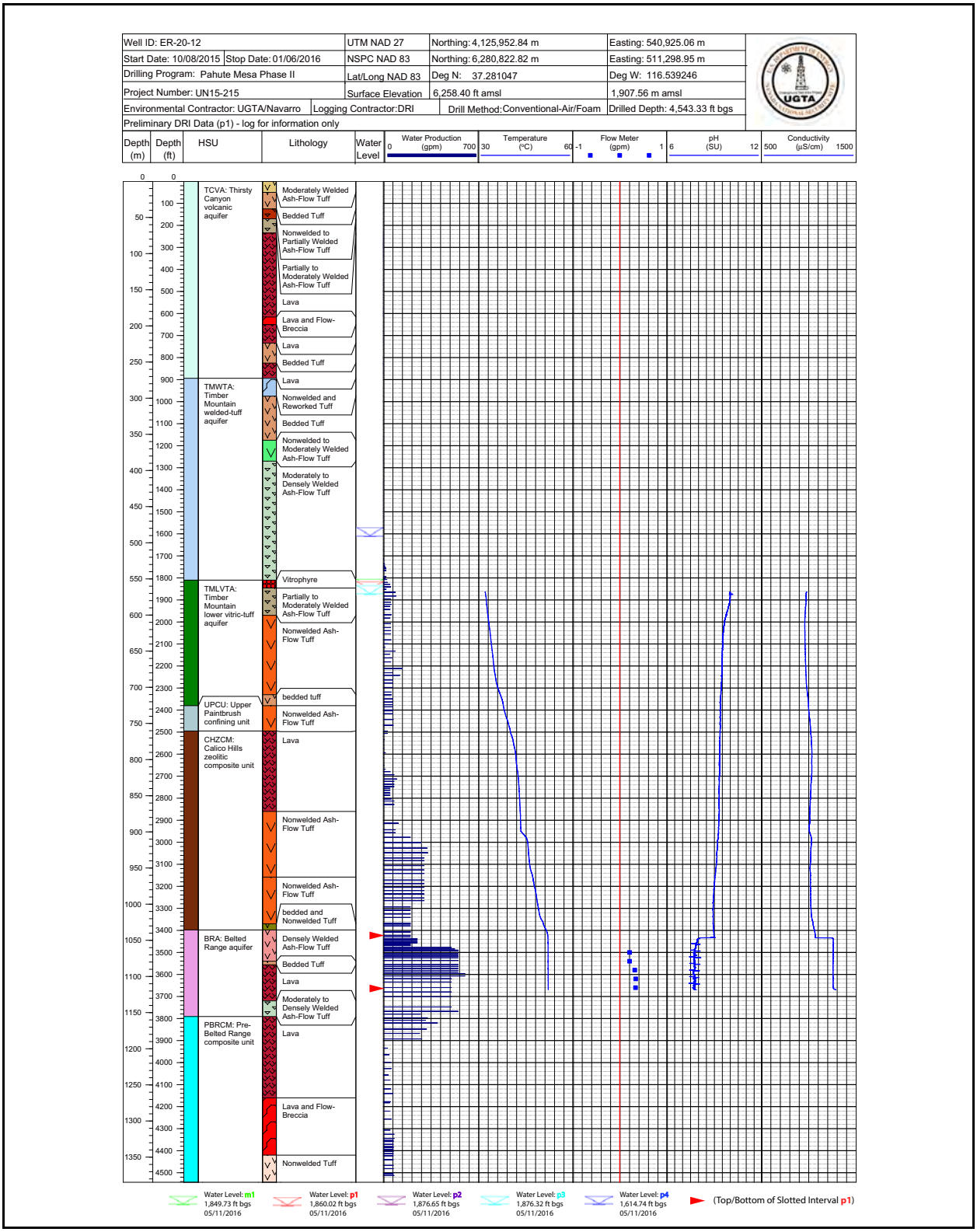

Figure 2-6
Geohydrologic Logging of ER-20-12 Piezometer p1 Conducted by DRI in June 2016

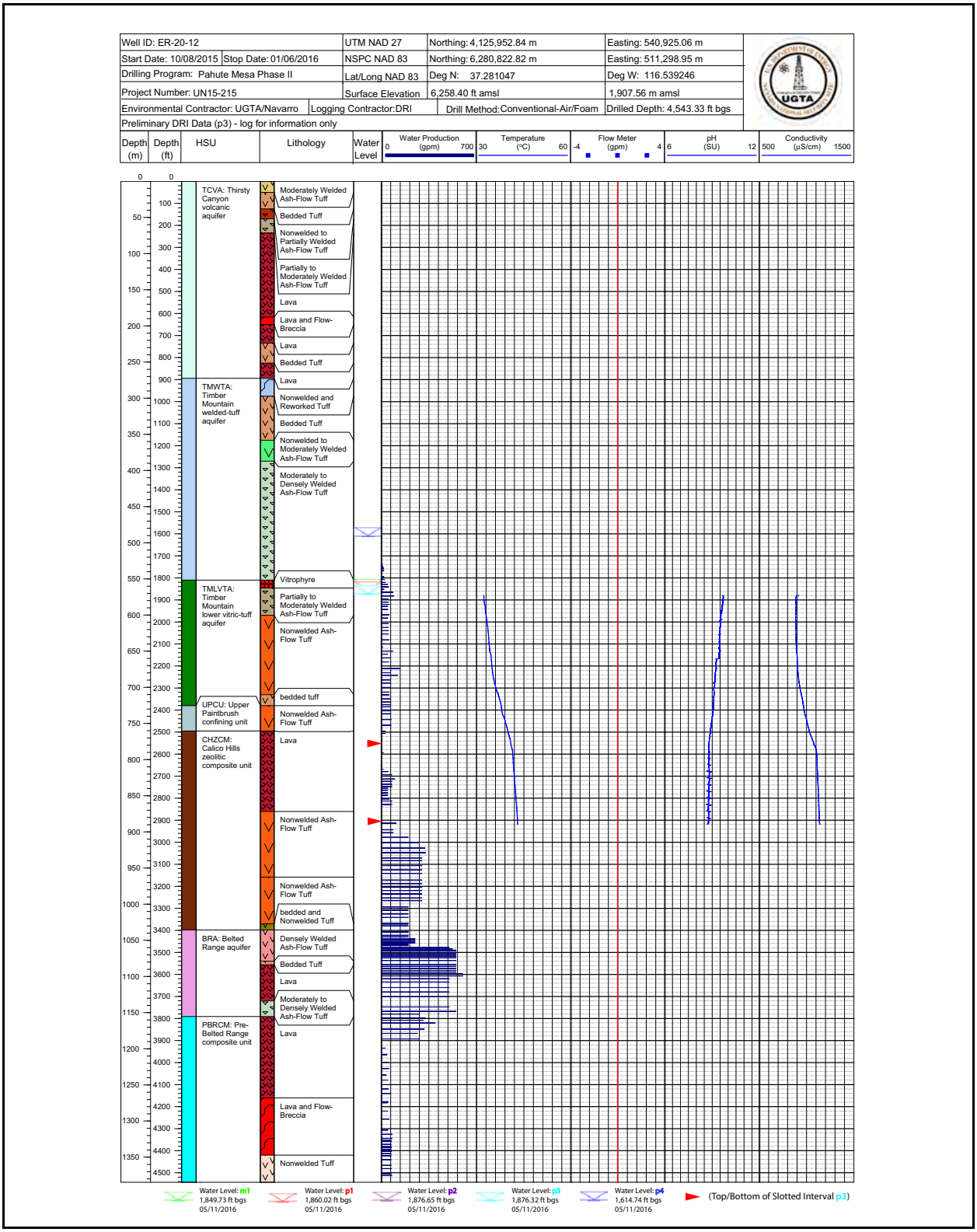

Figure 2-7
Geohydrologic Logging of ER-20-12 Piezometer p3 Conducted by DRI in June 2016

2.8.1 Pressure and Temperature Response to Pumping

Figure 2-3 shows that heads ***increased*** in piezometers p2 and p3 and in the main completion (m1) in response to the pumping of piezometer p1 during the week-long pumping period, and recovered for about an equal amount of time afterwards. Heads in piezometer p4 were unaffected by the pumping. Temperature and head data were combined in Figure 2-4. The LTWLM data were adjusted for the plot, offset to a zero value corresponding to the initial value for each PXD record, and plotted along with the temperature recorded by the PXD. The temperature record was similarly very stable, but increased during the pumping period and recovered for about an equal amount of time afterwards. Temperature in piezometer p4 was unaffected. The plot (Figure 2-4) shows that the change in pressure is about equal for all of the PXDs except p4 and corresponds to an equal increase in temperature. The increase in temperature is most likely due to the drawing of formation water to piezometer p1, which then heated the standing water in the other piezometers. The observations are consistent with a thermal response in head, with the addition of thermal energy to the fluid potential without thermal equilibration of the water column density. The response corresponds to an equilibration of temperature to the same value in the affected piezometers and main completion (m1).

2.8.2 Water-Quality Monitoring

Tritium samples were collected after DRI logging in June 2016; water-quality samples including ^{3}H were collected during the pumping of piezometer p1 in July to gauge whether piezometer development was occurring as indicated by stabilization of the select water-quality parameters. The ^{3}H samples were collected to monitor ^{3}H levels and to evaluate whether consistent values indicated stabilized formation ^{3}H levels. An inline water-quality monitor could not be used with the low pump rates of the rod pump; thus, only grab samples analyzed in the field lab were available.

2.8.2.1 Grab Sample Monitoring of Piezometer p1

During rod pumping of p1, analyses of temperature, DO, pH, bromide, turbidity, and SEC were conducted in the field laboratory on grab samples collected from the wellhead manifold valve of the rod pump. The temperature-dependent parameters of DO and pH are plotted on Figure 2-8, alongside of temperature and the cumulative production volume, with a linear slope corresponding to the 2.7 gpm constant pump rate of the rod pump. The values of temperature are stable at about 26 °C, but these are significantly less than the 32 to 35 °C values recorded by the PXDs in piezometers p2, p3,

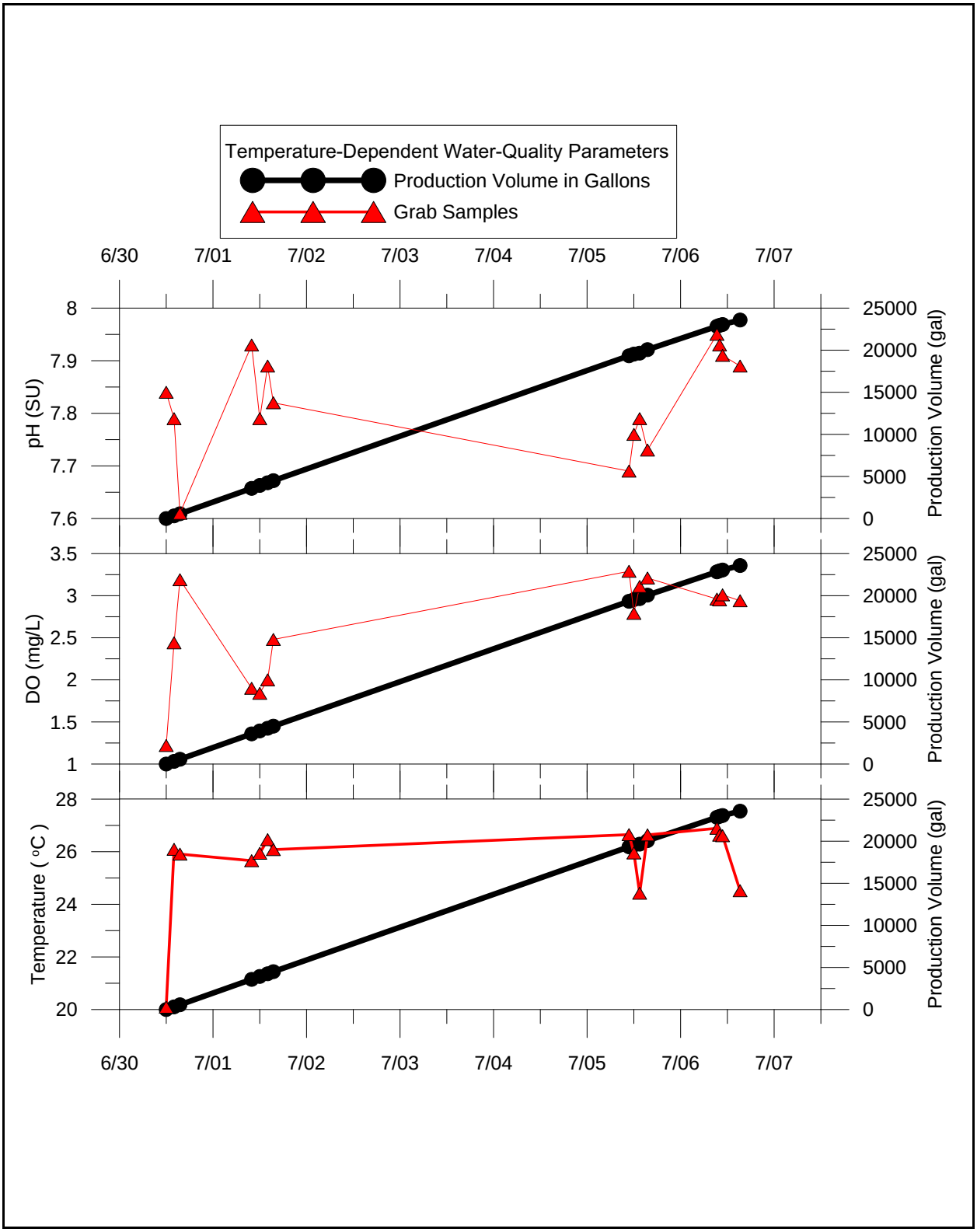

Figure 2-8
Temperature-Dependent Water-Quality Parameters from Grab Samples during Rod Pumping of ER-20-12 Piezometer p1 in July 2016

and p4 as well as the main completion (m1) (Figure 2-4), and likely reflect equilibration to ambient atmospheric conditions near the top of the well. The DO and pH values were not stabilized. Values of bromide, turbidity, and SEC are plotted (Figure 2-9) alongside of the cumulative production volume. Although the values of bromide and turbidity were low, the levels did not decline. The value of SEC continued to decline rather than stabilizing. Taken together, the water-quality and bromide parameters indicate that well development from rod pumping was not complete.

2.8.2.2 Tritium Monitoring of Piezometer p1

During rod pumping of p1, ^{3}H levels were measured with an auto-sampler at four-hour increments (Table 2-5). Except for three samples of significantly increased values occurring in two events, values were consistently in the range of 20,000 pCi/L throughout the six-day period (Figure 2-10).

2.8.2.3 Depth-Discrete Bailer Sampling at p1, p3, and m1; and Wellhead Sampling at p1

On June 9 and 10, 2016, after DRI logging was completed, samples for ^{3}H were collected and sent to GEL for analysis. The depth-discrete bailer samples were collected from piezometers p1 and p3, and the main completion (m1). On July 6, after rod pumping was completed, a wellhead sample was collected for GWC from piezometer p1, with commercial laboratory results presented in Table 2-6 and LLNL results presented in Table 2-7.

2.9 Cyclic Pump Testing (August, 2016)

Equipment was mobilized in August 2016 to conduct a step test and constant-rate pump test of the ER-20-12 main completion (m1). During two function tests on August 11, the well was unable to sustain the minimum pump rate required for the pumping assembly; thus, a series of cyclic pump tests were conducted from August 12 to August 19, 2016.

2.9.1 Pumping Equipment

A single electric submersible pump, controlled through a variable speed controller (VSC), was used in Well ER-20-12 for WDT, followed by replacement with a dedicated sampling pump. The WDT pump was installed over the period of August 8 to 10, 2016, and function tested on August 11, 2016, for WDT operations. The WDT pump was removed from the well over the period of August 23 to

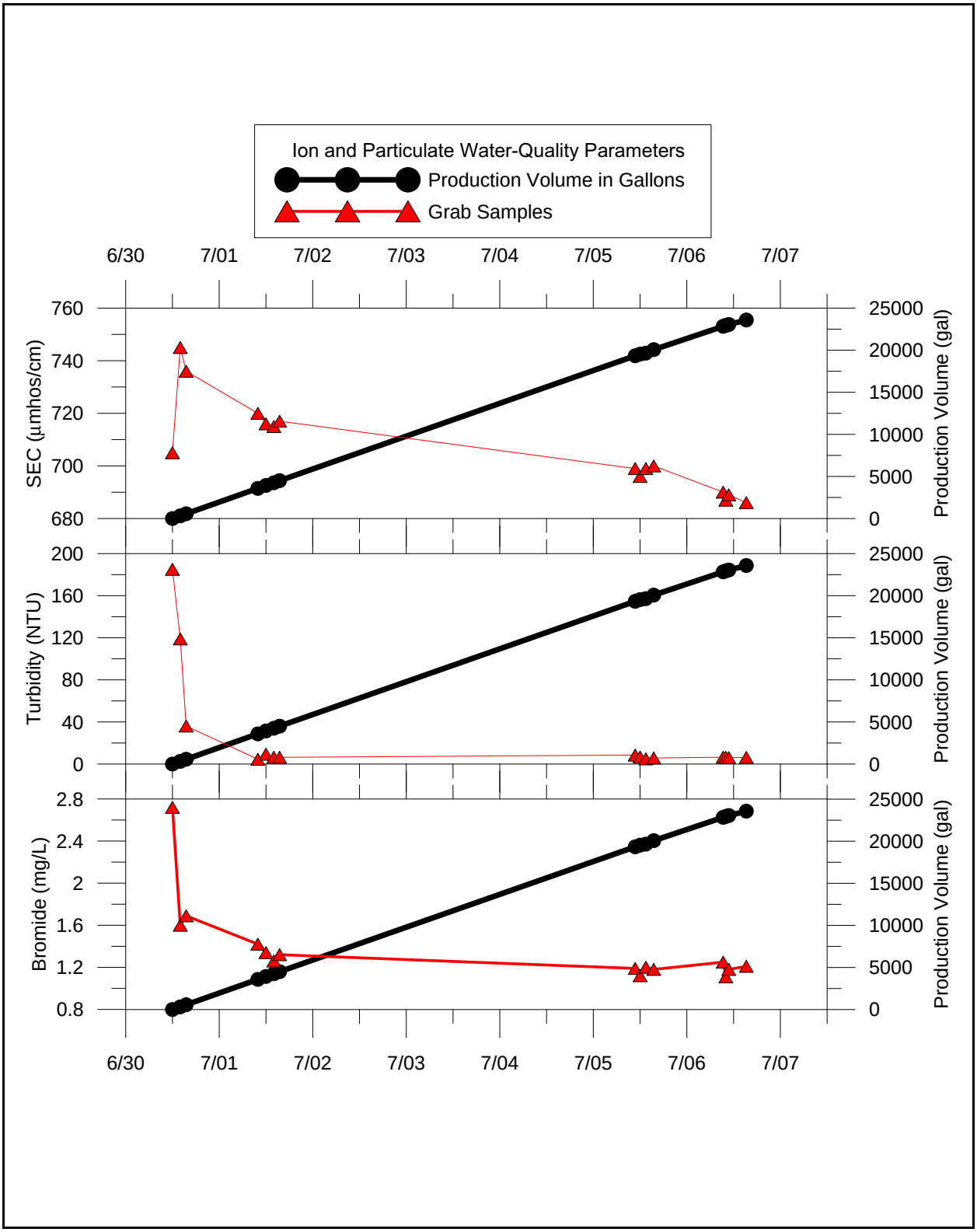

Figure 2-9
Ion and Particulate Water-Quality Parameters from Grab Samples during Rod Pumping of ER-20-12 Piezometer p1 in July 2016

Table 2-5
Tritium Levels in ER-20-12 Piezometer p1 during Rod Pumping in July 2016

Date, Time	Sample Number	Results (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Comments
06/30/2016, 11:58	ER-20-12-063016-1	747	1,163	2,152	Initial discharge, gray, turbid
06/30/2016, 11:59	ER-20-12-063016-2	1,241	1,110	1,891	Initial discharge, gray, turbid
06/30/2016, 12:59	ER-20-12-063016-3	3,039	1,099	1,698	Collected at sampling port, clear
06/30/2016, 16:00	ER-20-12-063016-4	19,464	1,821	1,863	Collected at sampling port, clear
07/01/2016, 08:30	ER-20-12-070116-5	19,982	1,824	1,856	Collected at sampling port, clear
07/01/2016, 12:00	ER-20-12-070116-6	18,750	1,779	1,860	Collected at sampling port, clear
07/01/2016, 16:00	ER-20-12-070116-7	19,027	1,777	1,850	Collected at sampling port, clear
07/01/2016, 20:00	ER-20-12-070116-8	17,664	1,746	1,859	Collected with auto-sampler, clear
07/02/2016, 00:00	ER-20-12-070216-9	18,550	1,774	1,861	Collected with auto-sampler, clear
07/02/2016, 04:00	ER-20-12-070216-10	18,108	1,767	1,872	Collected with auto-sampler, clear
07/02/2016, 08:00	ER-20-12-070216-11	25,421	1,975	1,845	Collected with auto-sampler, clear
07/02/2016, 12:00	ER-20-12-070216-12	18,895	1,801	1,855	Collected with auto-sampler, clear
07/02/2016, 16:00	ER-20-12-070216-13	18,871	1,781	1,861	Collected with auto-sampler, clear
07/02/2016, 20:00	ER-20-12-070216-14	18,382	1,771	1,867	Collected with auto-sampler, clear
07/03/2016, 00:00	ER-20-12-070316-15	17,734	1,777	1,873	Collected with auto-sampler, clear
07/03/2016, 04:00	ER-20-12-070316-16	18,028	1,778	1,855	Collected with auto-sampler, clear
07/03/2016, 08:00	ER-20-12-070316-17	21,053	1,874	1,874	Collected with auto-sampler, clear
07/03/2016, 12:00	ER-20-12-070316-18	19,579	1,818	1,860	Collected with auto-sampler, clear
07/03/2016, 16:00	ER-20-12-070316-19	18,814	1,780	1,860	Collected with auto-sampler, clear
07/03/2016, 20:00	ER-20-12-070316-20	18,275	1,784	1,853	Collected with auto-sampler, clear
07/04/2016, 00:00	ER-20-12-070416-21	18,362	1,786	1,855	Collected with auto-sampler, clear
07/04/2016, 04:00	ER-20-12-070416-22	18,458	1,783	1,845	Collected with auto-sampler, clear
07/04/2016, 08:00	ER-20-12-070416-23	18,764	1,802	1,864	Collected with auto-sampler, clear
07/04/2016, 12:00	ER-20-12-070416-24	19,037	1,800	1,848	Collected with auto-sampler, clear
07/04/2016, 16:00	ER-20-12-070416-25	27,117	2,014	1,846	Collected with auto-sampler, clear
07/04/2016, 20:00	ER-20-12-070416-26	46,721	2,474	1,848	Collected with auto-sampler, clear
07/05/2016, 00:00	ER-20-12-070516-27	19,673	1,814	1,850	Collected with auto-sampler, clear
07/05/2016, 04:00	ER-20-12-070516-28	19,210	1,806	1,853	Collected with auto-sampler, clear
07/05/2016, 08:00	ER-20-12-070516-29	19,790	1,821	1,857	Collected with auto-sampler, clear
07/05/2016, 12:00	ER-20-12-070516-30	17,769	1,760	1,809	Collected from sampling port, clear
07/05/2016, 16:00	ER-20-12-070516-31	18,864	1,748	1,748	Collected with auto-sampler, clear
07/05/2016, 20:00	ER-20-12-070516-32	19,626	1,778	1,739	Collected with auto-sampler, clear
07/06/2016, 00:00	ER-20-12-070616-33	19,271	1,773	1,743	Collected with auto-sampler, clear
07/06/2016, 04:00	ER-20-12-070616-34	17,393	1,712	1,750	Collected with auto-sampler, clear
07/06/2016, 08:00	ER-20-12-070616-35	18,245	1,708	1,715	Collected with auto-sampler, clear
07/06/2016, 12:00	ER-20-12-070616-36	17,476	1,718	1,757	Collected from sampling port, clear
07/06/2016, 15:15	ER-20-12-070616-37	18,782	1,756	1,732	Collected from sampling port upon completion of groundwater sampling, clear

Note: Rod pump intake at 2,017.32 ft bgs

MDA = Minimum detectable activity

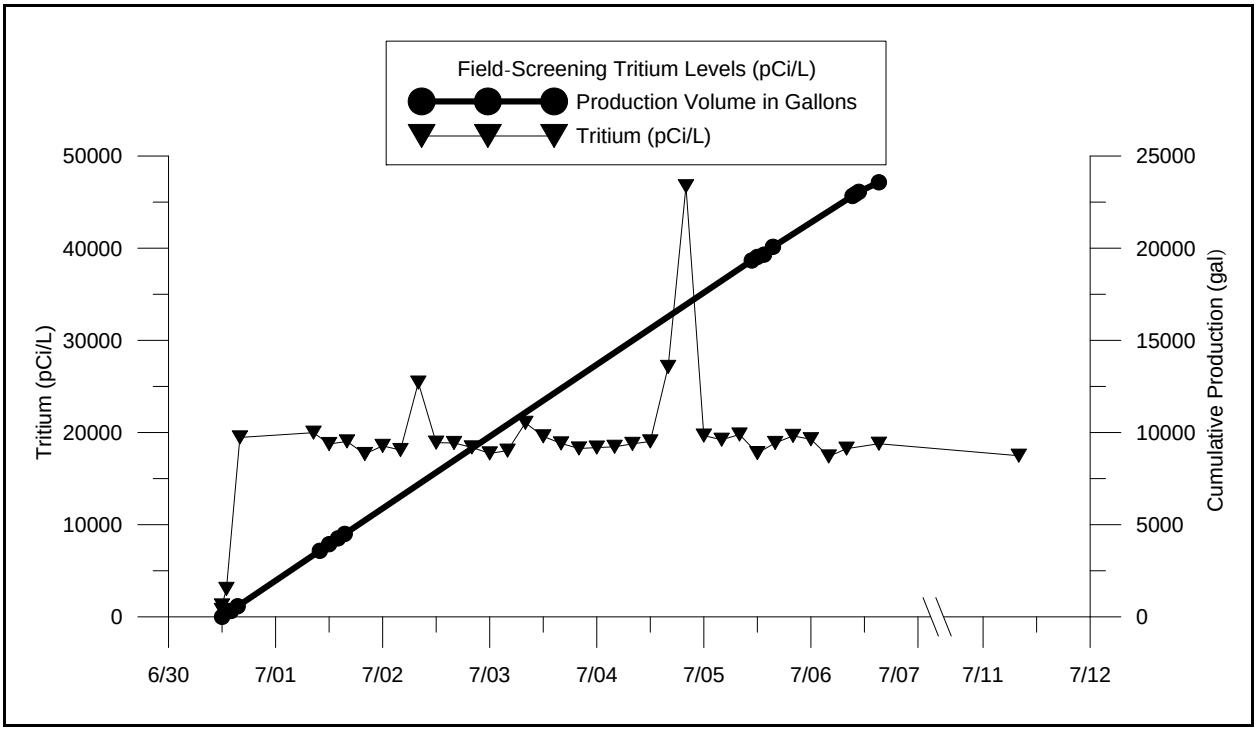

Figure 2-10
Tritium Levels during Rod Pumping of ER-20-12 Piezometer p1 in July 2016

August 25, 2016, upon completion of the WDT operations. The dedicated sampling pump was installed over the period of August 25 to 26, 2016, and function tested August 26, 2016. The total dynamic head versus production curves for the pumps are included in Appendix B.

2.9.1.1 Pump Installation

The pump used for the WDT of the main completion (m1) was installed from August 2 to August 4, 2016, and consisted of a seal above the motors and a pump above the seal. The pump intake was located at the base of the pump section above the seal. The overall pump assembly length was 75.64 ft. The pump was installed on 3.5-in. CS tubing. A check valve was incorporated in the production tubing just above the pump. The function of the check valve was to prevent water in the production tubing above the water level in the well from flowing back into the well when the pump was turned off. In addition, a properly functioning check valve provides immediate flow-rate information at the surface when the pump is started. The check valve incorporated a sheer pin that allowed the production tubing to be drained before the pump was removed from the well. Table 2-8 identifies the pumping equipment installed, including the dedicated sampling pump installed once the WDT activities were concluded. The top of the WDT pump assembly was located at a depth of

Table 2-6
Analytical Results from GEL for GWC Samples Collected at ER-20-12 Piezometer p1
(Page 1 of 2)

Analyte	Analytical Method [a]	Detection Limit [b]	Wellhead Composite Samples 138-070616-1 138-070616-1F		Wellhead Composite Duplicate QC Samples 138-070616-2 138-070616-2F	
			Total	Dissolved	Total	Dissolved
Metals (mg/L)						
Aluminum	SW-846 6010 [c]	0.2	0.2 U	0.2 U	0.2 U	0.2 U
Arsenic		0.03	0.03 U	0.03 U	0.03 U	0.03 U
Barium		0.005	0.00748	0.00617	0.00656	0.00607
Cadmium		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Calcium		0.2	7.68	7.32	7.18	7.14
Chromium		0.005	0.0317	0.00123 J	0.00722	0.00111 J
Iron		0.1	7.62	3.92	4.68	3.81
Lead		0.01	0.01 U	0.01 U	0.01 U	0.01 U
Lithium		0.01	0.0808	0.0854	0.0864	0.085
Magnesium		0.3	0.149 J	0.157 J	0.123 J	0.144 J
Manganese		0.01	0.142	0.112	0.117	0.11
Potassium		0.15	5.52	5.26	5.24	5.19
Selenium		0.03	0.03 U	0.03 U	0.03 U	0.03 U
Silicon		0.1	29.1	27.9	27.4	27.3
Silver		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Sodium		0.3	145	149	146	147
Strontium		0.005	0.0134	0.014	0.0143	0.0142
^{238}U	SW-846 6020 [c]	0.0002	0.000143 J	0.000123 J	0.000117 J	0.000127 J
Mercury	SW-846 7470/7471 [c]	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Inorganics (mg/L unless otherwise noted)						
Bromide	EPA 300.1 [d]	0.2	--	0.489	--	0.462
Chloride		4		80.7		80.9
Fluoride		0.1		1.96		1.85
Sulfate		8		112		112
Total Dissolved Solids	EPA 160.1 [e]	37	378 J	--	--	--
Total Suspended Solids	EPA 160.2 [e]	5	1.14 U			

Table 2-6
Analytical Results from GEL for GWC Samples Collected at ER-20-12 Piezometer p1
(Page 2 of 2)

Analyte	Analytical Method [a]	Detection Limit [b]	Wellhead Composite Samples 138-070616-1 138-070616-1F		Wellhead Composite Duplicate QC Samples 138-070616-2 138-070616-2F	
			Total	Dissolved	Total	Dissolved
Organics (mg/L)						
Total Organic Carbon	EPA 145.1 [e]	1	0.394 J	--	0.33 U	--
Redox Parameter (mg/L)						
Total Sulfide	EPA 376.1 [e]	2.5	--	--	1 UJ	--
Radiological Indicator Parameters (pCi/L)						
		MDC [f]	Result	Error	Result	Error
^{3}H	EPA 906.0 [g]	192	18,900	3,670	18,600	3,630
Gross Alpha	EPA 900.0 [g]	2.94, 2.52	0.997 U	1.73	0.636 U	1.45
Gross Beta		1.52, 1.42	5.73	1.44	3.74	1.14
Gamma Spectroscopy	EPA 901.1 [g]	Varies by Nuclide	ND	Varies by Nuclide	ND	Varies by Nuclide
^{90}Sr	EPA 905.0 [g]	0.832, 0.852	0.104 U	0.447	-0.463 U	0.359

Source: Navarro, 2016d

[a] For commercial laboratory analysis, the most current EPA or equivalent accepted standard laboratory analytical methods may be used as appropriate to attain specified detection limits.
[b] Detection limit varies by instrument and dilution of sample. Where more than one detection limit is given, they apply to the samples in the order presented.
[c] EPA, 2013
[d] EPA, 1997
[e] EPA, 1983
[f] MDC varies by matrix, instrument, and count rates. Where more than one detection limit is given, they apply to the samples in the order presented.
[g] EPA, 1980

EPA = U.S. Environmental Protection Agency
MDC = Minimum detectable concentration
mg/L = Milligrams per liter
QC = Quality control
Sr = Strontium
U = Uranium

F = Filtered
J = Result is estimated.
ND = No gamma spectroscopy nuclides detected above detection limits.
UJ = Compound was non-detect, but result is estimated
U = Compound was analyzed for but was not detected (“Non-detect”).
-- = No result.

Table 2-7
Analytical Results from LLNL for GWC Samples Collected at ER-20-12 Piezometer p1

Analyte	Analytical Method	Detection Limit	Wellhead Composite Samples 138-070616-5 138-070616-5F		Wellhead Composite Duplicate QC Samples 138-070616-6 138-070616-6F	
Inorganics (mg/L)						
			Total	**Dissolved**	**Total**	**Dissolved**
DIC	SOP-UGTA-116	0	--	31.6	--	--
Age and Migration Parameters						
$^{2}H/^{1}H$	SOP-UGTA-128	NA	-115.856 per mil	--	-116 per mil	--
$^{18}O/^{16}O$			-14.76 per mil	--	--	--
$^{87}Sr/^{86}Sr$	SOP-UGTA-117		--	0.04 per mil	--	--
$^{87}Sr/^{86}Sr$			--	0.709231 ratio	--	--
$^{13}C/^{12}C$	SOP-UGTA-116		--	-2.34 per mil	--	--
Radiological Indicator Parameters (pCi/L)						
		MDC	**Result**	**Error**	**Result**	**Error**
^{14}C	SOP-UGTA-136	NA	0.1595	0.0015	--	--

Source: Navarro, 2016d

C = Carbon
DIC = Dissolved inorganic carbon
H = Hydrogen
^{2}H = Deuterium
O = Oxygen
SOP = Standard operating procedure

F = Filtered
-- = No result

Table 2-8
Pump Specifications for Well ER-20-12

Pump Components	Length (ft)	Model/Type/Series	Serial Number
Baker Hughes High-Volume 4.0-in. Pump—WDT			
Pump	24.92	Flex 31/PMSSD	14017827
Tandem Seal	9.12	Centrilift/DFST3	11852029
Upper Motor	20.82	Centrilift/DNE11	21D48010
Lower Motor	20.78	Centrilift/DMFU1	21D48009
Schlumberger Dedicated Sampling Pump (Installation Date: 08/26/2016)			
Pump	9.28	REDA D800N /400/400	BFC6H06713
Seal	8.03	REDA 400/456, BPBSL-S/LT	DCC6H06711
Motor	8.39	REDA/RA-S, M-TRM, AFL, GRB	1CC1L02071

2,166.64 ft bgs; the pump intake was at 2,191.56 ft bgs (approximately 340 ft below the top of the water column); and the bottom of the pump assembly was at 2,221.50 ft bgs.

The dedicated sampling pump assembly was installed from August 24 to August 25, 2016. The top of the pump assembly was set at a depth of 2,150.22 ft bgs, with the pump intake at 2,159.50 ft bgs (approximately 310 ft below the top of the static water column); and the bottom of the pump assembly at 2,175.92 ft bgs.

2.9.1.2 Variable Speed Controller

The VSC is used to regulate the power to the pump and vary the production rate. The VSC has two modes of operation. Mode 1 is used to set the power frequency (in hertz [Hz] cycles per second) to a fixed value. The amperage automatically adjusts to meet the motor requirement; the input voltage is fixed via the power transformer. The typical frequency range is approximately 45 to 70 Hz to stay within the pump motor operating range for amperage and temperature. When starting the pump, achieving full speed (i.e., production rate) required up to 30 sec. Mode 2 is designed to automatically meter the discharge rate by communicating with the inline flowmeter and adjusting the pump operating parameters. In Mode 2, the VSC regulates the pump to maintain a constant-flow rate.

2.9.1.3 Pump Function Test

Function testing refers to starting the pump, producing water to the surface, running the pump at different frequencies throughout the operating range, checking for proper operation, and confirming that pump operating parameters are within acceptable limits. In addition, the production rates at each frequency setting are determined. The manually recorded function test information is reported in Table 2-9. The flow rates could not be sustained due to excessive drawdown in the well. The pump was shut off about 25 minutes after function testing had started. Approximately 1,045 gal was pumped.

2.9.2 Development Plan

The generic plan for development is discussed in the *Phase II Testing Plan: Central and Western Pahute Mesa, Nevada Test Site, Nye County, Nevada* (NNES, 2010a). A brief summary of the plan is presented in Section 1.4. Development activities and durations were scheduled based on previous

Table 2-9
Function Test Results for Pump Installations at Well ER-20-12

Date	Time	VSC (Hz)	VSC (Amps)	Flow Rate (gpm)
Function Test of Pump for Development and Cyclic Pump Testing				
08/11/2016	12:45	50	145	43
08/11/2016	12:55	52	ND	52
08/11/2016	13:01	54	ND	58
08/11/2016	13:06	56	ND	64
Function Test of Dedicated Sampling Pump				
08/26/2016	15:06	50	130	10
08/26/2016	15:08	52	136	15
08/26/2016	15:11	54	144	19
08/26/2016	15:14	56	154	22
08/26/2016	15:16	58	149	24
08/26/2016	15:19	60	152	26
08/26/2016	15:21	62	157	28
08/26/2016	15:24	64	168	30

ND = No data

site experience and could be changed as the work progressed based on evaluation of the progress of development.

2.9.3 Pump Operation during Well Development and Cyclic Testing

Pump operational parameters from the VSC and flowmeter were recorded manually on UGTA pumping rate and drawdown data forms and reported in the UGTA Morning Reports. This information was compared with the datalogger record to verify pumping rates.

2.9.4 Well Development and Cyclic Testing Description and Field Summary

Well development encompasses removing residual drilling fluids from the well completion, establishing a good hydraulic connection with the formation, and reestablishing the natural water quality so that representative GWC samples can be obtained.

The development process consists of pumping the well at a sufficiently high rate to remove the residual drilling fluids and sediment left from drilling and completion. Step-drawdown testing is

incorporated into the well development. The step-drawdown tests consist of pumping the well at various set rates and monitoring the drawdown at each rate. The data from the step-drawdown tests are used to evaluate well performance.

The first attempts to conduct well development and step-drawdown testing began with two tests on August 11, 2016. Given the well's inability to sustain the pumping rates of the function test, an initial pump rate of 35 gpm was used, the minimum rate needed to maintain the pump's cooling system. The VSC was operated in Mode #1, with the motor frequency fixed at 47 Hz while the initial 35 gpm pump rate was allowed to change as needed to keep the pump within operational limits.

During the first test, the field technicians noticed that the datalogger was not reporting flow rates consistent with those determined from observed production volumes, and excessive drawdown was observed in the main completion m1 access line. The test was stopped after 31 minutes and approximately 1,045 gal had been produced from the well, at an average pump rate of 34 gpm. The datalogger was reprogrammed, and the well was allowed to recover for approximately one hour.

A second test was conducted over the course of an hour and 21 minutes, during which time the pump rate dropped from 37 to 28 gpm as the drawdown increased, ultimately to 189 ft at which point the pump was shut off. An additional volume of approximately 2,300 gal of groundwater was extracted from the well.

For the remainder of the field WDT activities from August 11 through August 19, 2016, the pump was run an additional 18 times, the durations and yields of the tests summarized in Table 2-10. In general, for each test the pump rate was approximately 30 gpm, except on August 15 and August 17, where the pump was run at a higher rate, approximately 50 gpm, for a shorter time, approximately 10 to 15 minutes, on the hour, 4 or 5 times per day. Between each test, the well was allowed to recover approximately one hour, or was left to recover overnight. During these operations, a total of 32,603 gal of fluid was extracted from the well and discharged into the sumps.

2.9.5 Well Development and Cyclic Testing Physical Monitoring

For monitoring head response during WDT, PXDs were installed in Well ER-20-12, including the main completion's access line (m1), on August 11, 2016, and piezometers p1 and p2 on August 12, 2016. Fluid pressure (psia), pump rate (gpm), barometric pressure (mBar), and temperature (°C) data

Table 2-10
Pump Rates and Durations of Tests during Cyclic Testing at Well ER-20-12
(Page 1 of 6)

Elapsed Time (hrs:mins)	Date and Time	Hz	Amps	Metered Pump Rate (gpm)	Avg Metered Pump Rate (gpm)	Cumulative Volume (gal)	Avg Pump Rate from Volume (gpm)	m1 Access Line Drawdown (ft)	p1 Drawdown (ft)	p2 Drawdown (ft)	Test #	Datalogger File Name *.xlsx
0:26	08/11/2016 12:40	50	145	43.2	52.1[a]	0	33.7 [a]	111	0	0	1	ER-20-12_PT_01.xlsx
	08/11/2016 12:52	ND	ND	43.5		90		ND	ND	ND		
	08/11/2016 12:55	52	ND	51.6		ND		158	0	0		
	08/11/2016 13:01	54	ND	58.1		ND		191	0	0		
	08/11/2016 13:06	56	145	64.3		ND		ND	0	0		
	08/11/2016 13:11	ND	ND	63.3	NA	1,045		>250	0	0		
1:06 Recovery Time												
1:21	08/11/2016 14:17	47	141	33.1	31.9	ND	31.1	ND	NA	NA	2	ER-20-12_PT_02.xlsx
	08/11/2016 14:21	48	140	37.1		1,142		ND	NA	NA		
	08/11/2016 14:40	48	140	32.0		ND		137	NA	NA		
	08/11/2016 14:42	ND	ND	31.6		1,870		ND	NA	NA		
	08/11/2016 15:05	ND	ND	30.0		2,555		ND	NA	NA		
	08/11/2016 15:31	ND	ND	29.1		3,347		ND	NA	NA		
	08/11/2016 15:35	ND	ND	28.9		NA	NA	189	NA	NA		
	08/11/2016 15:38	ND	ND	0.0	NA	NA	NA	ND	NA	NA		

Table 2-10
Pump Rates and Durations of Tests during Cyclic Testing at Well ER-20-12
(Page 2 of 6)

Elapsed Time (hrs:mins)	Date and Time	Hz	Amps	Metered Pump Rate (gpm)	Avg Metered Pump Rate (gpm)	Cumulative Volume (gal)	Avg Pump Rate from Volume (gpm)	m1 Access Line Drawdown (ft)	p1 Drawdown (ft)	p2 Drawdown (ft)	Test #	Datalogger File Name *.xlsx
21:52 Recovery Time												
1:00	08/12/2016 13:30	48	149	33.4	30.5	3,947	29.3	96	0	0	3	ER-20-12_PT_03.xlsx
	08/12/2016 13:40	48	137	31.7		4,209		136	0	0		
	08/12/2016 13:50	48	137	30.8		4,511		158	0	0		
	08/12/2016 14:00	48	137	30.0		4,812		172	0	0		
	08/12/2016 14:10	48	136	29.5		5,103		180	0	0		
	08/12/2016 14:20	48	136	29.2		5,423		186	0	0		
	08/12/2016 14:30	48	136	28.9		5,703		190	0	0		
19:45 Recovery Time												
1:00	08/13/2016 10:15	48	138	32.4	30.3	6,174	29.1	122	0	1.8	4	ER-20-12_PT_04.xlsx
	08/13/2016 10:30	48	137	30.5		6,646		160	0	1.7		
	08/13/2016 10:45	48	137	29.9		7,051		179	0	1.7		
	08/13/2016 11:00	48	136	29.7		7,481		184	0	1.7		
	08/13/2016 11:15	48	136	28.9		7,919		190	0	1.6		

Table 2-10
Pump Rates and Durations of Tests during Cyclic Testing at Well ER-20-12
(Page 3 of 6)

Elapsed Time (hrs:mins)	Date and Time	Hz	Amps	Metered Pump Rate (gpm)	Avg Metered Pump Rate (gpm)	Cumulative Volume (gal)	Avg Pump Rate from Volume (gpm)	m1 Access Line Drawdown (ft)	p1 Drawdown (ft)	p2 Drawdown (ft)	Test #	Datalogger File Name *.xlsx
1:20 Recovery Time												
1:15	08/13/2016 12:35	48	138	35.5	31.0	8,184	29.8	66	0	1.8	5	ER-20-12_PT_05.xlsx
	08/13/2016 12:50	48	137	32.1		8,650		125	0	1.7		
	08/13/2016 13:05	48	136	30.4		9,084		159	0	1.7		
	08/13/2016 13:20	48	136	29.7		9,558		176	0	1.7		
	08/13/2016 13:35	48	136	29.2		9,945		177	0	1.7		
	08/13/2016 13:50	48	136	28.9		10,420		190	0	1.7		
20:20 Recovery Time												
1:00	08/14/2016 10:10	48	138	33.6	30.4	10,796	30.4	98	0.2	2.6	6	ER-20-12_PT_06.xlsx
	08/14/2016 10:25	48	137	30.9		11,265		143	0.1	2.6		
	08/14/2016 10:40	48	137	29.7		11,727		165	0.3	2.6		
	08/14/2016 10:55	48	136	29.1		12,189		177	0.3	2.5		
	08/14/2016 11:10	48	136	28.7		12,622		184	0.2	2.5		

Table 2-10
Pump Rates and Durations of Tests during Cyclic Testing at Well ER-20-12
(Page 4 of 6)

Elapsed Time (hrs:mins)	Date and Time	Hz	Amps	Metered Pump Rate (gpm)	Avg Metered Pump Rate (gpm)	Cumulative Volume (gal)	Avg Pump Rate from Volume (gpm)	m1 Access Line Drawdown (ft)	p1 Drawdown (ft)	p2 Drawdown (ft)	Test #	Datalogger File Name *.xlsx
1:10 Recovery Time												
1:15	08/14/2016 12:20	48	138	35.5	31.0	12,840	29.3	56	0.2	2.6	7	ER-20-12_PT_07.xlsx
	08/14/2016 12:35	48	137	32.1		13,280		121	0.2	2.6		
	08/14/2016 12:50	48	136	30.4		13,729		156	0.2	2.5		
	08/14/2016 13:05	48	136	29.7		14,193		172	0.2	2.6		
	08/14/2016 13:20	48	136	29.3		14,630		181	0.2	2.6		
	08/14/2016 13:35	48	136	28.7		15,040		186	0.4	2.5		
20:45 Recovery Time												
0:07	08/15/2016 10:20	54	151	57.1	55.7	15,338	53.1	128	0.4	3.1	8	ER-20-12_PT_08.xlsx
	08/15/2016 10:27	54	150	54.2		15,710		194	0.7	3.1		
0:58 Recovery Time												
0:07	08/15/2016 11:25	53.9	151	57.3	56.0	16,258	53.4	126	0.7	3.1	9	ER-20-12_PT_09.xlsx
	08/15/2016 11:32	53.9	150	54.7		16,632		198	0.6	3.1		
0:52 Recovery Time												
0:09	08/15/2016 12:24	53.9	151	58.4	56.7	17,000	52.2	104	0.7	3	10	ER-20-12_PT_10.xlsx
	08/15/2016 12:33	53.9	151	54.9		17,470		191	0.7	3.1		

Table 2-10
Pump Rates and Durations of Tests during Cyclic Testing at Well ER-20-12
(Page 5 of 6)

Elapsed Time (hrs:mins)	Date and Time	Hz	Amps	Metered Pump Rate (gpm)	Avg Metered Pump Rate (gpm)	Cumulative Volume (gal)	Avg Pump Rate from Volume (gpm)	m1 Access Line Drawdown (ft)	p1 Drawdown (ft)	p2 Drawdown (ft)	Test #	Datalogger File Name *.xlsx
0:52 Recovery Time												
0:08	08/15/2016 13:25	53.9	150	57.9	56.4	17,941	52.9	114	0.6	3.1	11	ER-20-12_PT_11.xlsx
	08/15/2016 13:33	53.9	150	54.8		18,364		193	0.6	3.1		
23:27 Recovery Time												
0:45	08/16/2016 13:00	48	137	32.3	30.3	18,832	30.1	115	1.01	0.42	12	ER-20-12_PT_12.xlsx
	08/16/2016 13:20	48	136	29.9		19,448		158	0.96	0.28		
	08/16/2016 13:45	48	136	28.7		20,186		176	0.94	0.28		
20:22 Recovery Time												
0:15	08/17/2016 10:07	53.9	150	54.3	54.3	20,941	50.3	191	1.17	0.91	13	ER-20-12_PT_13.xlsx
1:04 Recovery Time												
0:15	08/17/2016 11:11	54	150	55.6	55.6	21,680	49.3	161	1.31	0.98	14	ER-20-12_PT_14.xlsx
0:51 Recovery Time												
0:15	08/17/2016 12:02	54	150	56.3	56.3	22,388	47.2	149	1.22	1	15	ER-20-12_PT_15.xlsx
0:49 Recovery Time												
0:15	08/17/2016 12:51	54	150	56.4	56.4	23,148	50.7	147	1.2	1	16	ER-20-12_PT_16.xlsx
0:49 Recovery Time												
0:15	08/17/2016 13:40	54	150	56.8	56.8	23,869	48.1	140	1.2	0.98	17	ER-20-12_PT_17.xlsx

Table 2-10
Pump Rates and Durations of Tests during Cyclic Testing at Well ER-20-12
(Page 6 of 6)

Elapsed Time (hrs:mins)	Date and Time	Hz	Amps	Metered Pump Rate (gpm)	Avg Metered Pump Rate (gpm)	Cumulative Volume (gal)	Avg Pump Rate from Volume (gpm)	m1 Access Line Drawdown (ft)	p1 Drawdown (ft)	p2 Drawdown (ft)	Test #	Datalogger File Name *.xlsx
20:35 Recovery Time												
2:00	08/18/2016 10:15	48	137	31.4	29.7[a]	24,612	23.2[a]	124	1.41	1.1	18	ER-20-12_PT_18.xlsx
	08/18/2016 10:40	48	136	29.4		25,378		160	1.41	1.1		
	08/18/2016 11:50	48	135	28.3		27,399[a]		179	1.34	1.2		
	08/18/2016 12:15	48	135	28.1		28,098[a]	29.1	180	1.46	1.1		
1:00 Recovery Time												
0:55	08/18/2016 13:15	53.9	149	54.3	54.3[a]	28,950	43.8[a]	188	1.38	1.1	19	ER-20-12_PT_19.xlsx
	08/18/2016 14:10	53.9	149	54.3		29,806	31.1[a]	190	1.39	1.3		
19:20 Recovery Time												
1:25	08/19/2016 9:30	48	137	31.8	29.7	30,171	28.6	113	1.29	1.23	20	ER-20-12_PT_20.xlsx
	08/19/2016 10:00	48	136	29.1		30,840		153	1.29	1.17		
	08/19/2016 10:55	48	135	28.2		32,603		173	1.53	1.21		

[a] Discrepancy exists between metered versus volumetrically determined pump rates.

were recorded continuously until the PXDs were removed August 22 and 23, 2016. Figure 2-11 shows the PXD and temperature data for the entire WDT period. The left y-axis is scaled for the change in pressure (pounds per square inch [psi]). The right y-axis is scaled on the left for the pump rate and on the right for the temperature. The PXD pressures shown in Figure 2-11 are changes in pressure (psi) from originally recorded total pressures (psia). Sealed, absolute type PXDs were used to measure the combined water head and barometric pressure on the PXD.

2.9.5.1 Pressure Response during Well Development and Cyclic Testing

Figure 2-11 shows the pressure and temperature responses in the m1 access line and piezometers p1 and p2 to pumping stresses of 20 cyclic pump tests over the course of the week from function testing on August 11 to the end of cyclic testing on August 19, 2016. Piezometers p1 and p2 did not record a significant pressure response relative to the pressure changes recorded for m1. Pressure changes of approximately 80 psia in m1 corresponded to a typical drawdown range of 190 ft, while pressure changes of about 0.65 psia in p1 and p2 correspond to about 1.5 ft of drawdown (Table 2-10). Figure 2-12 shows the pressure and temperature responses in the m1 access line and piezometers p1 and p2 to the pumping stresses of a single day, August 18, 2016, pump cycling period #18 analyzed in Section 3.4.1. The plot more clearly shows that the pump rate would not stabilize, decaying while drawdown increased until complete shutoff, after which both pressure and temperature would recover.

2.9.5.2 Groundwater Temperature Data during Well Development and Cyclic Testing

Figure 2-13 shows an increase in temperature in the main completion (m1) as well as both piezometers in response to pumping, followed by a temperature decay. The temperature response is most likely the result of drawing warmer formation water to the well, which then gradually cools due to diffusion into the complete well string and mixing after the pump is shut off. The peak temperature attained in each successive test increased to a maximum temperature of about 49 °C.

2.9.5.3 Hydrophysical Logging during Well Development and Cyclic Testing

No hydrophysical logging was conducted while groundwater was being produced.

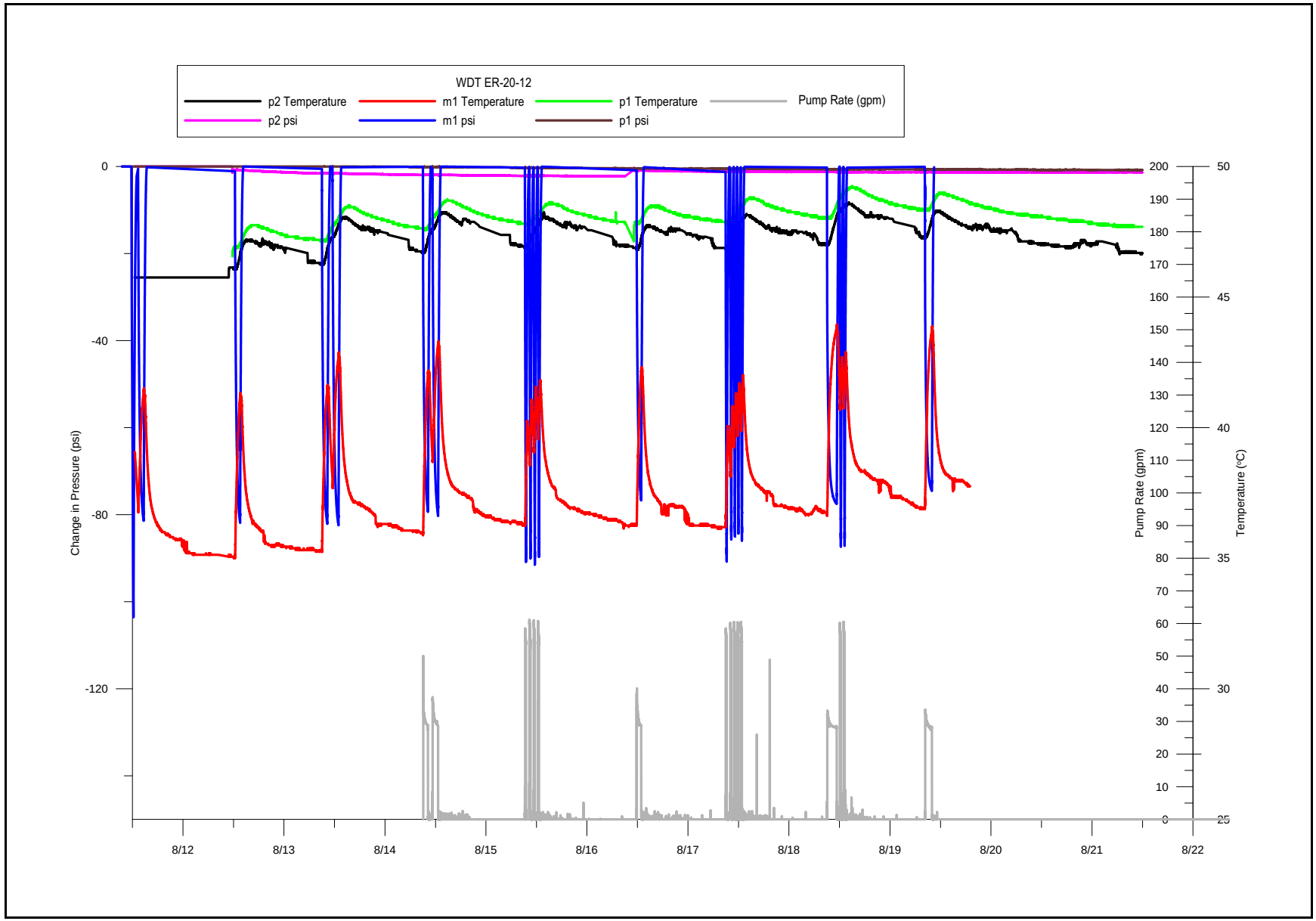

Figure 2-11
Pressure and Temperature Responses to Cyclic Pump Testing of the ER-20-12 Main Completion (m1) in August 2016

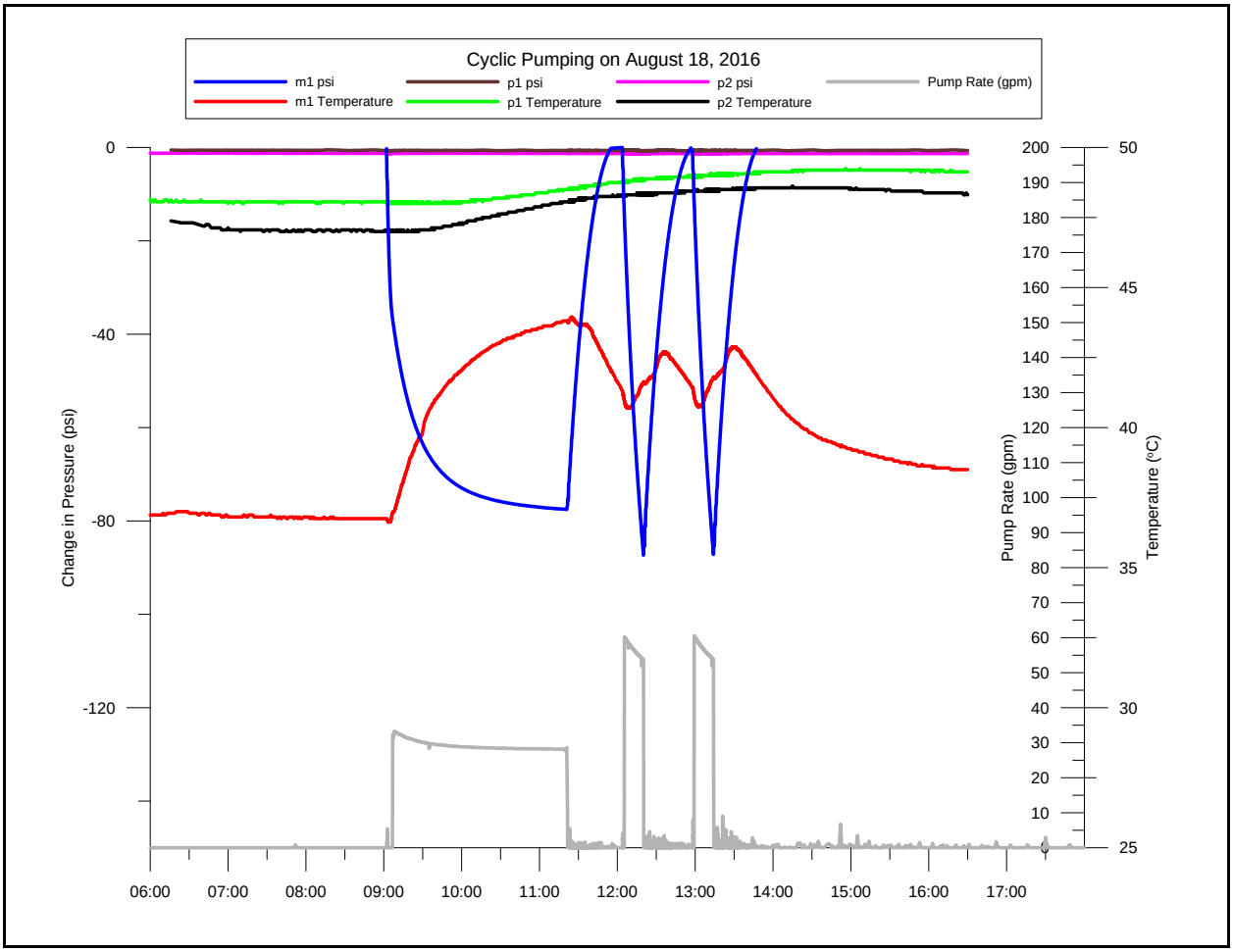

Figure 2-12
Pressure and Temperature Responses to Cyclic Pump Testing of the ER-20-12 Main Completion (m1) on a Single Day (August 18, 2016)

2.9.6 Well Development and Cyclic Testing Chemical Monitoring

Groundwater chemical monitoring was conducted during pumping operations, including general water-quality monitoring, GWC analyses, and ^{3}H monitoring. Water-chemistry logging was not conducted during WDT.

Water-quality monitoring data were evaluated as an indication of the progress achieved in well development. Monitoring the pumped discharge was accomplished through the use of two different methods: (1) grab samples collected from the wellhead sampling port (see Section 2.9.6.1) and (2) continuous inline monitoring with a Hydrolab Quanta Multiprobe (see Section 2.9.6.2). The grab samples and inline monitoring results represent the composite parameter values for the groundwater produced.

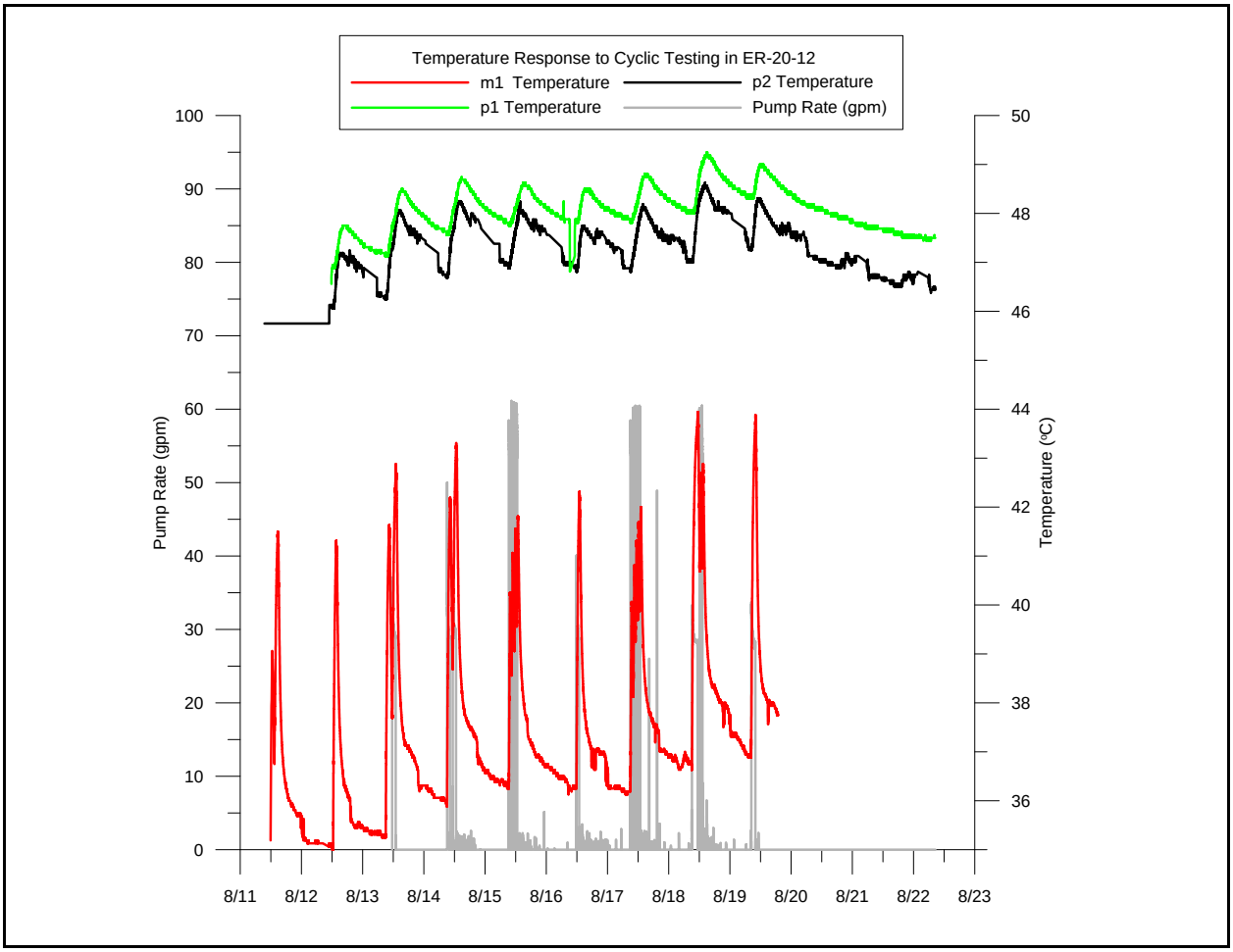

Figure 2-13
Temperature Increases and Decay in Response to Cyclic Pumping at Well ER-20-12 in August 2016

In addition, water-quality samples were collected for analysis by GEL, the Navarro-subcontracted analytical laboratory (discussed in Section 2.9.6.4). The samples were collected from the main completion (m1) from the pump wellhead while the well was under production, typically at approximately 30 gpm. Additional samples were collected with a depth-discrete bailer from piezometers p2 and p4 on August 30 and 31, 2016, respectively.

The standard monitoring parameters measured during WDT operations included pH, SEC, groundwater temperature, turbidity, bromide ion, and DO. Bromide was added to the drilling fluid as a tracer and is monitored in grab samples to gauge the progress of drilling fluid removal. Samples for ^{3}H analysis were collected and analyzed in compliance with the approved fluid-management strategy.

Tritium levels were monitored in the main completion (m1) during the cyclic pump testing and are discussed in Section 2.9.6.5.

2.9.6.1 Grab Sample Water-Quality Monitoring during Well Development and Cyclic Testing

Grab samples were obtained from the main completion (m1), taken from the wellhead manifold valve approximately once every half hour during intervals when the pump was operating, during daylight operations. The grab sample analyses used the equipment and methods described in Section 2.2. All instruments were calibrated at the beginning of each shift in accordance with the Standards-Based Management System (SBMS) procedure "Water Quality Monitoring" in the "UGTA Field Measurements and Monitoring" subject area (Navarro, 2016g). Calibration checks were completed at the end of each shift. A Hydrolab Quanta Multiprobe and a Horiba pH/ION meter were used to analyze water-quality grab samples.

Figures 2-14 and 2-15 show plots of the grab sample water-quality parameter data as well as the cumulative production. Figure 2-14 displays the temperature-dependent parameters, DO, pH, and temperature. Values of the conservative parameters, including bromide, turbidity, and SEC are plotted in Figure 2-15.

The pH monitored in the grab samples generally declined from approximately 8.9 to 7.8 during pumping operations but then returned to a value of about 8.6 when sampled using the dedicated sampling pump on August 30, 2016, approximately 10 days after pumping.

DO concentrations initially declined from about 5 mg/L and stabilized at approximately 3 mg/L during pumping, but then returned to a value of about 5 mg/L on August 30, 2016, a pattern similar to the results for pH.

Values for SEC were stable at approximately 820 micromhos per centimeter (µmhos/cm) throughout the pump-testing period. One post-pumping sampling result on August 30, 2016, was consistent with the result, while the next on August 31, 2016, was slightly higher.

Turbidity values were mostly stabilized between 100 and 200 nephelometric turbidity units (NTU). One post-pumping sampling result on August 30, 2016, was nearly double these results, but the next

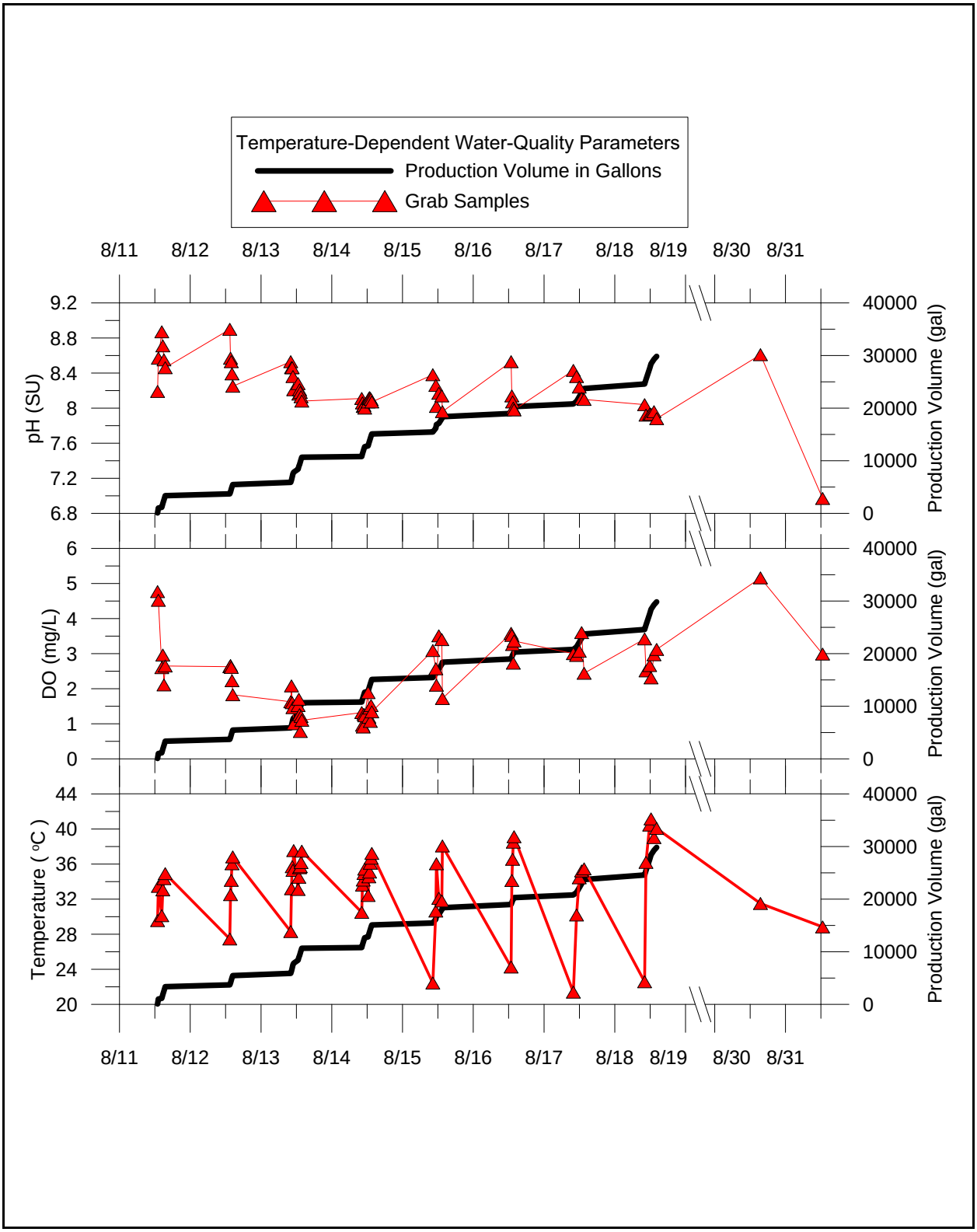

Figure 2-14
Grab Sampling Temperature-Dependent Water-Quality Parameters during Cyclic Pump Testing at Well ER-20-12 in August 2016

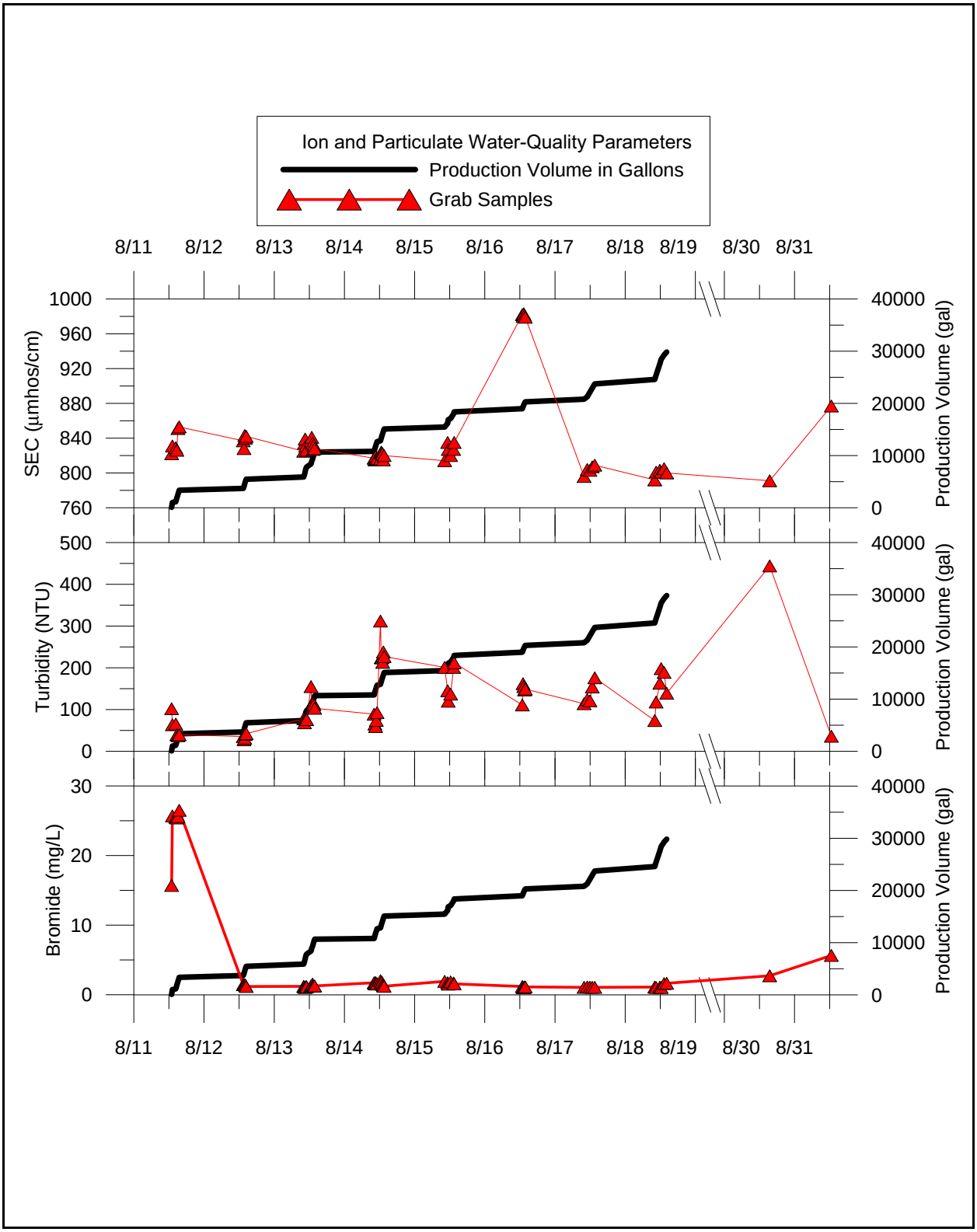

Figure 2-15
Grab Sampling Ion and Particulate Water-Quality Parameters during Cyclic Pump Testing at Well ER-20-12 in August 2016

on August 31, 2016, was less than 100 NTU. These values may reflect secondary well development from running the dedicated sampling pump.

Bromide concentrations abruptly dropped with production, from approximately 25 mg/L to about 1 mg/L. Bromide is mixed with the drilling fluid as a tracer, and its concentration is an indication of the well development achieved. The results indicate that the removal of drilling fluid was largely complete.

The combined results indicate that significant development has been achieved, though pH, SEC, and turbidity levels remain elevated or did not stabilize in post-pumping sampling results. During the development and step-drawdown testing, the grab sample water-quality parameters varied as follows:

- The pH levels ranged between 6.97 to 8.90 SU.
- The DO levels ranged between 0.78 to 5.16 mg/L.
- The SEC values ranged between 784 to 983 µmhos/cm.
- The turbidity ranged between 27.8 to 444.0 NTU.
- The bromide concentrations ranged between 1.01 to 26.50 mg/L.

The grab sample analytical data are presented in tables in Appendix D.

2.9.6.2 Inline Water-Quality Monitoring during Development and Cyclic Testing

Inline water-quality monitoring was conducted with a Hydrolab Quanta Multiprobe. Groundwater temperature, SEC, DO, pH, and turbidity were recorded by a datalogger at either 10- or 15-minute intervals, but only while the pump was operating during well development and cyclic testing. The Hydrolab Quanta Multiprobe was taken offline during pump shutdowns/startups to prevent damage to the sensors. The inline system remained online during flow-logging activities. The flow rate to the Hydrolab Quanta Multiprobe was measured with a Kobold flowmeter and recorded by the datalogger separately from the main production flowmeter. The Hydrolab Quanta Multiprobe was calibrated, and maintenance was performed before well development and again before the constant-rate testing in accordance with manufacturer's instructions and SBMS procedure "Water Quality Monitoring" in the "UGTA Field Measurements and Monitoring" subject area (Navarro, 2016g).

Because the inline Hydrolab is calibrated relatively infrequently as compared to the grab sampling Hydrolab, the grab sample results are taken as the definitive values. The inline data are meant to

indicate trends and to reveal changes that occur when personnel are not on site to collect and analyze grab samples.

The inline water-quality parameter data are plotted with cumulative production on Figures 2-16 and 2-17. The Hydrolab is offline when pumping is offline; thus, the data end with the cessation of pumping. Figure 2-16 displays the temperature-dependent parameters, including temperature, DO, and pH. Values of the conservative parameters–including bromide, turbidity, and SEC—are plotted in Figure 2-17.

The pH measured inline generally declined from values as high as 9.3 to 8.0 during pumping operations. The values steadily dropped with each pumping cycle, then rose to a new initial value starting the next cycle. Generally, both the new initial values and ending values declined with each pumping cycle.

DO concentrations ranged from 0.44 to 0.13 mg/L but generally showed consistent initial and ending values around 0.25 and 0.15 mg/L, respectively. The pattern is similar to the results for pH.

Values for SEC were initially as high as 848 µmhos/cm and declined only modestly with each pumping cycle. The levels then stabilized around a value of 825 µmhos/cm.

With some higher initial values, turbidity levels were mostly stabilized around 200 NTU.

During development and cyclic pump testing, the inline water-quality parameters varied as follows:

- The pH levels ranged between 9.3 and 8.0 SU.
- The DO levels ranged between 0.44 and 0.13 mg/L.
- The SEC values ranged between 848 and 808 µmhos/cm.
- The turbidity ranged between 670.8 to 35.8 NTU.

Bromide concentrations were not monitored inline. The electronic data files for the inline monitoring data are on the DVD that accompanies Appendix E.

2.9.6.3 I-CHEM Water-Chemistry Logging during Development and Cyclic Testing

No geochemical logging was conducted while groundwater was being produced.

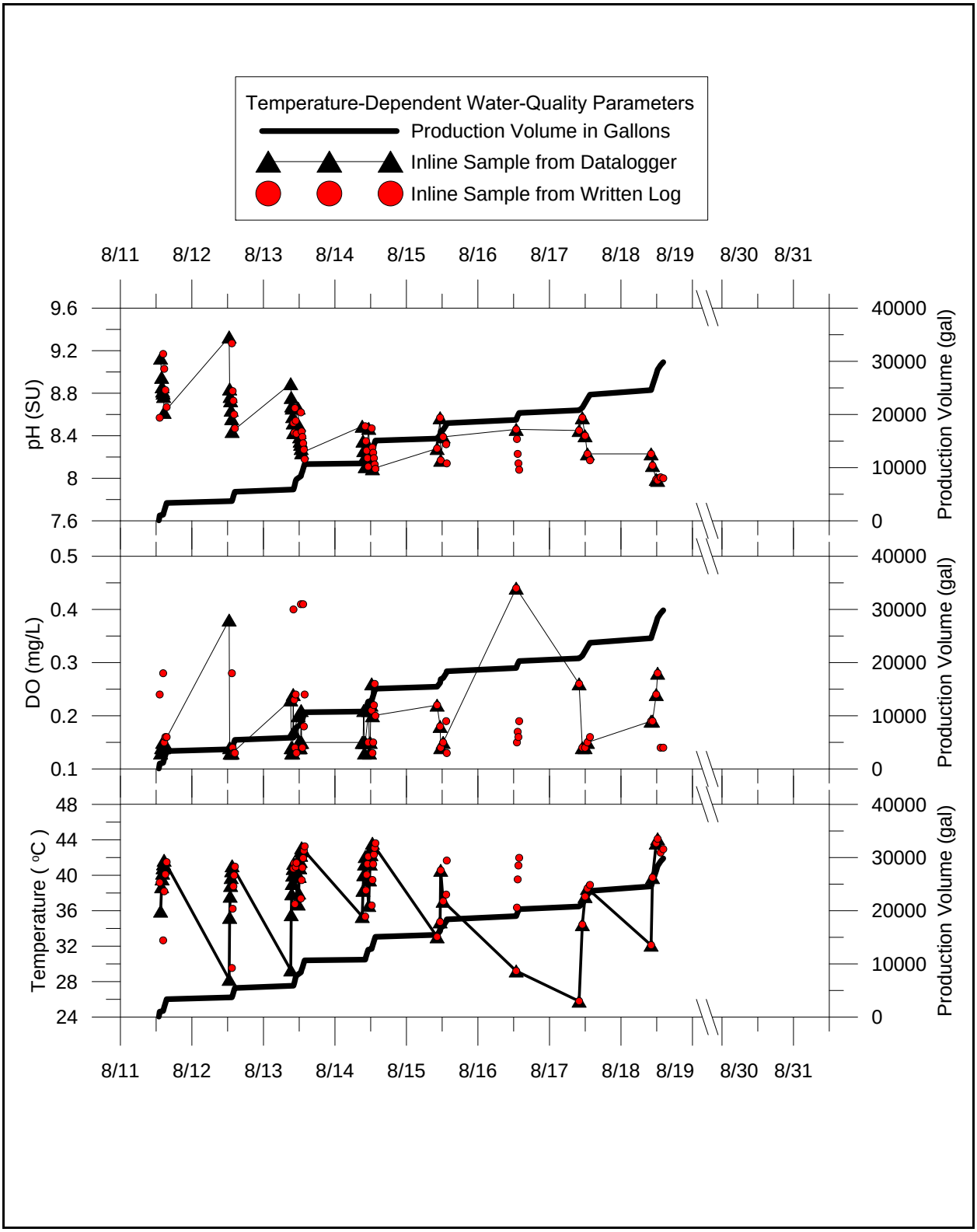

Figure 2-16
Inline Monitoring Temperature-Dependent Water-Quality Parameters during Cyclic Pump Testing at Well ER-20-12 in August 2016

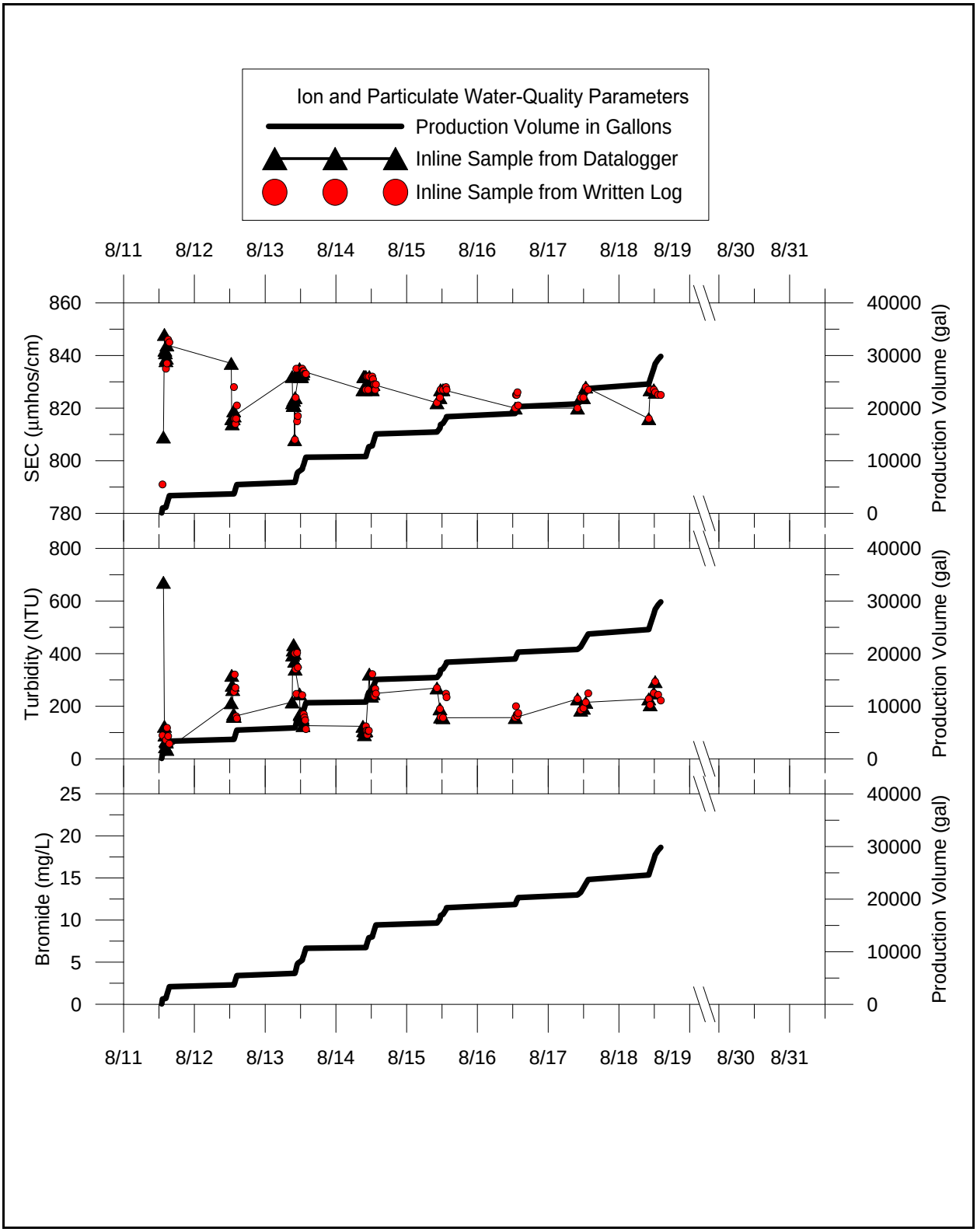

Figure 2-17
Inline Monitoring Ion and Particulate Water-Quality Parameters during Cyclic Pump Testing at Well ER-20-12 in August 2016

2.9.6.4 GWC Sampling during Development and Cyclic Testing

GWC samples for analysis by the Navarro-subcontracted analytical laboratory were collected from the main completion (m1) at the wellhead near the end of pumping on August 19, 2016. The sample and a duplicate were collected from the m1 effective open interval (3,916 to 4,543 ft bgs) while the well was under production at 30 gpm. The analytical results from GEL for these samples are summarized in Table 2-11, and the analytical results from LLNL are summarized in Table 2-12.

Table 2-11
Analytical Results from GEL for GWC Samples Collected at ER-20-12 Main Completion (m1)
(Page 1 of 3)

Analyte	Analytical Method [a]	Detection Limit [b]	Wellhead Composite Samples 138-081916-1 138-081916-1F		Wellhead Composite Duplicate QC Samples 138-081916-2 138-081916-2F	
			Total	Dissolved	Total	Dissolved
Metals (mg/L)						
Aluminum	SW-846 6010 [c]	0.2	1.03	0.2 U	1.18	0.2 U
Arsenic		0.03	0.03 U	0.03 U	0.03 U	0.03 U
Barium		0.005	0.0152	0.00306 J	0.0167	0.00321 J
Cadmium		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Calcium		0.2	17.5	15.8	17.9	16.6
Chromium		0.005	0.00915	0.005 U	0.0095	0.005 U
Iron		0.1	9.55	0.116	9.55	0.183
Lead		0.01	0.01 U	0.01 U	0.01 U	0.01 U
Lithium		0.01, 0.02	0.0962	0.106	0.0998	0.1
Magnesium		0.3	0.305	0.216 J	0.305	0.183 J
Manganese		0.01	0.33	0.188	0.333	0.167
Potassium		0.15	4.45 J	3.97 J	4.6 J	4.12 J
Selenium		0.03	0.03 U	0.03 U	0.03 U	0.03 U
Silicon		0.1	20.7	17.4	21.8	18.3
Silver		0.005	0.00101 J	0.005 U	0.005 U	0.005 U
Sodium		0.3	149	141	150	149
Strontium		0.005	0.0407	0.0343	0.0417	0.0375
^{238}U	SW-846 6020 [c]	0.0002	0.00278	0.00297	0.00336	0.00355
Mercury	SW-846 7470/7471 [c]	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U

Table 2-11
Analytical Results from GEL for GWC Samples Collected at ER-20-12 Main Completion (m1)
(Page 2 of 3)

Analyte	Analytical Method [a]	Detection Limit [b]	Wellhead Composite Samples 138-081916-1 138-081916-1F		Wellhead Composite Duplicate QC Samples 138-081916-2 138-081916-2F	
			Total	Dissolved	Total	Dissolved
Inorganics (mg/L unless otherwise noted)						
Bromide	EPA 300.1 [d]	0.2	--	0.444	--	0.452
Chloride		4		82.4		86 J-
Fluoride		0.1		1.87		1.87
Sulfate		8		112		114 J-
Alkalinity (as $CaCO_3$)	EPA 310.1 [e]	13.3, 4	93.7 J+	--	127	--
Bicarbonate Alkalinity (as $CaCO_3$)		13.3, 4	93.7 J+		127	
Carbonate Alkalinity (as $CaCO_3$)		13.3, 4	4.83 U		1.45 U	
Total Dissolved Solids	EPA 160.1 [e]	14.3	504	--	491	--
Total Suspended Solids	EPA 160.2 [e]	6.25, 10	28 J		34 J	
pH (SU)	EPA 150.1 [e]	0.1	8.16 J-		8.17 J-	
Specific Conductivity (µmhos/cm)	EPA 120.1 [e]	14.5	767		780	
Organics (mg/L)						
Total Organic Carbon	EPA 145.1 [e]	1	1.21	--	1.18	--
Redox Parameter (mg/L)						
Total Sulfide	EPA 376.1 [e]	2.5	1 U	--	1 U	--
Radiological Indicator Parameters (pCi/L)						
		MDC [f]	**Result**	**Error**	**Result**	**Error**
^{3}H	EPA 906.0 [g]	252, 251	34,000	6,610	33,600	6,540
Gross Alpha	EPA 900.0 [g]	2.85, 2.95	10.8	3.97	10.5	3.71
Gross Beta		1.49, 1.5	6.07	1.79	7.49	1.96
^{238}Pu	HASL 300/ Pu-10-Rc [h]	0.0504, 0.0356	0.0347 U	0.0374	0.00907 U	0.0223
$^{239/240}Pu$		0.0701, 0.0182	-0.0129 U	0.0284	0.00605 U	0.0178
Gamma Spectroscopy	EPA 901.1 [g]	Varies by Nuclide	ND	Varies by Nuclide	ND	Varies by Nuclide

Table 2-11
Analytical Results from GEL for GWC Samples Collected at ER-20-12 Main Completion (m1)
(Page 3 of 3)

Analyte	Analytical Method [a]	Detection Limit [b]	Wellhead Composite Samples 138-081916-1 138-081916-1F		Wellhead Composite Duplicate QC Samples 138-081916-2 138-081916-2F	
			Total	Dissolved	Total	Dissolved
^{214}Bi	EPA 901.1 [g]	13.3, 8.04	11.3 U	9.79	19.8	9.71
^{14}C	EPA EERF C-01 [i]	343	--	--	6.14 U	198
^{36}Cl	EPA 902.0 [g]	23.6, 23.8	0.444 U	13.8	2.11 U	14
^{129}I	EPA 902.0 [g]	6.43	--	--	-1.83 U	3.59
^{90}Sr	EPA 905.0 [g]	0.987, 0.982	-0.616 U	0.454	-0.2 U	0.501
^{99}Tc	HASL TCW-02 [h]	7.95, 7.82	-1.01 U	4.62	-2.96 U	4.5

Source: Navarro, 2016d

[a] For commercial laboratory analysis, the most current EPA or equivalent accepted standard laboratory analytical methods may be used as appropriate to attain specified detection limits.
[b] Detection limit varies by instrument and dilution of sample. Where more than one detection limit is given, they apply to the samples in the order presented.
[c] EPA, 2013
[d] EPA, 1997
[e] EPA, 1983
[f] MDC varies by matrix, instrument, and count rates. Where more than one detection limit is given, they apply to the samples in the order presented.
[g] EPA, 1980
[h] DOE, 1997
[i] EPA, 1984

EERF = Eastern Environmental Radiation Facility
HASL = Health and Safety Laboratory

Bi = Bismuth
$CaCO_3$ = Calcium carbonate
Cl = Chloride

I = Iodine
Pu = Plutonium
Tc = Technetium

F = Filtered
J = Result is estimated.
J+ = Estimated bias high.
J- = Estimated bias low.
ND = No gamma spectroscopy nuclides detected above detection limits.
U = Compound was analyzed for but was not detected (“Non-detect”).
-- = No result.

Table 2-12
Analytical Results from LLNL and USGS for GWC Samples Collected at ER-20-12 Main Completion (m1)

Analyte	Analytical Method	Detection Limit	Wellhead Composite Samples 138-081916-3		Wellhead Composite Duplicate QC Samples 138-081916-4	
Inorganics (mg/L)						
			Total	**Dissolved**	**Total**	**Dissolved**
DIC	SOP-UGTA-116	0	--	32.6	--	--
Age and Migration Parameters						
$^{2}H/^{1}H$	SOP-UGTA-128	NA	-115.3 per mil	--	--	--
$^{18}O/^{16}O$			-14.78 per mil	--	--	--
$^{87}Sr/^{86}Sr$	SOP-UGTA-117		0.13 per mil	--	--	--
$^{87}Sr/^{86}Sr$			0.709294 ratio	--	--	--
$^{13}C/^{12}C$	SOP-UGTA-116		--	-3.38 per mil	--	--
$^{234}U/^{235}U$	SOP-UGTA-118		0.028618 ratio	--	--	--
$^{234}U/^{238}U$			0.00020768 ratio	--	--	--
$^{235}U/^{238}U$			0.00020768 ratio	--	--	--
$^{236}U/^{235}U$			7.6E-6 ratio	--	--	--
$^{34}S/^{32}S$ [a]	USGS-YM-GCP-44	0	--	19.2 per mil	--	--
Radiological Indicator Parameters (pCi/L)						
		MDC	**Result**	**Error**	**Result**	**Error**
^{234}U	SOP-UGTA-134	NA	7.14	0.38	--	--
^{235}U			0.0871	0.0046	--	--
^{236}U			4.1E-6	0	--	--
^{238}U			1.89	0.11	--	--
^{14}C	SOP-UGTA-136		0.2365	0.0016	--	--

Source: Navarro, 2016d

[a] $^{34}S/^{32}S$ sample analyzed by USGS.

S = Sulfur

-- = No result

The samples collected and analyses performed for this sampling event were collected according to Record of Technical Change No: 002 (N-I, 2013b) for the N-I well development, testing, and sampling FI (N-I, 2012) and the FAWP (Navarro, 2016e). The parameters and analytical methods were selected in accordance with the Navarro well development, testing, and sampling FI (Navarro, 2016a).

2.9.6.5 Tritium Field Monitoring Results

During well development and cyclic testing of the main completion (m1), field ^{3}H levels were measured from samples collected with an auto-sampler, collected at pump start up and before pump shutdown for each pumping cycle. The results along with the Navarro field-screening MDAs are summarized in Table 2-13. In addition, field ^{3}H levels were measured from bailer samples taken from piezometers p2 and p4 on August 30 and August 31, 2016, respectively. These field monitoring samples were given sample numbers and analyzed by Navarro Radiation Services using an LSC at Building 23-310 in Mercury, Nevada. An additional set of samples from p2 and p4 bailers were collected and sent to GEL for ^{3}H analysis and are reported in Section 5.0.

Table 2-13
Tritium Levels in the ER-20-12 Main Completion (m1) and in Piezometers p2 and p4 during Cyclic Pump Testing in August 2016
(Page 1 of 2)

Date and Time	Sample Number	Results (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Comments
Main Completion (m1)					
08/11/2016, 12:55	ER-20-12-081116-1	28,591	1,972	1,490	Initial discharge
08/11/2016, 13:11	ER-20-12-081116-2	32,038	2,019	1,422	Taken before pump shutdown
08/11/2016, 15:31	ER-20-12-081116-3	31,521	1,952	1,374	Taken before pump shutdown
08/12/2016, 13:25	ER-20-12-081216-1	33,045	2,088	1,458	Taken at pump start-up
08/12/2016, 14:25	ER-20-12-081216-2	33,547	2,047	1,407	Taken before pump shutdown
08/13/2016, 10:05	ER-20-12-081316-1	32,700	2,098	1,504	Taken at pump start-up
08/13/2016, 13:50	ER-20-12-081316-2	34,558	2,100	1,455	Taken before pump shutdown
08/14/2016, 10:10	ER-20-12-081416-1	33,483	2,071	1,446	Taken at pump start-up
08/14/2016, 13:35	ER-20-12-081416-3	32,176	2,255	1,695	Taken before pump shutdown
08/15/2016, 10:17	ER-20-12-081516-1	30,575	2,273	1,910	Taken at pump start-up
08/15/2016, 13:32	ER-20-12-081516-2	30,902	2,141	1,715	Taken before pump shutdown
08/16/2016, 12:50	ER-20-12-081616-1	31,168	2,151	1,715	Taken at pump start-up
08/16/2016, 13:50	ER-20-12-081616-2	30,970	2,098	1,665	Taken before pump shutdown
08/17/2016, 09:57	ER-20-12-081716-1	29,149	2,119	1,746	Taken at first pump start-up

Table 2-13
Tritium Levels in the ER-20-12 Main Completion (m1) and in Piezometers p2 and p4 during Cyclic Pump Testing in August 2016
(Page 2 of 2)

Date and Time	Sample Number	Results (pCi/L)	Error (pCi/L)	MDA (pCi/L)	Comments
08/17/2016, 13:36	ER-20-12-081716-2	32,294	2,126	1,632	Taken at last pump shutdown
08/18/2016, 10:07	ER-20-12-081816-1	33,535	2,111	1,587	Taken at first pump start-up
08/18/2016, 14:12	ER-20-12-081816-2	32,243	2,128	1,620	Taken at last pump shutdown
08/19/2016, 09:23	ER-20-12-081916-1	33,444	2,074	1,522	Taken at pump start-up
08/19/2016, 10:51	ER-20-12-081916-2	34,240	2,153	1,605	Taken before pum55p shutdown
08/26/2016, 15:02	ER-20-12-082616-01	30,602	1,964	1,465	Taken during function testing of the dedicated electric submersible sampling pump
Piezometers p2 and p4					
08/30/2016, 15:30	ER-20-12-083016-1	2,087	1,093	1,656	Grab sample from bailer at 2,920 ft bgs in p2
08/31/2016, 12:30	ER-20-12-083116-1	39,579	2,262	1,601	Grab sample from bailer at 1,617 ft bgs in p4

Note: Pump intake at 2,191.56 ft bgs

The ^{3}H field monitoring levels in the main completion (m1) were relatively stable, with values somewhat cyclic but consistently in the range of 29,000 to 35,000 pCi/L throughout the six-day period (Figure 2-18).

The ^{3}H levels detected in the p2 and p4 depth-discrete bailer samples, analyzed by Navarro Radiation Services, were 2,087 and 39,579 pCi/L, respectively. The Navarro field-screening MDAs for these samples ranged from 1,601 to 1,656 pCi/L.

Grab samples were also collected daily from the pumped discharge for the determination of ^{3}H activity as specified in the Strategy Letter (NNSA/NFO, 2015a) and the FMP (NNSA/NSO, 2009b). The FMP results are presented in Section 6.0. The Navarro field-screening MDAs for these samples ranged between 1,258 and 1,923 pCi/L.

2.9.7 Cessation of Pumping and Recovery Monitoring

Pumping was suspended at 10:55 on August 19, 2016, with a total of 32,609 gal of groundwater produced since the start of WDT operations. The total flow was discharged into the first (Sump #1).

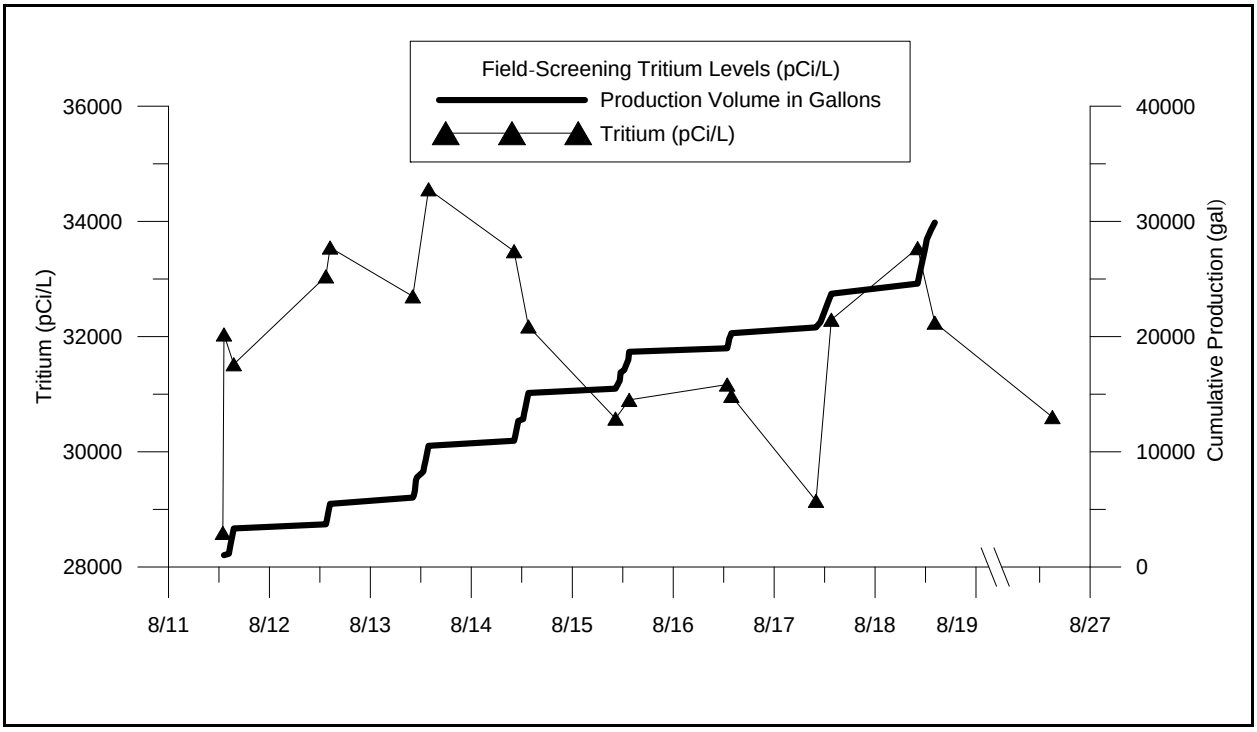

Figure 2-18
Tritium Field Monitoring Levels in the ER-20-12 Main Completion (m1) during Cyclic Pump Testing in August 2016

Discharge to the ground surface was negligible; however, most of the discharge in Sump #1 infiltrated through the tear in the liner. Recovery monitoring was continuous via the automated PXD datalogger system until August 22, 2016, when the PXDs were removed from the main completion (m1) in preparation for removal of the testing pump, as well as from piezometers p1 and p2.

2.9.8 Dedicated Sampling Pump Installation

The testing pump was removed from August 23 to August 25, 2016. The dedicated sampling pump was installed in the well on August 25 to 26, 2016. Pump specifics are given in Table 2-8 and VSC controller specifics in Table 2-9. The pump intake was set at 2,159.50 ft bgs. The top of the pump was set at 2,150.22 ft bgs and the bottom at 2,175.92 ft bgs, respectively. The pump was function tested on August 26, 2016. An initial frequency of 54 Hz was run to produce water, then lowered to 50 Hz to start the function test. The pump was then operated at 50, 52, 54, 56, 58, 60, 62, and 64 Hz for 15 minutes each corresponding to 10, 15, 19, 22, 24, 26, 28, and 30 gpm (Table 2-9). The function test was stopped after approximately two hours, with a total of 654 gal pumped.

3.0 REDUCTION AND EVALUATION OF AQUIFER STRESS DATA

This section presents basic reduction, processing, and analysis of the data collected during predevelopment water-level and WDT monitoring operations at Well ER-20-12, as well as LTWLM data indicating a response at Well PM-3 to Well ER-20-12 drilling activities before the ER-20-12 WDT. It includes a discussion of water-level measurements, cyclic pump rate drawdown testing analysis, wellbore storage, and a time-series analysis of a drawdown response at PM-3, considering barometric effects, Earth tides, background water levels from a well unaffected by the pumping, and a review of pumping rates and their effective schedule, with timing relative to events during drilling. Specific capacity and other constant pumping rate test analyses were not attainable due to insufficient yield of the well resulting in unsustainable pumping.

3.1 Barometric Efficiency

Barometric efficiency was not calculated for Well ER-20-12 due to an insufficient amount of LTWLM data available from the well.

3.2 Representative Water-Level Measurements

Table 2-2 reported the water-level measurements taken the same day (May 11, 2016) in the ER-20-12 main completion (m1) and the well's four piezometers, p1 through p4; as well as in Wells U-20m PS 1D, PM-3-1, and PM-3-2. The measurements are consistent with regional and temporal background head trends, with the notable exception of the shallow (water table) piezometer, p4. The piezometer p4 head of 1,415.39 m amsl is approximately 80 m higher than the lowest ER-20-12 head in piezometer p2, whereas the main completion (m1) and remaining piezometers p1 and p3 have heads within 8.2 m of p2. The net result is that a significant downward head gradient exists from p4, completed in the TMWTA and TMLVTA, above the UPCU, to units completed below the UPCU. Vertical head gradients in the well are convergent to piezometer p2, completed in the zone of a significant fracture and corresponding water production zone encountered within the CHZCM during drilling. An upward gradient exists from m1 to p1, and from p1 to p2. A downward gradient exists from p4 through the UPCU confining unit to p3, and from p3 to p2. TFM flow logs conducted by DRI (Figures 2-5 though 2-7) indicate downward flow throughout the entire well. The lowest head in

piezometer p2 is most likely due to enhanced fracture flow providing a local hydraulic connection to a region of relatively low heads.

The head in p4 is also anomalously high relative to wells to the east and south on the regional water-level map of Fenelon et al. (2016, Figure 5), whereas the completions below the UPCU are in general agreement with these levels. However, the head in p4 is in the same range as a set of wells to the northwest: Wells PM-2, UE-20p, and UE-20j WW enclosed by the 4,600-ft head contour of the water-level map (Fenelon et al., 2016, Figure 5). The lateral extent of the anomalously high head in p4, completed above the UPCU, is unknown due to lack of data. Though the p4 head is higher than the top of the p4 screen, it most likely reflects the water table elevation. The water table level must be inferred beyond ER-20-12 to the northeast toward HANDLEY, and the southwest toward PM-3. The water table is shown as laterally continuous on Figure 5-7 of the ER-20-12 well completion report (NNSA/NFO, 2016), extending from U-20m/UE-20j near HANDLEY to the water table head in Well PM-3-2 to the southwest. The UE-20j and ER-20-12 water table heads are much higher than both the water table head in PM-3-2 and the heads for CHZCM-PBRCM, which are HSUs below the UPCU. The water table head in ER-20-12 corresponds to its completion in the TMWTA and TMLVTA. The water table head in PM-3-2 corresponds to its completion in the UPCU. If these water tables are hydraulically connected, the water table crosses the contact between the TMWTA and TMLVTA, and the contact between the TMLVTA and UPCU, which implies that the Timber Mountain aquifers are de-watered to the southwest. In addition, if these water table heads are hydraulically connected continuously across these HSUs, the 84-m head change results in a significant regional gradient, nearly 20 times greater than the regional gradient depicted in Fenelon et al. (2016). The heads in PM-3 are in the same range as (within 20 ft of) the lowest heads in ER-20-12 below the UPCU, and are most likely equilibrated and in hydraulic connection with them. This alternatively implies that the water table at ER-20-12_p4 is significantly isolated from these heads, or that a major downward flow equilibrates the water table heads between ER-20-12 and PM-3-2.

3.3 Groundwater Temperature and pH Logs

DRI collected TFM logs, as well as combined logs of groundwater temperature, pressure, pH, and SEC profiles under ambient conditions. The tool also collected bromide and DO logs as indicators of residual well drilling fluids. The logs were collected in June 2016, before sampling in July and WDT

in August. The well had been undisturbed for more than six months after drilling activities concluded in January 2016.

Figures 2-5 through 2-7 show the groundwater temperature profiles with depth, collected by DRI in the main completion and piezometers p1 and p3 from June 7 to June 10, 2016. The results are plotted with the estimated production data with depth, collected during drilling from October 2015 through December 2016. The pressure profiles are not shown because they plot as essentially straight lines, showing constantly increasing pressure with depth, indicating a constant density profile below the water table. The SEC and pH logs were run within casing, and thus the profiles do not represent variation in aquifer chemistry with depth. Figure 2-5 shows that temperature rose to a stable value of 52 °C at the depth of the BRA, corresponding to the highest water production during drilling, then reached a stable value of 54 °C in the interval of the m1 screen, indicating that the well is relatively isothermal. The TFM log show that flow is downward in the region of the m1 screen, completed in the PBRCM. Downward flow is consistent with the isothermal profile in the well. A pH of ~8.2 is logged at the screen. Figure 2-6 shows that temperature of 52 °C in the p1 screen is consistent with the m1 temperature profile. A pH of ~7.5 is logged in the p1 screen, completed in the BRA. Figure 2-7 shows that the p3 screened interval in the CHZCM has different values: a temperature of ~42 °C and a pH of ~8.5. Piezometer p3 is screened above the fractures that significantly increased water production in the borehole during drilling, and thus divides zones thermally and geochemically above and below.

A similar isothermal temperature profile from the geophysical logging, conducted across the CHZCM in the open borehole, corresponded to the specific depth at which water production increased during drilling. The time at which the depth was encountered during drilling was used to approximate the starting time of the increased water production, a significant aquifer stress used for aquifer hydraulic evaluation (see Section 3.6).

3.4 Hydraulic Testing of the PBRCM HSU from ER-20-12_m1

This section presents evaluation of the hydraulic responses observed during cyclic pump testing of the Well ER-20-12 main completion (m1), conducted to ascertain the hydraulic properties of the PBRCM. As part of WDT, water quality was also monitored and analyzed to both determine the extent of development and characterize the groundwater extracted from the PBRCM HSU. PXDs with higher rated pressure capacity— which are required for the set depths needed to record

drawdowns from pump testing—were installed on August 11, 2016, in the main completion access line (m1), and on August 12, 2016, in piezometers p1 and p2 before the initiation of the pump test. Table 3-1 summarizes the set depths and corresponding water levels for the pump-test PXDs in m1, p1, and p2, as well as initial e-tape measurements of water levels in the non-instrumented piezometers p3 and p4.

3.4.1 Cyclic Pump Testing of ER-20-12_m1

Pump testing of the Well ER-20-12 main completion (m1), screened in the PBRCM HSU, was conducted from August 11 to 18, 2016. After pump function testing was completed August 11, 2016, 20 successive pump tests, recurring at regular intervals, were run for development and aquifer testing purposes. Most of the tests ranged from 0.5 to 1.5 hours at a rate of approximately 30 gpm, the minimum rate required for the pump horsepower, selected with an expectation of higher pump rates required. An Excel file, ER-20-12_WDT_2016_P_T.xlsx, of the datalogger values, with each of the 20 tests separately numbered, is on the DVD that accompanies Appendix E. Table 2-8 shows the duration, pumping rate, recovery period, and hydraulic response during the cyclic tests. Data from each test were extracted from the datalogger file, recording continuous water-level measurements, and stored in separate files where elapsed time could be calculated from the noted initial time the pump was turned on for the specific test period, with each dataset including the recovery period.

Two of the datasets were evaluated, test #2 from August 11, 2016, early in the WDT period, and test #18 from August 18, 2016, late in the WDT period. The cyclic pumping of test #18 on August 18, 2016, is shown in Figure 2-12. Given the short, unsustainable nature of the tests, separating the effects of wellbore storage from the actual aquifer response early in the test is critical to the analysis. Thus, the Dougherty-Babu method (Dougherty and Babu, 1984), which accounts for wellbore storage, was selected for the aquifer test evaluation.

Figure 3-1 is a plot for test #2 of both drawdown and its first time derivative (plotted on a logarithmic y-axis) versus elapsed time (plotted on a logarithmic x-axis). This plotting arrangement enables aquifer analysis by the Dougherty-Babu pump-test method (Dougherty and Babu, 1984) by matching its type curves. Given that the 32-gpm pump rate was not sustainable, it is uncertain whether the drawdown response to pumping reflects aquifer or wellbore storage parameters. In the Dougherty-Babu model, the slope of the drawdown and its first time derivative in log-log space are identical during the interval of the test when water is derived exclusively from wellbore storage, then

Table 3-1
Summary of Pump-Test Configuration Including PXD Set Depths

Well	Elevation (ft amsl)	TD to Bottom of Screen (ft bgs)	e-tape Water Level (ft bgs)	Set psia	Set Barometer (mBar)	Submerged Depth (ft)	PXD elevation (ft amsl)	Static WL (ft amsl)	EOI Top (ft amsl)	EOI Bottom (ft amsl)	EOI length (ft)	Water Height above Top of EOI (ft)	Water Height above Piezometer Bottom (ft)	Water Height above PXD (ft) = Submerged Depth
Open Borehole	6,258.4	4,543.33	1,614.74	NA	NA	NA	NA	4,643.66	6,258.4	1,715.1	4,543.3	0	2,929	1
m1 INW/PT12	6,258.4	4,431.15	1,849.62	118.525	815.228	246.039	4,162.74	4,408.78	2,342.4	1,715.1	627.3	2,066.38	2,582	246
p1	6,258.4	3,665.85	1,859.48	513.831	816.618	1,157.517	3,241.40	4,398.92	2,915.4	2,533.4	382.0	1,483.52	1,806	1,158
p2	6,258.4	3,142.13	1,875.51	495.100	811.800	1,114.487	3,268.40	4,382.89	3,205.4	3,101.4	104.0	1,177.49	1,267	1,114
p3	6,258.4	2,915.08	1,876.32	NA	NA	NA	NA	4,382.08	3,748.1	3,311.5	436.6	633.98	1,039	1
p4	6,258.4	1,901.79	1,614.74	NA	NA	NA	NA	4,643.66	4,572.7	3,971.4	601.4	70.91	287	1

diverge until the derivative approaches a constant value (plateau) as the drawdown increases at a constant rate, indicative of the aquifer response. In Figure 3-1, the plot of the drawdown response together with its time derivative shows the interval of equal slope, and a departure, matching a Dougherty-Babu type curve, approaching a constant value. A value of 8.2 square meters per day (m^2/day) for transmissivity results from the type curve match.

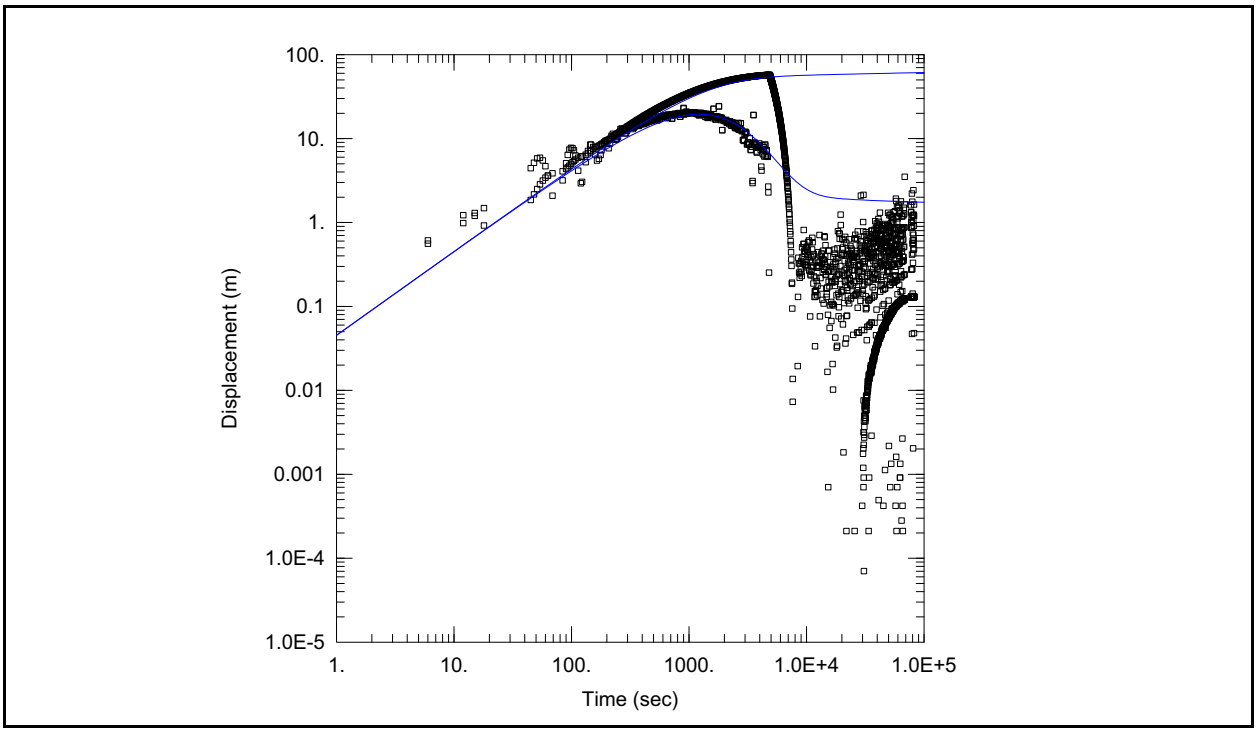

Figure 3-1
Analysis of Cyclic Pump Test #2 Using the Method of Dougherty-Babu (1984)
Note: Black squares = Displacement data converted from changes in pressures recorded from PXD; blue line = type curve of the Dougherty-Babu (1984) pump test model.

Figure 3-2 (top) is a drawdown and time-derivative plot for test #18 for evaluation by the Dougherty-Babu pump-test method using an assumed pump rate of 29.5 gpm. Though the shape of the type curves matches the data, the type curves plot at values of higher drawdown. The resulting transmissivity value was thus only 43 percent of the value of the earlier test #2. Given some discrepancy between the 29.5 gpm pump rate data versus volumetric production data, collected over the period of the test and its successor (test #19), it is possible that a lower effective pump rate was actually attained. Using a reduced pump rate of 20 gpm, versus 29.5 gpm, the data and type curves match (Figure 3-2 [bottom]). Though a higher value of transmissivity is obtained using the lower pump rate, the value is still only 66 percent of the earlier test #2. Well production was not improved

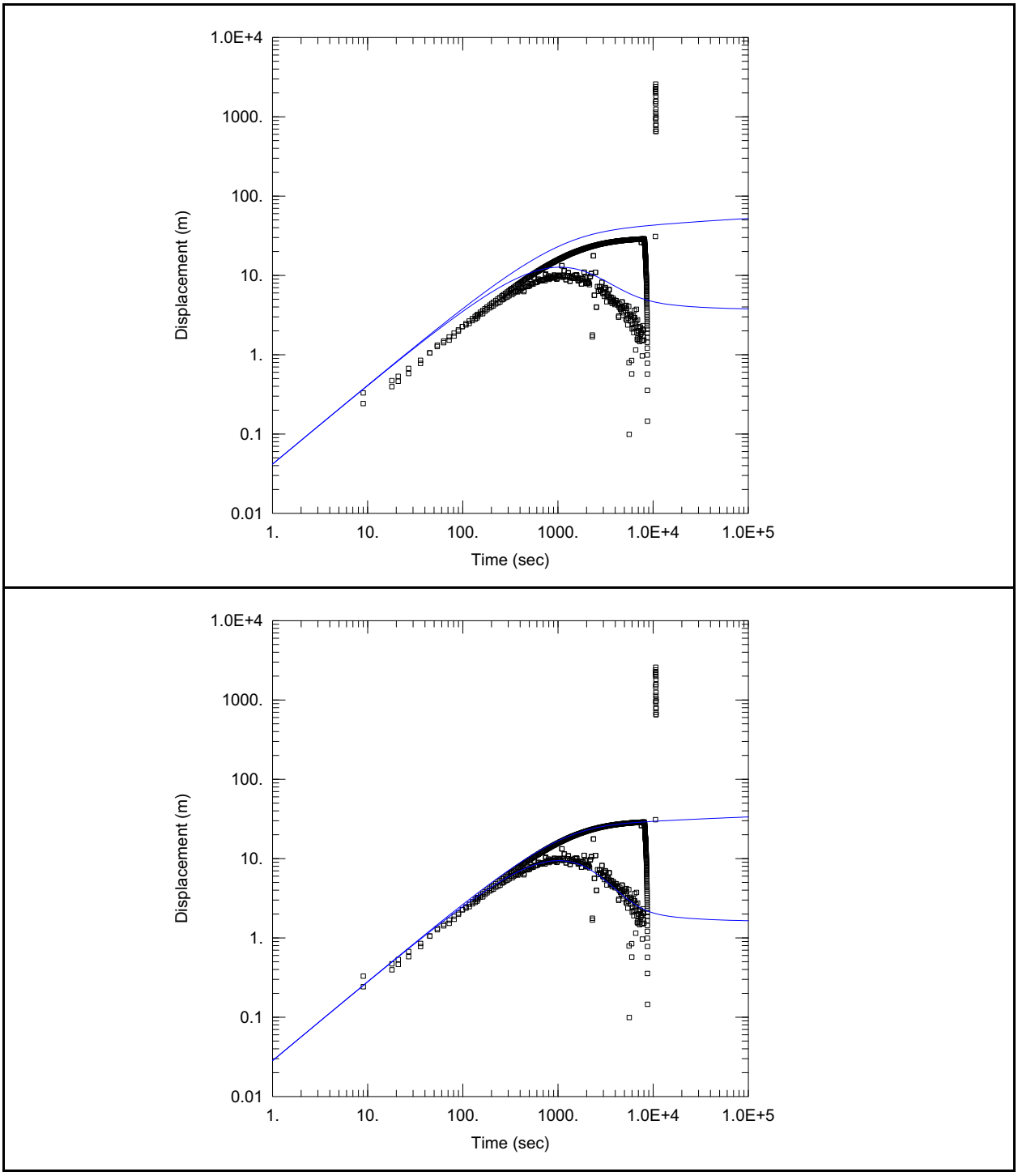

Figure 3-2
Analysis of Cyclic Pump Test #18 Using the Method of Dougherty-Babu (1984)

Notes: Top: The best-fitting type curve is above the data from excessive pump rate in the model. Bottom: A lower estimate of the pump rate results in a better fit of the type curve. Black squares = Displacement data converted from changes in pressures recorded from PXD; blue line = type curve of the Dougherty-Babu (1984) pump test model.

as expected with subsequent well development from subsequent testing. The value of transmissivity was not increased.

3.5 Water-Quality Results: Geochemical Observations of the PBRCM HSU from ER-20-12_m1

3.5.1 Field Monitoring of Geochemical Parameters

Field geochemical parameters from both inline and grab samples were analyzed during WDT activities to monitor water quality during pump testing. The samples represent average values for groundwater drawn to the well over the entire production interval during pumping. Water-quality samples were collected during cyclic pump testing, including inline water-quality monitoring samples analyzed in a HydroLab, grab samples for analysis in a field laboratory, ^{3}H monitoring samples, and GWC samples collected at the end of pump testing for analysis in an analytical laboratory.

3.5.1.1 Water-Quality Monitoring

Inline monitoring of water quality was analyzed using a Hydrolab and recorded at regular intervals by a datalogger. A discussion of the monitoring methods and results is presented in Section 2.9.6.2 and summarized in Figures 2-16 and 2-17. Results are within the electronic files in Appendix E.

3.5.1.2 Water-Quality Grab Samples

Grab samples were collected from the pumped discharge and analyzed using a Hydrolab. The parameters measured in the field laboratory are EC, pH, DO, turbidity, and bromide. A discussion of the grab sample monitoring methods and results is presented in Section 2.9.6.1 and summarized in Figures 2-14 and 2-15. Results are tabled in Appendix D.

3.5.1.3 Tritium Monitoring

Tritium samples were collected in grab samples from the pumped discharge and analyzed by Navarro Radiation Services using an LSC at regular intervals during WDT water production. The results are presented in Table 2-13 and summarized in Figure 2-18.

3.5.2 Groundwater Characterization Results

GWC samples were collected from the ER-20-12 main completion (m1) at the end of WDT activities. A summary of the methods and results are presented in Section 2.9.6.4 and summarized in Table 2-7.

3.6 Series SEE Analysis of the Hydraulic Influence of Well ER-20-12 Drilling Activities on Well PM-3

Due to the availability of continuous LTWLM data in the Pahute Mesa area, a hydraulic response was detected in PM-3 during the drilling and installation of Well ER-20-12 (Figure 3-3). Although not part of the originally proposed WDT scope of work, an analysis of the response provided an estimate of aquifer properties at the scale of the large radial distances between Wells ER-20-12 and PM-3. PM-3 was effectively used as an observation well, under the influence of the water production associated with drilling ER-20-12, Thus the water production from drilling constituted a pumping stress originating from ER-20-12.

The response also provided a way of evaluating the hydraulic properties of the HSUs above the PBRCM, with water production coming from the BRA and the CHZCM (Figure 3-4). These water-producing units are between the PBRCM and the UPCU. In the region of ER-20-12 itself, it is unlikely that the ER-20-12 water production stress affected the overlying UPCU or the HSU units above it. Piezometer p4, later screened across both the TMLVTA and TMWTA above the UPCU, exhibited a significantly higher head than the units below the UPCU. However, in the region of PM-3, drawdowns were observed in PM-3-2, screened in the UPCU, in response to the ER-20-12 drilling production (Figure 3-3). Drawdown was also observed in PM-3-1, screened below the UPCU and above the PBRCM, the same interval as the water-producing zone at ER-20-12. However, the HSUs of the corresponding interval are different; PM-3-1 is screened in the TCA and LPCU, two units that pinch out and do not laterally trace with the CHZCM and BRA (the HSUs comprising the interval of the water-producing zone at ER-20-12) (Figure 3-4).

The Microsoft Excel workbook provided with the *Documentation of a Spreadsheet for Time-Series Analysis and Drawdown Estimation* (Halford, 2006) was used to analyze time-series data, using time series of background water levels, barometric pressure, gravity and dry Earth tides, and water production to model the response in PM-3-1. The PM-3-1 PXD's raw pressure, including atmospheric pressure, recorded by the datalogger in psia units, is assumed to be a combined signal of other time series, and thus is simulated in the analysis using the Water Level Model (WLM) tool in SeriesSEE.

Figure 3-3
Absolute Pressure in PM-3_p1 and PM-3_p2 Showing Response to Drilling Production from Well ER-20-12

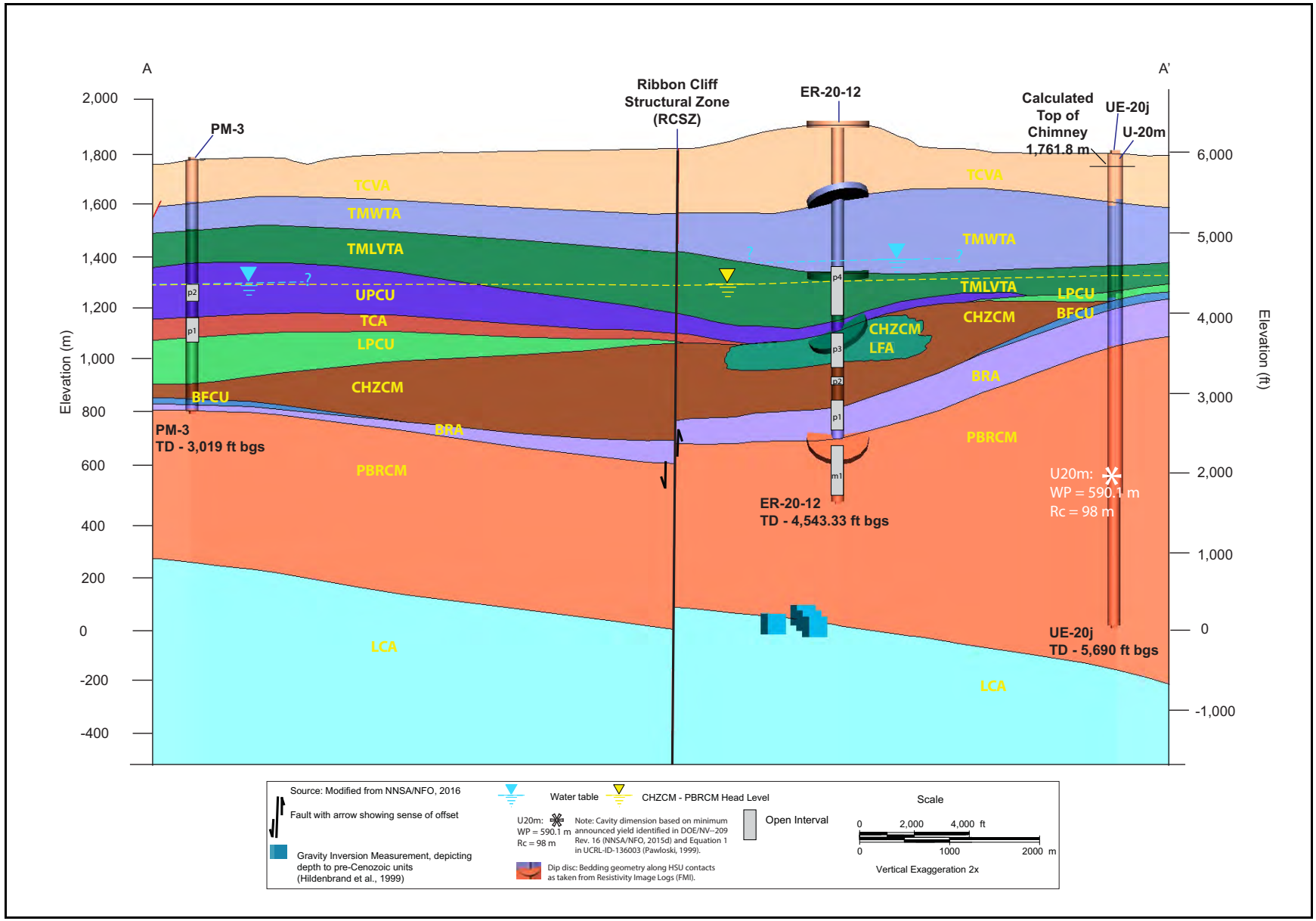

Figure 3-4

HSUs and Water Levels in Well UE-20j near the HANDLEY Test and Wells ER-20-12 and PM-3

Note: EOIs are shown for the wells.

The WLM uses a multiplier coefficient, a phase shift coefficient, and an averaging period. These three parameters are estimated by regression to the data from each series signal used in the analysis, with the assumption that the signals (when converted to psig equivalents) are ultimately additive by superposition. The WLM uses the PEST software (Doherty, 2010a and b) to perform the model parameter estimation. Using an uncorrected pressure as the simulated signal, the separate barometric pressure signal can be used as one of the time series in the analysis, with estimated coefficients related to the barometric efficiency of the well. The raw pressure from LTWLM background well (ER-20-7, which was unaffected by the pumping) was used to provide a background series, essentially a proxy for regional hydraulic responses—mostly, but not exclusively, related to climatic events. Each series in the analysis is entered multiple times into the input, each with a different averaging period used to calculate a moving average along the series with time. The different averaging periods, typically ranging from hours to days, allow for determining different time-scale dependent effects on the moving averages within each series. A set of time periods were used for each series, with successive durations approximately doubling, ranging from 1 hour to 14 days. In addition to these series based on recorded data, time series were calculated in the WLM from mathematical models of known physical phenomenon, including Earth tides (gravity and dry) calculated by equations summarized in Harrison (1971), and superposed pumping effects calculated by the Theis equation (1935). The Earth tide calculations are dependent only upon inputs of latitude, longitude, and elevation. The Theis calculations are dependent only upon pumping schedule information (the pumping series), and the known distance between the pumping well (ER-20-12) and the observation well (PM-3-1).

A 240-day analysis period was chosen from October 24, 2015, to June 20, 2016, to allow for a minimum 30 days of background normalizing before the pumping stress began, and a recovery period of about six months (Figure 3-5). SeriesSEE incorporates the pump rates and their changes as superposed Theis effects, referred to in the WLM as Theis transforms. For a pumping analysis based on drilling water production, a detailed history of drilling activities was compiled for the analysis period. Table 3-2 provides a summary of the drilling events that led to water production changes, their timing according to depth below ground surface, and an estimate of the production rate. In addition, the table reports the timing of related hydraulic responses at PM-3-1.

The estimated water production during drilling is presented on the DRI logs that were taken during pre-development LTWLM from the main completion (m1) and piezometer p1 and p3, Figures 2-5

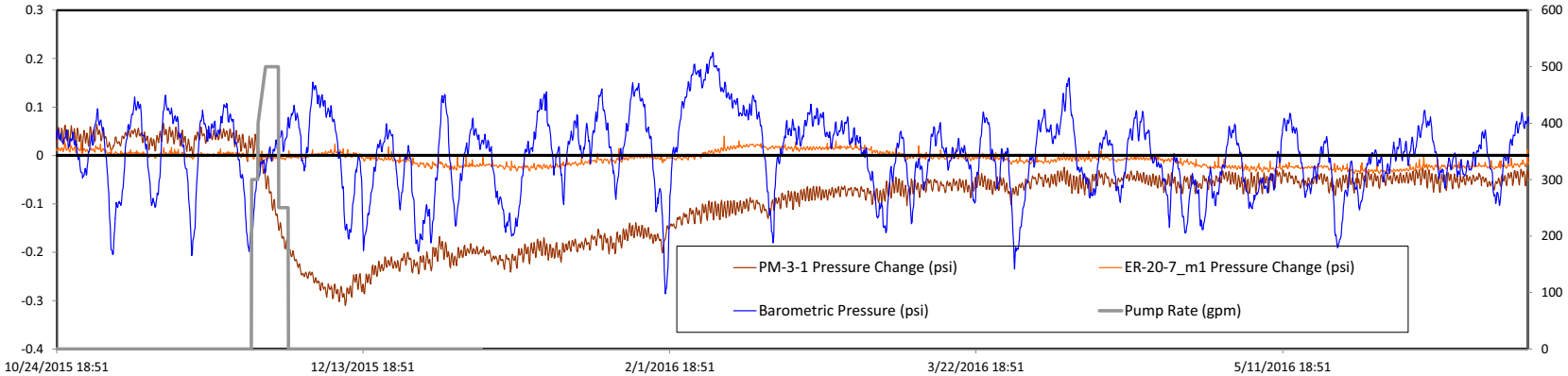

Figure 3-5
Barometer, Background Water Levels, Pump Rate, and Response in PM-3-1 Used in SeriesSEE Analysis

Table 3-2
Events Affecting Production Rates during Drilling of ER-20-12 and Water Levels in PM-3

Date and Time	Depth (ft bgs)	Event	PM-3 Head (ft bgs)	Simplified Flow Rate
11/19/2015, 06:30	2,500	1. Drilling tags CHZCM.	--	0
11/24/2015, 05:30	2,500	2. Casing set, resume drilling CHZCM.	--	0
11/25/2015, 13:00	2,970	- First significant fracture on FMI log.	--	0
11/25/2015, 14:20	2,983	3. Spike in flow rate; max head in PM-3 drilling CHZCM.	1,454.10 [a]	300
11/25/2015, 21:56	3,111	- Major horizontal fracture encountered.	1,454.23	300
11/26/2015, 08:20	3,290	4. Maximum psi in PM-3 before drawdown.	1,454.34 (20.457 raw psi)	300
11/26/2015, 14:10	3,370	5. Maximum head in PM-3 before drawdown.	1,454.33	300
11/26/2015, 16:30	3,400	- Drilling tags BRA.	1,454.34	300
11/27/2015, 19:28	3,403	- Resume drilling BRA.	1,454.49	400
11/29/2015, 22:15	3,790	- Tag PBRCM.	1,454.82	500
12/01/2015, 15:00	4,352	- End of drilling 18.5-in. borehole.	1,455.04	250
12/05/2015, 21:00	4,352	6. Minimum head in PM-3 before recovery.	1,455.43	0
12/11/2015, 00:30	4,352	7. Minimum psi in PM-3 before recovery.	1,454.82 (20.141 raw psi)	0
12/21/2015, 18:00	4,352	8. Concrete into fracture zone 3,157 to 2,999 ft bgs.	1,454.80	0
01/02/2016, 02:30	4,543	9. Drilling resumes/completes with 8.5-in. borehole.	1,454.97	0

[a] Barometer corrected.

-- = No values

FMI = Formation MicroImager

through 2-7, respectively. A significant increase in water production, interpreted as the initiation of the main pumping stress inducing the drawdown in PM-3-1, was encountered while drilling the CHZCM. The water production increased further while drilling the BRA. Water production was halted with the cessation of drilling upon completing the 18.5-in. borehole. During drilling, a geolograph records the date and time when each specific 1-ft depth is encountered below ground surface. Together with the drilling and production events recorded on the drilling morning reports, a production schedule was produced to be used as the pumping rate time series in the SeriesSEE (Table 3-2). The date and time of responses at PM-3 shown on the table were taken from the LTWLM datalogger that recorded the pressure corresponding to water levels of interest.

The following summary of significant events is included on Table 3-2. Vertical partitions corresponding to the dates are shown on Figure 3-6. The CHZCM was first encountered at 2,500 ft bgs. Drilling was suspended on November 19, 2015, to set the casing. After the casing was set, drilling resumed on November 24. Water production increased significantly when drilling encountered a fracture, later observed on an FMI log, on the afternoon of November 25. With heads previously rising in PM-3, this timing corresponded exactly to the timing of the maximum head, adjusted for atmospheric pressure, recorded at PM-3 during the drilling of the CHZCM, before leveling off and eventually drawing down. A pump rate of 300 gpm was used for the interval of time between encountering the fracture to reaching the BRA on November 26. Increased water production in the BRA was estimated at 400 gpm, increasing to 500 gpm when drilling resumed on November 27. Production dropped to 250 gpm when the PBRCM was encountered November 29, and ceased altogether when drilling ended with the completion of the 18.5-in. borehole. The head in PM-3, corrected for atmospheric pressure, reached a maximum before drawdown, and a minimum before recovery, on November 26 and December 5, respectively. The raw pressure in PM-3-1 reached a maximum before drawdown, and a minimum before recovery, on November 26 and December 11, respectively. These PM-3-1 responses indicate that drawdown was relatively quick with respect to increased production, within 24 hours, whereas recovery lagged the cessation of drilling production, beginning 4 to 10 days after drilling and production stopped December 1, 2015.

Residuals in the WLM indicated a reasonable fit of the simulation to the data, though they increased during the initial drawdown descent, as well as during some intervals of the recovery, possibly related to well completion activities. These activities include a significant volume of fluid introduced to the

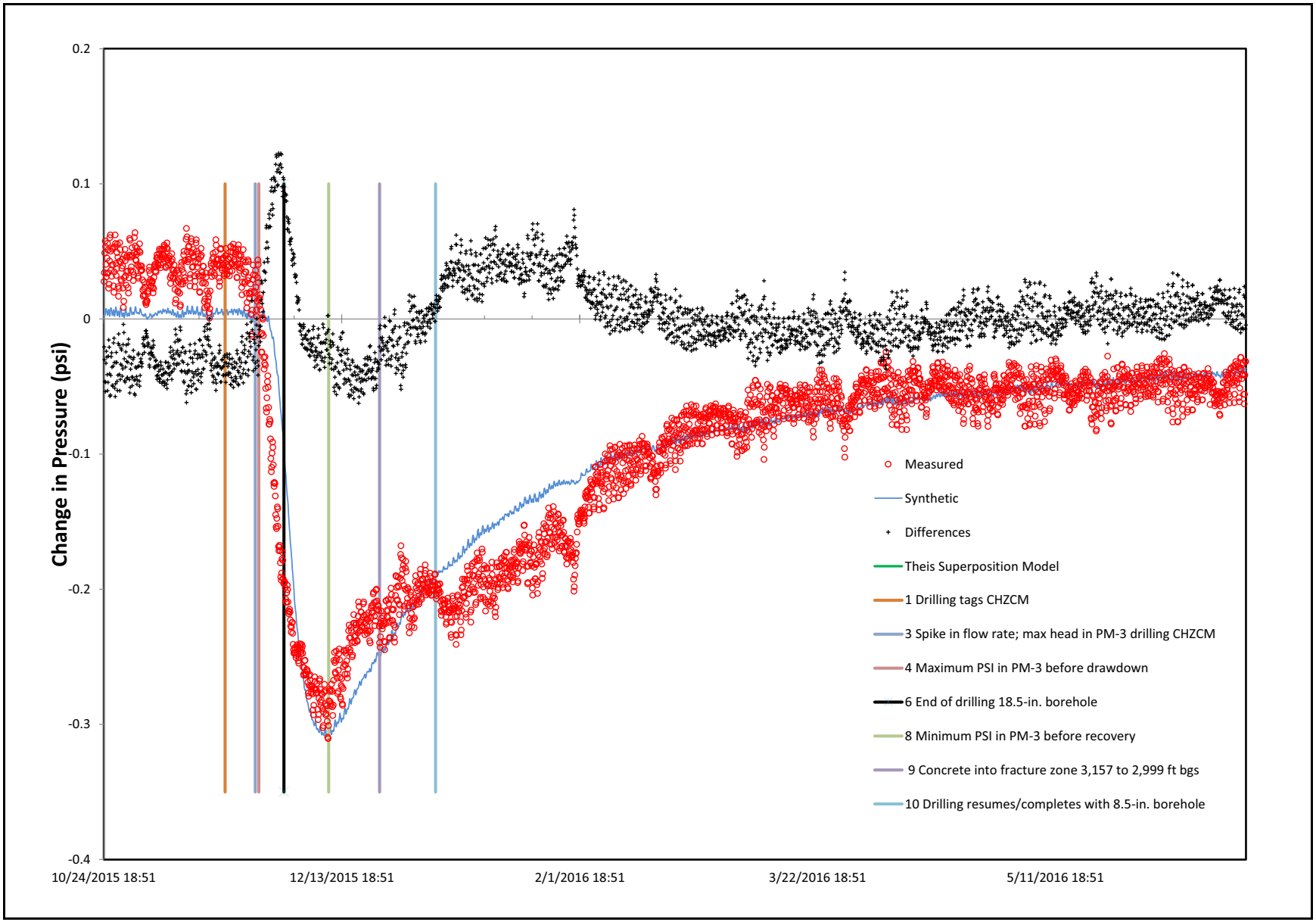

Figure 3-6
SeriesSEE Analysis of Measured PM-3-2 Water Levels (Red) Showing Simulated Levels (Blue), Theis Response (Green), Residuals (Black), and Events Affecting Drilling Production Rate at Well ER-20-12 (Vertical Bars)

borehole December 21, during cement operations for completing piezometer p3, and the continued drilling and completion of the smaller 8.5-in. borehole on January 2, 2016.

The combined series were collated into an Excel spreadsheet and imported into an SeriesSEE workbook. Several tools were used to remove known spikes in the data, as well as offset each signal so that the combined signals could be viewed at the same psia scale. Several choices are available for offsetting data; the option to offset each series to its first value was chosen to center each series about the origin. The 240-day analysis period was selected. The finalized input is shown in Figure 3-5. The corresponding SeriesSEE workbook (Excel file PM-3_p1_Series_SEE_version_04_ Simplified_Q_B_4obs_Tg_Td.xlsm) is on the DVD that accompanies Appendix E. The WLM model then generated the simulated result and calculated the residual with the data. The final result is shown in Figure 3-5. The corresponding SeriesSEE workbook (Excel file PM-3_PSI_version_04_ SUCCESSFUL_run_02_WLM_with_Events.xlsm) is on the DVD that accompanies Appendix E.

As shown in Figure 3-6, the Theis model drawdown component and its recovery comprises the major portion of analysis simulation. The corresponding drawdown curve observed in PM-3-2 corroborates that the responses are due to pumping. From the parameter estimation of the Theis components, composed of Theis transforms in response to the variable pumping schedule, a single value of transmissivity and storativity was estimated. The transmissivity of 349.4 m^2/day and storativity of 5.97×10^{-4} are considered to be within the reasonable range of the parameters in the volcanic HSUs of Pahute Mesa. Of note, the resulting transmissivity, which is representative of several aquifer and confining units above the PBRCM and at the scale of the distance between Wells ER-20-12 and PM-3, is about 2 orders of magnitude higher than the transmissivities obtained from other pump-test analyses for the PBRCM alone.

4.0 GEOLOGY AND HYDROGEOLOGY

4.1 Introduction

This section describes the geology and hydrogeology of Well ER-20-12. The following discussion and interpretations are primarily based on the detailed lithologic log presented in Appendix A. The detailed lithologic log was developed using the drill cuttings, sidewall cores, preliminary field lithologic log, and borehole geophysical and hydrophysical logs. Additional information with respect to the geometry and nature of bedding, flow features, and fractures was provided by NSTec geologists using the FMI (e.g., resistivity image log) geophysical log. This log provides detailed information with respect to the true dip and dip azimuth of bedding and fracture features observed in the borehole. This information was available only below the water table. Additionally, select cutting samples obtained from the borehole were analyzed by LANL scientists to provide confirmatory data derived from detailed petrographic, mineralogic, and geochemistry analysis to confirm stratigraphic unit and alteration assignments made based on visual observation and petrophysical data (geophysical logs).

4.2 Geology

The following subsections discuss the geologic setting of the Pahute Mesa area and Well ER-20-12 (see Section 4.2.1), the stratigraphy and lithology of units penetrated by Well ER-20-12 (see Section 4.2.2), and the alteration of the rocks in Well ER-20-12 (see Section 4.2.3). Detailed descriptions of the stratigraphy, lithology, and alteration found are provided in the detailed lithologic log provided in Appendix A. Tables 4-1 and 4-2 provide definitions of stratigraphic units and HSUs used respectively in various other figures and tables in this report.

4.2.1 Geologic Setting

Well ER-20-12 is located in the far northwestern portion of the NNSS, within the topographical margin of Western Pahute Mesa. Pahute Mesa is a high volcanic plateau within the southwestern Nevada volcanic field (Byers et al., 1976). Surface drainage in the vicinity of Well ER-20-12 is generally to the southwest through Thirsty Canyon. Physiographically, the well site lies east of the

Table 4-1
Key to Stratigraphic Units and Symbols of the Well ER-20-12 Area
(Page 1 of 2)

Stratigraphic Unit	Map Symbol
Thirsty Canyon Group	**Tt**
Trail Ridge Tuff	Ttt
Pahute Mesa Tuff	Ttp
Comendite of Ribbon Cliff	Ttc
Volcanics of Fortymile Canyon	**Tf**
rhyolite of Beatty Wash	Tfbw
Timber Mountain Group	**Tm**
Ammonia Tanks Tuff	Tma
Ammonia Tanks mafic-rich Tuff	Tmar
Ammonia Tanks bedded tuff	Tmab
Basalts of Bullfrog Hills	Tmt
Rainier Mesa Tuff	Tmr
Rainier Mesa bedded tuff	Tmrb
Rainier Mesa mafic-rich Tuff	Tmrr
Rainier Mesa mafic-poor Tuff	Tmrp
Rhyolite of Fluorspar Canyon	Tmrf
Paintbrush Group	**Tp**
Tiva Canyon Pahute Mesa Lobe	Tpcm
Calico Hills Formation	**Th**
Calico Hills rhyolitic lava	Thrl
Calico Hills mafic-rich Tuff	Thr
Calico Hills lithic-rich Tuff	Th
Calico Hills bedded tuff	Th
Crater Flat Group	**Tc**
Bullfrog Tuff	Tcb
Tram Tuff	Tct
Crater Flat bedded tuff	Tc
Belted Range Group	**Tb**
Comendite of Chartreuse	Tbdc
Grouse Canyon Tuff	Tbg
Comendite of Quartet Dome	Tbq

Table 4-1
Key to Stratigraphic Units and Symbols of the Well ER-20-12 Area
(Page 2 of 2)

Stratigraphic Unit	Map Symbol
Volcanics of Quartz Mountain	**Tq**
rhyolite of Handley	Tqj
middle rhyolite	Tqh
Paleozoic Rocks	**Pz (Undifferentiated)**

Table 4-2
Key to HSUs and Symbols of the Well ER-20-12 Area

HSU	Map Symbol
Thirsty Canyon volcanic aquifer	TCVA
Timber Mountain welded-tuff aquifer	TMWTA
Timber Mountain lower vitric-tuff aquifer	TMLVTA
Upper Paintbrush confining unit	UPCU
Calico Hills zeolitic composite unit	CHZCM
Belted Range aquifer	BRA
Pre-Belted Range composite unit	PBRCM

topographic expression of the Black Mountain caldera and its structural margin, and west of the topographic and structural margins of the buried Silent Canyon caldera complex (SCCC).

Figure 4-1 shows the location of Well ER-20-12, the surficial geology, and the prominent structural and caldera boundaries. Much of Pahute Mesa overlies the buried SCCC, which consists of two overlapping calderas: the Grouse Canyon caldera and the younger Area 20 caldera (Sawyer and Sargent, 1989). These calderas were formed by voluminous eruptions of ash-flow tuffs of generally rhyolitic composition, between approximately 14 million years ago (Ma) and 13 Ma (Sawyer et al., 1994). The SCCC was eventually filled and buried by younger tuff and lava erupted from nearby vents and calderas between approximately 13 Ma and 9 Ma. In the vicinity of Well ER-20-12, these caldera-filling and -burying volcanic units, from oldest to youngest, include tuff and lava of the Crater Flat Group (Tc), the Calico Hills Formation (Th), and the Paintbrush Group (Tp). Overlying these units is a series of welded ash-flow tuffs—including the Rainier Mesa Tuff (Tmr), Ammonia Tanks Tuff (Tma), Rocket Wash Tuff (Ttr), Pahute Mesa Tuff (Ttp), and Trail Ridge Tuff (Ttt)—which cap much of Pahute Mesa (Slate et al., 1999). The Rainier Mesa Tuff (Tmr) and Ammonia

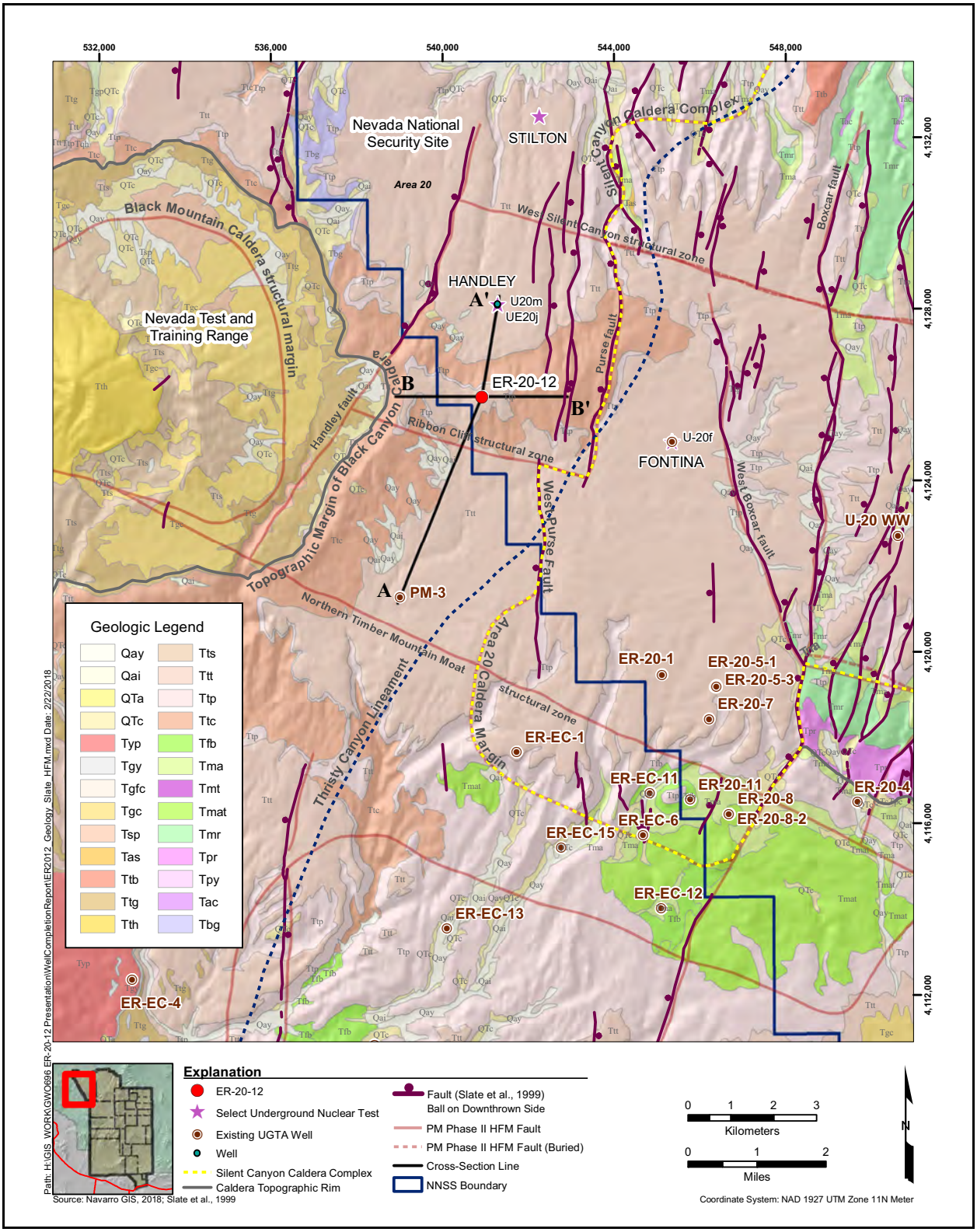

Figure 4-1
Surface Geologic Map of the Well ER-20-12 Area

Tanks Tuff (Tma) were erupted 11.6 and 11.45 Ma, respectively, from the Rainier Mesa and Ammonia Tanks calderas (Sawyer et al., 1994), both of which are part of the Timber Mountain caldera complex (TMCC), located just south of Well ER-20-7. The Pahute Mesa Tuff (Ttp) and Trail Ridge Tuff (Ttt) were erupted 9.4 and 9.3 Ma, respectively, from the Black Mountain caldera (Slate et al., 1999) located west of Well ER-20-12. The Trail Ridge Tuff (Ttt) forms the ground surface at the well site. (Figure 4-1). In general, the area surrounding Well ER-20-12 consists of relatively flat-lying Miocene-age volcanic rocks, predominately nonwelded to densely welded ash-flow tuff, lavas, and bedded tuffs. Given the present understanding of groundwater flow in the area of Well ER-20-12, the well is downgradient of the STILTON (U20p) and HANDLEY (U20m) UGTs.

Major structural features in the vicinity of Well ER-20-12 are related in some degree to caldera formation; the notable exception may be the Thirsty Canyon lineament, which likely predates caldera formation. Significant nearby geologic structural features are shown in Figure 4-2, including the Ribbon Cliff structural zone (RCSZ) and the Northern Timber Mountain Moat structural zone (NTMMSZ), both of which lie to the south of the well location approximately 1.2 km (0.8 mi) and 5.7 km (3.6 mi), respectively. These west–northwest-trending structures are inferred geophysically by Mankinen et al. (1999) and Grauch et al. (1997), and suggest a down-to-the-southwest normal sense of displacement to the fault blocks. Recent drilling as part of the Pahute Mesa-Oasis Valley (PM-OV) Phase I drilling (DOE/NV, 2000) confirmed that a displacement exists along the NTMMSZ of as much approximately 244 m (800 ft). Based on these observations, the RCSZ may have similar displacement, also to the southwest. The Handley fault lies approximately 2.8 km (1.74 mi) to the west, and West Silent Canyon structural zone lies approximately 4.27 km (2.65 mi) to the north. The Purse fault and the Thirsty Canyon lineament (Mankinen et al., 1999; Grauch et al., 1997) are prominent structural features or zones located approximately 2.81 km (1.75 mi) and 3.30 km (2.05 mi), respectively, to the east of Well ER-20-12 location and bound the SCCC to the west.

The Thirsty Canyon lineament is recognized only from its geophysical expression, as shown in Figure 4-3. The lineament appears to be a significant structural feature that extends approximately 38.9 km (24.2 mi) beginning in the area of Oasis Valley to the southwest and extending along a generally northeast direction, where it passes east of Well ER-20-12, in the vicinity of the Purse fault. The Thirsty Canyon lineament appears to predate the onset of volcanism in the area and may have influenced the location and formation of calderas in the region during the Miocene. The location of

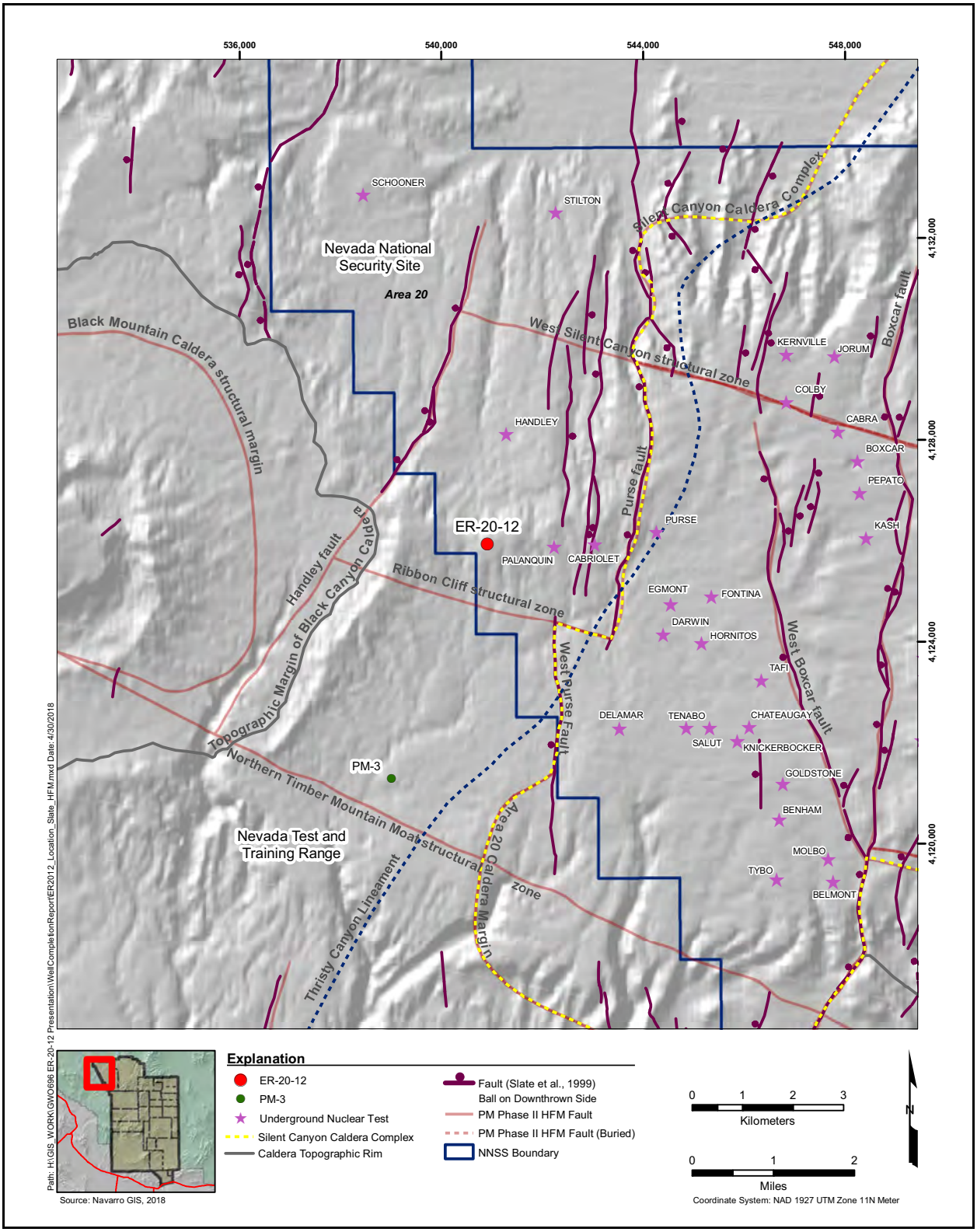

Figure 4-2
Geologic Structure Map of the Well ER-20-12 Area

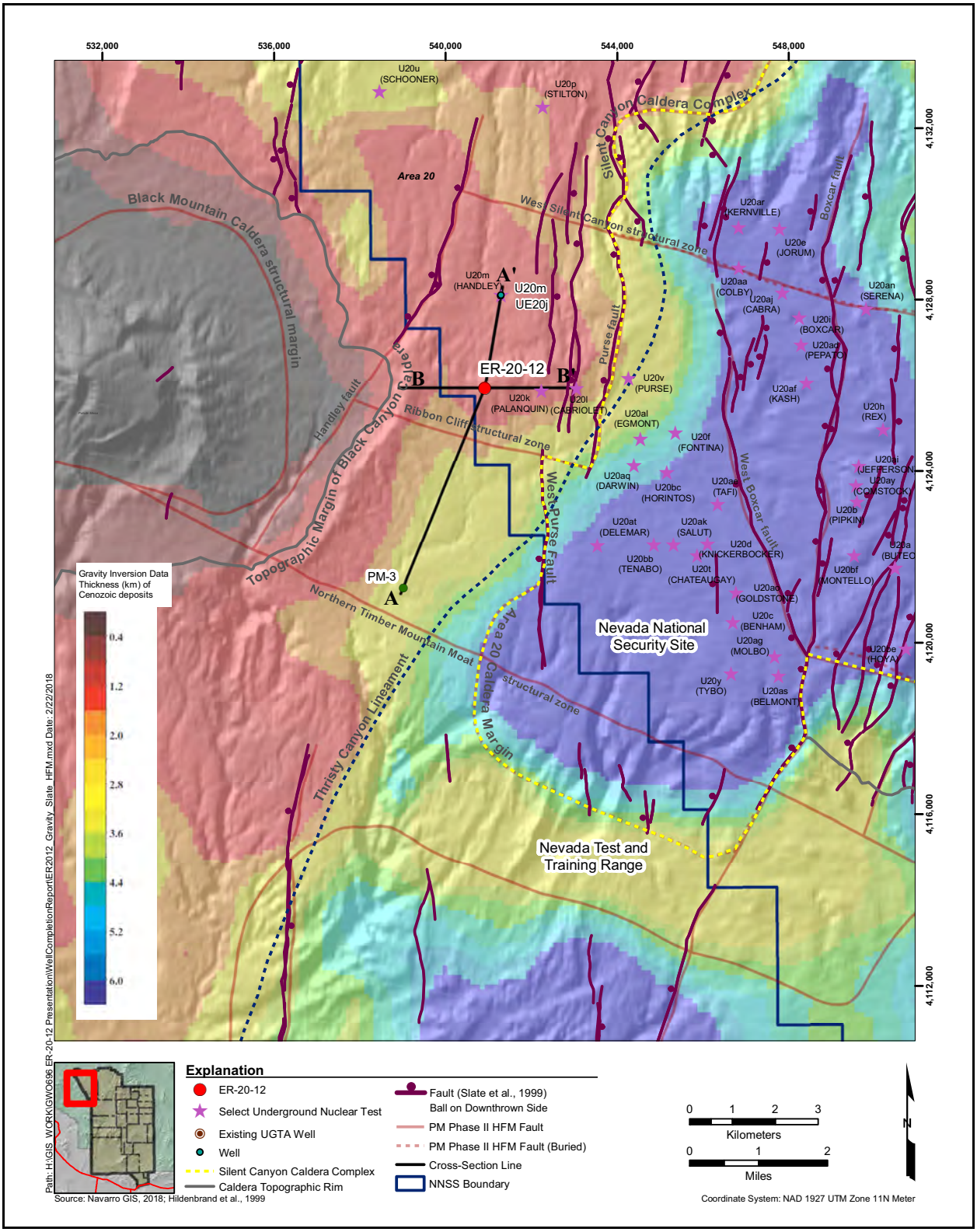

Figure 4-3
Gravity Inversion Map

the Purse fault also suggests that it may be sympathetic to the lineament and may be a near-surface expression of the more prominent yet buried Thirsty Canyon lineament structural feature.

Geophysical data acquired using gravity inversion and resistivity techniques (such as audio-magnetotelluric), which were used to help define the Thirsty Canyon lineament, suggest that areas to the west of the lineament along the approximate trace along the SCCC margin (Purse fault)—and, more specifically, in the area of Well ER-20-12—may be suggestive of a structural high along the SCCC margin. This structural high, as inferred from these geophysical surveys, may represent the presence of Pre-Cenozoic rocks bounding the SCCC at relatively shallow depths from the present surface. This structural high, if present, would likely be in the area of Well ER-20-12 and would extend along the western margin of the SCCC to the southwest and to the northeast. Numerous other normal faults have also been mapped on the surface in Pahute Mesa (Slate et al., 1999); these faults are shown on Figure 4-2.

4.2.2 Stratigraphy and Lithology

The stratigraphic and lithologic units penetrated in Well ER-20-12 are illustrated in Figure 4-4, and the distribution of stratigraphic units in the vicinity of the well is shown in cross section in Figure 4-5. Complete lithologic descriptions, stratigraphic assignments, and their respective depth intervals can be found in Appendix A. Identification of stratigraphic and lithologic units was aided by correlation with nearby boreholes (U-20m PS 1D, PM-3, UE-20j, U-20p), and the PM-OV HFM (BN, 2002). In addition, subsequent petrographic and chemical analysis (X-ray diffraction [XRD]/X-ray fluorescence [XRF]), as performed by LANL, was helpful in the identification and confirmation of stratigraphic assignments.

Drilling at Well ER-20-12 started in moderately to densely welded ash-flow tuffs assigned to the Trail Ridge Tuff (Ttt) of the Thirsty Canyon Group (Tt), which forms the ground surface in the vicinity of the well. The Thirsty Canyon Group (Tt) erupted between 9.15 and 9.4 Ma from the Black Mountain caldera (Sawyer et al., 1994) located approximately 1.99 km (1.23 mi) to the west. The initial samples collected from approximately 21.3 m (70 ft) bgs were bedded tuffs to nonwelded ash-flow tuffs of the Trail Ridge Tuff (Ttt), and the base of the unit was identified at 38.1 m (125 ft) bgs. Below the Trail Ridge Tuff (Ttt) was 33.5 m (110 ft) of nonwelded to moderately welded Pahute Mesa Tuff (Ttp), and 199.7 m (655 ft) of the Comendite of Ribbon Cliff (Ttc). The Comendite of Ribbon Cliff (Ttc)

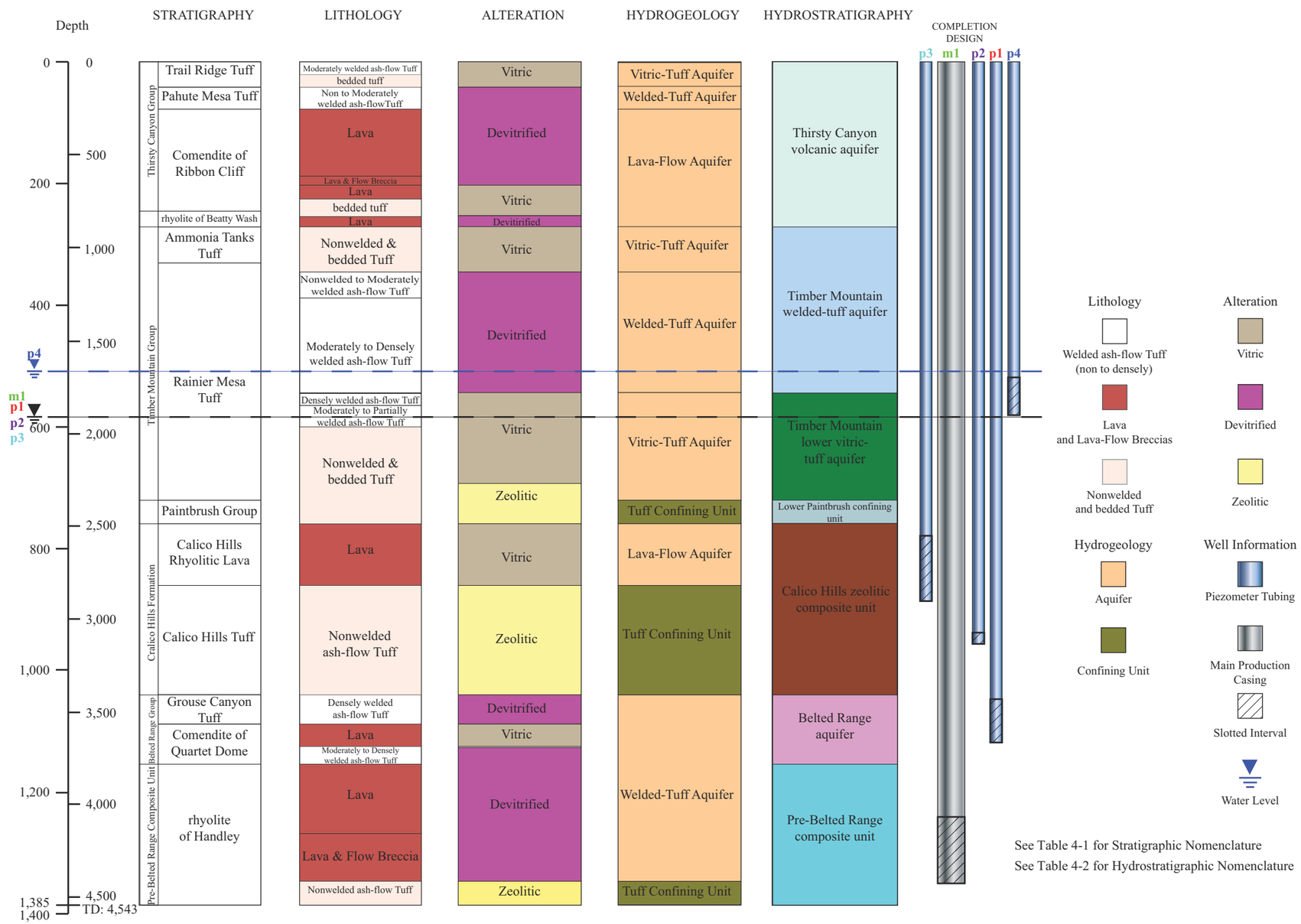

Figure 4-4
Graphical Presentation Showing Geology and Hydrogeology for Well ER-20-12

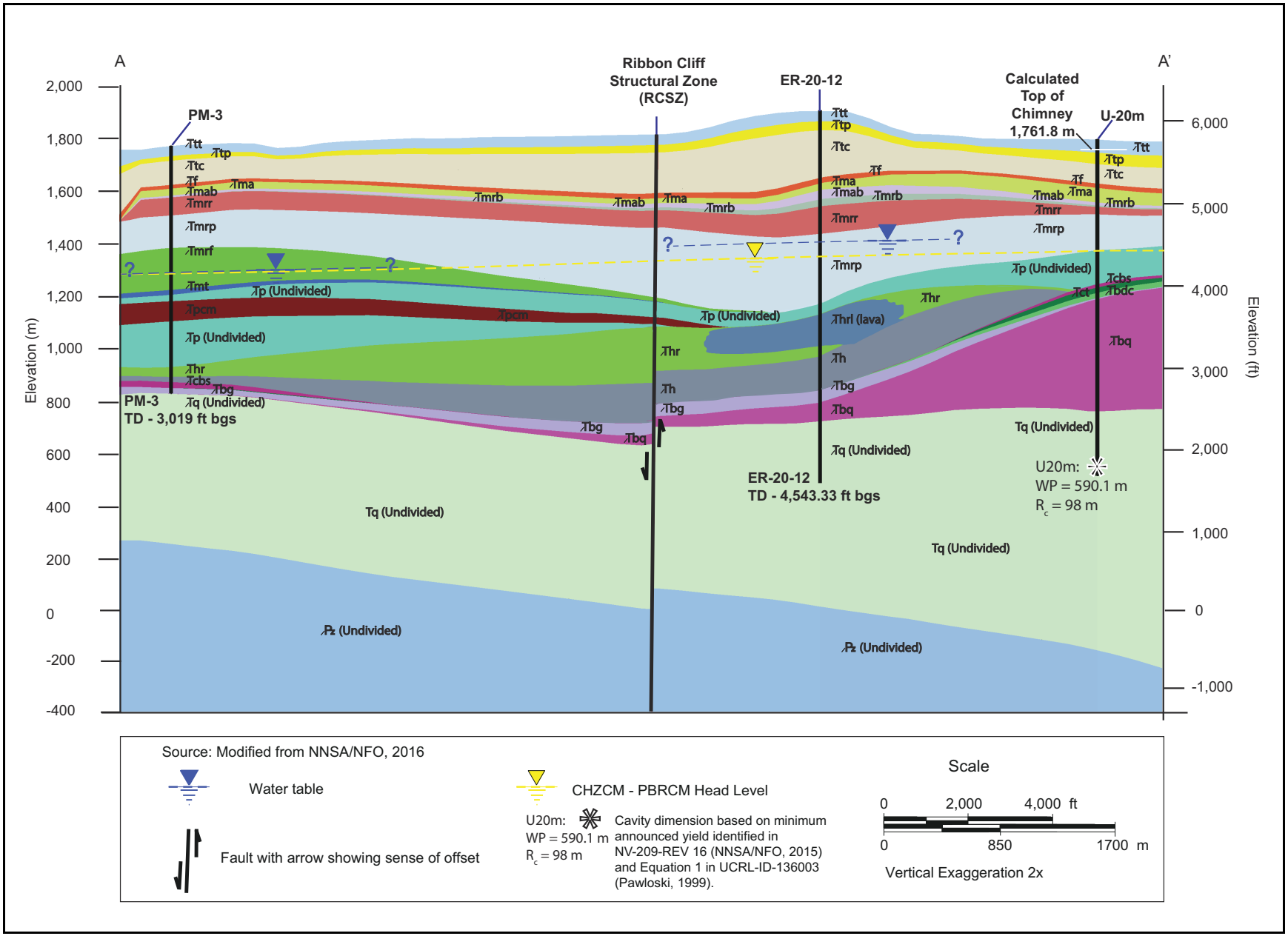

Figure 4-5
Southwest–Northeast Stratigraphic Cross Section A–A' through Well ER-20-12

consists of a series of lavas, lava-flow breccia, and basal bedded tuff. This unit was thicker than predicted. A total of 251.5 m (825 ft) of the Thirsty Canyon Group (Tt) was penetrated.

The Volcanics of Fortymile Canyon (Tf), rhyolite of Beatty Wash (Tfbw) was encountered below the Thirsty Canyon Group (Tt). Well ER-20-12 penetrated a total of 21.0 m (69 ft) from 251.5 to 272.5 m (825 to 894 ft) of devitrified and vapor phase altered lavas. The rhyolite of Beatty Wash (Tfbw) was identified based on stratigraphic position between the Thirsty Canyon Group (Tt) and the Timber Mountain Group (Tm) as well as the lack of lithics and pumice fragments in the lava.

The Timber Mountain Group (Tm) was encountered after penetrating a thin interval of the Volcanics of Fortymile Canyon (Tf). The Timber Mountain Group (Tm) is composed of the Ammonia Tanks Tuff (Tma), which erupted 11.45 Ma, and the Rainier Mesa Tuff (Tmr), which erupted 11.6 Ma from the TMCC (Sawyer et al., 1994) located approximately 25.6 km (16 mi) to the southwest. The borehole penetrated 452.9 m (1,486 ft) of Timber Mountain Group (Tm) tuffs from 272.5 to 725.4 m (894 to 2,380 ft). Timber Mountain Ammonia Tanks mafic-rich Tuff (Tmar) was penetrated from 272.5 to 297.2 m (894 to 975 ft), and was identified based on its stratigraphic position below the Thirsty Canyon Group (Tt) and on the mineralogic assemblage, including terminated and dipyramidal quartz crystals, biotite, and sphene. The Timber Mountain Ammonia Tanks and Rainier Mesa bedded tuffs (Tmab/Tmrb) follows from 297.2 to 358.1 m (975 to 1,175 ft). These units are recognizable based on the highly concentrated crystal fragment content due to most of the vitric ash being washed away by the drilling process.

Below the Timber Mountain Ammonia Tanks and Rainier Mesa bedded tuffs (Tmab/Tmrb) is a thick section of Timber Mountain Rainier Mesa Tuff (Tmr) identified by its stratigraphic position and the mineralogic assemblage, including the presence of terminated quartz, and biotite. The Timber Mountain Rainier Mesa Tuff (Tmr) is subdivided as follows: from 358.1 to 460.3 m (1,175 to 1,510 ft) is assigned to the Rainier Mesa mafic-rich Tuff (Tmrr); and from 460.3 to 710.2 m (1,510 to 2,330 ft) is assigned to the Rainier Mesa mafic-poor Tuff (Tmrp). A densely welded vitrophyre occurs within this unit from 551.7 to 562.7 m (1,810 to 1,846 ft). Also, this portion of the borehole, from the vitrophyre and below, is vitric with a gradual downward transition to devitrified ash-flow tuffs followed by zeolitic/argillic alteration; from 710.2 to 725.4 m (2,330 to 2,380 ft) is the Rainier Mesa bedded tuff (Tmrb), which marks the base of the Timber Mountain Group (Tm). The water

table occurs with the upper portion of the Tmrr with an observed DTW of approximately 492.2 m (1,615 ft) bgs.

The Paintbrush Group (Tp), undifferentiated, was encountered from 725.4 to 760.5 m (2,380 to 2,495 ft) for a total of 35.1 m (115 ft) penetrated. The unit consists of crystal-poor ash-flow tuffs and is pervasively zeolitized. The Paintbrush Group (Tp) is represented wholly by a thin zeolitic ash-flow tuff. The Paintbrush Group (Tp) rocks erupted from calderas and vents that appear to be coincident with the TMCC between 12.7 and 12.8 Ma (Sawyer et al., 1994).

Below the Paintbrush Group (Tp), Well ER-20-12 penetrates a predominantly vitric lava flow and an underlying series of partially zeolitized ash-flow tuffs from 760.5 to 1,035.7 m (2,495 to 3,398 ft). The lava and underlying ash-flow tuffs are assigned to the Calico Hills Formation (Th). The assignment was based on stratigraphic position below the Paintbrush Group (Tp) and the mineral assemblage observed, consisting of phenocrysts of quartz (terminated, frosted to clear, no resorption texture; biotite and textural features). Detailed petrographic and chemical analysis performed by LANL on cuttings samples selected from this interval also confirm the Calico Hills Formation (Th) assignment. The lava within the upper portion of the interval between 758.9 to 871.7 m (2,490 to 2,860 ft) bgs exhibits a typical rhyolitic lava-flow profile (i.e., pumiceous lava top, vitrophyric layer, stoney core, basal vitrophyric layer, basal flow breccia underlain by a pumice fall). The underlying nonwelded to lower lithic-rich ash-flows tuffs are variably zeolitic. Notably, this interval contributed significantly to the produced groundwater flow observed during drilling, based on the fractured nature of both the underlying lavas and ash-flow tuffs (Figures 2-5 through 2-7).

Well ER-20-12 next penetrated rocks of the Belted Range Group (Tb). Belted Range Group (Tb) units erupted from the now-buried Grouse Canyon caldera, which is included as part of the SCCC located approximately 14 km (8.67 mi) east of the Well ER-20-12 location. Although the exact location of the Grouse Canyon caldera is uncertain, as it is deeply buried in the SCCC, it is clear based on the outflow geometries of the ash-flow tuffs such as the Grouse Canyon Tuff (Tbg) that they are sourced from within the SCCC. The eruption of these units took place between 13.85 and 13.5 Ma (Sawyer et al., 1994). A total of 48.2 m (158 ft) of Grouse Canyon Tuff (Tbg) was identified in Well ER-20-12; the unit was intercepted from 1,035.7 to 1,083.9 m (3,398 to 3,556 ft), including 4.9 m (16 ft) of a basal bedded tuff. Underlying the Grouse Canyon Tuff (Tbg) was 71.6 m (235 ft) of the Comendite of Quartet Dome (Tbq) that was penetrated from 1,083.9 to 1,155.5 m (3,556 to

3,791 ft). The Comendite of Quartet Dome (Tbq) consists of a lava flow, vitrophyric to partially altered, and a moderately to densely welded ash-flow tuff. Alternatively, the ash-flow may also be interpreted as a devitrified lava. The Belted Range units contributed significantly to the observed groundwater production during drilling, which is supported by the nature of fracturing observed in cuttings and resistivity image logs such as the FMI.

Pre-Belted Range rocks were encountered beginning at 1,155.5 m (3,791 ft) bgs. The rhyolite of Handley (Tqj)—consisting of a series of lavas, lava and flow breccia, and a lower nonwelded ash-flow tuff—was intercepted from 1,155.5 to 1,384.8 m (3,791 to 4,543.33 ft) bgs for a total thickness of 229.3 m (752.33 ft). The source of these Pre-Belted Range rocks is believed to be eruptions related to within the SCCC. However, these rocks are not well known, and the information related to these units is restricted to deeper boreholes located near the location of Well ER-20-12, including Wells U-20m PS 1D and UE-20j. Well ER-20-12 was drilled to a TD of 1,384.8 m (4,453.33 ft) bgs; at this depth, the borehole continued to penetrate nonwelded ash-flow tuffs of the rhyolite of Handley (Tqj).

4.2.3 Alteration

The volcanic rocks of the Thirsty Canyon Group (Tt), Volcanics of Fortymile Canyon (Tf), and the Timber Mountain Group (Tm) are a mixture of nonwelded to densely welded tuffs, bedded tuffs, and lavas. Unaltered rocks include nonwelded and bedded tuffs that have retained their original vitric (i.e., glassy character). The welded portions of the ash-flow tuffs are mostly devitrified as a result of recrystallization of the original glass matrix to microcrystalline quartz and feldspars during cooling and degassing as the welding process progressed. Portions of the lavas are also locally devitrified. Generally, from 0 to 725.4 m (0 to 2,380 ft) bgs, the nonwelded tuffs and bedded tuffs are vitric to partially devitrified with some minor argillic alteration and/or vapor phase alteration; lavas and densely to moderately welded tuffs at Well ER-20-12 are typically mostly devitrified. The exception to this is the Timber Mountain Rainier Mesa Tuff (Tmr) vitrophyre and lower moderately to nonwelded subzones, which are vitric to partially vitric. Below 725.4 m (2,380 ft) bgs, beginning with the Paintbrush Group (Tp) nonwelded tuffs, the nonwelded tuffs are typically variably but pervasively altered to zeolites, and locally argillized. Lavas along with moderate to densely welded tuffs are less altered and variably devitrified. Due to the dense nature of the glass, the lavas of the Calico Hills Formation (Th) and the Comendite of Quartet Dome (Tbq) are vitric to devitrified with very minor

incipient zeolitic or argillic alteration. Portions of the Comendite of Quartet Dome (Tbq) and the rhyolite of Handley (Tqj) show strong devitrification textures overprinted by apparent quartzo-feldspathic alteration. Near the TD of the well, the rhyolite of Handley (Tqj) from 1,268.9 to 1,347.2 m (4,160 to 4,420 ft) bgs exhibits apparent chloritic alteration.

4.3 Predicted and Actual Geology

The observed stratigraphic sequence and lithology encountered in Well ER-20-12 differed from the predicted stratigraphy and associated lithologies in a number of areas, as shown in Figure 4-6. This is not surprising, as the subsurface geology in the area of Well ER-20-12 is not particularly well constrained with the exception of a few nearby wells (i.e., U-20m PS 1D, UE-20j, and PM-3). Although these wells provide some sense of the stratigraphic package of rock units locally present, the location of ER-20-12 near the western edge of the SCCC presents some uncertainty with respect to structural influences and the thickness of units related to their nature (i.e., lavas) and their respective eruptive sources. Differences between predicted and actual geology in boreholes are not uncommon, especially in areas with minimal geologic controls. These differences arise from the complex relationships between topographic, volcanic, and structural processes within caldera forming systems. The principal stratigraphic differences between the predicted stratigraphy and the actual stratigraphy beginning at the surface were that the Thirsty Canyon Group (Tt) was approximately 73.1 m (240 ft) thicker than predicted; this is principally attributed to the increased thickness of the lavas present within Comendite of Ribbon Cliff (Ttc). The Timber Mountain Group (Tm) was approximately 36.6 m (120 ft) thicker, and the Paintbrush Group (Tp) was approximately 36.6 m (120 ft) thinner. The Calico Hills Formation (Th) was not expected to be present at Well ER-20-12 and was thought to be restricted to the SCCC to the east of the well location. Well ER-20-12 intersected approximately 102.1 m (335 ft) of the Calico Hills rhyolitic lava (Thrl), approximately 42.7 m (140 ft) thicker than the predicted thickness of the Bullfrog and Tram Formations thought to be present. The underlying Belted Range Group (Tb), consisting of the Grouse Canyon Tuff (Tbg) and Comendite of Quartet Dome (Tbq), was approximately 36.6 m (120 ft) thicker. The Volcanics of Quartz Mountain (Tq), the rhyolite of Handley (Tqj) was encountered approximately 213.4 m (700 ft) lower than anticipated. In addition, the predicted zone of groundwater saturation was apparent at a slightly higher level within the Timber Mountain Group (Tm) units.

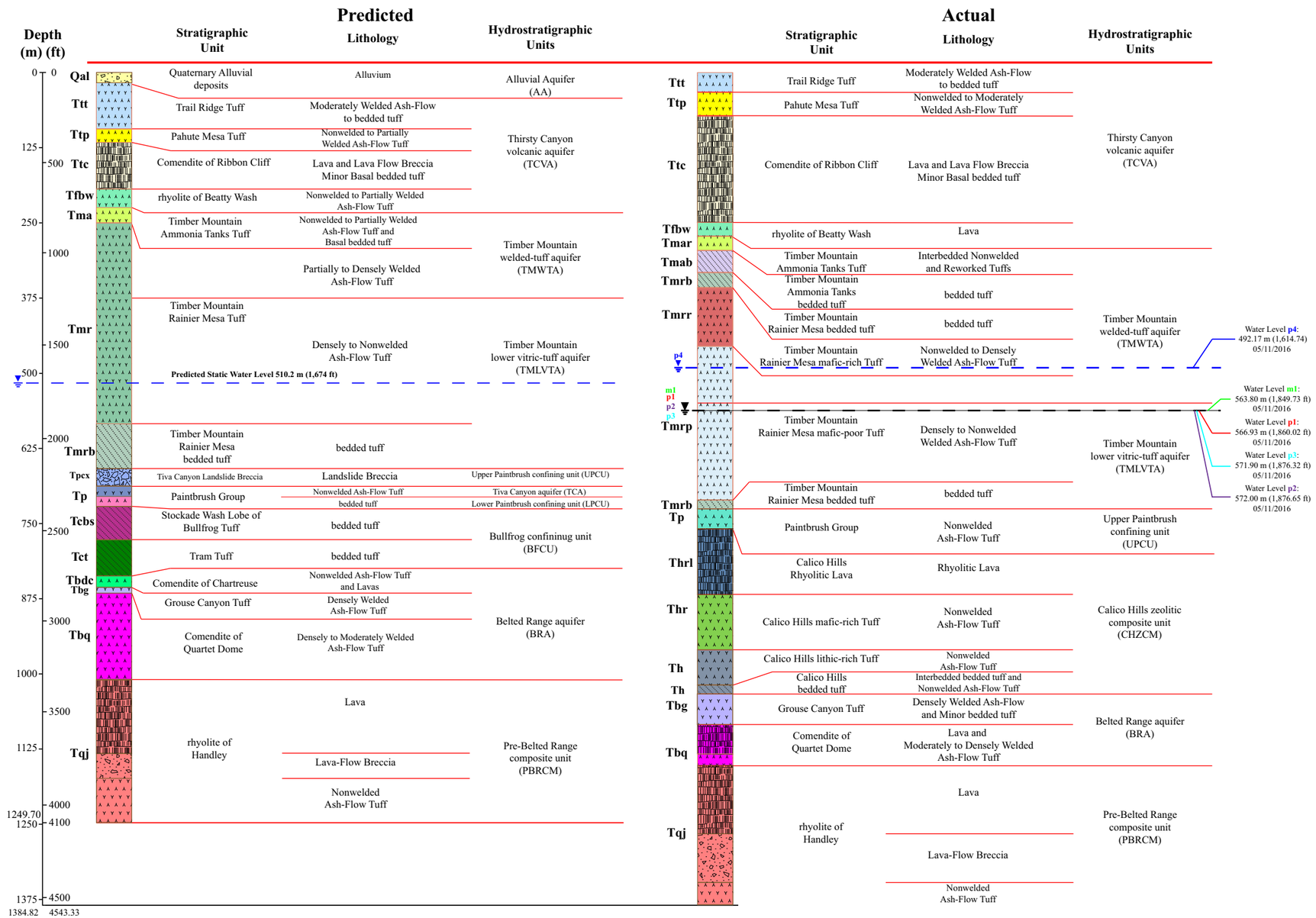

Figure 4-6
Predicted and Actual Stratigraphy at Well ER-20-12

A review of resistivity image logs (FMI) acquired in the open borehole during the drilling of Well ER-20-12 provided information on the nature of fracture and bedding within units encountered in the borehole. Due to the nature of the FMI logging tool, this information is available only for units penetrated below the water table at approximately 492.2 m (1,615 ft) bgs. Bedding planes from approximately 548.6 to 731.5 m (1,800 to 2,400 ft) bgs are generally flat lying with dips between 0 to 10 degrees, while from approximately 853.4 to 1,371.6 m (2,800 to 4,500 ft) bgs the dip ranges from 10 to 35 degrees. The change in dip magnitude and azimuth of bedding plane features suggests that geologic or structural processes were active, up to and including the eruption and deposition of, at least portions of the Calico Hills Formation (Th). Units from the Paintbrush Group (Tp) and above appear to have shallower bedding dips and a different azimuth orientation of bedding features. These geometries suggest the structural influences in the area had subsided, allowing the younger Timber Mountain and Thirsty Canyon units to be deposited with more flat-lying dips. Figures 4-7 and 4-8 provide cross-section views of the hydrostratigraphy and show the observed bedding geometries noted at the contacts between units.

As a part of the effort to better understand the geology at depth in the area of Well ER-20-12, gravity inversion data (Hildenbrand et al., 1999) as shown in Figure 4-2 was integrated into the PM-OV HFM and referenced in cross-sectional views through Well ER-20-12 as shown in Figures 4-7 and 4-8. The gravity anomalies expressed in these cross sections are shown as thicknesses of Cenozoic units. When rendered in these cross sections, the most conservative gravity measurements are presented and, as such, are biased to a show a greater thickness of Cenozoic units than actually calculated in the original reporting (Hildenbrand et al., 1999). This measured gravity inversion data, when shown in cross section (Figures 4-7 and 4-8), provide the estimated depth to Pre-Cenozoic units in the area. These data in conjunction with geologic data from Wells ER-20-12, PM-3, and U-20m PS 1D allowed for interpretation of the presence of Pre-Cenozoic units in the subsurface beyond the depth of Well ER-20-12. The data suggest that the Pre-Belted Range units may be thinner than previously thought, and a possible structurally influenced high area of Pre-Cenozoic units may exist in the area of Well ER-20-12. This portion of Pahute Mesa is located to the west of the Grouse Canyon and Area 20 calderas, which are included in the larger SCCC. The western margin of these calderas was likely influenced or controlled by the Thirsty Canyon lineament. It is postulated that gravity expression of Thirsty Canyon lineament, as shown in Figure 4-3, suggests a structural high to the west of the lineament, which appears coincident with the structural margin of the SCCC.

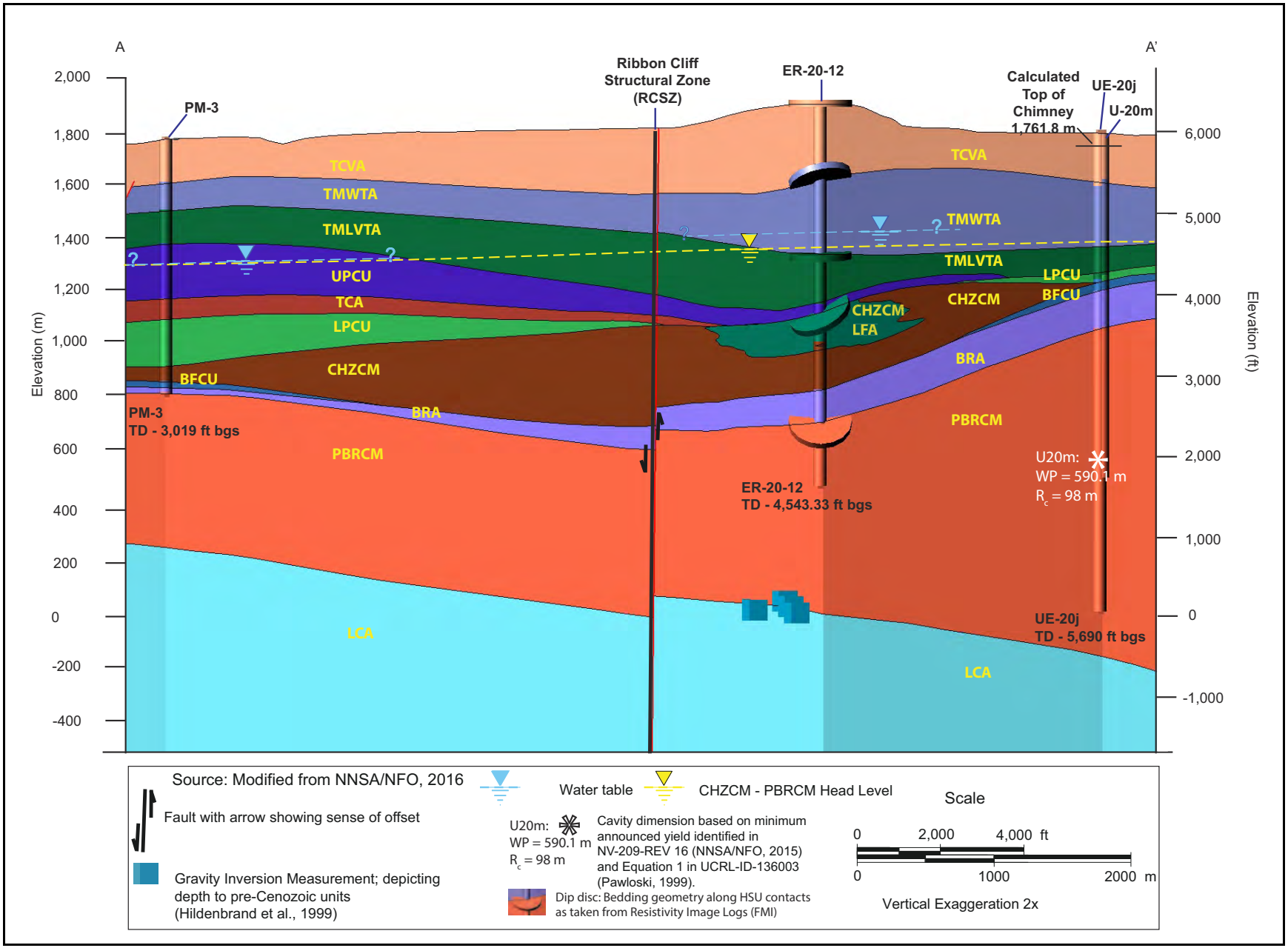

Figure 4-7
Southwest–Northeast Hydrostratigraphic Cross Section A–A' through Well ER-20-12

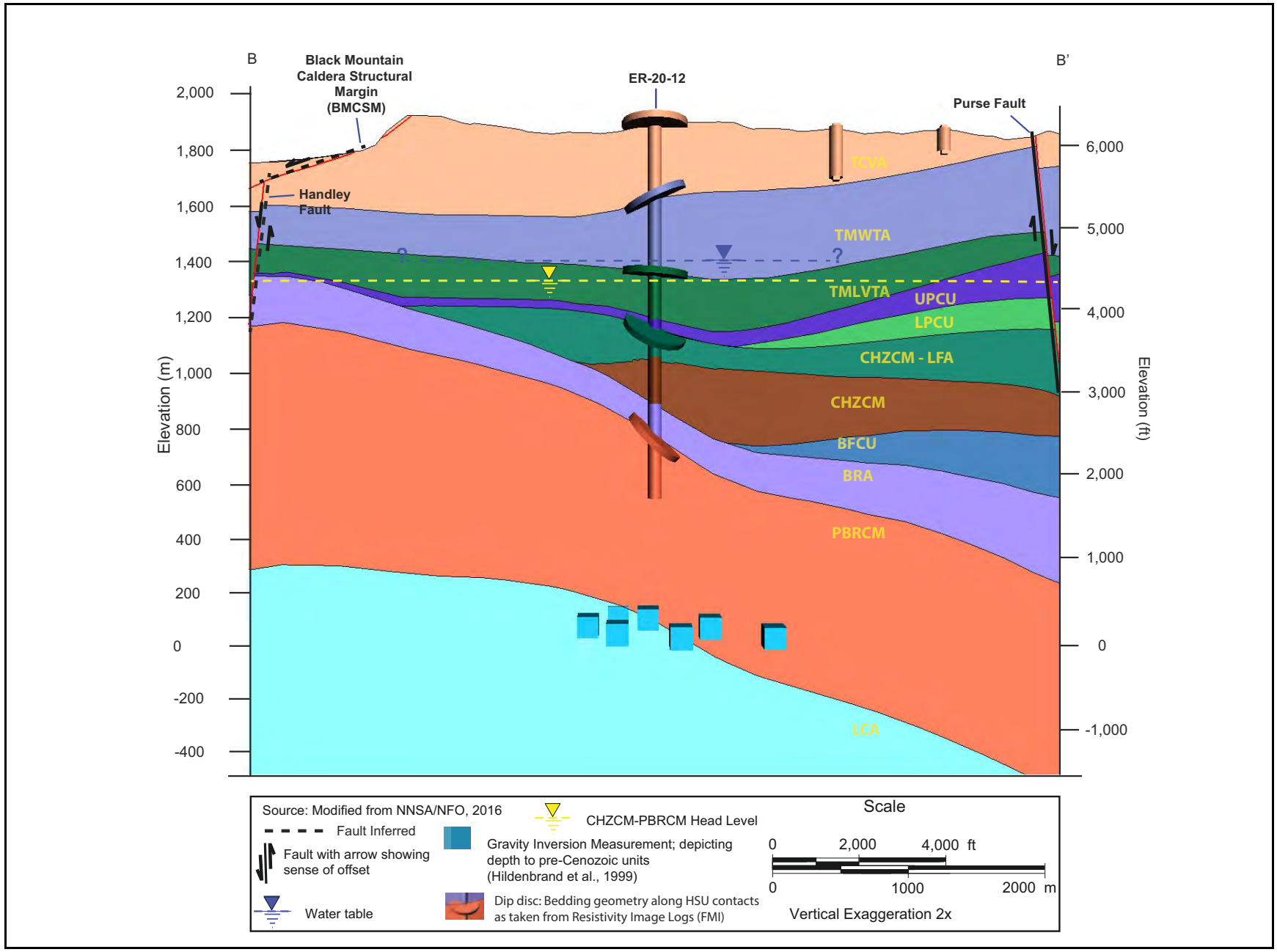

Figure 4-8
East–West Hydrostratigraphic Geologic Cross Section B–B' through Well ER-20-12

4.4 Hydrogeology

The saturated portion of Well ER-20-12 consists of a series of predominantly aquifer-type rocks. These rocks are hydrogeologically assigned to WTAs, VTAs, and LFAs. The package of aquifer-type rock units is divided by tuff confining units that consist of zeolitically altered nonwelded ash flows. The nonwelded tuffs of the Paintbrush group (Tp) are altered to zeolite and locally argillized, and separate the WTAs above from the LFAs of the Calico Hills Formation (Th) below. The nonwelded and zeolitic altered tuffs of the Calico Hills Formation (Th) that underlie the lavas of the Calico Hills Formation (Th), although altered, appear to be productive based on water production estimates during drilling. This productivity appears to be related to the extent of fracturing observed within this unit. Below the Calico Hills Formation (th), Well ER-20-12 encountered predominantly LFAs and WTAs assigned stratigraphically to the Belted Range Group (Tb) and those units of the Pre-Belted Range rocks. Figure 4-6 shows the predicted versus actual stratigraphy and hydrostratigraphic assignments.

The distribution of HSUs in the vicinity of Well ER-20-12 is shown in cross section in Figures 4-7 and 4-8. The well penetrated a total of seven HSUs: the TCVA (unsaturated), TMWTA (saturated below 492 m [1,615 ft] bgs), TMLVTA (saturated), UPCU (saturated), CHZCM (saturated), BRA (saturated), and PBRCM (saturated).

Before drilling, it was predicted that the water table would be encountered at 510.2 m (1,674 ft) bgs within the WTA of the Rainier Mesa Tuff (Tmr). This water level occurs with the lower WTA in the Rainier Mesa Tuff (Tmr). The observed water table measured on May 11, 2016, was 492.2 m (1,614.74 ft) bgs and was found to occur at a somewhat higher than predicted level but, as predicted, within the WTA of the Rainier Mesa Tuff (Tmr). During drilling, water production was first noted in Well ER-20-12 at approximately 519.7 m (1,705 ft) bgs in the TMWTA, approximately 30.48 m (100 ft) below the subsequent measurement of the water table at approximately 492 m (1,615 ft) bgs.

During drilling operations, the 66.04-cm (26-in.) borehole was advanced to the tuff confining unit within the Paintbrush Group (Tp), and 50.80-cm (20-in.) surface casing was installed to provide hydraulic isolation of the saturated TMWTA and the TMLVTA. Drilling was continued in saturated lavas and WTAs below to a depth of 1,384.7 m (4,543 ft) bgs. During drilling and construction, it was noted that the measured water levels within the borehole and subsequent cased completions on May 11, 2016, indicated a significantly lower water level in those WTA and LFA units below the UPCU. Measurements range from approximately 562.7 to 571.8 m (1,846 to 1,876 ft) bgs. These

measurements indicate a potential head difference of up to 79.8 m (262 ft) and indicate that the groundwater in the aquifers above the UPCU is isolated from the units below the confining unit. Figures 4-7 and 4-8 illustrate the observed differences in the measured water levels in cross section.

5.0 GROUNDWATER CHEMISTRY

This section presents an evaluation of groundwater chemistry data for ER-20-12 and other wells in the vicinity. Comprehensive groundwater chemistry evaluations for Pahute Mesa are presented in Thomas et al. (2002), Kwicklis et al. (2005), Rose et al. (2006), and Kwicklis (2009). This section integrates the new data northwest of the Thirsty Canyon lineament and east of the Black Canyon caldera with these earlier investigations in a qualitative manner. Wells included in this evaluation, along with the primary HSU sampled within each well, are presented in Figure 5-1.

5.1 Sample Collection and Analysis

Details of the sampling activities associated with ER-20-12 drilling operations are presented in the ER-20-12 completion report (NNSA/NFO, 2016), and those associated with WDT operations are presented in Sections 2.0 and 3.0 of this report. Navarro monitored discharged drilling fluids during borehole advancement for pH, temperature, and SEC and used these data to evaluate changes in groundwater conditions during drilling. In addition, depth-discrete wireline bailer samples were collected during drilling from a depth of 556 m (1,825 ft) bgs in the open borehole on November 6, 2015. Two sets of bailer/duplicate samples were collected on December 6, 2015: one from 1,082 m (3,550 ft) bgs and the other at 1,295 m (4,250 ft) bgs. Additionally, one set of bailer/duplicate samples was collected on January 4, 2016, from 1,319 m (4,328 ft) bgs. The depth-discrete bailer samples were analyzed by GEL.

Groundwater samples were collected from piezometer p1 on July 6, 2016, after a seven-day period of rod-pump well development, taken from the rod pump's wellhead sampling port. A total of 23,575 gal had been removed before sampling. Groundwater samples were collected from the main completion (m1) from the WDT pump on August 19, 2016, immediately after cyclic testing activities were completed. The well was developed from 20 cyclic pump tests over a period of nine days, each test lasting one to two hours, pumping at a rate of approximately 30 gpm. A total of 32,603 gal had been removed before sampling.

Laboratory analysis was conducted by LLNL for stable and radiometric isotopes, GEL for GWC analysis, and USGS for sulfur isotopes. GEL, the commercial laboratory, is certified by the State of

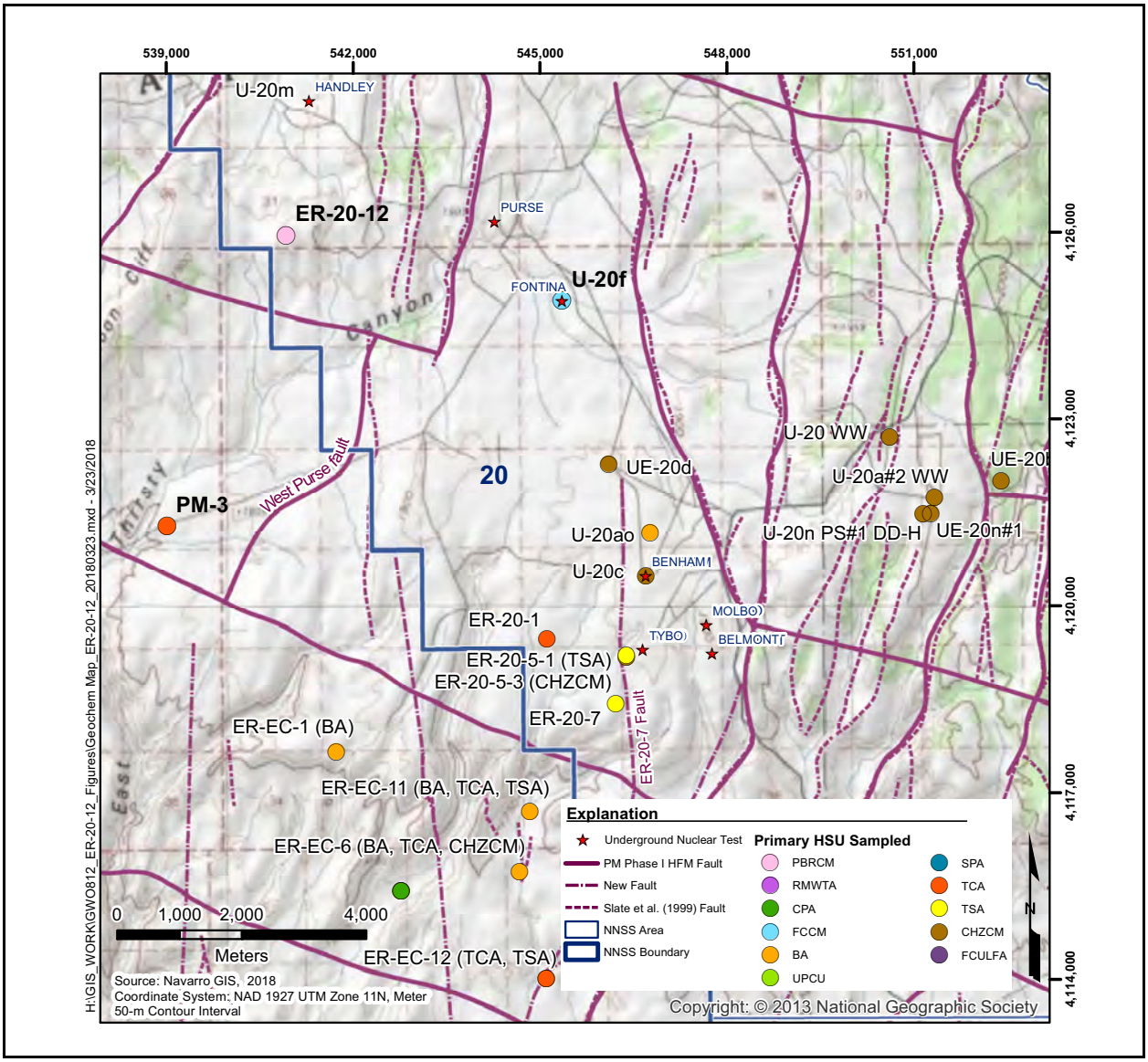

Figure 5-1
Sampling Locations

Note: The HSU associated with the most shallow completion is shown for multiple completion wells that sample multiple HSUs. The label indicates HSUs for all completions.

Nevada; the other laboratories provide state-of-the-art analyses not available from commercial laboratories in addition to analyses used to corroborate commercial laboratory results. The analytes measured at each laboratory and their results are presented for piezometer p1 in Tables 2-6 and 2-7, and for the main completion (m1) in Tables 2-11 and 2-12.

As described in Section 2.8.2, water-quality measurements (temperature, bromide, pH, SEC, DO, and turbidity) and ^{3}H analyses were made on grab samples collected during rod pumping of piezometer p1

in July 2016. As described in Section 2.9.2, water-quality measurements were made on both grab and inline monitoring samples throughout WDT operations on the main completion (m1). Stabilization of the water-quality parameters is an indication that water produced from the well is representative of the formation water. The stability of the water-quality measurements over the large volume of water produced and specific capacity values indicate that ER-20-12 main completion (m1) was sufficiently developed to provide GWC samples representative of the formation water. Though development was not as complete, GWC samples were collected from piezometer p1 after rod pumping (Sections 2.8.2 and 2.9.2).

GWC samples were collected from piezometer p1 on July 6, 2016, and from the main completion (m1) on August 19, 2016. The field water-quality parameters measured at the time of sample collection, along with bailer samples from piezometers p2 and p4, are provided in Table 5-1. The field water-quality parameters are within normal ranges and relatively similar between the four sampling intervals. A notable exception is the pH of piezometer p4 with a value of approximately 7, whereas the remaining intervals are near or above a pH of 8. In addition, piezometer p4 has a significantly higher head than the remaining intervals. These anomalies in the shallowest completion indicate that the associated water has had either lesser groundwater evolution, reflecting values closer to meteoric pH values, or possibly a different geochemical evolution. The evolution of groundwater in Pahute Mesa may be following a trend of increasing pH and increasing sodium (Na) + potassium (K) in downgradient waters (see Section 5.2.3).

5.2 Analytical Results

The following subsection presents major-ion, stable-isotope, and RN data for the samples collected from ER-20-12 piezometer p1 and main completion (m1), and other wells in the vicinity. The ER-20-12 laboratory results are presented for piezometer p1 in Tables 2-6 and 2-7, and for the main completion (m1) in Tables 2-11 and 2-12. The major-ion and stable isotope data for piezometer p1 and the main completion (m1) are summarized in Table 5-2. These results and all others presented within this section are stored in the UGTA Chemistry Database (Navarro, 2016h). For the UGTA ER wells, results for the pumped wellhead samples collected during WDT operations are used for the evaluation. The average is presented when multiple results are available for a single analyte and well.

Table 5-1
Water-Quality Parameters and ^{3}H Levels from the EOIs of Well ER-20-12

Zone	Date and Time [a]	Temperature (°C)	pH (SU)	SEC (μmhos/cm)	DO (mg/L)	Turbidity (NTU)	Sample Number	^{3}H (pCi/L)	Error (pCi/L)	Detection Limit (pCi/L)	Sample Method
m1	08/19/2016, 09:27	39.65	7.87	784	2.07	172	138-081916-1	34,000	6,610	252	Wellhead sample from wellhead manifold sampling port at m1
p1	07/06/2016, 11:26	26.61	7.91	689	3.01	6.2	138-070616-1	18,900	3,670	192	Wellhead sample from wellhead manifold sampling port at p1
p2 [b]	08/30/2016, 15:20	31.5	8.61	791	5.16	444	138-083016-1	2,830	583	204	Discrete bailer
p3 [c]	06/10/2016, 12:40	--	--	--	--	--	138-061016-1	U 267	137	204	Discrete bailer (by DRI)
p4 [b]	08/31/2016, 12:25	28.84	6.97	877	2.99	36	138-083116-3	38,700	7,500	200	Discrete bailer

[a] Sampling time reported is for the ^{3}H analysis, sampled the same day as the water-quality and ^{3}H field-screening samples.
[b] Piezometers p2 and p4 ^{3}H samples were reported from the UGTA Geochemistry Database (Navarro, 2016i), as corrected to account for a sample labeling error.
[c] Piezometer p3 water-quality sampling was not part of the original work scope.

U = Compound was analyzed for but was not detected (“Non-detect”).
-- Not measured

Table 5-2
Major-Ion and Stable Isotopes from ER-20-12 Piezometer p1 and Main Completion (m1)

ER-20-12	Database [a]	Date	Sample Type	Filtered	Na	K	Ca	Mg	HCO_3	CO_3	SO_4	Cl	δD	$\delta^{18}O$	$\delta^{13}C$
p1	AS	07/06/2016	Regular	Y	149	5.26	7.32	0.157 J	--	--	112	80.7	--	--	--
	AS	07/06/2016	Field Duplicate	Y	147	5.19	7.14	0.144 J	--	--	112	80.9	--	--	--
	AS	07/06/2016	Regular	N	145	5.52	7.68	0.149 J	--	--	--	--	--	--	--
	AS	07/06/2016	Field Duplicate	N	146	5.24	7.18	0.123 J	--	--	--	--	--	--	--
	AS	07/06/2016	Field Alkalinity	N	--	--	--	--	108.8	0.0	--	--	--	--	--
	GE	07/06/2016	Regular	--	--	--	--	--	--	--	--	--	-115.856	-14.76	-2.34
	GE	07/06/2016	Field Duplicate	--	--	--	--	--	--	--	--	--	-116	-14.85	-2.39
m1	AS	08/19/2016	Regular	Y	141	3.97 J	15.8	0.216 J	--	--	112	82.4	--	--	--
	AS	08/19/2016	Field Duplicate	Y	149	4.12 J	16.6	0.183 J	--	--	114 J-	86 J-	--	--	--
	AS	08/19/2016	Regular	N	149	4.45 J	17.5	0.305	114.22 J+	<2.898	--	--	--	--	--
	AS	08/19/2016	Field Duplicate	N	150	4.6 J	17.9	0.305	154.813	<0.87	--	--	--	--	--
	AS	08/19/2016	Lab Alkalinity	N	--	--	--	--	127	0.0	--	--	--	--	--
	GE	08/19/2016	Regular	--	--	--	--	--	--	--	--	--	-115.3	-14.78	-3.38
	GE	08/19/2016	Field Duplicate	--	--	--	--	--	--	--	--	--	-116	-14.83	-3.3

[a] AS = Analytical Services Database (Navarro, 2016d); GE = UGTA Geochemistry Database (Navarro, 2016i)

Ca = Calcium
CO_3 = Carbonate
HCO_3 = Bicarbonate
Mg = Magnesium
SO_4 = Sulfate
$\delta^{13}C$ = delta carbon-13
δD = delta deuterium
$\delta^{18}O$ = delta oxygen-18

J = Estimated value.
J+ = The result is an estimated quantity, but the result may be biased high.
J- = The result is an estimated quantity, but the result may be biased low.
-- = Not measured

5.2.1 Major Ions

The dissolved constituents in groundwater provide a record of the minerals encountered as water moves through an aquifer; therefore, the major-ion characteristics of groundwater can provide insight on groundwater source areas and flow directions. A Piper diagram—illustrating the relative major-ion concentrations in groundwater from ER-20-12 and other wells in the vicinity—is presented in Figure 5-2. The major ions consist of calcium (Ca^{2+}), potassium (K^{+}), magnesium (Mg^{2+}), sodium (Na^{+}), chloride (Cl^{-}), sulfate (SO_4^{2-}), bicarbonate (HCO_3^{-}), and carbonate (CO_3^{2-}). The Piper diagram presents relative concentrations in percent milliequivalents per liter (%meq/L) and is used to classify various groundwater chemistry types (or facies) and illustrate the relationships that may exist between water samples. The relative concentrations of cations and anions are presented in the left and right triangles, respectively, and are projected onto the central diamond to present the combined major-ion chemistry (Figure 5-2). The symbol colors are selected to improve visualization of sampling locations that plot close to one another.

The Piper diagram shows that Na+K dominates the cations in the study area groundwaters. The relative concentrations of anions are substantially more variable (Figure 5-2); the dominant anion in most samples is HCO_3, but significant relative concentrations of Cl^{-} and SO_4^{2-} also exist in many of the samples. The groundwaters vary from an Na+K-HCO_3 type (greater than 50 percent HCO_3^{-} as the dominant anion) to an Na+K-HCO_3/SO_4/Cl type (relatively equal concentrations of the three anions are present). These groundwater types are characteristic of waters that have dissolved volcanic rhyolitic lava, ash-fall and ash-flow tuffs, and associated volcanic alluvium (Schoff and Moore, 1964; Thomas et al., 2002; Rose et al., 2006). Elevated levels of Cl and SO_4 are thought to result from interaction with hydrothermally altered zones, and this is supported by examination of drill core and cuttings from wells in the area.

The ER-20-12 samples are plotted on the Piper diagram and are classified as a mixed-type facies Na+K-HCO_3/Cl+SO_4 with roughly equal relative concentrations of the anions: HCO_3 and Cl+SO_4 (Figure 5-2). These samples exhibit similar major-ion chemistry as samples in the northern section of the Thirsty Canyon generally west of the Purse fault and ER-20-7 fault, a well grouping of Kwicklis et al. (2005): ER-EC-1, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-8, and PM-3. The wells to the east are predominantly Na+K-HCO_3 type.

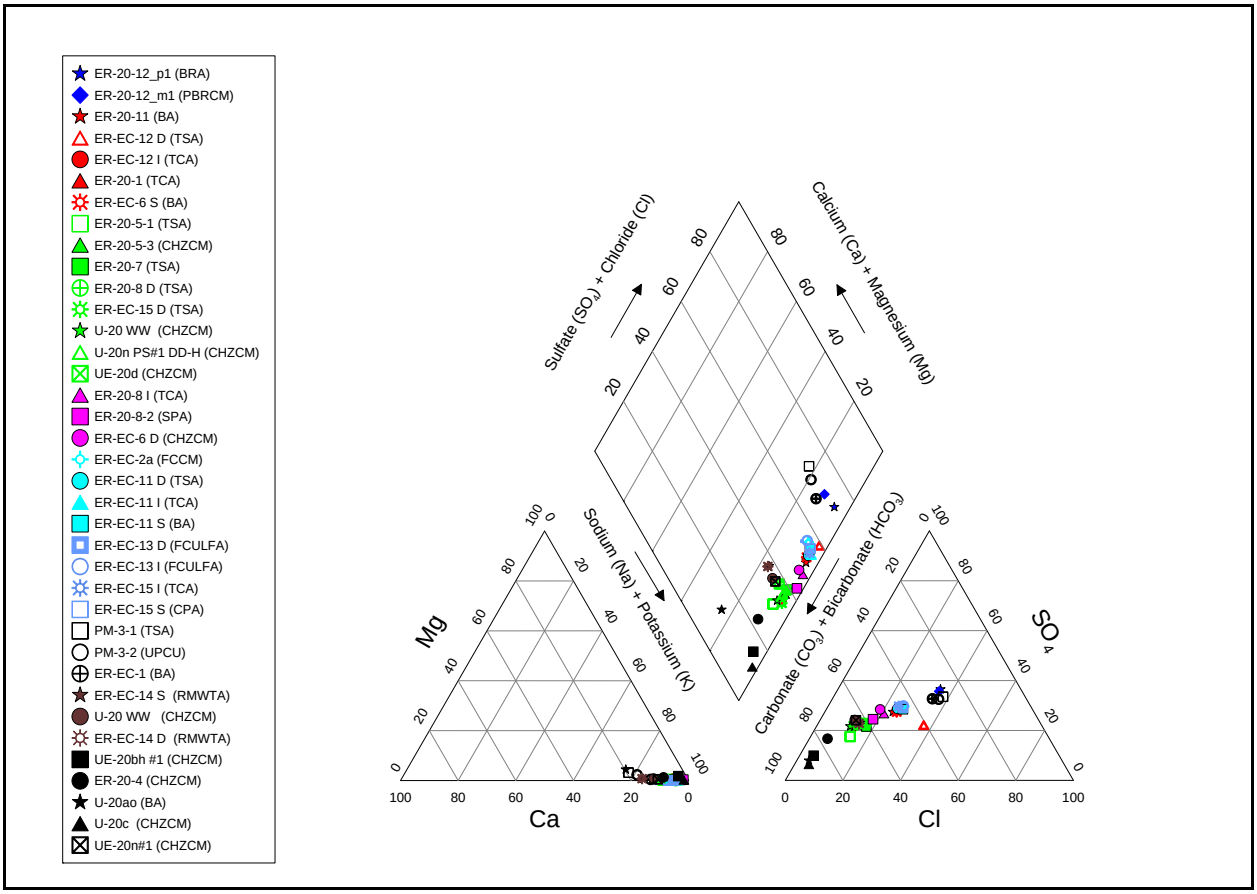

Figure 5-2
Piper Diagram Illustrating Groundwater Major-Ion Chemistry of Well ER-20-12 and Wells in the Vicinity
Source: Modified from Navarro, 2016c

Cl typically behaves conservatively in groundwater; it is highly soluble and does not participate in any common geochemical reactions at concentrations typical of NNSS groundwaters. Therefore, preliminary flow paths can be evaluated based on Cl concentrations. The average Cl concentration in the ER-20-12 samples is 82 mg/L (Table 5-2). The lowest Cl concentrations, ranging from 3 to 13 mg/L, are observed in wells located in the northeastern portion of the study area (i.e., east of the ER-20-7 and Purse faults). The highest Cl concentrations, ranging from 95 to 110 mg/L, are observed in ER-EC-1 and PM-3 located in Thirsty Canyon. Groundwater samples from wells downgradient toward Oasis valley exhibit a range in Cl concentrations intermediate to these values and are potentially a mixture of groundwater from these two areas. These general trends were also described in the earlier investigations (Thomas et al., 2002; Kwicklis et al., 2005; and Rose et al., 2006).

5.2.2 Stable Isotopes

Hydrogen and oxygen isotopes are conventionally reported as delta (δ) values representing per mil (‰) variations in the isotope ratio of the sample relative to a reference standard. The stable isotopes of hydrogen (δD) and oxygen ($\delta^{18}O$) are intrinsic to the water molecule and therefore behave conservatively in most groundwater systems. In the water cycle, these isotopes are fractionated between the liquid and vapor phases during evaporation and condensation processes. Once precipitation has infiltrated to the water table, the stable isotope values are unaffected by water-rock interaction at temperatures below approximately 100 °C (Criss, 1999). These isotopes are therefore used along with Cl as conservative tracers for evaluating groundwater origin and flow paths. Plots of δD versus $\delta^{18}O$ and δD versus Cl are presented in Figures 5-3 and 5-4, respectively.

The δD and $\delta^{18}O$ stable isotope composition of ER-20-12 and wells from the surrounding area are shown on Figure 5-3. For reference, the global meteoric water line (GMWL) defined by Craig (1961) and the local meteoric water line (LMWL) defined by Ingraham et al. (1990) are included on the plot. The meteoric water lines represent the observed correlations in $\delta^{18}O$-δD values of precipitation samples from around the world and from the NNSS, respectively. The GMWL is defined by the equation $\delta D = 8\delta^{18}O + 10$ (Craig, 1961), while the LMWL is defined by the equation $\delta D = 6.87^{18}O - 6.5$ (Ingraham et al., 1990). The symbol colors correspond to the primary HSU sampled, using the red (TCA) symbol color of PM-3-1 for ER-20-12_m1 and ER-20-12_p1, screened in the deeper PBRCM and BRA, respectively. All samples plot below the present-day GMWLs and LMWLs, suggesting that the groundwater has either evolved by fractionation off of the line, or has mixed with groundwater of different isotopic composition. The presence of anomalously light isotopic values [e.g., PM-3-1, ER-20-8 (D), ER-EC-13 (I), ER-EC-15 (I +S), ER-20-12 (p1)] indicates the presence and/or mixing with fossil (Pleistocene) groundwater of a colder climate (i.e., unrelated to present precipitation) (Merlivat and Jouzel, 1979).

The δD and $\delta^{18}O$ stable isotope composition of ER-20-12 groundwater is quite similar to that in other samples collected from units at or below the TCA, although they are within the typical measurement uncertainty (δD = ±2 per mil and $\delta^{18}O$ = ± 0.2 per mil) of most other nearby sampling locations. The groundwater in the eastern portion of the investigation area may have a larger proportion of modern recharge, given that these samples are heavier in δD (Figure 5-3). This is consistent with higher recharge in the eastern portion of Pahute Mesa compared with the western, and downward

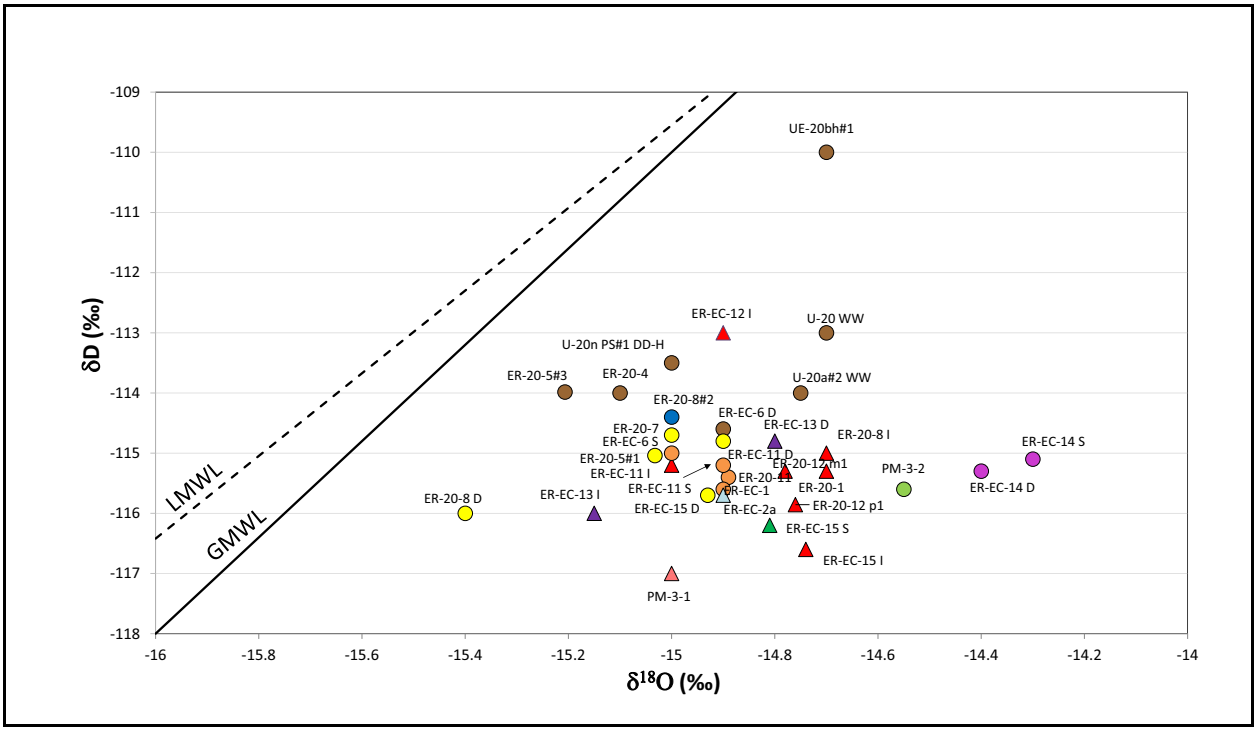

Figure 5-3
Plot of δD versus δ18O
Source: Modified from Navarro, 2016c
Note: Symbol color represents the primary HSU as shown in Figure 5-1.

gradients in the eastern area (Blankennagel and Weir, 1973). It therefore appears that there may be some long-term climatic influences on the stable isotope data.

The available data with both δD versus Cl show that the results for the ER-20-12 piezometer p1 and main completion (m1) plot along a trend of decreasing δD with increasing Cl (Figure 5-4). This trend is statistically consistent with the mixing of relatively dilute, average meteoric waters, seasonally and paleoclimatically spread along the meteoric line, with average fractionated waters of higher total dissolved solids (TDS) (including Cl and SO_4) sourced from brines or geothermal springs. Waters fractionating off of the meteoric water line by evaporative processes increase in both δD and $\delta^{18}O$. Waters fractionating off of the meteoric water line in geothermal springs typically increase the $\delta^{18}O$ value only. Both fractionation trends statistically result in water with a relatively lighter δD value for a given $\delta^{18}O$ value with respects to the meteoric water line. Both fractionation trends typically result in water with a higher Cl content. Thus, on average, for a given $\delta^{18}O$, waters spread along the meteoric water line have a higher δD value than fractionated water. A mixing trend would exhibit decreasing δD with increasing fractionation and associated increasing Cl content. However, an individual evolution pathway to lighter δD cannot be explained without mixing. The most common

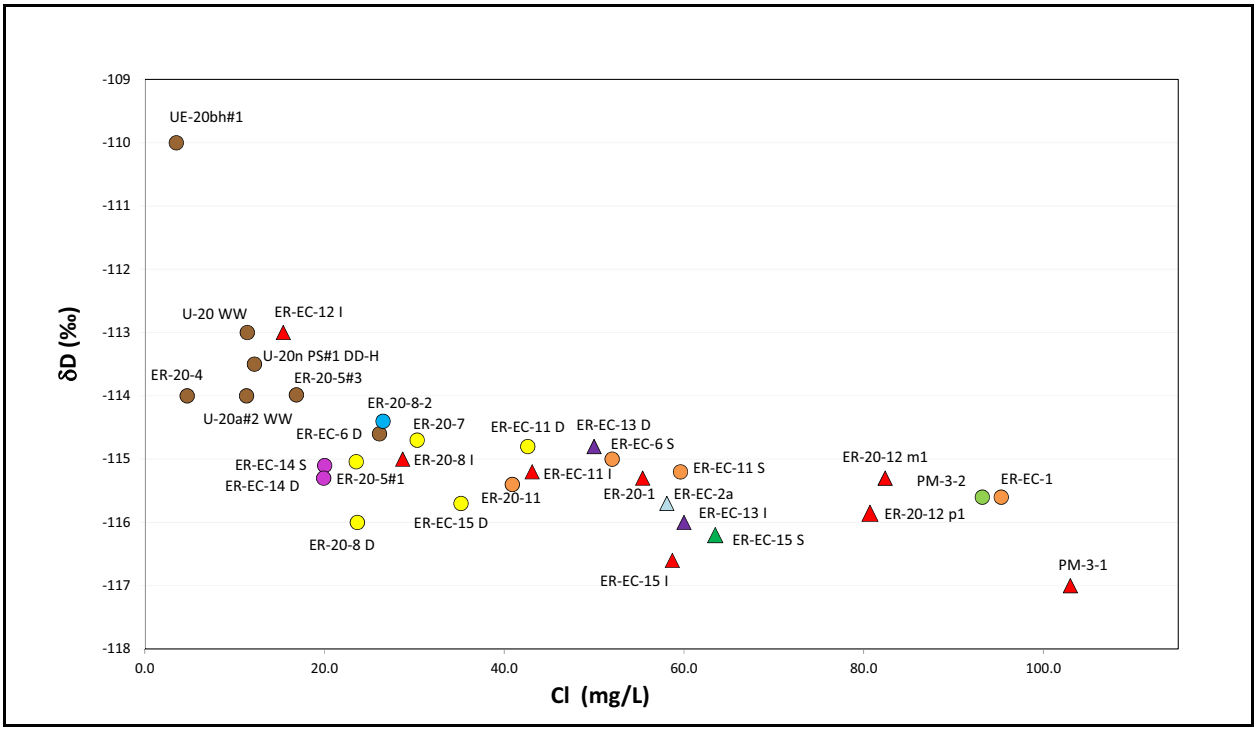

Figure 5-4
Plot of δD versus Cl
Source: Modified from Navarro, 2016c
Note: Symbol color represents the primary HSU as shown in Figure 5-1.

and likely fractionation processes involved in groundwater evolution increase $\delta^{18}O$ with either fixed or increasing δD. Thus, a groundwater initially on the meteoric water line cannot progress to lighter values, especially for water already with the lightest values of δD that also exhibit the highest values of Cl (e.g., PM-3-1 with δD = -117 per mil and Cl = 100 mg/L). The light δD/high Cl values imply that the fractionated water must have mixed with a meteoric water even lighter than the measured δD to achieve the measured δD. Possible sources of fractionated water with elevated levels of Cl include areas east of the Purse fault, east of ER-20-12, such as the area of UE-20f (see Figures 4-1 and 5-1) with evidence of hydrothermally altered zones in drill core cuttings. This water may have mixed with isotopically light water in the northern section of Thirsty Canyon, particularly west of the Purse fault and up groundwater gradient from ER-20-12, to form the water composition observed at PM-3. This most likely represents mixing of "fossil" (Pleistocene) groundwater north of ER-20-12 with geothermal spring water east of the Purse fault, associated with the margin of the SCCC (Figure 4-1).

5.2.3 Implications of Anomalous Water Levels, ^3H, and pH in Piezometer p4 for the Interpretation of Groundwater Flow

The interpretation of groundwater flow, from upgradient sources of ^3H (i.e., HANDLEY) to ER-20-12 and downgradient to PM-3, must incorporate observations of anomalous high head, ^3H, and pH in piezometer p4, the shallowest piezometer at ER-20-12. The high head is consistent with groundwater levels northwest of the Purse fault, suggesting the respective groundwater systems are related. However, data showing equivalent high heads to the south of ER-20-12 are non-existent. Evidence that the corresponding shallow groundwater system is relatively hydraulically isolated from PM-3 (Sections 3.2 and 3.6) makes inference of any shallow groundwater flow path from ER-20-12 problematic. However, the presence of ^3H in piezometer p4 (Table 5-1 and Section 2.9.6.5) implies that the shallow groundwater is flowing past ER-20-12 from upgradient sources of ^3H.

In addition, an anomalously low pH in piezometer p4 of 6.97 (Table 5-1) indicates that the groundwater is either less evolved or has undergone a different geochemical evolution than the deeper completions at ER-20-12. Lowered groundwater pH can have a profound effect on the transport of RNs by increasing the solubility of metals, including RNs, and by increasing porosity by dissolving in situ carbonate cements. The pH of meteoric water and shallow groundwater is largely controlled by the carbonate system. The pH of meteoric water in equilibrium with the atmospheric levels of carbon dioxide (CO_2) is 5.6 and can be even lower under conditions of acid precipitation. Relatively acidic waters from the atmosphere, picking up additional carbonic acid in the soil zone, will leach existing carbonate minerals in the soil zone, neutralizing the acid and thereby increasing pH. In the absence of carbonate minerals, other mineral phases such as zeolites, or volcanic glass may exchange acid with cations—usually univalent cations such as Na^{1+} and K^{1+}—thereby increasing pH (Hoover, 1968; Gislason et al., 1996; Fairchild et al., 1999). Either mechanism for increasing pH increases the amount of carbonate and bicarbonate buffers that are stable in solution. Evolved groundwater on Pahute Mesa typically has pH levels that are 8 or higher.

If groundwaters become sufficiently saturated with divalent cation (usually Ca^{2+} or Mg^{2+}), carbonate minerals can precipitate (or re-precipitate) within pore spaces and on fault structures. If the water is allowed to degas (lowering the partial pressure of CO_2), the pH will increase and induce calcite precipitation, which acts as a buffer and stabilizes or even lowers the pH back downward (Deffeyes, 1965; Stumm and Morgan, 1981, Figure 4.5). On the other hand, if the water is not allowed to degas (such as in a closed system), precipitation of calcite and other carbonates with

divalent cations (e.g., iron siderite) can still occur if saturation of both the divalent cations and the carbonate/bicarbonate anions can be achieved. The net result—in this case, of non-degassing precipitation of carbonate—is for pH to decrease (Deffeyes, 1965; Stumm and Morgan, 1981, Figure 4.5). This mechanism could be responsible for lowering the pH of an evolved groundwater from levels above 8 to levels below.

Regions composed of predominantly felsic igneous rocks, such as New England and the high ground on Pahute Mesa, usually lack sufficient carbonate/bicarbonate minerals to substantially increase pH. The pH of groundwater and surface water in New England is typically less than 7. Though perhaps more common in the Western United States, a pH value above 8 in regions of felsic igneous rocks is uncommon and requires a mechanism. The dissolution of volcanic glass and/or acid cation exchange with zeolites is the most likely. Though zeolitic minerals and volcanic glass can increase pH by exchange of acid and cation, the cation is usually univalent (Na^{1+} and K^{1+}). The resulting sodium carbonates are highly soluble: for example, sodium bicarbonate solubility (nahcolite; 96 grams per liter [g/L]) and sodium carbonate solubility (natron; 215 g/L) is at least 4 orders of magnitude higher than the solubility of calcium carbonate (calcite; 6.17×10^{-3} g/L). The result is that bicarbonate is retained in solution, and the pH is allowed to rise to the level of bicarbonate equilibrium, where pH = 8.3 at standard temperature and pressure (Stumm and Morgan, 1981, Figure 4.2). If the groundwater encounters a source of divalent cation, in the absence of degassing, carbonate mineral precipitation will cause the pH to drop back down.

Figure 5-5 shows the levels of bicarbonate and calcium for Pahute Mesa wells with respect to the equilibrium concentrations and the stability of solid calcite on a plot of pH versus total inorganic carbon, taken from Stumm and Morgan (1981, Figure 4.3). Solid calcite is stable in the green region where two conditions are met: (1) the calcium concentration is above the Ca^{2+} equilibrium line shown in solid green, and (2) the bicarbonate concentration is above the HCO_3^- equilibrium line, coincident with the total alkalinity (acid-neutralizing capacity [ANC]) line shown in solid blue. The Pahute Mesa calcium versus pH values plot within the orange closed polyline and clearly show that most of the Ca^{2+} levels are well below the levels needed for calcite equilibrium (i.e., the water is undersaturated with respects to calcium). The Pahute Mesa bicarbonate versus pH values plot within the blue closed polyline and clearly show that almost all of the levels are well above the levels needed for calcite equilibrium (i.e., the water is supersaturated with respects to bicarbonate). This is consistent with a sodium carbonate water starved of divalent cation as discussed above.

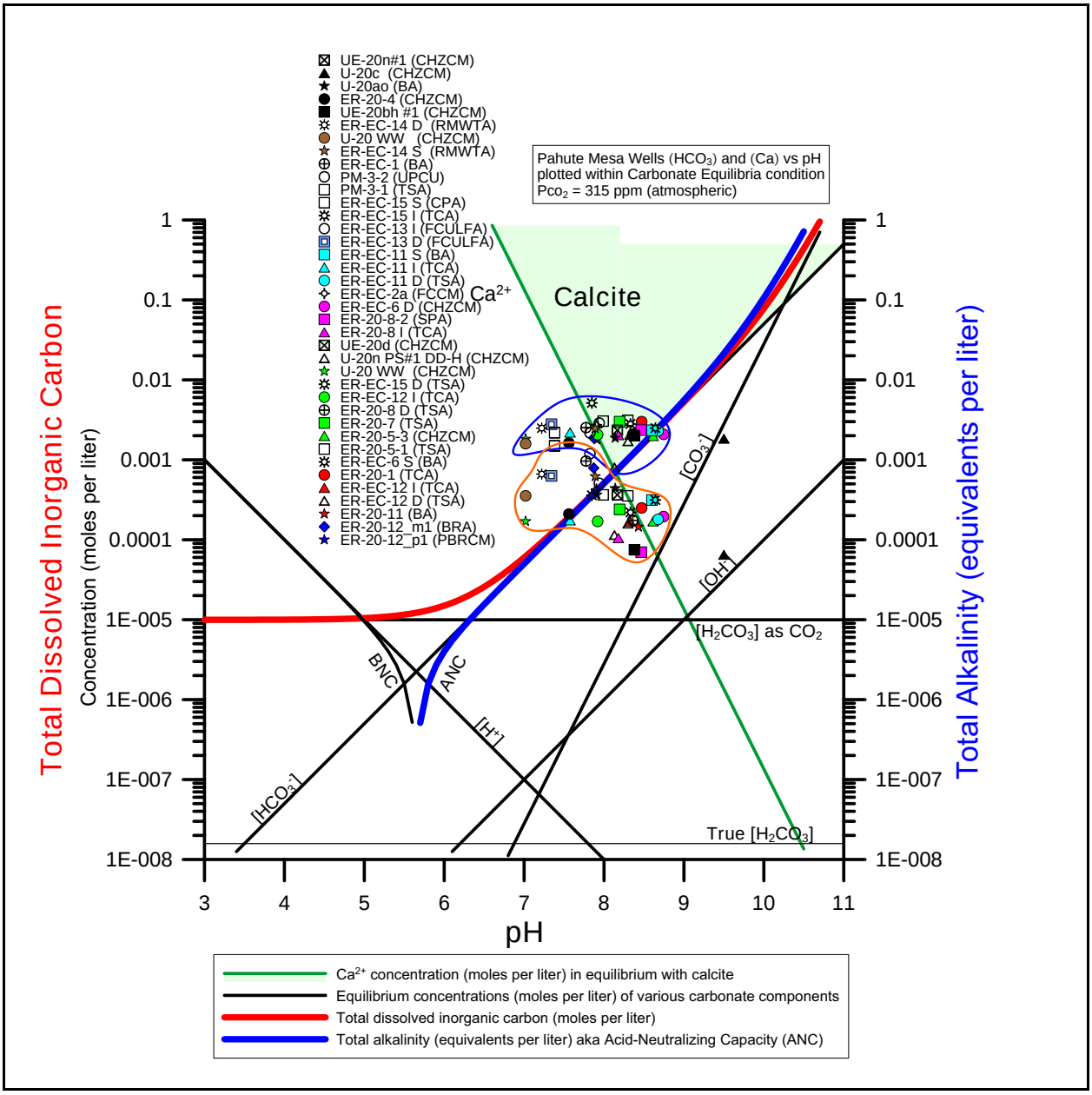

Figure 5-5
HCO_3 and Ca versus pH from Select Pahute Mesa Wells of the Study Area Plotted within the Carbonate Equilibria Conditions
Note: Well names and symbols from Figure 5-2.

One possible explanation of the lower pH in piezometer p4 is that a less evolved groundwater, with a shorter flow path and less water rock interaction, is connected to a recharge zone. In this case, the low pH simply reflects more recent interaction with meteoric water of low pH. However, an alternative explanation is that an evolved groundwater, with a pH of 8 or higher typical of Pahute Mesa, has encountered a source of divalent cation, allowing for precipitation of calcite, without degassing

(closed system), and thus a lowering of pH. Though piezometer p4 is the shallowest completion at ER-20-12, its effective open interval is 1,900 ft bgs, a depth that would allow for significant evolution of the groundwater to high pH, from sufficiently long flow paths and time for the water-rock interactions with volcanic glass and zeolites, post recharge. Subsequently encountering a source of divalent cation, and the resultant precipitation of carbonate minerals, may have lowered pH to observed values. Possible sources of divalent cation are (1) carbonate rocks and/or (2) new solutes from mixing with a groundwater of different composition from a different source or flow path. Carbonate rocks are known to exist at depth. Alternatively, the western edge of the SCCC may be the source of higher TDS, as discussed in Section 5.2.2 and Figure 5-4. Elevated levels of SO_4 and Cl are observed in PM-3 and ER-20-12, possibly sourced from deep geothermal sources. Kwicklis et al. (2005) discuss the possibility of deep geothermal sources of water near U-20f, located near the FONTINA test shown on Figure 5-1. This source may also have provided divalent cation. This water may have mixed with the shallow groundwater at piezometer p4, providing the source of divalent cation for the precipitation of carbonate minerals and corresponding lowering of pH.

5.2.4 Radionuclides

Samples collected during WDT were analyzed for a suite of RNs included in the radiologic source term (Finnegan et al., 2016). The RNs and their respective maximum contaminant levels (MCLs) are presented in Table 5-3 (CFR, 2016). In some cases, RN analyses are performed using different methods, and analytical detection limits may vary considerably depending on the method. For instance, LLNL uses an accelerator mass spectrometer for ^{14}C, ^{129}I, and ^{36}Cl analysis that provides detection limits several orders of magnitude below the traditional methods of the commercial laboratory.

Table 5-3
Maximum Contaminant Levels
(Page 1 of 2)

RN	MCL [a] (pCi/L)
^{3}H	20,000
^{14}C	2,000
^{36}Cl	700
^{90}Sr	8
^{99}Tc	900

Table 5-3
Maximum Contaminant Levels
(Page 2 of 2)

RN	MCL [a] (pCi/L)
^{129}I	1
^{137}Cs	200
^{152}Eu	200
^{154}Eu	60
$^{234/235/236/238}U$	30 µg/L
$^{238/239/240}Pu$	15
^{241}Am	15

[a] Source: CFR, 2016

Am = Americium
Cs = Cesium
Eu = Europium
Ho = Holmium
I = Iodine
Nb = Niobium
Np = Neptunium
Pu = Plutonium
Sn = Tin
Sr = Strontium
Tc = Technetium
Th = Thorium
U = Uranium
µg/L = Micrograms per liter

Note: No SDWA activity to dose factor is available for some RNs (e.g., ^{94}Nb, ^{121m}Sn, ^{126}Sn, ^{150}Eu, ^{166}Ho, ^{232}Th, and ^{237}Np) included by Finnegan et al. (2016) in the radiologic source term.

Table 5-4 presents a summary of RN data for wells in the vicinity of ER-20-12. The reported concentrations are an average when multiple measurements were made during the particular sampling event. For those measurements reported below the detection limit (i.e., reported with a "<"), the result associated with the lowest detection limit is reported. For instance, the value would be reported as "<0.1 pCi/L" if a given analyte were reported below the detection limits of 0.1, 0.2, and 10 pCi/L.

It is instructive to plot the data from Table 5-4 as scatter plots of ^{3}H versus other test-associated and mobile RNs. There appears to be a strong correlation between ^{3}H and ^{14}C at ^{3}H activities above 1,000 pCi/L (Figure 5-6). Data from ER-20-5, ER-20-7, ER-20-11, and ER-20-8 appear in a straight line with a slope slightly below 1, indicating that ^{14}C is slightly depleted in the highest ^{3}H activity samples (or, conversely, that ^{14}C is enriched in the lower ^{3}H activity samples). This suggests that ^{14}C transport behavior differs slightly from that of ^{3}H, possibly due to its volatility and loss to the vadose zone. Surprisingly, the ER-20-12 data do not fall along the same slope as ER-20-5 and ER-20-7. This suggests that the ER-20-12 plume is compositionally different from the ER-20-5 plume, as might be expected based on hydrologic and spatial considerations. Importantly, the PM-3 ^{3}H activity

Table 5-4
RN Concentrations (pCi/L) for Select Sampling Locations
(Page 1 of 2)

Location	ISPID	Year	^{3}H	^{14}C	^{36}Cl	^{99}Tc	^{129}I	^{137}Cs
ER-20-5-1	ER-20-5-1_m1	2015	2.5E+07 [a] | 2.6E+07 [b]	165	5.7	0.43	0.20	<6.7
ER-20-5-3	ER-20-5-3_m1	2015	8.4E+04 [a] | 8.2E+04 [b]	2.7	0.014	0.009	4.0E-04	<6.1
ER-20-7	ER-20-7_m1	2014	1.6E+07 [a] | 1.6E+07 [b]	118	2.5	<7	0.14	<6.2
ER-20-11	ER-20-11_m1	2013	1.9E+05 [a] | 1.8E+05 [b]	3.8	0.073	0.953	4.4E-03	6.2
ER-20-12	ER-20-12_p1	2016	1.89E+04 [a] | 2.14E+04 [b]	0.16 [b]	0.013 [b]	<0.0006 [b]	3.2E-05 [b]	<4.9 [a]
	ER-20-12_m1	2016	3.40E+04 [a] | 3.72E+04 [b]	0.24 [b]	0.013 [b]	0.0032 [b]	4.6E-05 [b]	<4.5 [a]
ER-EC-11	ER-EC-11_p1	2014	8.0 [a, c] | 11.8 [b]	0.086	8.0E-04	<4.5E-04	1.3E-06	<7.5
	ER-EC-11_p2	2014	11.5 [a] | 11.3 [b]	0.082	1.6E-03	<4.5E-04	2.3E-04	<7.3
	ER-EC-11_p3	2014	16,100 [a] | 16,400 [b]	0.63 [d]	7.9E-03	<4.5E-04	3.8E-04	<6.8
ER-EC-6	ER-EC-6_m2	2014	<2.3 [a] | <0.5 [b]	0.04 [e]	5.0E-04	<6.8	3.5E-07	<6.6
	ER-EC-6_m3	2014	<2.4 [a]	--	--	--	--	--
	ER-EC-6_m4	2015	5.2 [a] | 4.2 [b]	0.05 [e]	9.0E-04	<6.8	<1.7E-09	<6.3
ER-20-8	ER-20-8_m1	2011	267 [e] | 128 [f]	0.06	9.2E-04	<7.1	3.5E-05	<0.05
	ER-20-8_m2	2015	4,590 [a] | 4,060 [b]	0.34 [d]	5.5E-03	<7.2	3.8E-04	<6.2
ER-20-8-2	ER-20-8-2_m1	2014	2,600 [a] | 2,600 [b,g]	0.22 [d]	3.4E-03	0.067	2.4E-04	<7.8
ER-EC-1	ER-EC-1_m1-3	2009	<1 [b]	0.003	1.7E-03	<8.4	<2.8 [h]	<9.3
ER-EC-12	ER-EC-12_m1	2012	4.2 [a] | 7.9 [b]	0.140	4.6E-03	<5.8	3.7E-04	<0.02
	ER-EC-12_m2	2011	<2.1 [a] | <1 [b]	0.030	2.9E-04	<7.4	1.1E-06	<0.04
ER-EC-13	ER-EC-13_m1	2013	<3.0 [a] | <0.3 [b]	0.145	9.8E-04	<6.2	1.8E-07	<0.06
	ER-EC-13_m2	2012	<2.2 [a] | <0.3 [b]	0.028	1.0E-03	<6.6	1.3E-07	<0.08
ER-EC-14	ER-EC-14_m1	2014	<2.0 [a] | <0.3 [b]	0.067	3.6E-04	<4.5E-04	1.8E-07	<7.3
	ER-EC-14_m2	2014	<1.6 [a] | <0.4 [b]	0.016	3.6E-04	6.1E-03 [c]	1.1E-07	<8.7

Table 5-4
RN Concentrations (pCi/L) for Select Sampling Locations
(Page 2 of 2)

Location	ISPID	Year	^{3}H	^{14}C	^{36}Cl	^{99}Tc	^{129}I	^{137}Cs
ER-EC-15	ER-EC-15_m1	2014	<2.0 [a] | <1 [b]	0.007	5.3E-04	<0.34	1.5E-06	<7.6
	ER-EC-15_m2	2014	<2.1 [a] | <0.4 [b]	0.021	1.0E-03	1.9E-03 [c]	7.1E-06	<6.6
	ER-EC-15_m3	2013	<2.1 [a] | <0.3 [b]	0.078	1.1E-03	<4.0E-04	1.2E-06	<8.9

[a] Commercial laboratory result.
[b] LLNL result.
[c] Reported as an estimate.
[d] Reported as an estimate that is biased low.
[e] Reported as an estimate that is biased high.
[f] Result for a 2014 bailed sample from the deep piezometer (ER-20-8_p1). Tritium in a 2014 bailed sample from the shallow piezometer (ER-20-8_p3) was 1.8E+03 pCi/L.
[g] Maximum ^{3}H concentration from this interval of ER-20-8-2 in 2014 (2,670 pCi/L) was a bailed sample collected from ER-20-8-2-p1.
[h] ^{129}I was not analyzed for in the 2009 sample, The reported value is for a sample collected in 2003.

ISPID = Integrated Sampling Plan Identifier

-- = Not available

Note: When multiple values are reported the maximum value is reported. LLNL analytical results are reported for ^{14}C, ^{36}Cl, ^{99}Tc, and ^{129}I and LANL results are reported for ^{137}Cs, when available. Detection limits are significantly lower for the LLNL and LANL analyses when compared to the commercial laboratory.

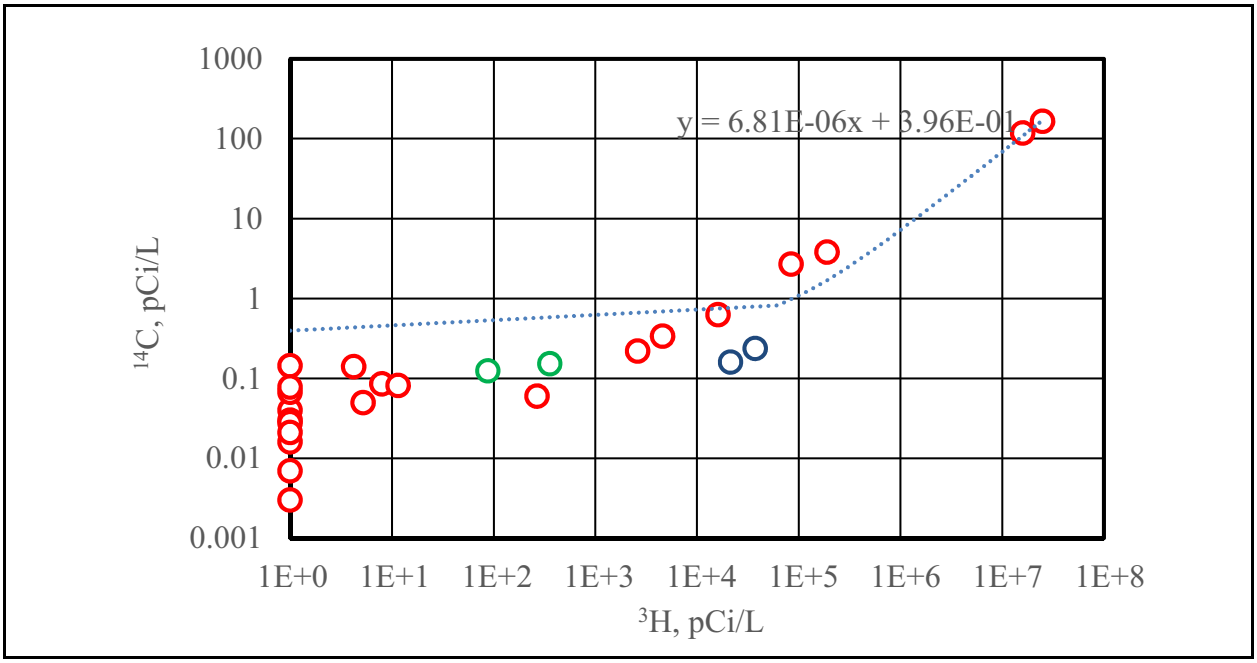

Figure 5-6
Scatter Plot of ^{3}H and ^{14}C in the Vicinity of Well ER-20-12

Source: Zavarin, 2017

Note: Samples with ^{3}H activities below 1 pCi/L were arbitrarily plotted as 1 pCi/L. Data from ER-20-12 (blue) and PM-3 (green) highlighted for emphasis.

(green data) is quite low, and the associated ^{14}C activity is likely influenced by natural ^{14}C background activity. Thus, one cannot establish a link between ER-20-12 and PM-3 contamination using ^{14}C and ^{3}H data. Lastly, these data suggest that ^{14}C activities are unlikely to reach MCL levels unless ^{3}H activities are well above 108 pCi/L. Because these activities are not observed at the NNSS, it is unlikely that ^{14}C would contribute to contaminant boundaries.

At ^{3}H activities above 1,000 pCi/L, one can also see a correlation between ^{3}H and ^{36}Cl (Figure 5-7). In this case, both ER-20-12 and PM-3 data fall along the same slope with all the data from nearby wells. Below 1,000 pCi/L ^{3}H, the influence of natural ^{36}Cl masks the correlation between ^{3}H and ^{36}Cl. As in the case of ^{14}C, these data suggest that ^{36}Cl activities would reach their MCL is samples with ^{3}H activities greater that 109 pCi/L. Since these ^{3}H activities have not been observed in any NNSS wells, it seems unlikely that ^{36}Cl will contribute to contaminant boundaries.

Similar patterns are observed between ^{129}I and ^{3}H (Figure 5-8). In this case, ^{129}I activities at ER-10-12 appear to be depleted relative to other wells, suggestive of a distinct plume composition. Due to the very low ^{129}I activities in uncontaminated groundwater, the correlation between ^{3}H and ^{129}I continues

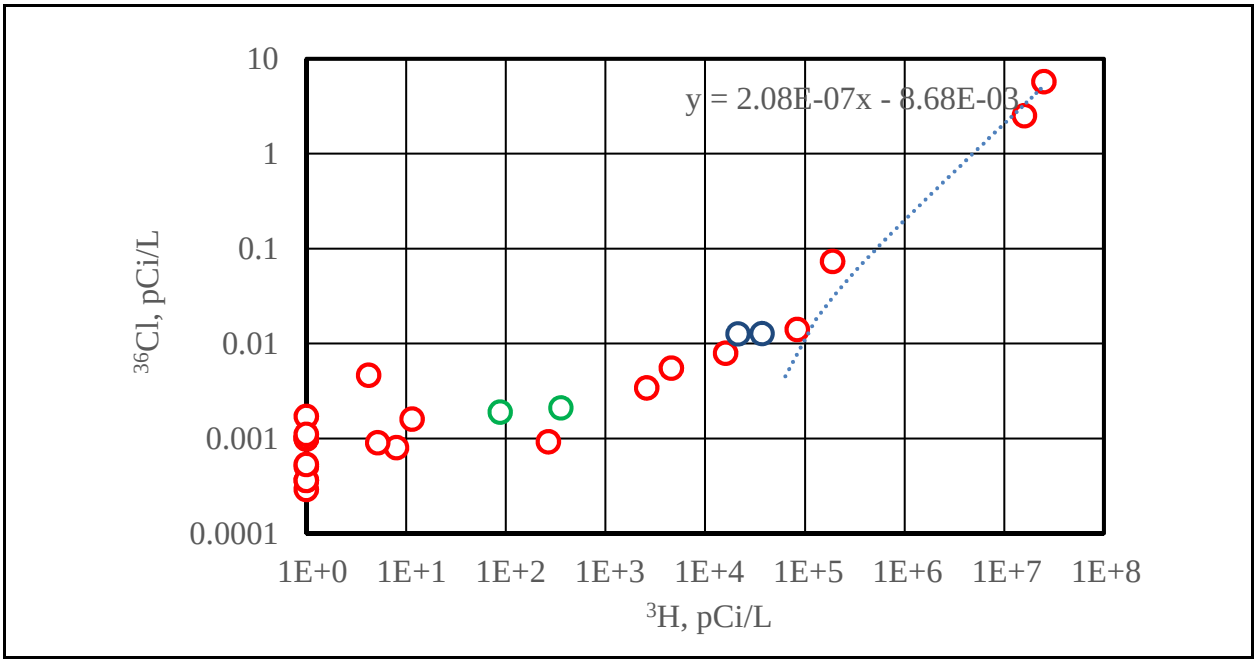

Figure 5-7
Scatter Plot of ^{3}H and ^{36}Cl in the Vicinity of Well ER-20-12

Source: Zavarin, 2017

Note: Samples with ^{3}H activities below 1 pCi/L were arbitrarily plotted as 1 pCi/L. Data from ER-20-12 (blue) and PM-3 (green) highlighted for emphasis.

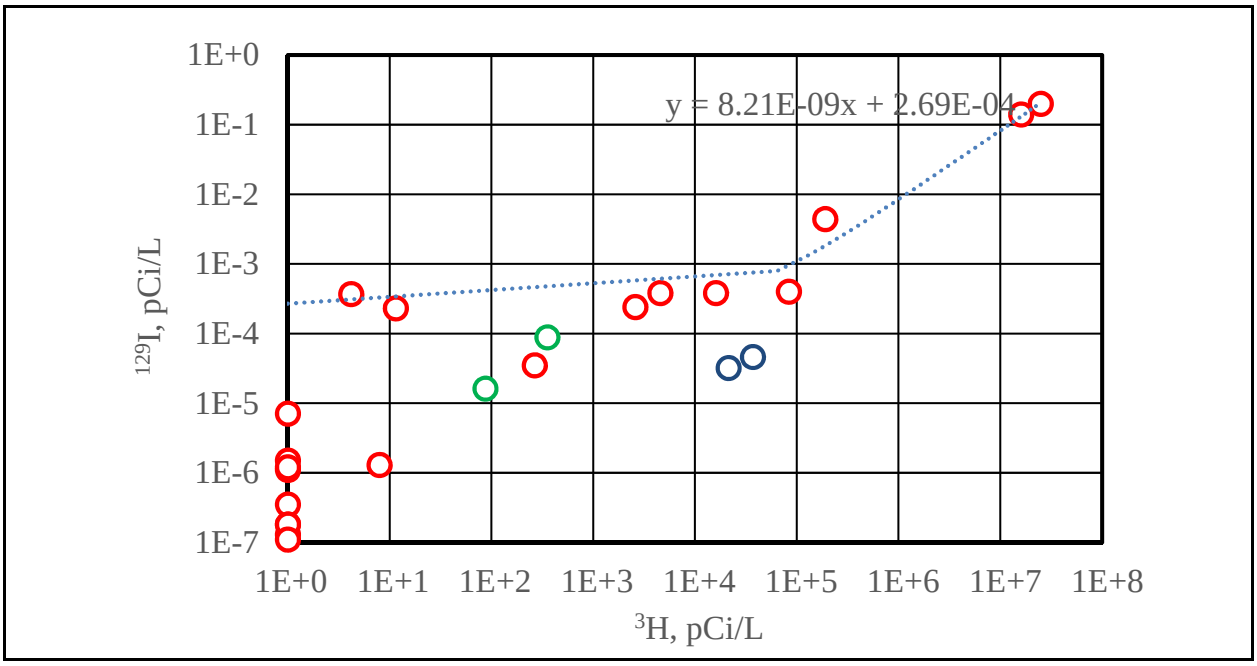

Figure 5-8
Scatter Plot of ^{3}H and ^{129}I in the Vicinity of Well ER-20-12

Source: Zavarin, 2017

Note: Samples with ^{3}H activities below 1 pCi/L were arbitrarily plotted as 1 pCi/L. Data from ER-20-12 (blue) and PM-3 (green) highlighted for emphasis.

down to ^{3}H activities as low as 10 pCi/L. Interestingly, two data points do not fall along this correlation line. These are associated with ER-EC-11-p2 and ER-EC-12_m1. Somewhat high ^{36}Cl activities were observed in these wells as well. Importantly, these data suggest that ^{129}I activities would reach their MCL is samples at ^{3}H activities of 108 pCi/L. This suggests that ^{129}I may reach MCL activities in locations where maximum ^{3}H activities are observed. Thus, ^{129}I has some potential to contribute to contaminant boundaries.

Due to the limited observations of detectable ^{99}Tc, a correlation between ^{3}H and ^{99}Tc is not readily apparent (Figure 5-9). However, ^{99}Tc activities greater than 1 pCi/L have not been reported in nearby wells. Thus, it appears unlikely that ^{99}Tc would contribute significantly to contaminant boundaries.

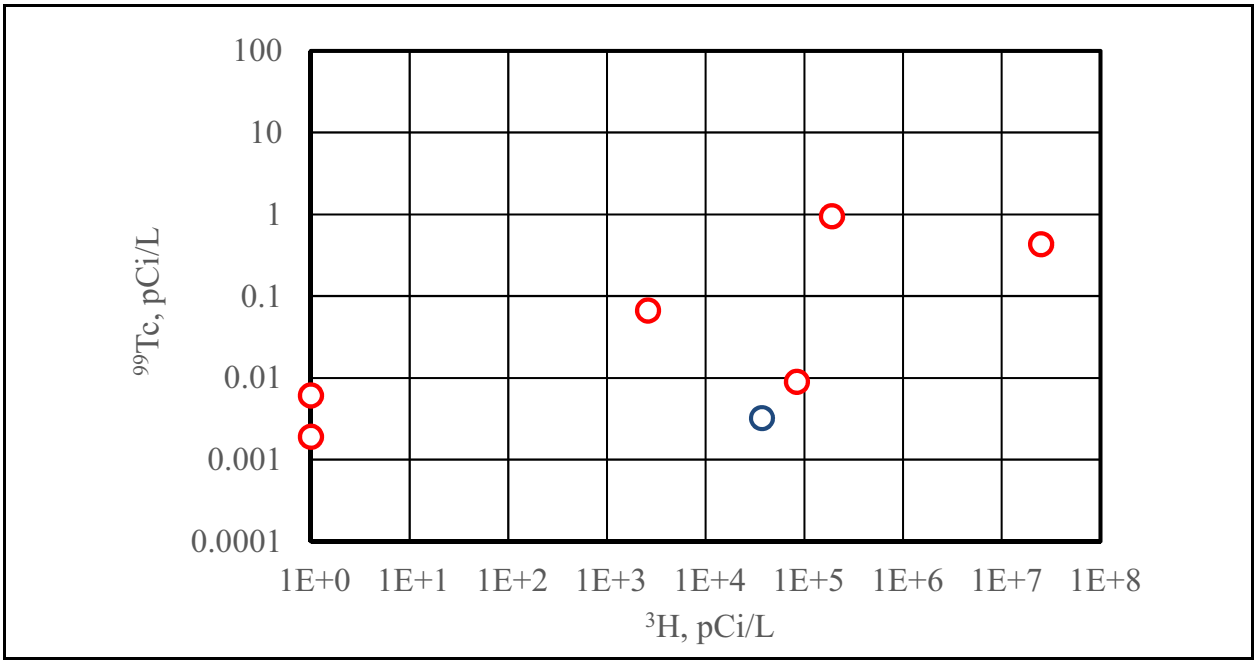

Figure 5-9
Scatter Plot of ^{3}H and ^{99}Tc in the Vicinity of Well ER-20-12
Source: Zavarin, 2017
Note: Samples with ^{3}H activities below 1 pCi/L were arbitrarily plotted as 1 pCi/L. Data from ER-20-12 (blue) and PM-3 (green) highlighted for emphasis.

6.0 ENVIRONMENTAL COMPLIANCE

This section discusses fluid and waste management during WDT activities at Well ER-20-12.

6.1 Fluid Management Plan

Guidelines for managing fluids generated during well drilling, development, testing, and sampling of UGTA wells are provided in the UGTA FMP (NNSA/NSO, 2009b). The well-specific fluid management strategy letter (NNSA/NFO, 2015a), as required by the UGTA FMP and approved by NDEP, addresses specific fluid management strategies employed at Well ER-20-12 for fluid-generating activities relating to WDT. During well development, testing, and sampling operations, ^{3}H samples were collected daily to meet the requirements stated in the FMP and in accordance with the Navarro FAWP (Navarro, 2016e).

6.1.1 Fluid Containment and Disposition

Two onsite infiltration basins (Sumps #1 and #2) were constructed to contain fluids and drill cuttings during drilling, well development, testing, and sampling operations at Well ER-20-12. Sump #1 has a 2.8-million-gal capacity for fluid containment. Although Sump #1 is lined, the liner was torn during drilling operations, allowing fluids to impact the ground surface. A second unlined sump (Sump #2) has not been used. The sumps are approximately 3.0 m (10 ft) deep from the floor of the sump to the drill pad surface. Fluid volumes produced from the well were monitored using a calibrated flowmeter. Approximately 33,646 gal of groundwater was pumped from the well during WDT activities.

The FMP (NNSA/NSO, 2009b) and the Well ER-20-12 FMP strategy letter (NNSA/NFO, 2015a) establish concentrations for specified parameters below which purged fluids may be discharged either to an unlined containment basin or infiltration area, or directly to the ground surface. Purged fluids were discharged into Sump #1. Because the liner was torn, the purged water then infiltrated the area below the sump. The FMP confirmatory sampling results (Table 6-1) met the FMP criteria for fluid discharge to an unlined sump.

Table 6-1
Analytical Results for FMP Samples
Collected from ER-20-12 Main Completion (m1) at 2,192 ft bgs

Analyte	Analytical Method [a]	Detection Limit	138-081916-7 and 138-081916-7(F) [b]		138-081916-8 and 138-081916-8(F) [b]	
			Total	Dissolved	Total	Dissolved
Metals (mg/L)						
Arsenic	SW-846 6010 [c]	0.03	0.03 U	0.03 U	0.03 U	0.03 U
Barium		0.005	0.0235	0.00426 J	0.0222	0.00421 J
Cadmium		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Chromium		0.005	0.0136	0.005 U	0.0127	0.005 U
Lead		0.002	0.000885 J	0.002 U	0.000821 J	0.002 U
Selenium		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Silver		0.005	0.005 U	0.005 U	0.005 U	0.005 U
Mercury	SW-846 7470 [c]	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Radionuclides (pCi/L)						
		MDC [d]	Result	Error	Result	Error
Gross Alpha	EPA 900.0 [e]	2.98, 2.95	8.56	3.24	6.81	2.69
Gross Beta		2.29, 2.06	2.65 U	1.52	3.3 U	1.53
^{3}H	EPA 906.0 [e]	243, 246	31,000	6,030	30,900	6,000

[a] For commercial laboratory analysis, the most current EPA or equivalent accepted standard laboratory analytical methods may be used as appropriate to attain specified detection limits.
[b] Sample number 138-081916-8 identifies the duplicate sample of 138-081916-7. Sample numbers ending with "F" identify filtered samples reported as "Dissolved."
[c] EPA, 2013
[d] MDC varies by matrix, instrument, and count rates. Where two detection limits are given, the first corresponds with sample number 138-081916-7, the second with 138-081916-8.
[e] EPA, 1980

J = Result is estimated.
U = Compound was analyzed for but was not detected ("Non-detect").

The volumes of fluids produced during WDT are presented in Table 6-2, the Fluid Disposition Reporting Form. At the completion of WDT operations on September 1, 2016, an estimated total of 216 cubic meters (m^3) (57,232 gal) of purged water had been discharged into Sump #1.

6.1.2 Tritium Monitoring

In accordance with Section 4.2, "Other Well-Site Activities," of the FMP (NNSA/NSO, 2009b) and the approved Strategy Letter (NNSA/NFO, 2015a), grab samples for ^{3}H analysis were collected from the wellhead sampling port on a daily basis. Samples were stored on site and delivered daily to

Table 6-2
Well ER-20-12 Fluid Disposition Reporting Form

UGTA FLUID DISPOSITION REPORTING FORM

Site Identification: ER-20-12
Site Location: Nevada National Security Site
Site Coordinates (UTM NAD 27, Zone 11) N 4,125,952.84; E 540,925.06
Well Classification: ER Hydrogeologic Investigation Well
Navarro Project No: UN16-205

Report Date: 08/31/2017
NNSA/NFO Activity Lead: Bill Wilborn
Navarro Project Manager: Ken Rehfeldt
Navarro Site Representative: Jeff Wurtz
Navarro Field Environmental Specialist: Mark Heser

Well Construction Activity	Activity Duration		#Ops. Days [a]	Well Depth (m)	Import Fluid (m^3)	Sump #1 Volumes (m^3)		Sump #2 Volumes (m^3)		Infiltration Area [c] (m^3)	Other [d] (m^3)	Fluid Quality Objective Met?
	From	To				Solids [b]	Liquids	Solids [b]	Liquids	Liquids		
Phase I: Vadose-Zone Drilling	10/8/2015 11/8/2015	10/21/2015 11/15/2015	21	492.25	1,096.00	252.92	3,748.00	N/A	N/A	N/A	N/A	Yes
Phase I: Saturated-Zone Drilling	10/22/2015 11/15/2015	10/25/2015 1/3/2016	22	892.55	1,550.00	319.81	7,764.00	N/A	N/A	12,893	N/A	Yes
Phase II: p1 Purging	6/30/2016	7/6/2016	7	1,384.80	0.00	0.00	89.27	N/A	N/A	N/A	N/A	Yes
Phase II: m1 Purging	8/11/2016	8/19/2016	9	1,384.80	0.00	0.00	123.74	N/A	N/A	N/A	N/A	Yes
Phase II: Final Development	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cumulative Production Totals to Date:			59	1,384.80	2,646.00	572.73	11,725.01	N/A	N/A	12,893	N/A	N/A

[a] Operational days refer to the number of days that fluids were produced during at least part (>3 hours) of one shift.

[b] Solids volume estimates include calculated added volume attributed to rock bulking factor.

[c] Discharge to an NDEP approved infiltration area as defined in the Well-Specific Fluid Management Strategy Letter for ER-20-12

[d] Other refers to fluid conveyance to other fluid management devices or facilities: e.g., baker tank or transported to another well site for storage.

N/A = Not Applicable; m = meters; m^3 = cubic meters

Total Facility Capacities (at 8 ft fluid level): Sump # 1 = 10,900 m^3 Sump #2 = 1,547 m^3 Infiltration Area (assuming very low/no infiltration) = N/A

Remaining Facility Capacity (Approximate) as of 09/02/2016: Sump #1 = 10,900 m^3 Sump #2 = 1,547 m^3

Current Average Tritium, Sump #1 FMP samples = N/A - sump is dry; all water has infiltrated through tear in liner.

Navarro Authorizing Signature/Date: /s/ Jeffrey A. Wurtz 4-30-18

8/14/2017 N-300

Navarro Radiological Services (Building 23-310) for ^{3}H analysis using an LSC. All samples were processed and analyzed by Navarro personnel in accordance with Navarro procedures (Navarro, 2016g).

In June, after installation of the pump rod in piezometer p1, purging operations of p1 began. Tritium samples were collected from the wellhead manifold sampling port during the first day of purging. Over the next six days of purging, time-series ^{3}H samples were collected every four hours using an auto-sampler. The ^{3}H samples were analyzed by Navarro radiological control technicians. The ^{3}H results indicate that ^{3}H levels were consistently at or just below the SDWA limit of 20,000 pCi/L (CFR, 2016), except for four samples. As shown in Table 6-3, ^{3}H analyses for the discharge samples from piezometer p1 ranged from 747 to 46,721 pCi/L.

Table 6-3
Final ^{3}H Results for Pahute Mesa WDT Operations at ER-20-12 Piezometer p1
(Page 1 of 2)

Sample Number	Navarro ^{3}H Analysis Results (pCi/L)	MDA (pCi/L)	Sample Description
ER-20-12-063016-1	747	2,152	Daily grab sample, initial discharge
ER-20-12-063016-2	1,241	1,891	Daily grab sample, initial discharge
ER-20-12-063016-3	3,039	1,698	Collected at sampling port
ER-20-12-063016-4	19,464	1,863	Collected at sampling port
ER-20-12-070116-5	19,982	1,856	Collected at sampling port
ER-20-12-070116-6	18,750	1,860	Collected at sampling port
ER-20-12-070116-7	19,027	1,850	Collected at sampling port
ER-20-12-070116-8	17,664	1,859	Collected with auto-sampler
ER-20-12-070216-9	18,550	1,861	Collected with auto-sampler
ER-20-12-070216-10	18,108	1,872	Collected with auto-sampler
ER-20-12-070216-11	25,421	1,845	Collected with auto-sampler
ER-20-12-070216-12	18,895	1,855	Collected with auto-sampler
ER-20-12-070216-13	18,871	1,861	Collected with auto-sampler
ER-20-12-070216-14	18,382	1,867	Collected with auto-sampler
ER-20-12-070316-15	17,734	1,873	Collected with auto-sampler
ER-20-12-070316-16	18,028	1,855	Collected with auto-sampler
ER-20-12-070316-17	21,053	1,874	Collected with auto-sampler
ER-20-12-070316-18	19,579	1,860	Collected with auto-sampler
ER-20-12-070316-19	18,814	1,860	Collected with auto-sampler

Table 6-3
Final ^3H Results for Pahute Mesa WDT Operations at ER-20-12 Piezometer p1
(Page 2 of 2)

Sample Number	Navarro ^3H Analysis Results (pCi/L)	MDA (pCi/L)	Sample Description
ER-20-12-070316-20	18,275	1,853	Collected with auto-sampler
ER-20-12-070416-21	18,362	1,855	Collected with auto-sampler
ER-20-12-070416-22	18,458	1,845	Collected with auto-sampler
ER-20-12-070416-23	18,764	1,864	Collected with auto-sampler
ER-20-12-070416-24	19,037	1,848	Collected with auto-sampler
ER-20-12-070416-25	27,117	1,846	Collected with auto-sampler
ER-20-12-070416-26	46,721	1,848	Collected with auto-sampler
ER-20-12-070516-27	19,673	1,850	Collected with auto-sampler
ER-20-12-070516-28	19,210	1,853	Collected with auto-sampler
ER-20-12-070516-29	19,790	1,857	Collected with auto-sampler
ER-20-12-070516-30	17,769	1,809	Collected with auto-sampler
ER-20-12-070516-31	18,864	1,748	Collected with auto-sampler
ER-20-12-070516-32	19,626	1,739	Collected with auto-sampler
ER-20-12-070616-33	19,271	1,743	Collected with auto-sampler
ER-20-12-070616-34	17,393	1,750	Collected with auto-sampler
ER-20-12-070616-35	18,245	1,715	Collected with auto-sampler
ER-20-12-070616-36	17,476	1,757	Collected with auto-sampler
ER-20-12-070616-37	18,782	1,732	Collected with auto-sampler

In August, after installation of the high-volume electric submersible pump in the main completion (m1), purging operations of m1 began. Tritium samples were collected from the wellhead manifold sampling port. Due to excessive drawdown in m1, samples were collected at the start-up of the pump and just before the pump was shut off. The ^3H results indicate that ^3H levels were consistently above the SDWA limit of 20,000 pCi/L (CFR, 2016). As shown in Table 6-4, ^3H analyses for the discharge samples from the main completion (m1) ranged from 28,591 to 34,558 pCi/L.

In August, piezometers p2 and p4 were sampled with a depth-discrete bailer. The daily FMP ^3H sample from piezometer p2 was collected at a depth of 2,920 ft bgs; the result of 2,087 pCi/L is below the SDWA limit. The daily ^3H sample from p4 was collected at a depth of 1,617 ft bgs; the result of 39,579 pCi/L is above the SDWA limit. Table 6-5 presents the results of the depth-discrete bailer sampling.

Table 6-4
Final ^3H Results for Pahute Mesa WDT Operations at ER-20-12 Main Completion (m1)

Sample Number	Navarro ^3H Analysis Results (pCi/L)	MDA (pCi/L)	Sample Description
ER-20-12-081116-1	28,591	1,490	Initial discharge
ER-20-12-081116-2	32,038	1,422	Collected before pump shutdown
ER-20-12-081116-3	31,521	1,374	Collected before pump shutdown
ER-20-12-081216-1	33,045	1,458	Collected at pump start-up
ER-20-12-081216-2	33,547	1,407	Collected before pump shutdown
ER-20-12-081316-1	32,700	1,504	Collected at pump start-up
ER-20-12-081316-2	34,558	1,455	Collected before pump shutdown
ER-20-12-081416-1	33,483	1,446	Collected at pump start-up
ER-20-12-081416-3	32,176	1,695	Collected before pump shutdown
ER-20-12-081516-1	30,575	1,910	Collected at pump start-up
ER-20-12-081516-2	30,902	1,715	Collected before pump shutdown
ER-20-12-081616-1	31,168	1,715	Collected at pump start-up
ER-20-12-081616-2	30,970	1,665	Collected before pump shutdown
ER-20-12-081716-1	29,149	1,746	Collected at pump start-up
ER-20-12-081716-2	32,294	1,632	Collected before pump shutdown
ER-20-12-081816-1	33,535	1,587	Collected at pump start-up
ER-20-12-081816-2	32,243	1,620	Collected before pump shutdown
ER-20-12-081916-1	33,444	1,522	Collected at pump start-up
ER-20-12-081916-2	34,240	1,605	Collected before pump shutdown
ER-20-12-082616-1	30,602	1,465	Collected during function test of dedicated electric submersible sampling pump

Table 6-5
Final ^3H Results for Pahute Mesa WDT Operations at ER-20-12 Piezometers p2 and p4

Sample Number	Navarro ^3H Analysis Results (pCi/L)	MDA (pCi/L)	Sample Description
ER-20-12-083016-1	2,087	1,656	Grab sample from bailer at 2,920 ft bgs at piezometer p2
ER-20-12-083116-1	39,579	1,601	Grab sample from bailer at 1,617 ft bgs at piezometer p4

6.2 Waste Management

Navarro was responsible for environmental compliance and waste management at the Well ER-20-12 site. Waste generated during the WDT operations consisted of hydrocarbon and sanitary wastes. Sanitary waste generated during the well development operations was routinely collected by NSTec and disposed of at the Area 23 solid waste landfill. Approximately 8 to 10 gal of solid hydrocarbon waste was generated from servicing and flushing of the high-volume electric submersible pump. The waste included kitty litter impacted by CL-5 pump oil, absorbent pads and rags. The waste was characterized using process knowledge and monitoring results. The hydrocarbon waste was removed from the Well ER-20-12 site and transported by Navarro personnel to Building 6-909 for interim storage until disposal by NSTec. The waste was ultimately disposed of at the U-10c industrial waste landfill in Area 9. Table 6-6 is a summary of the waste type, volume, and disposition of the waste stream.

Table 6-6
Final Waste Disposition for Well ER-20-12 WDT Operations

Container ID #	Start Date	Container Size	Container Type	Contents	Characterization	Disposition	Status/ Comments
ER-20-12-01-WDT	08/02/2016	55 gal	Open-top steel drum	Hydrocarbon Solids: absorbent pads, absorbent	Non-Haz, Non-Rad Hydrocarbon	Area 9 - U10c	Completed LVF received 07/10/2017
Total Waste Containers							
Lab Analytical waste: 0 Pads/debris: 1 Used oil (liquid): 0							
Total number of 5-gal waste containers: 0							
Total number of 55-gal waste containers: 1							

ID = Identification
LVF = Load Verification Form

7.0 OBSERVATIONS AND CONCLUSIONS

Well ER-20-12 was constructed as a part of the Pahute Mesa Phase II drilling program to evaluate possible sources and groundwater pathways to explain anomalous ^{3}H detections in groundwater from Well PM-3, providing additional information on water levels, geochemistry, and aquifer parameters. Well ER-20-12 was constructed between Well PM-3, approximately 5 km to the southwest off site, and the locations of the 1970 HANDLEY and 1975 STILTON UGTs, approximately 2 km and 7 km to the northeast, respectively. The main completion of ER-20-12 (m1) was finished in the PBRCM, and four piezometers were completed: p1 in the BRA, p2 in the ashflow tuff of the CHZCM, p3 in the rhyolite of the CHZCM, and p4 in the TMWTA and TMLVTA. This report provided a summary of the analysis of single-well tests from ER-20-12 as part of the proposed WDT, as well as an MWAT analysis of drawdowns in PM-3 in response to the drilling of ER-20-12.

WDT activities for ER-20-12 included LTWLM; well logging by DRI; a period of pre-WDT well sampling, including rod pumping of piezometer p1; and a period intended for well development pumping, step-rate pump testing, and constant-rate pump testing. Low water production prevented actual step-rate and constant-rate pump testing. Instead cycled pump testing was conducted, where the pump was completely shut off to allow water recovery, then turned on again, in repeated cycles.

LTWLM PXDs were installed in the main completion (m1) and the four piezometers in late May 2016. Water levels were monitored until the PXDs were replaced for pump testing, with some interruptions in data collection related to the DRI logging and pre-WDT well sampling. Water levels were obtained by either direct measurement or PXD on the same day (May 11, 2016) to establish relative head relationships considerably after well drilling but before LTWLM and WDT activities.

Significantly, the highest head was found in the shallowest piezometer, p4, monitoring the TMWTA and TMLVTA HSUs near the water table. The head in piezometer p4 is 260 ft (80 m) higher than the head in the next lowest piezometer, p3, and significantly higher than the other completions, all with heads within 30 ft of piezometer p3.

DRI conducted pre-WDT hydrophysical and geochemical logging in the main completion (m1) and piezometer p1, with an unsuccessful attempt in piezometer p3, from June 7 to 10, 2016. Flow was consistently downward in the main completion (m1) in the PBRCM, inconsistent with relatively lower heads in the shallower piezometers, p1 though p3. Flow was consistently upward in piezometer p1 in the BRA, consistent with lower heads in the shallower piezometers, p2 and p3. The BRA had sustained substantial water production during drilling.

Pre-WDT rod pumping and sampling of piezometer p1was conducted in July 2016 while monitoring the main completion and remaining piezometers. Heads in the main completion (m1) and piezometers p2 and p3 increased in response to increases in temperature from drawing warmer formation water to the well. Tritium levels in piezometer p1 were consistently around 20,000 pCi/L during the rod pumping period. Though some water-quality parameters (monitored in piezometer p1 during rod pumping) improved and stabilized, taken together, the water-quality parameters indicate that well development from the rod pumping was not complete.

A pump was installed in the main completion (m1) and function tested August 11, 2016, to attempt step testing and constant-rate pump testing. PXDs were installed in the main completion (m1) and piezometers p1 and p2 to monitor the pump testing, conducted from August 12 to 19, 2016. Twenty successive pump tests, recurring at regular intervals, were run for development and aquifer testing purposes. Water-quality parameters from the main completion (m1) were monitored throughout the cyclic WDT period. The combined results indicate that significant development has been achieved, though pH, SEC and turbidity levels remain elevated or did not stabilize in post pumping sampling results. Tritium levels monitored in the main completion (m1) during pumping were consistently around 30,000 pCi/L, including a sample taken August 26, 2016, from the dedicated sampling pump installed after WDT activities. In addition, bailer samples from piezometers p2 and p4 had ^{3}H levels of around 2,000 pCi/L and 40,000 pCi/L, respectively. Together with piezometer p1 sampling during rod pumping, consistent ^{3}H levels were thus encountered in the main completion (m1) and in piezometers p1, p2, and p4. Notably, the highest ^{3}H levels are near the water table in the TMWTA and TMLVTA of the shallowest piezometer, p4, along with its substantially higher head.

Most of the 20 cyclic tests lasted from 0.5 to 1.5 hours at a rate of approximately 30 gpm, the minimum rate required for the pump horsepower. Only the main completion (m1) under pumping stress showed any response to the pumping periods. Two of the 20 cyclic pumping datasets were

evaluated for determining the transmissivity of the PBRCM: test #2 from August 11, 2016, early in the WDT period; and test #18 from August 18, 2016, late in the WDT period. The Dougherty and Babu (1984) pump-test model was used to assess whether pumping had exceeded wellbore storage. In both tests, both the type curve and derivative curve approached a value just before pump shutoff, with test #1 yielding a value of 8.2 m^2/day and test #2 yielding a value of 5.4 m^2/day. Given that the pumping rates were unsustainable, these values, at best, represent maximum values of the transmissivity.

Drawdown was observed in LTWLM data from both completions of PM-3 in response to water production during the drilling of Well ER-20-12. SeriesSEE time-series analysis (Halford, 2006) was used to estimate aquifer properties at the scale of the large radial distances between Wells ER-20-12 and PM-3, effectively using PM-3 as an observation well, under the influence of water production from drilling, a pumping stress from ER-20-12. The primary water production from the ER-20-12 borehole occurred while drilling the CHZCM and BRA, while the response in PM-3-1 was from an effective open interval in the TCA and LPCU, and the response in PM-3-2 was from an effective open interval in the UPCU. Thus, the responses provided a way of evaluating the hydraulic properties of the HSUs above the PBRCM. The time series used in the analysis included the absolute psi response in Well PM-3-1, the barometer at the PM-3 wellhead, background water levels from Well ER-20-7 unaffected by pumping, mathematical models of Earth tides (gravity and dry), and the superposed pumping effects calculated by the Theis equation (1935). In addition, the analysis used periods of different water production rates reconstructed from different events that occurred while drilling. A single value of transmissivity (349.4 m^2/day) and storativity (5.97×10^{-4}) were obtained, within the reasonable range of the parameters in the volcanic HSUs of Pahute Mesa. The resulting transmissivity, representative of several aquifer and confining units above the PBRCM and at the scale of the distance between ER-20-12 and PM-3, is about 2 orders of magnitude higher than the transmissivities obtained for the PBRCM at the scale of the cyclic pump testing.

Groundwater samples were collected from piezometer p1 after a seven-day period of rod-pump well development had removed a total of 23,575 gal. Groundwater samples were collected from the main completion (m1) after WDT activities had removed a total of 32,603 gal. The samples were analyzed for major ions, stable isotopes, and RNs, to be compared with other wells in the vicinity for consistency with the overall trends discerned from the Pahute Mesa regional geochemistry. Field water-quality parameters were measured at the time of sample collection, along with bailer samples

from piezometers p2 and p4. The results were within normal ranges and relatively similar between the four sampling intervals. A notable exception is the pH of piezometer p4, with a value of approximately 7.0, whereas the remaining intervals are near or above a pH of 8.0.

The ER-20-12 samples plotted on the Piper diagram as a mixed-type facies Na+K-HCO_3/Cl+SO_4 with roughly equal relative concentrations of HCO_3 and Cl+SO_4. The samples exhibit similar major-ion chemistry as samples northwest of the Thirsty Canyon lineament, the Thirsty Canyon well grouping of Kwicklis et al. (2005): ER-EC-1, ER-EC-4, ER-EC-5, ER-EC-6, ER-EC-8, and PM-3. The Cl concentration in the ER-20-12 samples are consistent with a hypothesis that relatively dilute groundwater from Pahute Mesa flows southwest toward Thirsty Canyon, where it mixes with more concentrated groundwater flowing from the north and west of the Purse fault. ER-20-12 samples plot along a trend of decreasing δD with increasing Cl, consistent with an expected increasing fractionation of δD with waters increasing in TDS, including Cl, such as brines or hydrothermal waters.

Results of the analysis of δD and $\delta^{18}O$ plotted consistently with the results from other Pahute Mesa wells, parallel to the GMWLs and LMWLs, but with enrichment in $\delta^{18}O$, which indicate typical fractionation trends. All samples plot well below the present-day GMWLs or LMWLs, suggesting that the groundwater is mostly fossil groundwater unrelated to present precipitation. The stable isotopic composition of ER-20-12 groundwater is relatively light with respects to δD, similar to that in other samples collected from units at or below the TCA and in the western portion of the investigation area. The results are thus consistent with the working hypothesis that groundwater in the eastern portion of the investigation area has a larger proportion of modern recharge, as indicated by heavier δD values, with higher recharge and downward gradients in the eastern portion of the Mesa compared with the western. It therefore appears that there may be some long-term climatic influences on the stable isotope data.

Samples collected during WDT were analyzed for a suite of RNs included in the radiologic source term (Finnegan et al., 2016), including ^{3}H, ^{14}C, ^{36}Cl, ^{40}K, ^{90}Sr, ^{94}Nb, ^{99}Tc, ^{129}I, ^{137}Cs, $^{152,154}Eu$, $^{234, 235, 236, 238}U$, $^{238,239,240}Pu$, and $^{241,243}Am$. The RNs detected in the ER-20-12 samples include ^{14}C, ^{36}Cl, ^{99}Tc, ^{129}I, ^{137}Cs, and $^{234/235/236/238}U$. Tritium activities measured by LLNL and the commercial laboratory were consistent, giving high confidence in these measurements. No anthropogenic ^{236}U was detected,

suggesting the majority of U was of natural origin. While the ^{3}H activities are approximately 1 order of magnitude above the MCL (2.0E+04 pCi/L), all other RNs are well below their MCL.

Piezometer p4 is anomalous in many aspects: (1) a significantly higher head than the remaining intervals, (2) the highest levels of ^{3}H, and (3) a low pH that indicates that the associated water has had either a lesser or different geochemical evolution. The evolution of groundwater in Pahute Mesa generally follows a trend of increasing pH, the rise attributed to water-rock interactions that consume acid—particularly in reactions with zeolitic minerals—and raise carbonate/bicarbonate buffers due to a lack of divalent cation that would otherwise precipitate carbonate minerals. The lower pH is indicative of water that has had either more recent contact with the atmosphere (i.e., a lesser geochemical evolution) or has equilibrated with solid carbonate phases in the subsurface. The higher levels of ^{3}H in water nearer the water table suggest a connection may exist between the water table and the test chimneys above test cavities.

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Appendix A

Detailed Lithology and Stratigraphic Logs for Well ER-20-12

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 1 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
0-15.2 (0-50)	15.2 (50)	DA	N/A	**Moderately to Densely Welded Ash-Flow Tuff:** Drilled under NSTec supervision; no samples were collected by Navarro. Lithology inferred from bedrock exposures.	Trail Ridge Tuff (Ttt)
15.2-38.1 (50-125)	22.9 (75)	DA	N/A	**Bedded to Nonwelded Tuff:** vitric, crystal-poor, visible glass shards & bubbles with minor incipient alteration; matrix light gray (5YR 7/1) to light brown (5YR 5/6) with minor (<10%) pink (7.5YR 7/3) to pink (5YR8/4) fragments (ash shards and bubbles altered to clay, matrix partially altered); Phenocrysts (2-3%), plagioclase, quartz, mafics (<1%) biotite (black), magnetite (rare, some oxidized); Lithics: (<1%), lava (?), black (N2); Pumice (5-15%), light gray (5YR 7/1) > white (5YR 8/1) > gray (5YR 6/1), pumice range from 2-8 mm, vesicular/tubular structure with plagioclase phenocrysts; Comments: base of unit revised down to 125 ft bgs based on geophysics.	Trail Ridge Tuff (Ttt)
38.1-51.8 (125-170)	13.7 (45)	DB4, DA	N/A	**Nonwelded to Partially Welded Ash-Flow Tuff:** partially vitric to devitrified, vapor phase corrosion and mineralization; matrix reddish brown (5YR 5/3) to weak red (5R 4/2) to reddish black (5YR 2.5/1); Phenocrysts (3-5%), sanidine, plagioclase, olivine, mafics (<1%), biotite (some partially oxidized); Lithics: None noted; Pumice (5-15%), pumice cavities (rounded/blocky to weakly flattened); Comments: vapor phase mineralization, white (N9) coating (silica or analcime??) on some fractures? and cavities, from 125-150 ft bgs, (~50% contamination from above).	Pahute Mesa Tuff (Ttp)
51.8-71.6 (170-235)	19.8 (65)	DA	N/A	**Partially to Moderately Welded Ash-Flow Tuff:** crystal-poor, devitrified, vapor phase altered; matrix reddish-gray (10R 6/1) mottled with red (10R 5/6) and minor dusky red (5R 3/2, vitric); Phenocrysts (5-7%), sanidine, plagioclase, olivine (partially altered to iddingsite?), mafics (<1%), biotite, pyroxene (?); Lithics: None noted; Pumice (1-3%?), light gray (5YR 7/1, devitrified) and dark reddish brown (5YR 2.5/2), flattened and partially vitric; Comments: vapor phase corroded/mineralized spots and anastomosing veins, light gray (5YR 7/1), rare fragments of white (N9) to very pale blue (5B 8/2) silica (possibly vein/fracture filling).	Pahute Mesa Tuff (Ttp)

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 2 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
71.6-187.8 (235-616)	116.1 (381)	DA	122-125 (400-410)	**Lava:** crystal rich, variable vapor phase alteration, partially devitrified/partially vitric; matrix dark reddish-gray (10R 4/1) to reddish-gray (10R 5/1), with light gray (10R 7/1) mottling; Phenocrysts (10-15%), sanidine (5 -10%, some chatoyant), plagioclase (3-5%), mafics (1-3%), olivine (2%) (greenish pyroxene?), magnetite (1%), very fine (<0.5 mm, common) crystal grains (pyroxene/olivine?) increasing downward with devitrification; Lithics: None noted; Pumice: None noted; Comments: Some fragments weakly reactive with hydrochloric acid. Loose fragments of chalcedony (possibly analcime?), mottled white (N9) and strong brown (7.5YR 5/8), were observed throughout the interval–these are probably fracture fillings and coatings.	Comendite of Ribbon Cliff (Ttc)
187.8-198.1 (616-650)	10.4 (34)	DB4	N/A	**Lava and Lava-Flow Breccia:** devitrified to partially vitric, vapor phase alteration; matrix weak red (10R 4/2) mottled with minor red (10R 4/6) and light gray (5YR 7/1) to pale red (10R 7/4), altered (vapor phase?) material, some fine material may be ash coating lava fragments; Phenocrysts (5-10%), sanidine (some chatoyant), plagioclase, mafics (1%), olivine (fayalite), pyroxene (?), magnetite (partially oxidized); Lithics: None noted; Pumice: None noted; Comments: Alteration/Color change possibly represents oxidized base of the above lava flow, or a hiatus during which the top of the underlying vitric lava was oxidized/altered. The underlying unit is composed of vitric lava while the lava in the overlying interval is crystallized. Crystallized lava fragments in this interval may be the result of sloughing from the overlying unit.	Comendite of Ribbon Cliff (Ttc)

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 3 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
198.1-223.7 (650-734)	25.6 (84)	DA	216-219 (710-720)	**Lava:** devitrified, vapor phase altered/mineralized; matrix reddish-gray (10R 5/1) with light gray (10R 7/1) to light reddish brown (5YR 6/3) mottling; Phenocrysts (5-10%), sanidine (4%, some chatoyant), plagioclase (3%), mafics (1%), biotite, greenish pyroxene (?),magnetite; Lithics: None noted; Pumice (?), distinctive yellowish red (5YR 4/6) to strong brown (7.5YR 5/6), clay altered and vapor phase corroded material with abundant phenocrysts, possibly mixed pumiceous/blocky lava (?); Comments: loose fragments of white (N9) to very pale blue (5B 8/2) chalcedony observed throughout interval.	Comendite of Ribbon Cliff (Ttc)
223.7-251.5 (734-825)	27.7 (91)	DA, DB4	N/A	**Bedded Tuff:** vapor phase altered; from 734-754: matrix light brownish gray (2.5Y 6/2) and brown (7.5YR 4/4) to dark reddish brown (5YR 3/4), vitric; Phenocrysts (5-15%, mostly loose with some matrix), plagioclase, sanidine, qtz (?), mafics (<1%), biotite (?,oxidized), magnetite (oxidized); Lithics (1-2%) brown (7.5YR 4/4) and dark reddish brown (5YR 3/4) welded tuff fragments, corroded and vuggy with high porosity. **Bedded Tuff:** from 754-810: matrix gray (7.5Y 6/1) to pinkish gray (7.5Y 6/2) vitric with sugary texture; Phenocrysts (7%) primarily plagioclase and sanidine with minor quartz; Lithics: 1-2% fragments of welded tuff and other volcanics; pumice (5%), white (10YR 8/1), vitric; from 800-810: ~50% of sample: Lava (Basalt?): very dark gray (3/N) to black (2.5N); vuggy/vesicular with olivine altered to iddingsite, fragments of very pale blue (5B 8/2) chalcedony observed; Comment: May represent a thin Post Timber Mountain Basalt (Tftr) flow (?). Bedded Tuff: devitrified, vapor phase altered: from 810-825: ~5% basalt fragments, 15% welded tuff fragments, dark reddish gray (10R 4/1), remainder bedded material (?); Comments: possible/uncertain contamination?	Comendite of Ribbon Cliff (Ttc)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
251.5-272.5 (825-894)	21.0 (69)	DA	256-259 (840-850), 265-268 (870-880)	**Lava:** devitrified, vapor phase altered, crystal-poor; from 825-855: matrix light gray (7.5YR 7/1) to pale red (10R 6/2), from 855-894: fragments dark reddish gray (5YR 4/2) to reddish brown (5YR 4/3) and dark gray (10YR 4/1) to gray (10YR 6/1); Phenocrysts (5-10%) plagioclase, sanidine, sphene(?), mafics (<1%) biotite (black), hornblende, many phenocrysts are loose with little to no matrix; Lithics: None noted; Pumice: None noted.	rhyolite of Beatty Wash (Tfbw)
272.5-297.2 (894-975)	24.7 (81)	DB4, DA	N/A	**Nonwelded Ash-Flow Tuff:** vitric, crystal rich, mafic-rich; matrix white (2.5Y 8/1); Phenocrysts (10-15%) sanidine, quartz (term., dipyramidal, some with faint pink tint), plagioclase, sphene (?), mafics (1-2%+), biotite (black), pyroxene(?); Lithics (5-<10%), welded tuff/lava pinkish gray (7.5YR 7/1), pale red (7.5YR 7/4), and dark reddish gray (7.5YR 3/1), abundance appears to decrease with depth; Pumice (2-10%), light gray (5YR 7/1) and minor pinkish white (5YR 8/2), vitric to altered, vesicular/tubular structure; Comments: possible dark brown (7.5YR 3/3) volcanic glass, possible vapor phase alteration, heavy contamination from 894-940 (50-80%) decreasing (<50%).	Timber Mountain Ammonia Tanks mafic-rich Tuff (Tmar)
297.2-358.1 (975-1,088)	61.0 (200)	DA	320-323 (1,050-1,060)	**Bedded Tuff:** vitric to clay altered; From 975-1050: cuttings consist of ~50% phenocrysts; quartz (term., dipyramidal, some with faint pink tint), sanidine and plagioclase, matrix appears to have been washed away and crystals concentrated due to the drilling process; from 1,050-1,088: **Bedded to Nonwelded Ash-Flow Tuff:** vitric, crystal rich; matrix white (5Y 8/1) to pinkish gray (5YR 7/2); Phenocrysts (>15%), sanidine, quartz (some partially resorbed, dipyramidal, faint pink tint), plagioclase; Lithics, vitric to devtrified volcanics, Dark gray (5YR 4/1) to dark reddish gray (5YR 4/2).	Timber Mountain Ammonia Tanks bedded tuff (Tmab)

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 5 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
331.6-358.1 (1,088-1,175)	26.5 (87.0)	DA	N/A	**Bedded/Reworked Tuff:** vitric with some clay (?) alteration; matrix white (5YR 8/1) with some subordinate reddish yellow (7.5YR 8/6); Lithics (5-10%), lava gray (5YR 6/1) light reddish brown (5YR 6/3) with lesser amounts of welded tuff reddish yellow (5YR 6/8); Pumice (5-10%) white (5YR 8/1) and light gray (5YR 7/1), size range 1-2 mm most common, vitric, some vapor phase alteration, decreasing percentage with depth; Phenocrysts (10-15%): sanidine, 6% (some chatoyant); plagioclase, 3%; quartz, 3% (faint pink tint, dipyramidal), sphene (?); mafics (2%), biotite (black), rare pyroxene, magnetite(?).	Timber Mountain Rainier Mesa bedded tuff (Tmrb)
358.1-387.1 (1,175-1,270)	29.0 (95)	DA	378-381 (1,240-1,250)	**Nonwelded to Moderately Welded Ash-Flow Tuff:** devitrified, crystal rich, mafic-rich, vapor phase altered; matrix weak red (5R 5/3) to pale red (5R 6/1); Phenocrysts (10-20%), sanidine (6%), quartz (4%) (term., dipyramidal), plagioclase (3%), mafics (2%), biotite (unoxidized to oxidized), pyroxene (?), magnetite (?); Lithics (1-5%), welded tuff pale red (7.5YR 7/4); Pumice (2-5%) gray (5YR 6/1), white (5YR 8/1), reddish gray (5YR 5/2), flattening ratio increasing with depth, vapor phase altered, some relict vitric texture.	Timber Mountain Rainier Mesa mafic-rich Tuff (Tmrr)
387.1-460.3 (1,270-1,510)	73.2 (240)	DA	N/A	**Moderately to Densely welded Ash-Flow Tuff:** devitrified, crystal rich, mafic-rich, vapor phase altered; matrix mottled weak red (5R 4/2) to weak red (5R 5/4) with light gray (5YR 7/1) to white (5YR 8/1) spots or anastomosing veins, possibly collapsed pumice or vapor phase partings; Phenocrysts (10-15%), sanidine (some chatoyant), quartz (term., dipyramidal), plagioclase, mafics (1-2%), biotite (black), pyroxene (?). Lithics: None noted; Pumice (3-7%), color listed in matrix section; Comments: vapor phase alteration appears to be increasing with depth.	Timber Mountain Rainier Mesa mafic-rich Tuff (Tmrr)

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 6 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
460.3-551.7 (1,510-1,810)	91.4 (300)	DA	491-494 (1,610-1,620)	**Moderately to Densely welded Ash-Flow Tuff:** devitrified, crystal rich, mafic-poor, vapor phase altered; matrix mottled weak red (5R 4/2) to weak red (5R 5/4) with light gray (5YR 7/1) to white (5YR 8/1) spots or anastomosing veins, possibly collapsed pumice or vapor phase partings; Phenocrysts (10-15%), sanidine (some chatoyant), quartz (term.,dipyramidal), plagioclase, mafics (<1%), biotite (unoxidized to oxidized); Lithics: None noted; Pumice (10-15%), color listed in matrix section.	Timber Mountain Rainier Mesa mafic-poor Tuff (Tmrp)
551.7-562.7 (1,810-1,846)	11.0 (36)	DA	558-561 (1,830-1,840)	**Densely Welded Ash-Flow Tuff:** vitrophyre, crystal rich: matrix black (10YR 2/1), dark gray (10YR 4/1), light gray (10YR 7/1); Phenocrysts (10-15%): sanidine (4%, some chatoyant), plagioclase (3%, blocky), quartz (2%), mafic (<1%); Lithics: None noted; Pumice (% uncertain, probably low): light gray (5YR 7/1); Comments: glassy vitrophyre (shards) to granophyric texture, chips are typically tabular (platy) to sub-blocky.	Timber Mountain Rainier Mesa mafic-poor Tuff (Tmrp)
562.7-600.5 (1,846-1,970)	37.8 (124)	DA	573-576 (1,880-1,890)	**Moderately to Partially Welded Ash-Flow Tuff:** devitrified, crystal rich, mafic-poor: matrix red (10R 4/6), weak red (10R 5/3); Phenocrysts (10-15%): sanidine (7-8%), quartz (2-3%), plagioclase (<1%), mafics (<1%), biotite (unoxidized); Lithics (2-5%), lava yellowish red (5YR 5/8), reddish brown (5YR 5/3), volcanic glass (including spherules) very dark brown (7.5YR 2.5/2) > black (7.5YR 2.5/1); Pumice (1-3%), white (5YR 8/1) to reddish yellow (5YR 7/8), vitric (tabular) texture and varying amounts of alteration, generally 1-5 mm and evenly distributed; Comments: Significant increase in water production in this interval, down from the virtophyre through moderate and nonwelded vitric (?) zones, volcanic glass exhibits iridescent color play on external/internal surfaces.	Timber Mountain Rainier Mesa mafic-poor Tuff (Tmrp)

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 7 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
600.5-710.2 (1,970-2,330)	109.7 (360)	DA	610-613 (2,000-2,010), 698-701 (2,290-2,300)	**Nonwelded Ash-Flow Tuff:** mafic-poor, vitric to devitrified, altered (clay?) matrix; matrix from 1,970-2,080: light red (10R 6/6) to pinkish white (10R 8/2) with light gray (5YR 7/1); Phenocrysts (10+%): sanidine (4-6%, some chatoyant); quartz (2-4%), (term., dipyramidal); plagioclase (2%); mafics (<1%), biotite (unoxidized to oxidized); Lithics (2-5%), lava (vitric/aphyric) red (7.5R 4/8) to red (10R 4/6), welded tuff mottled reddish brown (2.5YR 4/4) and pale red (5YR 4/6), from2,195-2,330 lithic rich interval (15-25%), size ranges from 2-8 mm, lithics show some to abundant matrix; Pumice (15-20%), light gray (5YR 7/1), pinkish white (5YR 8/2), white (10R 8/1). *From 2,080-2,160:* matrix red (10R 4/6), pumice (% as above), light gray (5YR 7/1), pink (5YR 7/4)–more vitric, less argillically altered than above. *From 2,160-2,340:* matrix light reddish brown (5YR 6/4), pumice (% as above), white (10R 8/1), light gray (5YR 7/1).	Timber Mountain Rainier Mesa mafic-poor Tuff (Tmrp)
710.2-725.4 (2,330-2,380)	15.2 (50)	DB4	N/A	**Bedded and Reworked Tuff:** moderately to poorly indurated, crystal rich, mafic-poor; matrix brown (7.5YR 4.3 to 4.4), gray (7.5YR 5/1); Phenocrysts (10-15%): sanidine (3-4%); quartz (3-4%, rare terminations), plagioclase (<1%), mafics (1%), biotite (black), pyroxene(?); Lithics (3-7%), lava dark reddish gray (2.5YR 4/1), dusky red (10R 3/4), reddish gray (10R 5/1), size from <0.5-2 mm, rare up to 5 mm; Pumice (3-7%), white (N9), pinkish white (10R 8/2), light gray (10R 7/1), sub-rounded to rounded/blocky, altered; Comments: cuttings are a mix of bedded and reworked (some grading-crude?), fine grained material and contamination from above.	Timber Mountain Rainier Mesa bedded tuff (Tmrb)

Table A-1
Detailed Lithologic Log for Well ER-20-12
(Page 8 of 14)

Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
725.4-760.5 (2,380-2,495)	35.1 (115)	DA	747-750 (2,450-2,460)	**Nonwelded Ash-Flow Tuff and Tephra(?):** crystal-poor, pervasive zeolitic/argillic alteration: from 2,380-2,425: matrix pale olive (5Y 6/3), white (5Y 8/1), pink (7.5YR 8/3); Phenocrysts (2-5%), sanidine, plagioclase, mafics (<1%), biotite (black); Lithics (1-3%), welded tuff/lava dark reddish gray (2.5YR 4/1), pale red (10R 7/2), gray (7.5YR 5/1), sizes range from 1-4 mm; Pumice (5-15%?), pale yellow (5Y 8/3), yellow (10YR 8/6), very pale brown (10YR 8/2), and reddish yellow (7.5YR 8/6), exhibiting relict vitric texture, zeolitized; Comments: abundant contamination from bedded/reworked unit above. *From 2,425-2,495:* matrix white (7.5YR 8/1) and pinkish white (7.5YR 8/2); Phenocrysts (2-3%), sanidine, plagioclase, quartz (??), mafics (<1%), biotite, rare magnetite (?); Lithics (<1-3%), welded tuff red (10R 5/6), reddish gray (10R 6/1), dark red (10R 3/6), lava dark gray (5YR 4/1), reddish black (2.5YR 2.5/1); Pumice (1-2%?), white (7.5YR 8/1), altered, mostly 1-2 mm, with some exhibiting erosion and others having relict vitric textures; from 2,480-2,490 crystallized tuff with minor silicification and pervasive zeolitic alteration.	Paintbrush Group Undivided (Tp)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
760.5-871.7 (2,495-2,860)	111.3 (365)	DA, DB4, PSWC	847-850 (2,780-2,790)	**Lava:** crystal-poor, mafic-poor, vitric to devitrified, variable alteration near the top and base of flow; Phenocrysts (1-5%), sanidine, quartz, plagioclase, mafics (<1-1%), biotite (unoxidized to oxidized), hornblende (granular, very rare), phenocrysts difficult to distinguish from vitric matrix, numerous very fine (<0.5 mm) mafics/oxides (??); Lithics (<1-3%), welded tuff/lava pale red (7.5R 7/4) to weak red (5R 4/2); Comments: vitric material exhibits perlitic/spherulitic features and crackle textures; *From 2,495-2,530:* Pumiceous Lava; with minor intercalated bedded tuff (?); matrix (altered pumiceous material) light yellowish brown (10YR 6/4), pale yellow (5Y 7/3), and matrix (vitric material) gray (2.5YR 6/1) to dark reddish gray (2.5YR 4/1), grading into vitric lava; Pumice (10-15%), pale yellow (5Y 8/2) to white (2.5YR 8/1), blocky to prismatic, size ranges from <1-4 mm+. *From 2,530-2,660:* Lava (Vitrophyric); matrix pale green (5G 6/2) to light greenish gray (10GY 7/1) and light gray (N7) to dark gray (N4); Comments: fragments of chalcedony (<1-1%), light bluish gray (5B 8/1); *From 2,660-2,770:* Lava (Stoney Core), devitrified to aphyric; matrix mottled weak red (10R 4/3) to pale red (10R 6/2) with dark reddish gray (10R 3/1); Comments: fragments of chalcedony light bluish gray (5B 8/1) to white N9); *From 2,770-2,800:* Lava (Vitrophyric); same as at 2,530-2,660; *From 2,800-2,860:* Lava (Basal Flow Breccia); devitrified/vitric, zeolitic alteration; matrix olive gray (5Y 4/2) mottled reddish gray (5R 6/1) and weak red (5R 5/3), minor pinkish white (10R 8/2); Lithics: angular to rounded, from (<1-5 mm+), some sorting?; Pumice (5-15%), white (7.5R 8/1), pinkish white (7.5R 8/2), light greenish gray (10GY 8/1), zeolitic/argillically altered; Comments: base of lava revised downward to 2,860 ft bgs based on geophysics.	Calico Hills rhyolitic lava (Thrl)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
871.7-877.8 (2,860-2,880)	6.1 (20)	DB4	N/A	**Nonwelded Tephra:** crystal-poor, mafic-poor, argillic/zeolitic alteration; matrix brown (7.5YR 5/3) mottled with white (7.5 8/1); Phenocrysts (5-7%), sanidine, quartz (term., some partially resorbed), plagioclase, mafics (1%), biotite (black), magnetite(?) (oxidized rims); Lithics (1-2%), lava/welded tuff weak red (5R 4/2), dusky red (5R 3/2), weak red (7.5R 4/2), most are <2 mm but rarely to 5 mm; Pumice (20-40%), white (7.5R 8/1), pink (5YR 8/3), light red (2.5YR 7/6), mostly altered with felsic phenocrysts, some relict vitric texture; Comments: rare blebs of very pale blue (5B 8/2) chalcedony, interval may be pumice fall precursor eruption for lava flow? Interval may represent the basal/precursor eruptive flow of lava?	Calico Hills rhyolitic lava (Thrl)
877.8-962.6 (2,880-3,158)	84.7 (278)	DA, PSWC	881-884 (2,890-2,900)	**Nonwelded Ash-Flow Tuff:** crystal-poor, mafic-rich, argillic/zeolitically altered: matrix brown (7.5YR 5/3), pink (7.5YR 7/3), white (7.5YR 8/1); Phenocrysts (5-10%), sanidine, quartz (term.), plagioclase, mafics (2-3%) biotite (black), magnetite (very fine grains); Lithics (1-3%), lava/welded tuff weak red 5R4/2, dusky red (5R 3/2), weak red (7.5R 4/2), most are <2 mm but some up to 5 mm across; Pumice (20-30%), white (7.5R 8/1), pinkish white (7.5YR 8/2), pink (5YR 8/4), mostly <2-3 mm (possibly much larger), blocky/non-flattened, some have relict vitric textures; Comments: first observation at 3,100 ft of greenish gray (10Y 8/1) and light pink (7.5R 8/2) pumice, distinctive texture of ash-flow with blocky pumice, moderately to well indurated.	Calico Hills mafic-rich Tuff (Thr)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
962.6-1,027.2 (3,158-3,370)	64.6 (212)	DA, PSWC	969-972 (3,180-3,190)	**Nonwelded Ash-Flow Tuff:** crystal-poor, lithic rich, argillic/zeolitically altered, moderately to well indurated; from 3,158-3,190: matrix weak red (7.5R 5/4) to pale red (7.5R 6/3), and pale yellow (2.5Y 8/3), pink (5YR 8/3), white (5YR 8/1) spots (pumice fragments); Phenocrysts (2-5%), sanidine, quartz (term., frosted), plagioclase(?), mafics (1%) biotite (black), rare white (N9) to light bluish gray (5B 8/1) coating/fracture filling (soft); Lithics (5-15%), lava weak red (7.5R 5/4), weak red (10R 4/2), red (10R 4/8), range from (<1-5 mm+); Pumice (25-30%), pale yellow (2.5Y 8/3), pink (5YR 8/3), white (5YR 8/1), blocky/prismatic pumice, sugary textures, some relict vitric textures. *From 3,190-3,370:* matrix reddish brown (5YR 5/3) mottled red (7.5R 5/6), mottled texture for overall sample (matrix and pumice); Phenocrysts (3-7%), sanidine, quartz (term., frosted, clear, good crystal faces, no resorption), plagioclase, mafics (1%), biotite (black), very fine phenocrysts mafic & clear, to small to identify; Lithics (10-20%), lava/welded tuff weak red (10R 4/2), dusky red (10R 3/3), dark reddish gray (2.5YR 3/1), range from (<1-4 mm+); Pumice (20-40%), pinkish white (7.5YR 8/2), very pale brown (10YR 8/2), white (N9), distinctive blocky pumice ash-flow texture; Comments: some fragments appear as graded/reworked and bedded/ash-falls.	Calico Hills (Th)
1,027.2-1,035.7 (3,370-3,398)	8.5 (28)	NS	N/A	**Bedded to Nonwelded Ash-Flow Tuff:** crystal-poor, argillic/zeolitically altered; matrix pale yellow (5Y 8/3), white (N9 and 10YR 8/1), pinkish white (5YR 8/2); Phenocrysts: 1-2% sanidine, quartz, mafics (<1%?); Pumice white (N9), pinkish white (2.5YR 8/2); Comments: No Sample recovered in this interval, interpreted from geophysical logs and sample from 3,400-3,410.	Calico Hills (Th)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
1,035.7-1,079.0 (3,398-3,540)	43.3 (142)	DA	1,076-1,079 (3,530-3,540)	**Densely Welded Ash-Flow Tuff:** devitrified, crystal-poor; from 3,398-3,540: matrix mottled dark red (10R 3/6) with pale red (10R 6/4), ~10% nonwelded tuff, altered pinkish white (7.5YR 8/2) fragments–contamination from above; Phenocrysts (3-5%), sanidine (some chatoyant), plagioclase, mafics (<1%), biotite (unoxidized); Lithics (<1%), lava (?) very dark gray (7.5 YR 3/1); Pumice: None noted; Comments: ~1-2% of fragments appear brecciated (micro?), fragments are the same as the general tuff material with lighter colored (pink [7.5YR 8/3]) material. *From 3,450-3,460:* Zone of heavier contamination? *From 3,480-3,540:* Contains white (N8) to clear silica (some botryoidal) fracture filling, ~3-5%	Grouse Canyon Tuff (Tbg)
1,079.0-1,083.9 (3,540-3,556)	4.9 (16)	DA	N/A	**Bedded Tuff:** crystal-poor, altered (clay/zeolite?); from 3,540-3,556: matrix white (2.5YR 8/1) to pinkish white (2.5YR 8/2) to very pale brown (10YR 8/2), mixed with material from above, contacts adjusted by geophysics; Phenocrysts (2-3%), sanidine, plagioclase, mafics (<1%), biotite; Lithics (1%?), lava (?) light red (10R 6/8), dark reddish gray (10R 3/1), may be contamination from up hole?; Pumice (3%?), pinkish white (2.5YR 8/2) to very pale brown (10YR 8/3), very small; Comments: Some fragments appear granular texture with possible sorting?	Grouse Canyon bedded tuff (Tbgb)
1,083.9-1,133.9 (3,556-3,720)	50.0 (164)	DA, PSWC	1,109-1,113 (3,640-3,650)	**Lava:** vitrophyric; From 3,556-3,660: matrix greenish gray (5G 6/1) to grayish green (5G 5/2) to pale yellow (5Y 7/3), 3,660-3,680: pale yellow (5Y 8/2), ~50% of lava chips show incipient alteration (clay/zeolite??); Phenocrysts (3-5%?), sanidine, quartz (??), mafics (1%), biotite (unoxidized), pyroxene (rare), oxides (manganese) forms thin sheets/coatings on fractures/flow partings, difficult to distinguish clear felsic phenocrysts in glassy matrix; Lithics: None noted, lava fragments have no matrix–most likely contamination; Pumice (<1%), fused in glass–possible tubular texture); Comments: crackle and perlitic textured glass, 3,650-3,660: no returns.	Comendite of Quartet Dome (Tbq)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
1,133.9-1,155.5 (3,720-3,791)	21.6 (71)	DB4, PSWC	1,146-1,149 (3,760-3,770)	**Moderately to Densely Welded Ash-Flow Tuff:** devitrified, spherulitic, altered; matrix reddish brown (2.5YR 4/4) to light reddish brown (2.5YR7/4) to reddish yellow (5YR 6/6); Phenocrysts (2-3%), sanidine, plagioclase, quartz (?), mafics (1%), biotite (oxidized to unoxidized), pyroxene (??, granular blebs), oxides (?) appear in trains or disseminated in granular (devitrified?) matrix, possible oxide coating on "rare" surfaces; Lithics: None noted; Pumice (3-5%?), light pink (7.5YR 8/3), white (7.5YR 8/1), relict tubular structures (?) (alternatively may be radiating structures in masses of altered spherulites); Comments: chalcedony clear, white (N9), light bluish gray (10B 8/1), filling spherulitic cavities and fractures, possible foliation/flow banding features at 3,780-3,790, some fragments appear brecciated or flow laminated–alternatively interval may include or be a Basal Flow Breccia?	Comendite of Quartet Dome (Tbq)
1,155.5-1,268.0 (3,791-4,160)	112.5 (369)	DA, PSWC	1,216-1,219 (3,990-4,000)	**Lava:** crystal-poor, spherulitic, altered, devitrified (granular texture); matrix from 3,791-3,880: pinkish gray (5YR 7/2) to pinkish white (5YR 8/2), from 3,880-4,160 light gray (5YR 7/1) to pinkish gray (5YR 7/2); Phenocrysts (2-3%), sanidine, plagioclase?, mafics (<1%), biotite (unoxidized), oxides (very fine, in trains? or disseminated) similar to lava's above; Lithics (<1%), lava (?) black (5YR 2.5/1) [see percussion core descriptions]; Pumice: None noted; Comments: some fragments are a mix (single piece) of vapor phase/granular material and devitrified/spherulitic lava, spherulites are most abundant from 3,791-3,880 ft and decrease in abundance with depth.	rhyolite of Handley (Tqj)

Table A-1
Detailed Lithologic Log for Well ER-20-12
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Depth Interval m (ft)	Thickness m (ft)	Sample Type [a]	Depth of Analytical Samples [b] m (ft)	Lithologic Description [c]	Stratigraphic Unit (Map symbol)
1,268.0-1,347.2 (4,160-4,420)	79.2 (260)	DA, DB4, PSWC	1,283-1,286 (4,210-4,220)	**Lava and Flow Breccia:** crystal-poor, mafic-rich, vapor phase altered, chloritic?/ clay?, devitrified (granular texture); matrix from 4,160-4,250 dark red (2.5 YR 6/8) to light red (2.5 YR 6/8) to light gray (5YR 7/1); from 4,250-4,370 greenish gray (10YR 5/1), from 4,370-4,380 gravel/contamination, from 4,380-4,420 reddish brown (5YR 5/4) grading downward to pink (5YR 7/4); Phenocrysts (5-7%), sanidine, plagioclase, quartz (?), mafics (2-5%) biotite (oxidized, oxidized decreases with depth), oxides (very fine, in trains?); Lithics (<1%), lava (?) gray (N5), bluish black (10B 2.5/1); Pumice: None noted; Comments: 4,170-4,200: altered zone with strong silicification?	rhyolite of Handley (Tqj)
1,347.2-1,384.8 (4,420-4,543.33)	37.6 (123.33)	DB4	1,381-1,384 (4,530-4,540)	**Nonwelded Ash-Flow Tuff:** devitrified, altered (clay, vapor phase); matrix very pale brown (10YR 8/2) to white (10YR 8/1); Phenocrysts (5-10%), sanidine, plagioclase, quartz(?), mafics (<1-1%), biotite (oxidized-unoxidized, most are broken). Lithics (2-3%), lava (?) pink (7.5YR 8/4), gray (7.5YR 6/1); Pumice (3-7%?), white (7.5YR8/1) to reddish yellow (7.5 YR 8/6), many pumice have been plucked out blocky to subround, some relict tubular structures.	rhyolite of Handley (Tqj)

[a] Lithologic samples collected from interval during drilling and logging operations and utilized for lithologic interpretation. DA = drill cuttings that represent lithologic character of interval; **DB4** = cuttings intimate mixtures of units and/or drilling material, generally less than 50% of drill cuttings represent lithologic character of interval; PSWC = percussion sidewall core; NS = no sample.

[b] Depth of lithologic samples selected for laboratory analyses. Laboratory analyses include petrography (from polished thin sections), mineralogy (XRD), and chemistry (XRF). [c] Descriptions are based mainly on visual examination of lithologic samples using a 10x- to 40x-zoom binocular microscope, and incorporating observations from geophysical logs and sidewall cores. Colors describe wet sample color unless otherwise noted.

mm = Millimeter
N/A = Not applicable

Appendix B

Descriptions of Measurement Equipment Used and Submersible Pump Performance Curves

B.1.0 Descriptions of Measurement Equipment Used and Submersible Pump Performance Curves

This appendix contains descriptions of the measurement equipment used for collecting the WDT data in this report. In addition, the performance curves for the submersible pumps used for WDT activities at Well ER-20-12 are provided.

B.1.1 Measurement Equipment

In addition to the description of the measurement equipment, this appendix also provides basic information about the methods used to process the data to create the graphs presented in this report.

B.1.2 Depth-to-Water Measurements

DTW measurements are made with a calibrated e-tape equipped with a conductivity sensor. Incidental DTW measurements may also be recorded with instruments such as PXDs and other downhole logging tools run on wirelines.

DTW measurements (Section 2.3) were primarily made during the installation and removal of PXDs using calibrated e-tapes. DTW can also be reported on other logs such as water-chemistry parameter/temperature logs and flow logs; however, these other measurements do not provide the same degree of accuracy as the calibrated e-tapes. Formal measurements with e-tapes were made in accordance with the *Field Instruction for Underground Test Area Activity Well Development, Hydraulic Testing, and Groundwater Sampling* (N-I, 2012). These measurements were reported on the UGTA Depth-to-Water-Level Data Forms and Pressure Transducer Data Forms. The following subsection describes the e-tape and wirelines used by Navarro.

B.1.2.1 Solinst Electric Tapes

Navarro uses Solinst e-tapes of varying lengths for DTW measurements. The specific e-tape used for a measurement is selected according to the best fit for the specific need. The equipment number of the e-tape used is recorded on the UGTA Depth-to-Water-Level Data Forms. The e-tapes are calibrated

every two years against a reference steel tape maintained by USGS, and a calibration factor is determined to correct all measurements to a common reference for comparability.

B.1.3 Wirelines

Navarro has a variety of Comprobe, Mt. Sopris, and Century wireline winch units with varying cable lengths that are used to install PXDs and to run depth-discrete bailers downhole. Depth measurement is provided by a cable-length measurement wheel/counter mechanism. Although the wireline measurements are not calibrated, they do provide a good approximation of depth.

B.1.4 Barometers

Barometric pressure at Well ER-20-12 was measured using Viasala PTB110 barometers. The barometers are housed with the datalogger near the wellhead in a weatherproof enclosure that is vented to the atmosphere. The pressure sensor outputs an analog millivolt signal and is accurate to ± 0.3 hectopascal at 20 ºC. The barometer is used to take a single barometric pressure measurement when formal DTW measurements are taken. When PXDs are used in the wells to monitor total pressure below the water level, a pressure reading from the barometer at the wellhead is recorded each time a PXD pressure reading is recorded. The barometers are factory-calibrated every two years.

B.1.5 Pressure Transducers

INW Model PT12 and PT2X PXDs were used below the water level for automated recording of total pressure in wells and the groundwater temperature at the PXD. The INW PT12 PXDs are digital with a static accuracy of ± 0.06 percent of full-scale pressure. The PXDs are factory-calibrated every two years. The pressure values are absolute (as psia). The groundwater temperature, as monitored by the PXD, is recorded in degrees ºC with an accuracy of ± 0.5 ºC.

B.1.5.1 PXD Installation and Removal Procedures

PXD installations in a piezometer or main well completion are preceded by a DTW measurement with a calibrated e-tape. The DTW is measured, referenced to the ground surface, and recorded on a DTW data form. During PXD installations, depths and corresponding PXD pressures and temperatures are recorded at five stations on a PXD data form. The first station measurement is taken in the air just above the measured water surface, and the fifth station measurement is taken at or near

the final PXD set depth. The remaining three-station measurements are taken below the measured water surface and are roughly equally spaced between the measured water surface and the final PXD depth. During PXD removal, the order of measurement is reversed. Depths are recorded from the wireline counter installed on the PXD cable reel and referenced to the top of the casing. These measurements are used to check the linearity of the PXD response and to calculate a density conversion factor for the water column above the PXD. Once the PXD is removed, the DTW is measured and recorded.

The PXD installation depth is calculated using the DTW measurement and the PXD pressure at the installation depth attributable to water pressure. The PXD pressure at the set depth minus the PXD pressure in the air above the water surface is multiplied by the density conversion factor for groundwater at the temperature as measured by the PXD to give the PXD depth below the SWL. The PXD depth below SWL is then added to the measured DTW to determine the PXD installation depth. The installation depth of the PXD is verified by calculating the removal depth. When water levels and water temperature are relatively stable, there is generally good agreement between the calculated installation depth and calculated removal depth.

B.1.6 Production Flowmeter

The production rate at Well ER-20-12 was measured using a Foxboro IMT25 Transmitter and Foxboro 8004A Magnetic Flow Tube (4 in.). The meter uses a pulse signal to transmit production rate data to a datalogger and a 4-20 analog signal to transmit production rate data to the VSC. The meter is accurate to 0.25 percent of the flow rate being measured at flow velocities greater than or equal to 2.0 ft/s. The meter is factory-calibrated every two years.

B.1.7 Water-Chemistry Instrumentation

Measurement of temperature, pH, DO, SEC, and turbidity of grab samples was accomplished using a Hydrolab Quanta Multiprobe. A Horiba F-53 pH/ION meter (pH + bromide) was used to measure bromide in the grab samples. Water-chemistry parameters (pH, DO, SEC, temperature, and turbidity) were also measured continuously on a side stream from the wellhead discharge using a Hydrolab Quanta Multiprobe with a flow-through cell. Flow rate to the flow-through cell was controlled in the range of 1 to 3 gpm and was measured using an appropriately sized Kobold flowmeter.

B.1.8 Datalogger and Data Collection

Campbell Scientific CR1000 dataloggers were used for recording data (e.g., PXD pressure data, groundwater temperature, barometric pressure, and flow rates). The CR1000 is a fully programmable datalogger that uses digital communication (e.g., RS-485, SDI-12 protocol) with digital sensors or makes analog measurements (precision voltage measurement, pulse counter) for analog sensors. The analog sensors measure voltage across a precision resistor. The dataloggers are powered by external, deep-cycle batteries that are typically recharged using solar cells. The data collected are referenced to a specific date and time.

To avoid excessive data collection by the dataloggers, two programming protocols were used. The first protocol stored PXD data on a fixed time interval for all parameters. The second protocol was applied to the PXD and was driven by the amount of pressure change measured. When pressure changes were occurring rapidly, such as at times of initial drawdown or recovery, triggers set in the datalogger by Navarro field personnel initiated the collection of data at rapid intervals. When pressure changes were not changing rapidly, triggers set in the datalogger signaled the datalogger to decrease the frequency of sampling. Field personnel determined data-collection intervals based on the amount of pressure change observed during monitoring and based on the noise level experienced with preceding PXD measurements. Each data record includes the trigger number.

B.1.9 Datalogger Data Presentation

The datalogger data were imported into Microsoft Excel spreadsheets for review and processing. The following data presentation conventions were used:

- Time for data collected by CR1000 dataloggers is in calendar day, hours:minutes:seconds. This format is compatible with Microsoft Excel time formats.
- The WDT operations time data were collected in both Pacific Daylight Time and Pacific Standard Time (PST), depending on when the various phases of the work took place.
- The LTWLM time data were collected in PST.
- The graphs illustrate data collection timelines and present the gross features of the monitoring and testing data. Detailed evaluation of the data is supported through the inclusion of the raw data files.

- The PXD data are initially presented as the pressure recorded by the datalogger corresponding to the raw data in the data files. These data may be processed to various measures of head or head change (e.g., feet or meters) using density-conversion factors.
- The PXD pressure measurements are reported as psia.
- Barometric pressure was measured as absolute pressure in mBar. The barometric data are shown on graphs in units of mBar and scaled to the corresponding PXD pressure. The conversion was made using 1 mBar = 0.0145037738 psi. The accompanying DVD includes the original data files with barometric pressure in mBar.

Due to changing temperature with depth and/or differences in water quality with depth, the water density varies with time (changing temperature distribution) and depth in the water column. The data on water density in this report are presented in terms of the conversion factor for pressure in psi to the vertical height of the water column in feet. The density conversion factors were computed for the water column above the PXD using installation calibration information.

B.1.10 Downhole Logging and Data Presentation

The distribution of various parameters (i.e., vertical flow, temperature, pressure, and water chemistry) with depth was logged using downhole tools. The tools were run in the main completion and piezometers and included an I-CHEM chemistry tool and a TFM. Measurements were made under ambient (nonpumping) conditions (i.e., no groundwater production). These measurements are used to help identify the location of inflows and outflows along the wellbore as well as to provide the groundwater quality with depth. The data indicate variations in hydraulic conductivity and conductive features within the formations with which the well is in hydraulic communication and are used to aid selection of the depth at which to collect a depth-discrete bailer sample.

B.1.10.1 Water-Chemistry Logging

Personnel from DRI conducted water-chemistry logging using an I-CHEM chemistry tool. The chemistry tool is a 16-bit, high-resolution digital probe capable of measuring pressure (0 to 1,000 decibar); temperature (1 to 50 °C); EC (0 to 6,400 microsiemens per centimeter [µS/cm]); DO (0 to 50 parts per million [ppm], 0 to 500 percent saturation); and pH (0 to 14 SU) in groundwater wells with up to 3,300 ft of head and in wells as small as 48 mm (1.9-in.) diameter. The I-CHEM tool can be used under both stressed and ambient conditions. Inflections in the profile of measured parameters are indicative of the mixing of groundwater within the well and are used to select the stations for

TFM measurements and the depths at which to collect depth-discrete bailer samples. The tool is factory calibrated; the calibration is verified in the field, both before and after use.

B.1.10.2 Thermal Flowmeter

Personnel with DRI conducted flow logging under pumping conditions with a TFM for low-rate flow measurements. The TFM can detect vertical borehole flow rates as low as 0.19 liters per minute (0.05 gpm) at temperatures up to 70 °C.

The TFM measurements are made while the tool is stationary. A heat grid in the tool is activated, creating a pulse of warm water that moves with the natural groundwater flow. Thermistors placed above and below the heat grid measure the water temperature and changes in differential temperature. The peak arrival time of the heat pulse is determined. Calibrated responses in similar-sized wellbores or casing sizes are used to convert the travel time into volume per unit time and velocity, accounting for buoyancy effects (decreased density due to heating). The flow readings are significantly affected because the TFM tool is run in the piezometer rather than in the main completion (m1); thus, the principal value of the measurements obtained is as a qualitative indication of flow, not quantitative.

B.1.10.3 Downhole Log Data Presentation

The data files received from DRI are on the DVD that accompanies Appendix E. For this report, DRI log data were uploaded into LogPlot and presented in completion diagrams. The TFM logs are presented with positive and negative values: the positive values indicate upward flow, and the negative values indicate downward flow.

B.1.11 Radiologic Monitoring

Tritium activities were evaluated with respect to background activities, analytical error, and the FMP discharge criteria (see the fluid management strategy [NNSA/NFO, 2015]). During continuous pumping activities, daily samples were collected and analyzed for ^{3}H activity in accordance with the requirements of the FMP (NNSA/NSO, 2009). The samples were analyzed using a Packard LSC located in Mercury, Nevada, at Building 23-310. All samples were processed and analyzed by Navarro personnel in accordance with the Navarro procedures and desktop instructions. A table of the results of analyses is given in Section 6.1.2.

B.1.12 Pump Performance Curves

The pump performance curves are provided in Figures B-1 and B-2.

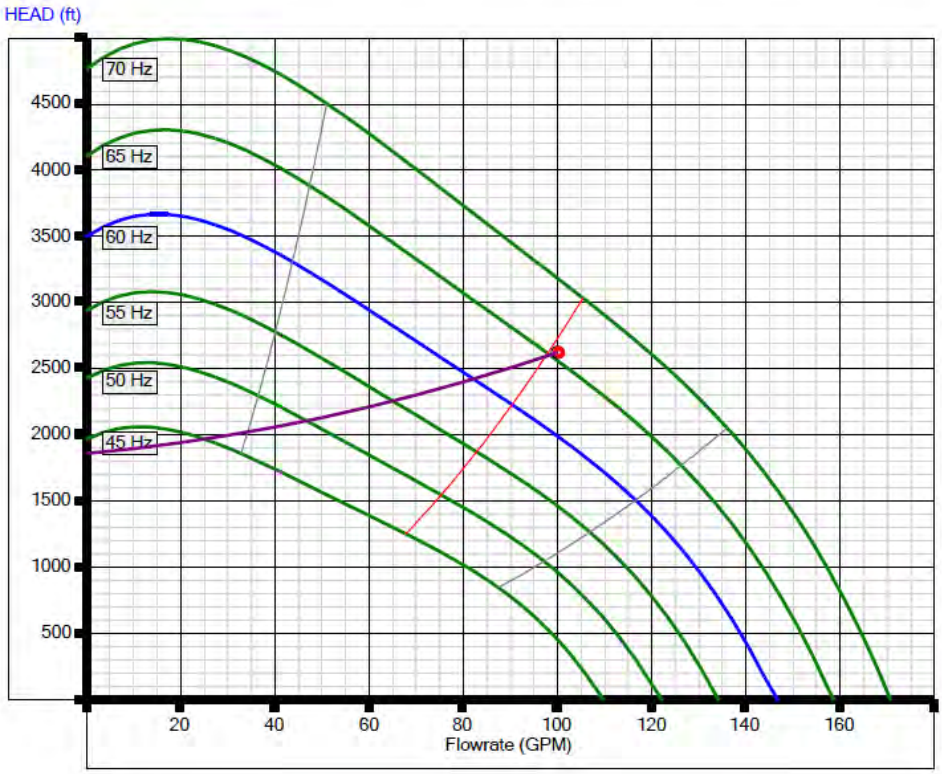
Baker Hughes Incorporated
(918) 341-9600 200W Stuart Roosa Dr, Claremore, OK 74017

Project: NST Test
Customer: NST
Well: Misc.
Engineer: Dave Patti

Pump: 96-400FLEX31SSD
Seal: 338DSFT3
Motor: 375DMF 130HP 1490V/ 65A (60 Hz)
Cable: #4 CPNF 5kV ,2210ft
MLE: #6 MLE-KLHT 5kV ,40.0ft
Controller: VSD 2250-VT 260kVA 480V/ 313A
Sensor: none

Case:
60-100 GPM NewTest pump design

96-400FLEX31SSD



AutographPC™ V9.5 File:NST Design 100 GPM- Intake at 2250ft 6-1-16.apcx
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Figure B-1
Well ER-20-12 Testing Pump Performance Curve

Company:	NST	**Project:**	ESP Design
Engineer:	Tom Hoyt	**Date:**	7/25/2016

Actual Pump Curve

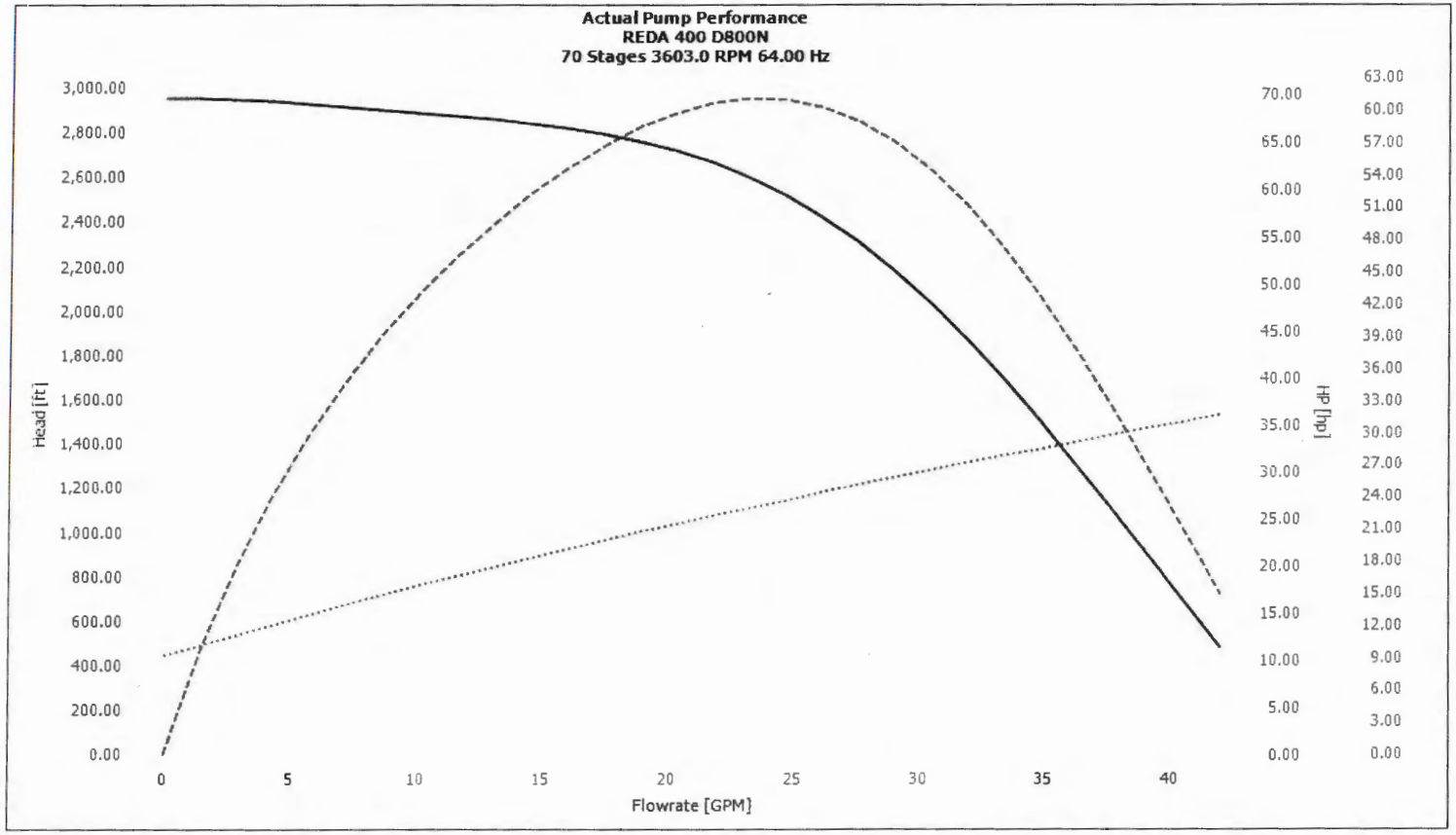

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Figure B-2
Well ER-20-12 Dedicated Sampling Pump Curve

B.2.0 REFERENCES

N-I, see Navarro-Intera, LLC.

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

Appendix C

Pressure Transducer Data Forms and UGTA Depth-to-Water-Level Data Forms for Well ER-20-12 WDT

C.1.0 WELL ER-20-12 PXD INSTALLATION AND REMOVAL

PXDs were installed in main completion and the piezometer at Well ER-20-12. The PXDs monitored the water pressure and groundwater temperatures. The PXD in the main completion (m1) monitored the PBRCM HSU; the PXD in piezometer p1 monitored the BRA HSU; piezometers p2 and p3 monitored the CHZCM HSU; and piezometer p4 monitored the TMWTA and TMLVTA HSUs. Tables C-1 through C-8 show the PXD installation and removal information for Well ER-20-12. The measured DTW and PXD information for Well ER-20-12 is recorded on forms included in Attachment C-1.

PXDs were also installed in Well PM-3 piezometers p1 and p2 during the drilling and WDT activities at Well ER-20-12. Tables C-9 through C-12 show the installation and removal information for Well PM-3.

Table C-1
Well ER-20-12_m1 INW PXD Installation (05/26/2016) and Removal (07/20/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21619035 Range 0-30 psia					
Installation Date: 05/26/2016					
Water-level depth: 1,849.81 ft bgs Barometric pressure: 809.75 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,839.90	1,858.03	1,863.18	1,868.36	1,873.57
PXD pressure (psi)	12.5141	14.1504	16.3688	18.5961	20.8435
PXD Temperature ($^{\circ}$C)	29.8750	32.1250	32.8125	32.8750	32.9375
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					15.54
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.69
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					19.34
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,869.15
Removal Date: 07/20/2016, PXD failed before removal					
Water-level depth: 1,849.65 ft bgs Barometric pressure: 814.42 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,839.90	1,858.03	1,863.18	1,868.36	1,873.57
PXD pressure (psi)	12.5872	14.2563	16.4562	18.6895	20.8990
PXD Temperature ($^{\circ}$C)	32.7500	32.8125	32.8750	32.8750	32.8750
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					15.54
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.64
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.34
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					19.44
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,869.09

Source: Navarro, 2017

Table C-2
Well ER-20-12_p1 INW PXD Installation (05/25/2016) and Removal (06/27/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21514012 Range 0-30 psia					
Installation Date: 05/25/2016					
Water-level depth: 1,849.64 ft bgs Barometric pressure: 808.97 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,849.64	1,868.72	1,873.11	1,877.51	1,881.90
PXD pressure (psi)	12.4580	14.3361	16.1916	18.0863	19.9785
PXD Temperature ($^{\circ}$C)	30.9375	31.9375	32.1875	32.2500	32.3750
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.18
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.64
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.34
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					17.57
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,877.51
Removal Date: 06/27/2016, PXD failed before removal					
Water-level depth: 1,860.15 ft bgs Barometric pressure: 815.78 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,849.64	1,868.72	1,873.11	1,877.51	1,881.90
PXD pressure (psi)	12.5662	14.3940	16.2809	18.1642	20.0327
PXD Temperature ($^{\circ}$C)	32.1250	32.1250	32.1250	32.1875	32.2500
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.18
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.64
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.34
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					17.45
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,877.60

Source: Navarro, 2017

Table C-3
Well ER-20-12_p2 INW PXD installation (05/26/2016) and Removal (07/27/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21112060 Range 0-30 psia					
Installation Date: 05/26/2016					
Water-level depth: 1,876.27 ft bgs Barometric pressure: 809.43 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,869.83	1,885.75	1,889.90	1,894.05	1,898.21
PXD pressure (psi)	12.5286	14.7195	16.4335	18.2190	20.0196
PXD Temperature ($^{\circ}$C)	30.9375	32.1875	32.6250	32.5000	32.5000
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					12.46
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.30
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.35
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					17.61
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,893.88
Removal Date: 07/27/2016, PXD failed before removal					
Water-level depth: 1,876.14 ft bgs Barometric pressure: 814.90 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,869.83	1,885.75	1,889.90	1,894.05	1,898.21
PXD pressure (psi)	12.6029	14.7443	16.5228	18.3270	20.1219
PXD Temperature ($^{\circ}$C)	32.5000	32.5000	32.5625	32.5625	32.6875
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					12.46
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.38
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					17.42
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,893.56

Source: Navarro, 2017

Table C-4
Well ER-20-12_p3 INW PXD Installation (05/25/2016) and Removal (07/20/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21509053 Range 0-30 psia					
Installation Date: 05/25/2016					
Water-level depth: 1,876.35 ft bgs Barometric pressure: 808.36 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,870.51	1,883.71	1,888.06	1,892.19	1,896.41
PXD pressure (psi)	12.4711	13.4858	15.3438	17.1261	18.9435
PXD Temperature ($^{\circ}$C)	31.5000	32.3750	32.6250	32.6250	32.6250
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					12.70
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.46
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.33
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					15.06
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,891.41
Removal Date: 07/20/2016, PXD failed before removal					
Water-level depth: 1,876.20 ft bgs Barometric pressure: 814.24 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,870.51	1,883.71	1,888.06	1,892.19	1,896.41
PXD pressure (psi)	12.5454	13.6434	15.5254	17.2911	19.0940
PXD Temperature ($^{\circ}$C)	32.6250	32.6250	32.6875	32.6875	32.6250
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					12.70
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.45
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.33
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					15.26
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,891.46

Source: Navarro, 2017

Table C-5
Well ER-20-12_p4 INW PXD Installation (05/26/2016) and Removal (07/20/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21619034 Range 0-30 psia					
Installation Date: 05/26/2016					
Water-level depth: 1,614.71 ft bgs Barometric pressure: 809.46 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,599.58	1,624.60	1,629.02	1,633.42	1,637.82
PXD pressure (psi)	12.4072	15.6644	17.5694	19.4608	21.3581
PXD Temperature ($^{\circ}$C)	29.6250	31.5000	31.7500	31.8750	31.8750
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.22
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.69
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					20.78
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,635.49
Removal Date: 07/20/2016, PXD failed before removal					
Water-level depth: 1,614.79 ft bgs Barometric pressure: 815.23 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,599.58	1,624.60	1,629.02	1,633.42	1,637.82
PXD pressure (psi)	12.4922	15.6175	17.5160	19.4113	21.3114
PXD Temperature ($^{\circ}$C)	31.8125	31.9375	31.9375	31.8750	31.9375
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.22
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.69
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					20.48
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,635.27

Source: Navarro, 2017

Table C-6
Well ER-20-12_m1 INW PXD Installation (08/11/2016) and Removal (08/22/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21112068 Range 0-300 psia					
Installation Date: 08/11/2016					
Water-level depth: 1,849.62 ft bgs Barometric pressure: 813.2 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,840	1,910	1,970	2,030	2,100
PXD pressure (psi)	12.6113	36.7701	62.5840	88.4063	118.5250
PXD Temperature ($^{\circ}$C)	31.1250	32.7714	33.3750	33.8125	34.5000
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					190.0
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					81.75
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					246.15
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					2,095.77
Removal Date: 08/22/2016, No signal from PXD, removal data not recorded					
Water-level depth: 1,848.82 ft bgs Barometric pressure: 812.20 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	N/A	N/A	N/A	N/A	N/A
PXD pressure (psi)	N/A	N/A	N/A	N/A	N/A
PXD Temperature ($^{\circ}$C)	N/A	N/A	N/A	N/A	N/A
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					N/A
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					N/A
Density (ft [of water column]/psi): delta depth/delta PXD pressure					N/A
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					N/A
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					N/A

Table C-7
Well ER-20-12_p2 INW PXD Installation (08/12/2016) and Removal (08/22/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21146033 Range 0-2,000 psia					
Installation Date: 08/12/2016					
Water-level depth: 1,875.51 ft bgs Barometric pressure: 816.46 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,850	2,160	2,450	2,740	3,000
PXD pressure (psi)	12.8900	134.7040	259.3520	383.8790	495.0320
PXD Temperature ($^{\circ}$C)	29.7500	34.8750	39.1375	43.5625	46.6875
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					840.0
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					360.33
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.33
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					1,123.97
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					2,999.48
Removal Date: 08/22/2016, PXD removed without recording removal data					
Water-level depth: 1,875.17 ft bgs Barometric pressure: 812.20 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	N/A	N/A	N/A	N/A	N/A
PXD pressure (psi)	N/A	N/A	N/A	N/A	N/A
PXD Temperature ($^{\circ}$C)	N/A	N/A	N/A	N/A	N/A
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					N/A
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					N/A
Density (ft [of water column]/psi): delta depth/delta PXD pressure					N/A
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					N/A
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					N/A

Table C-8
Well ER-20-12_p2 INW PXD Installation (08/16/2016) and Removal (08/22/2016)

Model INW PT12 PXD (nonvented, absolute) SN NA Range 0-2,000 psia					
Installation Date: 08/16/2016, Replaced PXD, no installation data recorded					
Water-level depth: 1,874.99 ft bgs Barometric pressure: 811.80 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,850	2,160	2,450	2,740	3,000
PXD pressure (psi)	N/A	N/A	N/A	N/A	495.1000
PXD Temperature ($^{\circ}$C)	N/A	N/A	N/A	N/A	47.4400
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					840.0
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					N/A
Density (ft [of water column]/psi): delta depth/delta PXD pressure					N/A
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					N/A
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					N/A
Removal Date: 08/22/2016					
Water-level depth: 1,875.17 ft bgs Barometric pressure: 812.20 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,850	2,160	2,450	2,740	3,000
PXD pressure (psi)	13.0727	132.1450	256.9060	381.9860	494.5630
PXD Temperature ($^{\circ}$C)	34.2500	37.8125	42.8750	45.3125	47.5000
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					840.0
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					362.42
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					1,115.98
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					2,991.15

Table C-9
Well PM-3_p1 INW PXD Installation (06/02/2015) and Removal (07/19/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21025064 Range 0-30 psia					
Installation Date: 06/02/2015					
Water-level depth: 1,456.57 ft bgs Barometric pressure: 820.41 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,450.81	1,463.37	1,468.00	1,472.68	1,477.36
PXD pressure (psi)	12.4798	14.4085	16.4060	18.4281	20.4435
PXD Temperature (°C)	31.0000	32.5000	33.1250	33.3125	33.4375
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.99
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.04
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					18.46
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,475.03
Removal Date: 07/19/2016					
Water-level depth: 1,457.03 ft bgs Barometric pressure: 827.25 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,450.81	1,463.37	1,468.00	1,472.68	1,477.36
PXD pressure (psi)	11.8055	14.2335	16.1378	18.1238	19.2480
PXD Temperature (°C)	33.1875	33.2500	33.2500	33.2500	33.3750
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.99
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.01
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.79
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					20.76
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,477.79

Source: Navarro, 2017

Table C-10
Well PM-3_p1 INW PXD Installation (07/19/2016) and Removal (09/12/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21224044 Range 0-30 psia					
Installation Date: 07/19/2016					
Water-level depth: 1,457.03 ft bgs Barometric pressure: 820.41 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,449.50	1,462.05	1,466.65	1,471.40	1,476.00
PXD pressure (psi)	12.5885	13.9500	15.9274	17.9730	19.9515
PXD Temperature (°C)	31.1875	32.7500	33.0625	33.1875	33.1875
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.95
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.00
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					17.11
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,474.14
Removal Date: 09/12/2016					
Water-level depth: 1,456.68 ft bgs Barometric pressure: 818.70 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,449.50	1,462.05	1,466.65	1,471.40	1,476.00
PXD pressure (psi)	12.4582	14.0130	15.9849	18.0442	20.0074
PXD Temperature (°C)	32.8125	32.9375	33.0000	32.9375	33.0625
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.95
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					5.99
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.33
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					17.57
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,474.25

Source: Navarro, 2017

Table C-11
Well PM-3_p2 INW PXD Installation (06/03/2015) and Removal (07/14/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21026009 Range 0-30 psia					
Installation Date: 06/03/2015					
Water-level depth: 1,454.51 ft bgs Barometric pressure: 819.12 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,450.69	1,461.58	1,466.19	1,470.87	1,475.52
PXD pressure (psi)	12.4596	14.3804	16.3704	18.3852	20.3873
PXD Temperature (°C)	30.1875	32.5000	32.9375	33.0625	33.1250
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.94
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.01
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					18.40
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,472.91
Removal Date: 07/14/2016					
Water-level depth: 1,454.94 ft bgs Barometric pressure: 827.79 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,450.69	1,461.58	1,466.19	1,470.87	1,475.52
PXD pressure (psi)	12.5877	14.4682	16.4507	18.4690	20.5093
PXD Temperature (°C)	32.8125	32.8750	32.8750	32.9375	32.9375
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.94
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.04
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.31
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					18.28
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,473.22

Source: Navarro, 2017

Table C-12
Well PM-3_p2 INW PXD Installation (07/14/2016) and Removal (09/12/2016)

Model INW PT12 PXD (nonvented, absolute) SN 21112045 Range 0-30 psia					
Installation Date: 07/14/2016					
Water-level depth: 1,454.94 ft bgs Barometric pressure: 827.79 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,450.75	1,461.62	1,466.25	1,470.92	1,475.59
PXD pressure (psi)	12.5943	14.4502	16.4398	18.4546	20.4633
PXD Temperature (°C)	31.8125	33.1875	33.3125	33.3750	33.4375
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.97
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.01
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.32
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					18.28
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,473.22
Removal Date: 09/12/2016					
Water-level depth: 1,454.68 ft bgs Barometric pressure: 820.14 mBar					
Stations	Cal 1	Cal 2	Cal 3	Cal 4	Cal 5
WRL/TOC (ft)	1,450.75	1,461.62	1,466.25	1,470.92	1,475.59
PXD pressure (psi)	12.4918	14.4996	16.4997	18.5112	20.4999
PXD Temperature (°C)	33.2500	33.2500	33.3125	33.3750	33.3750
Delta Depth (ft): Cal 5 - Cal 2 WRL/TOC					13.97
Delta PXD pressure (psi): Cal 5 - Cal 2 PXD pressure					6.00
Density (ft [of water column]/psi): delta depth/delta PXD pressure					2.33
Equivalent water column (ft): Cal 5 - Cal 1 PXD pressure x density of water					18.64
Calculated PXD depth (ft bgs): water-level depth + equivalent water column					1,473.32

Source: Navarro, 2017

C.2.0 REFERENCES

Navarro. 2017. *Long-Term Head Monitoring Data Report, Fiscal Year 2016,* Rev. 0, N/0002653--039. Las Vegas, NV.

Attachment C-1

Pressure Transducer Data Forms and UGTA Depth-to-Water-Level Data Forms

(44 Pages)

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 5-11-16

Current Activity: Measure water level in (m1)

Equipment Used: Solinst E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 56	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 5.5 -in.: X Casing ___Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 3.17 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: NA (mBar)	warm, clear, some wind

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., ~~feet~~, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	13:15	1853.10	x	0.999891	-	3.17	=	1849.73
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-275 Date: 5-11-16

Current Activity: Measure water level (PI)

Equipment Used: Solinst E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 6	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 5/14/18	**Measuring Point (MP) Description:** Top of 2 3/8 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999844	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: NA (mBar)	Warm, Clear, slight Breeze

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	14:20	1863.15	x	0.999844	-	2.84	=	1860.02
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 5-11-16

Current Activity: Measure water level (P2)

Equipment Used: Solinst E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 56	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: NA (mBar)	Warm, clear, some wind

Status (check all that apply):
X Static ___Pumping ___Recently Pumped ___Drilling ___ Recently Drilled ___Nearby Actively Pumping
___Nearby Recently Pumped ___Unknown ___Other:

Measurement Type:
X Single Zone (discrete) ___Multi Zone (composite) ___Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
___Open Borehole ___Other:

Note: Specify units (e.g. feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	12:45	1879.49	x	0.999891	-	2.64	=	1876.65
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 5-11-16

Current Activity: Measure water level (P3)

Equipment Used: Solinst E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 6	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 5/14/18	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999844	**Vertical Distance (VD) from MP to RED:** 2.94 (ft)
Decontamination Date: NA	**Weather Conditions:** warm, clear, some wind
Barometric Pressure: NA (mBar)	

Status (check all that apply):
X Static ___Pumping ___Recently Pumped ___Drilling ___ Recently Drilled ___Nearby Actively Pumping
___Nearby Recently Pumped ___Unknown ___Other:

Measurement Type:
X Single Zone (discrete) ___Multi Zone (composite) ___Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
___Open Borehole ___Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	14:45	1879.55	x	0.999844	-	2.94	=	1876.32
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 5-11-16

Current Activity: Measure water level (P4)

Equipment Used: Solinst E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 56	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 1.73 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: NA (mBar)	Warm, clear, some wind

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g. feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	12:15	1616.65	x	0.999891	-	1.73	=	1614.74
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UNS-225 Date: 5/25/16

Current Activity: Install PXD in (P1)

Equipment Used: 11 E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 808.971 (mBar)	Cool, cloudy, windy

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	10:40	1861.95	x	1.000448	-	2.84	=	1859.94
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: U015-225 Date: 5-25-16

Current Activity: Install PXD (P3)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 2.94 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 808.357 (mBar)	cool, windy, rain

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	13:00	1878.45	x	1.000448	-	2.94	=	1876.35
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 5/26/16

Current Activity: Install PXD (M1)

Equipment Used: e-tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 5.5 -in.: X Casing ___Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 3.17 (ft)
Decontamination Date: NA	**Weather Conditions:** warm, cloudy, slight wind
Barometric Pressure: 809.751 (mBar)	

Status (check all that apply):
X Static ___Pumping ___Recently Pumped ___Drilling ___ Recently Drilled ___Nearby Actively Pumping
___Nearby Recently Pumped ___Unknown ___Other:

Measurement Type:
X Single Zone (discrete) ___Multi Zone (composite) ___Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
___Open Borehole ___Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	13:10	1852.15	x	1.000448	-	3.17	=	1849.81
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: U015-225 Date: 5-26-16

Current Activity: Install PXD in (P2)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 809.434 (mBar)	Clear, cool, windy

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	0935	1878.62	x	1.000155	-	2.64	=	1876.27
***Out**			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 5/26/16

Current Activity: Install PXD (P4)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 1.73 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 809.464 (mBar)	Cool, cloudy, windy

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	11:25	1616.19	x	1.000155	-	1.73	=	1614.71
***Out**			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 6/6/16

Current Activity: Remove PXD (M1)

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 5.5-in.: X Casing ___Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 3.17 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 807.095 (mBar)	Warm, sunny, windy

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	14:10	1852.09	x	1.000448	-	3.17	=	1849.75
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 6-6-16

Current Activity: Remove PXD (P1)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 2 3/8 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 806.265 (mBar)	Warm, sunny, windy

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	15:56	1861.85	x	1.000448	-	2.84	=	1859.84
***Out**			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 6-6-16

Current Activity: Remove PXD (P3)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 2.94 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 807.248 (mBar)	Warm, sunny, windy

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	13:47	1878.40	x	1.000448	-	2.94	=	1876.30
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 p2 Project Number: UN16-205 Date: 6-09-16

Current Activity: Remove PXD for bailing piezometer

Equipment Used: Solinst E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: No 36	**Elevation of RED:** 6258.41 (ft AMSL) Surveyed on 6-08-16
Calibration Due Date: 10-11-16	**Measuring Point (MP) Description:** Top of ~~2.375~~ 1.9 MPP 6-9-16 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: N/A	**Weather Conditions:** Partly cloudy, 90°F, wind from south at 25-30 mph
Barometric Pressure: None Taken (mBar)	

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	1330	1878.61	x	1.000155	-	2.64	=	1876.26
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 p4 Project Number: UN16-205 Date: 6-09-16

Current Activity: Remove PXD to bail piezometer

Equipment Used: Solinst E-tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: No 36	**Elevation of RED:** 6258.41 (ft AMSL) Surveyed on 6-08-16
Calibration Due Date: 11-10-16	**Measuring Point (MP) Description:** MPP 6-9-16 Top of ~~2~~ 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 1.73 (ft)
Decontamination Date: N/A	**Weather Conditions:** Partly cloudy, 90°F, Wind from south at 25-30mph
Barometric Pressure: None Taken (mBar)	

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	1250	1616.15	x	1.000155	-	1.73	=	1614.67
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 6/13/16

Current Activity: Install PXD (P1)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 812.175 (mBar)	Warm, calm, sunny

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	13:00	1862.45	x	1.000448	-	2.84	=	1860.44
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 6/13/16

Current Activity: Install PXD (P2)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 812.875 (mBar)	Warm, calm, sunny

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	11:15	1878.71	x	1.000155	-	2.64	=	1876.36
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UD15-225 Date: 6/13/16

Current Activity: Install PXD (P3)

Equipment Used: e-tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 2 3/8 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.94 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 812.225 (mBar)	Warm, calm, sunny

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	14:50	1879.10	x	1.000155	-	2.94	=	1876.45
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: U015-225 Date: 6/13/16

Current Activity: Install PXD (P4)

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 1.73 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 813.030 (mBar)	Warm, calm, sunny

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	09:35	1616.26	x	1.000155	-	1.73	=	1614.78
***Out**			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN15-225 Date: 6/14/16

Current Activity: Install PXD (M1)

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 11	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 5.5 -in.: X Casing ___Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000448	**Vertical Distance (VD) from MP to RED:** 3.17 (ft)
Decontamination Date: NA	**Weather Conditions:** Warm, windy, sunny
Barometric Pressure: 806.724 (mBar)	

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	12:35	1851.91	x	1.000448	-	3.17	=	1849.57
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: U0115-225 Date: 6/27/16

Current Activity: Remove PXD From (P1)

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** ~~6252.32~~ 6258.41 (ft AMSL) 7-7-16
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 2 3/8 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 815.781 (mBar)	Hot, Windy, Clear

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	14:10	1862.70	x	1.000155	-	2.84	=	1860.15
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 (M1) Project Number: UN15-225 Date: 7-20-16

Current Activity: Remove PXD

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 5.5 -in.: X Casing ___Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 3.17 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 814.419 (mBar)	Windy, Hot, Clear

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
X Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	13:15	1852.53	x	1.000155	-	3.17	=	1849.65
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
(P1) pumped and sampled recently

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 (P3) Project Number: U015-225 Date: 7-20-16

Current Activity: Remove PXD

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: ~~11/10/16~~ 7-27-16 11/10/16	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.94 (ft)
Decontamination Date: NA	**Weather Conditions:** Windy, Hot, Clear
Barometric Pressure: 814.241 (mBar)	

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
X Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	15:10	1878.85	x	1.000155	-	2.94	=	1876.20
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
~~None~~ DN 7-20-16
(P1) pumped and sampled recently

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 (P4) Project Number: UN15-225 Date: 7-20-16

Current Activity: Remove PXD

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 1.73 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 815.234 (mBar)	Warm, windy, clear

Status (check all that apply): DN 7-2716
X Static ____Pumping X Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
X Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	11:00	1616.27	x	1.000155	-	1.73	=	1614.79
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
~~None~~ DN 7-2716 P1 recently pumped and sampled

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 (P2) Project Number: UN15-225 Date: 7/27/16

Current Activity: Remove PXD

Equipment Used: E-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 36	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/10/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing ___Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 1.000155	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: NA	**Weather Conditions:** Hot, calm, sunny
Barometric Pressure: 814.898 (mBar)	

Status (check all that apply):
X Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
X Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	10:50	1878.49	x	1.000155	-	2.64	=	1876.14
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN16-205 Date: 08/6/16

Current Activity: REMOVE/REINSTALL PXD IN P2

Equipment Used: E-TAPE	**Reference Elevation (RED) Description:** GROUND SURFACE
Equipment ID Number: 56	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: N/A	**Weather Conditions:** SUNNY, WARM, SLIGHT BREEZE
Barometric Pressure: 811.8 (mBar)	

Status (check all that apply):
__X__Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	1109	1877.83	x	0.999891	-	2.64	=	1874.99
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UW16-205 Date: 8/11/16

Current Activity: Prior to PXD install

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 3656	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 3.90 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 813.2 (mBar)	Warm, sunny, slight wind

Status (check all that apply):
X Static ___Pumping ___Recently Pumped ___Drilling ___ Recently Drilled ___Nearby Actively Pumping
___Nearby Recently Pumped ___Unknown ___Other:

Measurement Type:
X Single Zone (discrete) ___Multi Zone (composite) ___Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
___Open Borehole ___Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	09:10	1853.72	x	0.999891	-	3.90	=	1849.62
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
Access line in main completion next to pump string

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 P1 Project Number: UN16-205 Date: 8/12/16

Current Activity: Install PXD (P1)

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: ~~3656~~ 3656	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 2 3/8-in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 816.782 (mBar)	Warm, calm, sunny

Status (check all that apply):
__X__Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	09:30	1862.52	x	0.999891	-	2.84	=	1859.548
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 P2 Project Number: UN16-205 Date: 8/12/16

Current Activity: Install PXD (P2)

Equipment Used: e-Tape	**Reference Elevation (RED) Description:** Ground Surface
Equipment ID Number: 3656	**Elevation of RED:** 6252.32 (ft AMSL)
Calibration Due Date: 11/13/16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing X Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: NA	**Weather Conditions:**
Barometric Pressure: 816.455 (mBar)	Warm, calm, sunny

Status (check all that apply):
__X__Static ____Pumping ____Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping

____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)

____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	10:05	1878.35	x	0.999891	-	2.64	=	1875.51
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

None

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN16-205 Date: 8-22-16

Current Activity: Removing PXD from m1

Equipment Used: e-tape	**Reference Elevation (RED) Description: Ground Surface**
Equipment ID Number: 56	**Elevation of RED:** 6,252.32 (ft AMSL)
Calibration Due Date: 11-13-16	**Measuring Point (MP) Description:** Top of 2.375 -in.: ___Casing _X__Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 3.90 (ft)
Decontamination Date: N/A	**Weather Conditions:** Partly cloudy, Temp 85°F, wind 5 mph
Barometric Pressure: 812.200 (mBar)	

Status (check all that apply):
__ __Static ____Pumping __X__Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping

____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)

____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	12:20	1852.92	x	0.99891	-	3.90	=	1,848.82
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

Access line in the main completion (m1) banded to the pump string.

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN16-205 Date: 8-22-16

Current Activity: Removing PXD from p2

Equipment Used: e-tape	**Reference Elevation (RED) Description: Ground Surface**
Equipment ID Number: 56	**Elevation of RED:** 6,252.32 (ft AMSL)
Calibration Due Date: 11-13-16	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing _X_Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: N/A	**Weather Conditions:** Temp 72°F, cloudy, light rain, wind 5 mph
Barometric Pressure: 812.200 (mBar)	

Status (check all that apply): ~~8-22-10~~
__ __Static ____Pumping __X__Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping

_X_Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)

____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	1255	1878.01	x	0.999891	-	2.64	=	1,875.17
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

Water level in the p2 piezometer after removal of the PXD; not recently pumped.

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN16-205 Date: ~~8-22-16~~ 8-23-16 ~~8-22~~ 8-23-16

Current Activity: Removing PXD from p1

Equipment Used: e-tape	**Reference Elevation (RED) Description: Ground Surface**
Equipment ID Number: 5C	**Elevation of RED:** 6,252.32 (ft AMSL)
Calibration Due Date: 11-13-16	**Measuring Point (MP) Description:** Top of 2.375 -in.: ___Casing _X__Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 2.84 (ft)
Decontamination Date: N/A	**Weather Conditions:** Clear, Temp 75°F, wind 0-5 mph.
Barometric Pressure: 813.2 (mBar)	

Status (check all that apply): ~~8-22-16~~ 8-22-16

__ __Static ____Pumping ~~_X_~~ Recently Pumped ____Drilling ____ Recently Drilled ~~X~~ Nearby Actively Pumping

X Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:

__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)

____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	09:30	1862.27	x	0.999891	-	2.84	=	1,859.23
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

Water level in the p1 piezometer after removal of the PXD, ml was recently pumped.

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN16-205 Date: 8-30-16

Current Activity: Measure water level prior to bailer sampling P2

Equipment Used: e-tape	**Reference Elevation (RED) Description: Ground Surface**
Equipment ID Number: 56	**Elevation of RED:** 6,252.32 (ft AMSL)
Calibration Due Date: 6.999891	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing _X__Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 6.999891	**Vertical Distance (VD) from MP to RED:** 2.64 (ft)
Decontamination Date: N/A	**Weather Conditions:** SUNNY, 10-15 MPH WINDS, 80°F
Barometric Pressure: 834 (mBar)	

Status (check all that apply):
__ __Static ____Pumping __X__Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping
____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)
____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	0945	1878.45	x	0.999891	-	2.64	=	1,875.61
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:
Good tag on water, P2 piezometer.

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

UGTA Depth-to-Water Level Data Form

Well: ER-20-12 Project Number: UN16-205 Date: 8-30-16

Current Activity: Measure water level prior to bailer sampling (P4)

Equipment Used: e-tape	**Reference Elevation (RED) Description: Ground Surface**
Equipment ID Number: 56	**Elevation of RED:** 6,252.32 (ft AMSL)
Calibration Due Date: 0.999891	**Measuring Point (MP) Description:** Top of 1.9 -in.: ___Casing _X__Tubing ___Pump Tubing ___Other
Calibration Correction (CC) Factor: 0.999891	**Vertical Distance (VD) from MP to RED:** 1.73 (ft)
Decontamination Date: N/A	**Weather Conditions:** SUNNY, 10-15 mph WINDS, 80°F
Barometric Pressure: 834 (mBar)	

Status (check all that apply):
__ __Static ____Pumping __X__Recently Pumped ____Drilling ____ Recently Drilled ____Nearby Actively Pumping

____Nearby Recently Pumped ____Unknown ____Other:

Measurement Type:
__X__Single Zone (discrete) ____Multi Zone (composite) ____Isolated Zone (e.g., Bridge Plug/Packer): Deep/Intermediate/Shallow (circle one)

____Open Borehole ____Other:

Note: Specify units (e.g., feet, meters, millibars) on all measurements and document conversions.

Depth-to-Water Level:

	Time	DTW		CC		VD		DTWBGS
In	1010	1616.39	x	0.999891	-	1.73	=	1,614.48
*Out			x		-		=	

***Not used for e-tape measurements.**

Notes/Diagrams/Conversions:

Good reading, P4 piezometer

Note: If e-tape measures in meters, divide DTW by 0.3048 to get reading in feet (before multiplying by CC).

[redacted]

AMSL – Above mean sea level
CC – Calibration correction factor
DTW – Depth to water from MP
DTWBGS – Depth to water, below ground surface
MP – Measuring point
RED – Reference Elevation Description
VD – Vertical distance from MP to RED

Pressure Transducer Data Form

Well ID: ER-20-12 (P1)		Project Number: N015-225	Page 1 of 1
Installation Depth To Water Date/Time: 5/25/16 10:40		Removal Depth To Water Date/Time: 6/27/16 :	
Installation Depth To Water (ft bgs): 1859.94		Removal Depth To Water (ft bgs): 1860.15	
Method: E-tape # 11	Patm (mBar): 808.971	Method: E-tape # 36	Patm (mBar): 815.781
Weather: cool, cloudy, windy		Weather: Hot, Windy, Clear	
Pressure Transducer Make/Model INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 2151401 2	Cal Due Date: 7-24-17	Datalogger Serial No: 39212	Cal Due Date: 11-6-17
Pressure Transducer Range: 0-30 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: 2200 ft		Barometer Serial No: L3420384	Cal Due Date: 8-26-17

Installation Comments: surface: 10:42 hrs, 11.7310 psia, 23.5625°C, 808.979 mbar

address 1

Wireline Tag Depth: 1000 TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1849.64	1868.72	1873.11	1877.51	1881.90
Installation Data					
Time: PST	11:01	11:08	11:13	11:16	11:20
PXD (psi):	12.4580	14.3361	16.1916	18.0863	19.9785
PXD Temperature (Deg C):	30.9375	31.9375	32.1875	32.2500	32.3750
Patm (mBar):	808.815	808.818	808.658	808.577	808.415
Other:	—	—	—	—	—
Removal Data					
Time:	12:15	12:12	12.09	12.07	12.03
PXD (psi):	12.5662	14.3940	16.2809	18.1642	20.0327
PXD Temperature (Deg C):	32.1250	32.1250	32.1250	32.1875	32.2500
Patm (mBar):	815.255	815.741	815.741	815.902	815.902
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): 1849.64	Wireline Tag Depth (ft): 1000.11	Zero Point Depth (ft): 0.58

Removal Comments: surface: 12:33 hrs, 11.8300 psia, 30.3125 °C, 815.367 mbar

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 (M1)		Project Number: UN15-225	Page 1 of 1
Installation Depth To Water Date/Time: 5/26/16 13:10		Removal Depth To Water Date/Time: 7/20/16 13:15	
Installation Depth To Water (ft bgs): 1849.81		Removal Depth To Water (ft bgs): 1849.65	
Method: E-tape # 11	Patm (mBar): 809.751	Method: E-tape # 36	Patm (mBar): 814.419
Weather: warm, cloudy, slight wind		Weather: Windy, Hot, Clear	
Pressure Transducer Make/Model: INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 21619035	Cal Due Date: 5-11-18	Datalogger Serial No: 70659	Cal Due Date: 1-20-18
Pressure Transducer Range: 0-30 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: #117 (1980 ft)		Barometer Serial No: 23240273	Cal Due Date: 8-14-17

Installation Comments:
surface: 1221 hrs, 11.7578 psia, 23.0000°C, 809.747 mbar
address 60 PT12-2(1)

Wireline Tag Depth: 1000 TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1839.90	1858.03	1863.18	1868.36	1873.57

Installation Data

Time: PST	12:43	12:47	12:52	12:56	13:01
PXD (psi):	12.5141	14.1504	16.3688	18.5961	20.8435
PXD Temperature (Deg C):	29.8750	32.1250	32.8125	32.8750	32.9375
Patm (mBar):	809.585	809.419	809.256	809.083	809.412
Other:					

Removal Data

Time: PST	11:55	11:52	11:49	11:46	11:41
PXD (psi):	12.5872	14.2563	16.4562	18.6895	20.8990
PXD Temperature (Deg C):	32.7500	32.8125	32.8750	32.8750	32.8750
Patm (mBar):	814.491	814.653	814.815	814.983	814.569
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): 1839.90	Wireline Tag Depth (ft): 999.77	Zero Point Depth (ft): 0.42

Removal Comments: ~~873.80~~ 7-27-16 ~~1873.99~~ 7-27-16

surface: 1211 hrs, 11.8349 psi, 31.0000°C, 814.409

[redacted]

TOC-Top of casing
bgs-Below ground surface
PXD-Pressure transducer
WRL-Wireline
m-meters
mBar-Millibar
psi-Pound per square inch
ft-feet
Patm-Barometric Pressure

N-343

Pressure Transducer Data Form

Well ID: ER-20-12 (P2)		Project Number: UNI5-225	Page 1 of 1
Installation Depth To Water Date/Time: 5/26/16 09:35		Removal Depth To Water Date/Time: 7/27/16 10:50	
Installation Depth To Water (ft bgs): 1876.27		Removal Depth To Water (ft bgs): 1876.14	
Method: E-tape # 36	Patm (mBar): 809.434	Method: E-tape # 36	Patm (mBar): 814.898
Weather: Clear, cool, windy		Weather: Hot, calm, sunny	
Pressure Transducer Make/Model: INW/PT12		Datalogger Make/Model: CS/CR 1000	
Pressure Transducer Serial No.: 2111206D	Cal Due Date: 9/4/17	Datalogger Serial No: 39212	Cal Due Date: 11-6-17
Pressure Transducer Range: 0-30 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: #117 (2200 ft)		Barometer Serial No: L3420384	Cal Due Date: 8-26-17

Installation Comments:
Surface: 0857hrs, 11.7464psia, 14.0000°C, 809.544mbar
address 10

Wireline Tag Depth: 1000 ft TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1869.83	1885.75	1889.90	1894.05	1898.21

Installation Data

Time: PST	09:17	09:22 P.N. 5/26/16	09:28	09:37	09:41
PXD (psi):	12.5286	14.~~72~~ 7195	16.4335	18.2190	20.0196
PXD Temperature (Deg C):	30.9375	32.1875	32.6250	32.5000	32.5000
Patm (mBar):	809.993	809.900	809.979	809.871	809.853
Other:	—	—	—	—	—

Removal Data

Time: PST	09:26	09:24	09:21	09:18	09:14
PXD (psi):	12.6029	14.7443	16.5228	18.3270	20.1219
PXD Temperature (Deg C):	32.5000	32.5000	32.5625	32.5625	32.6875
Patm (mBar):	814.969	815.051	814.882	815.046	814.740
Other:	—	—	—	—	—

Removal Offset Data

Wireline Tag 1 Depth (ft): 1869.83	Wireline Tag Depth (ft): 999.68 (898.53)	Zero Point Depth (ft): 0.48 (1898.69)

Removal Comments: Surface; 09:46hrs, 11.8258psi, 29.6250°C, 815.121mbar

[redacted]

psi - 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface
PXD-Pressure transducer
WRL-Wireline
m-meters
mBar-Millibar
psi-Pound per square inch
ft-feet
Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 (P3)		Project Number: UN15-225	Page 1 of 1
Installation Depth To Water Date/Time: 5/25/16 1300		Removal Depth To Water Date/Time: 7/20/16 :	
Installation Depth To Water (ft bgs): 1876.35		Removal Depth To Water (ft bgs): 1876.20	
Method: E-tape # 11	Patm (mBar): 808.357	Method: E-tape # 36	Patm (mBar): 814.241
Weather: Cold, hail, rain, wind		Weather: Windy, Hot, Clear	
Pressure Transducer Make/Model: LNW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 21509053	Cal Due Date: 3-3-17	Datalogger Serial No: 39212	Cal Due Date: 11-6-17
Pressure Transducer Range: 0 - 30 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: 2200 Ft #117		Barometer Serial No: L3420384	Cal Due Date: 8-26-17

Installation Comments:
Surface: 12:19 hrs, 11.7023 psia, 16.6250°C, 808.196 mbar
address 38, DN 5-26-16 PT12 (3)(1)

Wireline Tag Depth: 1000 ft ~~#11~~ ~~DN~~ 7-22-16 TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1870.51	1883.71	1888.06	1892.19	1896.41

Installation Data

Time: PST	13:06	13:11	13:15	13:18	13:21
PXD (psi):	12.4711	13.4858	15.3438	17.1261	18.9435
PXD Temperature (Deg C):	31.5000	32.3750	32.6250	32.6250	32.6250
Patm (mBar):	808.550	808.263	808.107	808.108	808.108
Other:					

Removal Data

Time: PST	13:51	13:48	13:45	13:41	13:36
PXD (psi):	12.5454	13.6434	15.5254	17.2911	19.0940
PXD Temperature (Deg C):	32.6250	32.6~~8~~250 ~~DN~~ 7-22-16	32.6875	32.6875	32.6250
Patm (mBar):	814.112	814.425	814.592	814.112	814.518
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): 1870.51	Wireline Tag Depth (ft): 999.87	Zero Point Depth (ft): 0.51 ~~1896.92~~ ~~DN~~ 7-22-16

Removal Comments: None

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 (P4)		Project Number: UN15-725	Page 1 of 1
Installation Depth To Water Date/Time: 5/26/16 11:25		Removal Depth To Water Date/Time: 7/20/16 11:00	
Installation Depth To Water (ft bgs): 1614.71		Removal Depth To Water (ft bgs): 1614.79	
Method: E-tape # 36	Patm (mBar): 809.464	Method: E-tape # 36	Patm (mBar): 815.234
Weather: Cool, cloudy, windy		Weather: Warm, windy, clear	
Pressure Transducer Make/Model: ~~CS~~ DD 5-26-16 INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 21619034	Cal Due Date: 5-11-18	Datalogger Serial No: ~~39~~ DD 5-26-16 70659	Cal Due Date: 1-20-18
Pressure Transducer Range: 0-30 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: #117 (2000 ft)		Barometer Serial No: L3240273	Cal Date: 8-14-17

Installation Comments:
surface: 1037 hrs, 11.7614 psia, 19.7500°C, 809.833 mbar

address: 59 PT12-1(2)

Wireline Tag Depth: 1000 TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1599.58	1624.60	1629.02	1633.42	1637.82

Installation Data

Time: PST	10:58	11:03	11:07	11:10	11:14
PXD (psi):	12.4072	15.6644	17.5694	19.4608	21.3581
PXD Temperature (Deg C):	29.6250	31.5000	31.7500	31.8750	31.8750
Patm (mBar):	810.095	809.920	809.759	810.000	809.752
Other:					

Removal Data

Time: PST	09:43	09:40	09:37	09:33	09:27
PXD (psi):	12.4922	15.6175	17.5160	19.4113	21.3114
PXD Temperature (Deg C):	31.8125	31.9375	31.9375	31.8750	31.9375
Patm (mBar):	815.142	814.892	815.052	814.641	814.966
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): 1599.58	Wireline Tag Depth (ft): 999.78	Zero Point Depth (ft): 0.19

Removal Comments: ~~638.04~~ SW 7-27-16 ~~1638.01~~ SW 7-27-16

surface: 09:56 hrs, 11.8472 psi, 29.3750°C, 815.134

[redacted]

psi = 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface
PXD-Pressure transducer
WRL-Wireline
m-meters
mBar-Millibar
psi-Pound per square inch
ft-feet
Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: EL 20-12 (P2)		Project Number: UN16-205	Page 1 of 1
Installation Depth To Water Date/Time: 08 / 16 / 16 11:09		Removal Depth To Water Date/Time: 8 / 22 / 16 12:55	
Installation Depth To Water (ft bgs): 1874.99		Removal Depth To Water (ft bgs): 1875.17	
Method: E-tape # 56	Patm (mBar): 811.8	Method: E-tape # 56	Patm (mBar): 812.200
Weather: Sunny, warm, slight breeze		Weather: Wind 5mph Temp 72°F, cloudy, light rain,	
Pressure Transducer Make/Model: INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.:	Cal Due Date:	Datalogger Serial No: 70621	Cal Due Date: 1/19/18
Pressure Transducer Range: 0.2000 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: COMPROBE		Barometer Serial No: K1140011	Cal Due Date: 6/2/19

Installation Comments: SURFACE @ 11:38 HRS, 12.73 PSIA, 33.44°C, 811.8 mBARS

ADDRESS (4) PT 12-3 TRANSDUCER REPLACED ADDRESS (2) @ SET DEPTH OF 3000'BES w/o CAL. DEPTH CHECK DATA

Wireline Tag Depth: NA TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1850	2160	2450	2740	3000

Installation Data

Time: PST		N/A			12:07
PXD (psi):					495.1
PXD Temperature (Deg C):					47.44
Patm (mBar):					811.8
Other:					

Removal Data

Time: PST	09:07	09:02	08:57	08:52	08:46
PXD (psi):	13.070	132.145	256.906	381.986	494.563
PXD Temperature (Deg C):	34.2500	37.8125	42.8750	45.3125	47.5000
Patm (mBar):	812.231	812.234	812.229	812.242	812.326
Other:	NA	NA	NA	NA	NA

Removal Offset Data

Wireline Tag 1 Depth (ft): NA	Wireline Tag Depth (ft): NA	Zero Point Depth (ft): NA

Removal Comments: SURFACE: 09:25 hrs, 12.3414 psia, 23.4375°C, 812.288 mbar

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 (PZ)		Project Number: UNI6-205	Page 1 of 1
Installation Depth To Water Date/Time: 8/12/16 10:05		Removal Depth To Water Date/Time: 8/22/16 12:55	
Installation Depth To Water (ft bgs): 1875.51		Removal Depth To Water (ft bgs): 1875.17	
Method: E-tape # ~~36~~ 56	Patm (mBar): 816.455	Method: E-tape # 56	Patm (mBar): 812.200
Weather: 081616 Warm, calm, sunny		Weather: 72F, cloudy, light rain, 5 mph	
Pressure Transducer Make/Model: INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 21146033	Cal Due Date: 9/23/16	Datalogger Serial No: 20621	Cal Due Date: 1/19/18
Pressure Transducer Range: 0 - 2000 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: Comprobe		Barometer Serial No: K1140011	Cal Due Date: 6/2/19

Installation Comments: surface: 11:02 hrs, 12.1218 psia, 29.3750°C, 816.449 mbars

address: (2) PT12-3

Wireline Tag Depth: NA TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1850	2160	2450	2740	3000

Installation Data

Time: PST	11:22	11:28	11:33	11:39	11:46
PXD (psi):	12.8900	134.704	259.352	383.879	495.032
PXD Temperature (Deg C):	29.7500	34.8750	39.1375	43.5625	46.6875
Patm (mBar):	816.281	816.120	816.439	816.199	816.279
Other:	—		—	—	—

Removal Data

Time:					
PXD (psi):		NA			
PXD Temperature (Deg C):			081616		
Patm (mBar):					
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): NA	Wireline Tag Depth (ft): NA	Zero Point Depth (ft): NA

Removal Comments:

REMOVED @ 10:00 HRS ON 081616 W/O REMOVAL DATA. ML

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 M1		Project Number: UN16-205	Page 1 of 1
Installation Depth To Water Date/Time: 8/11/16 09:10		Removal Depth To Water Date/Time: 8/22/16 12:20	
Installation Depth To Water (ft bgs): 1849.62		Removal Depth To Water (ft bgs): 1848.82	
Method: E-tape # 3692	Patm (mBar): 813.2	Method: E-tape # 56	Patm (mBar): 812.200
Weather: Warm, Sunny, some wind		Weather: Partly cloudy, 85°F, wind 5mph	
Pressure Transducer Make/Model PT2X/INW		Datalogger Make/Model: INW/PT2X	
Pressure Transducer Serial No.: 21113059	Cal Due Date: 7/28/17	Datalogger Serial No: 21113059	Cal Due Date: 7/28/17
Pressure Transducer Range: 0-300 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: Comprobe 2300 FT (173)		Barometer Serial No: K1140011	Cal Due Date: 6/2/19

Installation Comments:
PXD CONFIGURATION (PT2X): #RECORDS; 300K, LOGGING INTERAL: 1MIN, FILE NAME: ER-20-12-081116
START PROGRAM AT: 0922 ON 8-11-16. INITIAL PSI: 11.82, TEMP: 29.56°C
Self Contained Transducer and datalogger.

Wireline Tag Depth: 1000 TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1840	1910	1970	2030	2100

Installation Data

Time: PST	10:05	10:13	10:18	10:23	10:29
PXD (psi):					
PXD Temperature (Deg C):			NA		
Patm (mBar):					
Other:					

Removal Data

Time:					
PXD (psi):					
PXD Temperature (Deg C):			NA		
Patm (mBar):					
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): NA	Wireline Tag Depth (ft): NA	Zero Point Depth (ft): NA

Removal Comments: Pressures and Temperatures obtained from PT2X download.

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 (M1)		Project Number: UN16-205	Page 1 of 1
Installation Depth To Water Date/Time: 8/15/16 09:10		Removal Depth To Water Date/Time: 8/22/16 12:20	
Installation Depth To Water (ft bgs): 1849.62		Removal Depth To Water (ft bgs): 1848.82	
Method: E-tape # ~~36~~ 56	Patm (mBar): 813.2	Method: E-tape # 56	Patm (mBar): 812.200
Weather: 08/16 Warm, Sunny, some wind		Weather: Partly cloudy, 85°F, wind 5mph	
Pressure Transducer Make/Model INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 2111 2068	Cal Due Date: 5/12/18	Datalogger Serial No: 70621	Cal Due Date: 1/19/18
Pressure Transducer Range: 0-300 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: Comprobe 173, 2300 FT		Barometer Serial No: K1140011	Cal Due Date: 6/2/19

Installation Comments: surface: 09:31 hrs, 11.8522 psia, 30.4375°C, 814.984 mbar

address: 61

Wireline Tag Depth: 1000 TOC/WRL (ft) —

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1840	1910	1970	2030	2100

Installation Data

Time: PST	10:05	10:13	10:18	10:23	10:29
PXD (psi):	12.6113	36.7701	62.5840	88.4063	118.525
PXD Temperature (Deg C):	31.1250	32.7714	33.3750	33.8125	34.500
Patm (mBar):	815.014	815.146	815.309	815.146	815.228
Other:	—	—	—	—	—

Removal Data

Time:					
PXD (psi):					
PXD Temperature (Deg C):			N/A		
Patm (mBar):					
Other:					

Removal Offset Data

Wireline Tag 1 Depth (ft): —	Wireline Tag Depth (ft): —	Zero Point Depth (ft): —

Removal Comments: No signal from PXD, removal data not recorded.

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Pressure Transducer Data Form

Well ID: ER-20-12 (P1)		Project Number: UN16-205	Page 1 of 1
Installation Depth To Water Date/Time: 8/12/16 09:30		Removal Depth To Water Date/Time: 8/23/16 09:30	
Installation Depth To Water (ft bgs): 1859.48		Removal Depth To Water (ft bgs): 1859.23	
Method: E-tape # ~~364~~ 56 08/16/16	Patm (mBar): 816.782	Method: E-tape # 56	Patm (mBar): 813.2
Weather: Warm, calm, sunny		Weather: clear, Temp 75, wind 0-5 mph	
Pressure Transducer Make/Model: INW/PT12		Datalogger Make/Model: CS/CR1000	
Pressure Transducer Serial No.: 21226022	Cal Due Date: 9/23/16	Datalogger Serial No: 70621	Cal Due Date: 1/19/18
Pressure Transducer Range: 0 - 2000 psi (a) or (g)		Barometer Make/Model: Vaisala/PTB110	
Wireline No.: Logging Trailer		Barometer Serial No: K1140011	Cal Due Date: 6/2/19

Installation Comments:
surface: 09:21 hrs, 12.5568 psia, 29.5625 °C, 816.782
address #3 (PT12-1)

Wireline Tag Depth: 1000 TOC/WRL (ft)

Calibration Depth Check Data

Station Number:	1 (Wireline Tag 1)	2	3	4	5
TOC/WRL (ft):	1850.0	2273.0	2696.0	3118.0	3050

Installation Data

Time: PST	09:47	09:55	10:01	10:08	10:18
PXD (psi):	13.2829	182.969	363.288	542.981	513.831
PXD Temperature (Deg C):	28.6250	35.4375	41.8125	45.8750	46.3125
Patm (mBar):	816.618	816.455	816.455	816.618	816.618
Other:	—	—	—	—	—

Removal Data

Time: PST	NA	10:00	09:54	09:50	09:40
PXD (psi):		182.074	362.571	428.202	513.080
PXD Temperature (Deg C):		38.3750	43.7500	44.5000	46.4375
Patm (mBar):		812.364	812.119	812.528	812.610
Other:		—	—	2850	—

Removal Offset Data

Wireline Tag 1 Depth (ft): NA	Wireline Tag Depth (ft): NA	Zero Point Depth (ft): NA

Removal Comments: The hoist motor failed during removal

[redacted]

psi * 2.307 = feet of water
TOC-Top of casing
bgs-Below ground surface

PXD-Pressure transducer
WRL-Wireline
m-meters

mBar-Millibar
psi-Pound per square inch
ft-feet

Patm-Barometric Pressure

Appendix D

Well ER-20-12
Grab Sample Water-Quality Data

Table D-1
Well ER-20-12 Grab Sample Water-Quality and Bromide Concentrations during WDT
(Page 1 of 3)

Date	Time	Temp (°C)	SEC (µs/cm)	pH (SU)	DO (mg/L)	Turbidity (NTU)	Bromide (mg/L)	Bromide Temp (°C)	Gallons per Minute	Total Gallons Pumped
Pre-development Rod Pumping of Piezometer p1										
06/30/2016	12:00	20.09	705	7.84	1.22	185	2.72	26.0	2.79	3
06/30/2016	14:00	26.09	745	7.79	2.44	119	1.60	25.9	2.61	319
06/30/2016	15:30	25.91	736	7.61	3.19	36.1	1.69	24.9	3.39	572
07/01/2016	09:55	23.02	720	7.93	1.90	4.6	1.42	25.6	2.62	3,585
07/01/2016	12:00	25.94	716	7.79	1.84	9.4	1.34	25.9	2.72	3,940
07/01/2016	14:00	26.46	715	7.89	2.00	6.6	1.26	25.9	2.42	4,258
07/01/2016	15:30	26.08	717	7.82	2.48	6.4	1.32	25.8	2.58	4,503
07/05/2016	10:45	26.65	699	7.69	3.29	8.6	1.19	25.7	2.53	19,333
07/05/2016	12:00	25.95	696	7.76	2.79	6.7	1.12	25.3	2.65	19,526
07/05/2016	13:30	24.42	699	7.79	3.11	5.0	1.20	24.6	2.64	19,650
07/05/2016	15:30	26.64	700	7.73	3.21	5.7	1.18	26.4	2.59	20,072
07/06/2016	09:20	26.89	690	7.95	2.96	6.5	1.25	25.7	2.63	22,830
07/06/2016	10:00	26.63	687	7.93	2.95	6.4	1.11	25.8	2.65	22,944
07/06/2016	10:45	26.61	689	7.91	3.01	6.2	1.18	24.1	2.64	23,057
07/06/2016	15:15	24.52	686	7.89	2.94	6.3	1.21	24.0	2.63	23,575
Pumping with Electric Submersible Pump of Main Completion (m1)										
08/11/2016	12:55	29.55	822	8.19	4.77	102	15.70	25.7	43.51	90
08/11/2016	13:11	33.45	831	8.57	4.52	63.7	36.90	25.7	62.32	1,023
08/11/2016	14:21	30.12	829	8.87	2.60	65.2	11.20	25.5	33.62	1,142
08/11/2016	14:42	33.06	826	8.71	2.96	39.7	8.01	25.4	31.55	1,870
08/11/2016	15:05	34.33	851	8.55	2.11	37.5	3.09	25.6	30.01	2,555
08/11/2016	15:31	34.92	853	8.46	2.65	39.6	2.63	26.5	29.12	3,347
08/12/2016	13:25	27.45	837	8.90	2.63	35.4	1.47	26.6	35.15	3,707
08/12/2016	13:40	32.51	828	8.57	2.66	27.8	1.46	26.3	32.01	4,089
08/12/2016	13:55	34.15	843	8.53	2.61	31.5	1.44	26.7	30.21	4,600
08/12/2016	14:10	36.03	840	8.39	2.23	40.6	1.36	26.2	29.48	5,057
08/12/2016	14:25	36.81	842	8.25	1.83	42.5	1.18	26.5	29.13	5,476
08/13/2016	10:05	28.31	825	8.53	1.63	78.0	1.21	26.3	34.44	5,881
08/13/2016	10:20	33.18	834	8.46	2.08	68.5	1.10	26.1	31.77	6,330
08/13/2016	10:35	35.70	839	8.46	1.60	78.3	1.04	27.1	30.50	6,911

Table D-1
Well ER-20-12 Grab Sample Water-Quality and Bromide Concentrations during WDT
(Page 2 of 3)

Date	Time	Temp (°C)	SEC (µs/cm)	pH (SU)	DO (mg/L)	Turbidity (NTU)	Bromide (mg/L)	Bromide Temp (°C)	Gallons per Minute	Total Gallons Pumped
08/13/2016	10:50	35.28	831	8.36	1.46	76.7	1.17	26.9	29.92	7,509
08/13/2016	11:05	37.54	826	8.21	1.00	75.9	1.14	25.5	29.13	7,809
08/13/2016	12:35	33.10	837	8.28	1.52	155	1.26	27.4	35.15	8,396
08/13/2016	12:50	34.49	841	8.16	1.70	113	1.24	27.1	31.54	8,934
08/13/2016	13:05	35.59	834	8.21	1.26	114	1.53	26.2	30.34	9,292
08/13/2016	13:20	35.70	827	8.18	0.78	116	1.30	25.3	29.65	9,762
08/13/2016	13:35	36.17	832	8.13	1.21	112	1.26	26.2	29.28	10,235
08/13/2016	13:50	37.47	828	8.08	1.10	103	1.27	26.2	29.07	10,663
08/14/2016	10:10	30.50	817	8.11	1.32	88.9	1.73	24.6	32.89	10,796
08/14/2016	10:25	33.60	815	8.06	0.96	65.2	1.56	24.3	30.90	11,336
08/14/2016	10:40	34.17	819	8.02	0.91	59.4	1.74	23.3	29.36	11,785
08/14/2016	10:55	34.93	816	8.03	1.27	74.1	1.55	23.8	29.44	12,246
08/14/2016	11:10	35.42	817	8.00	1.23	92.6	1.58	24.8	28.72	12,674
08/14/2016	12:20	32.41	816	8.07	1.89	312	2.03	24.3	36.10	12,835
08/14/2016	12:35	34.55	824	8.11	1.19	224	1.76	26.2	31.91	13,326
08/14/2016	12:50	35.09	823	8.12	1.45	224	1.83	24.5	30.51	13,786
08/14/2016	13:05	36.09	822	8.11	1.07	213	1.46	23.9	29.37	14,246
08/14/2016	13:20	36.68	815	8.10	1.52	238	1.28	25.7	29.28	14,690
08/14/2016	13:35	37.21	820	8.07	1.34	227	1.22	24.9	28.35	15,100
08/15/2016	10:17	22.43	814	8.38	3.09	201	1.92	23.4	58.34	15,474
08/15/2016	11:18	30.64	835	8.26	2.57	145	1.73	26.5	60.94	16,183
08/15/2016	11:30	36.04	827	8.02	2.10	120	1.52	27.4	55.36	16,884
08/15/2016	12:19	32.10	820	8.17	3.51	137	1.85	26.5	60.75	17,082
08/15/2016	13:20	31.80	827	8.14	3.40	201	1.69	26.6	60.33	18,005
08/15/2016	13:32	38.06	835	7.96	1.72	212	1.57	26.4	55.98	18,686
08/16/2016	12:50	24.25	982	8.53	3.58	111	1.19	24.3	34.51	18,984
08/16/2016	13:05	34.13	980	8.14	3.52	162	1.03	25.7	31.83	19,348
08/16/2016	13:20	36.55	983	8.07	3.26	155	1.01	26.1	30.08	19,824
08/16/2016	13:35	38.50	981	8.00	2.73	147	1.11	25.7	29.04	20,302
08/16/2016	13:50	39.12	979	7.98	3.36	149	1.12	25.4	28.62	20,711
08/17/2016	09:57	21.39	796	8.43	3.00	114	1.07	24.9	58.31	20,806

Table D-1
Well ER-20-12 Grab Sample Water-Quality and Bromide Concentrations during WDT
(Page 3 of 3)

Date	Time	Temp (°C)	SEC (µs/cm)	pH (SU)	DO (mg/L)	Turbidity (NTU)	Bromide (mg/L)	Bromide Temp (°C)	Gallons per Minute	Total Gallons Pumped
08/17/2016	11:02	30.20	804	8.36	2.95	124	1.12	25.2	60.11	21,272
08/17/2016	11:57	34.44	803	8.24	3.07	121	1.09	25.1	59.65	22,153
08/17/2016	12:45	35.22	807	8.11	3.60	154	1.06	25.6	59.62	22,925
08/17/2016	13:36	35.46	809	8.10	2.44	176	1.07	25.2	59.98	23,724
08/18/2016	10:07	22.58	792	8.04	3.42	73.8	1.11	25.2	33.22	24,594
08/18/2016	10:35	36.19	801	7.92	2.51	118	1.04	25.4	29.81	25,449
08/18/2016	11:50	40.45	803	7.93	2.66	163	1.08	25.7	28.38	27,535
08/18/2016	12:18	41.16	801	7.93	2.31	198	1.05	25.4	28.16	28,434
08/18/2016	13:18	39.02	805	7.96	2.97	159	1.61	25.1	54.09	29,272
08/18/2016	14:12	40.06	800	7.88	3.12	139	1.65	25.3	53.94	29,894
08/19/2016	09:23	29.30	792	7.85	2.05	110	2.35	25.6	32.71	30,035
08/19/2016	10:31	39.35	789	7.86	2.98	129	1.85	24.7	28.41	31,969
08/19/2016	10:51	39.65	784	7.87	2.07	172	2.50	25.0	28.17	32,585

Appendix E

Well ER-20-12 Electronic Data Files Generated during WDT Activities

E.1.0 ELECTRONIC DATA FILES

This appendix contains the electronic data file index for WDT activities at Well ER-20-12. The electronic data files are provided in this appendix on the DVD included with this report. These files represent various original data files or minimally processed files.

E.1.1 Baker Hughes Data Files

The Baker Hughes files include the pump specifications and pump curves.

E.1.2 DRI Data Files

The DRI I-CHEM Tool and TFM logs are included as original recorded data.

E.1.3 Navarro Data Files

The Navarro data files include hydraulic head; groundwater temperature at the PXDs; barometric pressure collected at Well ER-20-12 before, during, and after testing; and the production rate data at Well ER-20-12. The data files are included as Microsoft Excel workbooks.

E.1.4 Preliminary Distance-Drawdown Analyses

The LTWLM program data, analyzed using SeriesSEE (Halford, 2006), are provided as Microsoft Excel workbooks, with the Excel add-in for the analysis provided from Halford et al. (2016). Copies of the analysis workbooks in this appendix are on the DVD included with this report. The file names indicate the HSU and well data analyzed as well as the period of WDT at Well ER-20-12 represented by the analyses. The workbooks include the analyses of all the LTWLM data analyzed. In addition to the analysis workbooks, the LTWLM data files from which the data analyzed were extracted are included.

E.2.0 REFERENCES

Halford, K.J. 2006. *Documentation of a Spreadsheet for Time-Series Analysis and Drawdown Estimation*, Scientific Investigations Report 2006-5024. Carson City, NV: U.S. Geological Survey.

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