

Prepared in cooperation with the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, Office of Environmental Management under Interagency Agreement, DE-A152-07NA28100

Database of Groundwater Levels and Hydrograph Descriptions for the Nevada Test Site Area, Nye County, Nevada

Data Series 533
Version 7.0, October 2016

**U.S. Department of the Interior
U.S. Geological Survey**

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By Peggy E. Elliott and Joseph M. Fenelon

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U.S. Geological Survey**

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Conversion Factors, Datums, and Acronyms

Conversion Factors

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
foot squared per day (ft ² /d)	0.09290	meter squared per day (m ² /d)

Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft³/d)/ft²ft. In this report, the mathematically reduced form, foot squared per day (ft²/d), is used for convenience.

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83) unless otherwise stated.

Altitude, as used in this report, refers to distance above the vertical datum.

Acronyms

DOE	U.S. Department of Energy
NTS	Nevada Test Site
NWIS	National Water Information System
USGS	U.S. Geological Survey

Database of Groundwater Levels and Hydrograph Descriptions for the Nevada Test Site Area, Nye County, Nevada

By Peggy E. Elliott and Joseph M. Fenelon

Abstract

A database containing water levels measured from wells in and near areas of underground nuclear testing at the Nevada Test Site was developed. The water-level measurements were collected from 1941 to 2016. The database provides information for each well including well construction, borehole lithology, units contributing water to the well, and general site remarks. Water-level information provided in the database includes measurement source, status, method, accuracy, and specific water-level remarks. Additionally, the database provides hydrograph narratives that document the water-level history and describe and interpret the water-level hydrograph for each well.

Water levels in the database were quality assured and analyzed. Multiple conditions were assigned to each water-level measurement to describe the hydrologic conditions at the time of measurement. General quality, temporal variability, regional significance, and hydrologic conditions are attributed to each water-level measurement.

Introduction

The Nevada Test Site (NTS) is in Nye County, southern Nevada ([fig. 1](#)), about 65 mi northwest of Las Vegas, Nevada. From 1951 to 1992, 828 underground nuclear tests were completed at the NTS (U.S. Department of Energy, 2000). Most of the tests were done in five areas: Pahute Mesa, Rainier Mesa, Yucca Flat, Shoshone Mountain, and Frenchman Flat (Laczniak and others, 1996, fig. 2; U.S. Department of Energy, 2000, p. xviii; Wills, 2008, p. 14-1). All underground tests at Yucca Flat, Frenchman Flat, and Pahute Mesa were conducted in vertical shafts drilled into alluvial and volcanic rock, and in a few cases into carbonate and granitic rock. Nearly all tests

at Rainier Mesa and Shoshone Mountain were conducted in tunnel complexes mined into low-permeability, zeolitized tuff (National Security Technologies, LLC, 2007).

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office, under its Environmental Restoration Program, has a long-term program to investigate and remediate radionuclide contaminants generated on the NTS as a result of nuclear testing. As part of the program, DOE is evaluating what risk these contaminants may pose to the public. To help accomplish this objective, groundwater levels are being compiled and analyzed to better understand the groundwater flow system in areas of underground nuclear testing.

Purpose and Scope

This report documents and describes a comprehensive collection of water-level measurements made in and near areas of underground nuclear testing on the NTS since 1941. The water-level measurements and descriptions are stored in a Microsoft® Access database.

The process to develop the groundwater-level database (hereinafter water-level database) involved several steps. First, water-level measurements from wells in the study area and supporting information from various data sources were compiled and merged into the database. The supporting information, for use in interpreting the water-level measurements, includes site characteristics, well-construction information, lithologic logs, and contributing units for each well. Second, each water-level measurement was assigned multiple attributes to describe the hydrologic condition at the time of measurement. Third, a narrative was written for each well that provides information and comments about the well, water-level data for the well, and possible causes of water-level fluctuations.

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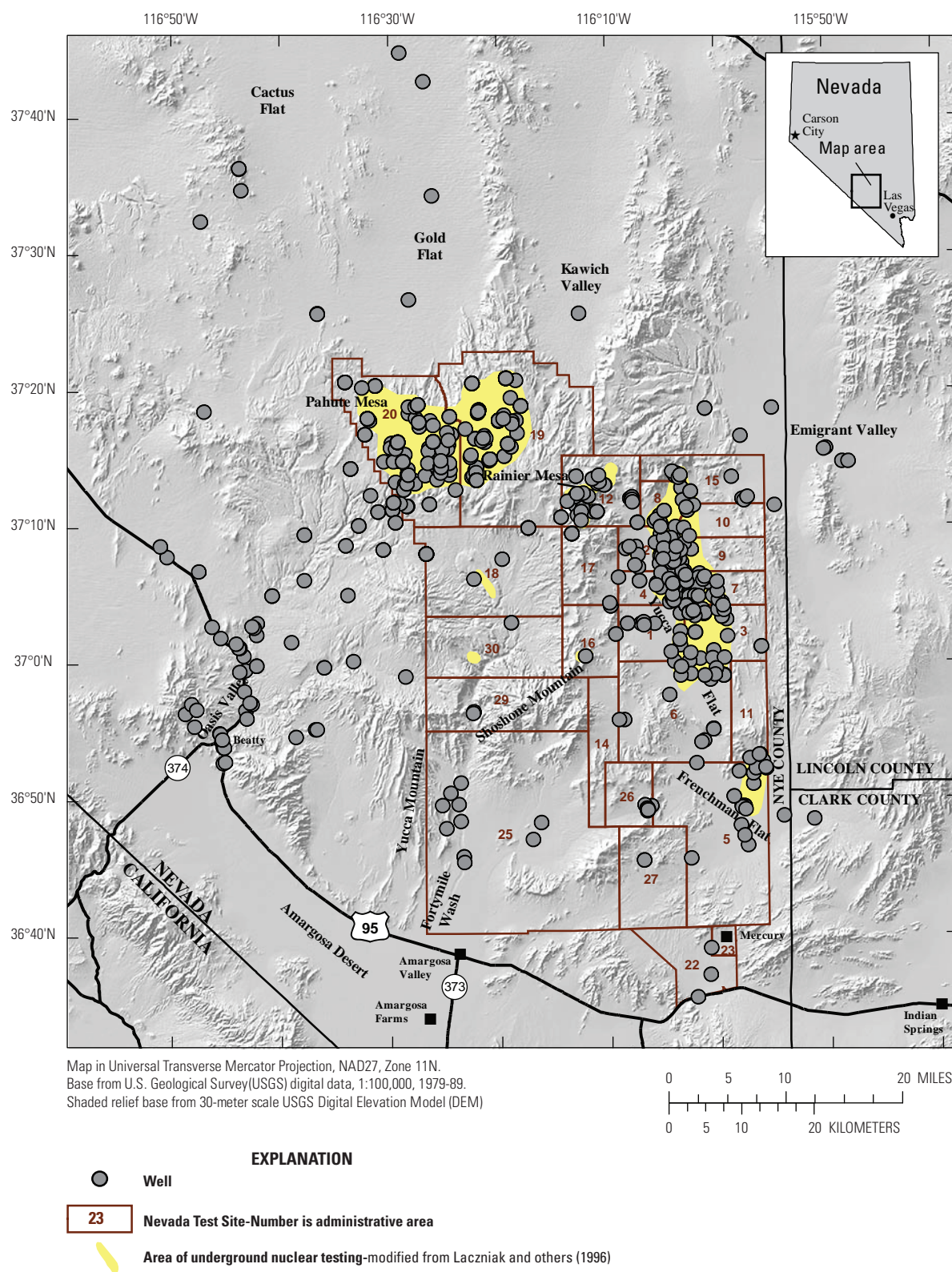


Figure 1. Areal distribution of wells in the water-level database for the Nevada Test Site area, Nye County, Nevada.

Water-level measurements, site characteristics, and well-construction information contained in the water-level database were obtained from the U.S. Geological Survey (USGS) National Water Information System (NWIS) database (U.S. Geological Survey, 2010a), available on the World Wide Web at <http://waterdata.usgs.gov/nv/nwis/> (hereinafter NWIS database). Prior to merging the NWIS data into the water-level database, a systematic quality-assurance review of data stored in the NWIS database and USGS data files in Henderson, Nev. for the wells was completed. Erroneous water-level data or duplicate sites were removed from or corrected in the NWIS database, and additional water-level measurements and site and construction information obtained from the data files were added to the NWIS database. Well-construction data were compiled from driller's logs, well completion reports, and other published and unpublished information. Lithologic data were obtained from Wood (2007) and units contributing water to the wells were modified after Fenelon and others (2010).

This report is the fifth in a series of studies by the USGS, in cooperation with DOE, to review NWIS data for quality assurance, add additional data previously missing from the NWIS database, and interpret historic water-level measurements in and near areas of underground nuclear testing on the NTS (Bright and others, 2001; Fenelon, 2000, 2005, 2006). This report updates water-level data published in previous reports, adds data from many additional wells, and compiles all available water-level data from underground test areas into a single database.

Description of Study Area

The study area includes the NTS and surrounding area, and incorporates areas of past underground nuclear testing on the NTS ([fig. 1](#)). The topography of the NTS includes volcanic highlands, such as Pahute and Rainier Mesas, and surrounding alluvial-filled basins. Altitudes in the study area range from about 2,400 to 8,500 ft.

The climate of the study area is arid to semiarid. Annual precipitation ranges from less than 5 in. on the lowest valley floors to about 13 in. in the highest upland areas (Soulé, 2006). Precipitation falls primarily as rain, and as snow at higher altitudes during the winter months. Streams in the study area are ephemeral and flow only for brief periods after infrequent, intense rainfall and during and soon after spring snowmelt.

The geology of the NTS and surrounding area is stratigraphically and structurally complex (Winograd and Thordarson, 1975; Laczniaik and others, 1996; Slate and others, 1999). Volcanic rocks dominate well completions in Pahute and Rainier Mesas, the Cactus Range, and some parts of Yucca, Frenchman, and Jackass Flats. The volcanic rocks predominantly consist of aquifers composed of welded ash-flow tuffs and lavas, and confining units composed of bedded air-fall and nonwelded ash-flow tuffs. Alluvial basin fill and carbonate rocks also are common in well completions,

and typically are aquifers. Alluvial fill is penetrated in some well completions, primarily in Yucca and Frenchman Flats, Emigrant and Oasis Valleys, and Gold Flat. Carbonate rocks typically lie beneath the alluvial and volcanic rocks and most commonly are intersected by wells in Yucca Flat where the depth to the top of carbonate rock is not excessive. A few wells in the study area are completed in sedimentary clastic rock and granite, which typically are confining units.

Aquifers at the NTS have been mapped as alluvial-volcanic or carbonate, based on lithology and hydraulic connection (Fenelon and others, 2010). These aquifers have been further classified as (1) "regional" if they form continuous flow systems connecting areas of recharge with areas of discharge, or (2) "local" if they are isolated by confining units and flow predominately as vertical leakage into the adjacent confining units.

Groundwater-Level Database

The USGS collects and maintains water-level data for wells on and near the NTS (U.S. Geological Survey, 2010b, at http://nevada.usgs.gov/doe_nv). As part of this data-collection program, current and historic water-level data are compiled, reviewed, and stored in the NWIS database. The water-level database in this report contains water-level measurements retrieved from the NWIS database for wells throughout the study area. Water-level data for these wells have been collected periodically since 1941.

Water-level data contained in the water-level database were collected from boreholes with single or multiple completions, or from measurement sites in mine shafts or tunnel complexes. As used in this report, the term "well" was chosen to represent a single, temporary or permanent completion in a borehole, where each completion defines a discrete open interval; a site used to measure depth to water in a flooded mine shaft; or a site in a tunnel used for measuring impounded tunnel water. Examples of multiple "well completions" in a single borehole may include (1) multiple temporary packed intervals, where each packed interval is considered a well completion, (2) multiple monitoring tubes or piezometers installed within the annulus of a main well completion, and (3) an open borehole that is monitored during a break in drilling (considered to be an initial well completion, as defined in this report) and then later deepened and completed (the only actual well completion in the borehole, but considered a second well completion in this report).

A unique site identification number and site name were established in the NWIS database for each well ([table A1](#) in [appendix A](#)). A "well," as used in this report, is referred to as a "site" in the NWIS database. Well and site are interchangeable in this report. All well names in this report are derived from the NWIS database.

Naming conventions for “wells” in the water-level database are as follows. The first part of a well name is the USGS borehole name ([table A1](#) in [appendix A](#); official NTS hole numbers also are provided in [table A1](#)). If a well completion represents the sole or final completion interval in a borehole, the entire well name typically is identical to the USGS borehole name—for example: well *UE-1a* (well names in this report are italicized). In boreholes with multiple completions, well names typically are differentiated from each other by a parenthetical expression added after the borehole name—for example: well *UE-2aa (2207 ft)*. A single number in the parenthetical expression refers to the depth of the well; two numbers separated by a dash refer to the depth of the top and bottom of the open interval in the well. In some cases, a well name consists of the borehole name and a non-parenthetical expression (main, piezometer) that follows the borehole name.

Methods and Data Sources

The water-level database in this report provides site information for each well, water-level and well-construction data, borehole lithology, units contributing water to the well, and information on the external conditions influencing each water level measured in the study area (NTS_WL.accdb in [appendix A](#)). Information in the water-level database was derived from datasets created for this study and datasets available from the NWIS database. Borehole-lithologic descriptions were obtained mostly from Wood (2007) and designation of units contributing water to the wells were modified after the subsurface hydrologic unit types described in Fenelon and others (2010).

A systematic quality-assurance review of site information and water-level data in the NWIS database through June 2016 for wells in the study area, and for data not previously published in Bright and others (2001) and Fenelon (2000, 2005, 2006) was completed for this study. This review included removing or correcting duplicate sites or erroneous water-level data in the NWIS database, and adding water-level measurements and site and construction information obtained from USGS data files stored in Henderson, Nev. that were previously missing from the NWIS database. A summary of water-level measurements for the wells is shown in [table A2](#) in [appendix A](#).

Periodic water-level measurements in the water-level database primarily were made by USGS or private contracting agencies working at the NTS using a calibrated electric tape, calibrated electric-cable unit (also known as iron-horse and wire-line device), and less commonly, a steel tape, fluid-density geophysical log, airline, float recorder, pressure transducer, and pressure gage. Most water-level measurements prior to 1996 were made with an electric-cable unit (Garber and Koopman, 1968), whereas more recent measurements typically were made using an electric tape. Electric tapes are calibrated annually at different water-level depths with a USGS steel reference tape. At the time of measurement, a correction factor is applied to the depth-to-water reading based on the annual calibration. Post-1995 measurements using electric tapes generally are more accurate (± 0.1 ft) than older measurements using electric-cable units or other methods (± 0.5 – 2 ft).

Water-level measurements collected from wells in boreholes that deviated from vertical during drilling were corrected for borehole deviation ([table 1](#)). As a general rule, water levels are corrected for borehole deviation if the correction is greater than 1.0 ft. Corrections less than 1.0 ft were not applied to water levels because at depths exceeding 1,000 ft for water levels in many wells on the NTS the uncertainty in the deviation correction can be as great or greater than the magnitude of the correction. Exceptions to this rule exist for some wells where the borehole deviation equations were developed under other water-level measurement programs. Water levels in these boreholes were corrected for borehole deviation although the corrections are less than 1 ft.

The equations used to calculate water-level corrections for borehole deviation are based on the source of information available, such as a drilling report or well diagram that reported the slant angle of the borehole or a borehole-deviation survey. When only the slant angle of the borehole is available, the angle of deviation along the measured depth interval is assumed constant and the correction equation is derived as follows:

$$V_d = M_d * \cos \theta, \quad (1)$$

where

V_d is corrected vertical water-level depth, in feet below land surface;

M_d is measured water-level depth, in feet below land surface;

Table 1. Equations used to correct water levels for borehole deviation in the Nevada Test Site area, Nye County, Nevada.

USGS borehole name: USGS borehole name as shown in [table A1](#) in [appendix A](#). Names in bold are boreholes intentionally drilled at a slant angle. **Equation used to derive borehole deviation equation:** Borehole deviation equations were derived using equations (1) and (2), which are described in the “[Groundwater-Level Database](#)” section of the report. **Depth interval over which correction applies:** Measured depth interval that bounds the minimum and maximum depths of historic water-level measurements. The depth interval is used in equation (2) to derive the borehole deviation equation. **Borehole deviation equation used to correct water levels:** V_d , corrected vertical water-level depth; M_d , measured water-level depth along slant hole. **Average water-level adjustment:** Average amount of adjustment subtracted from measured water level (M_d) to obtain corrected vertical water level (V_d); –, no adjustment applied.

USGS borehole name	Equation used to derive borehole deviation equation	Depth interval over which correction applies, in feet	Borehole deviation equation used to correct water levels	Average water-level adjustment, in feet
ER-6-2	2	1,701 – 1,877	$V_d = (M_d * 0.99771) + 2.12$	2.0
ER-16-1	¹ 1, 2	3,926 – 4,532	$V_d = (M_d * 0.9563) + 101.18$	81.1
ER-20-5-3	2	2,050 – 2,100	$V_d = (M_d * 0.994) + 6.22$	6.1
ER-20-12	² 2	1,492 – 1,912	$V_d = (M_d * 0.99914) - 0.94$	2.5
ER-EC-12	³ 2	1,315 – 1,415	$V_d = M_d - 1.10$	1.1
ME-2	1	0 – 274	$V_d = M_d * 0.6984$	45.8
RNM-1⁴	2	725 – 900	$V_d = (M_d * 0.94432) - 16.36$	60.3
U-2bs PS 1DB	1, 2	1,838 – 2,188	$V_d = (M_d * 0.8038) + 239.62$	180
U-2gg PS E3A	1	0 – 2,060	$V_d = M_d * 0.95106$	93.7
U-3cn 5	2	1,429 – 1,970	$V_d = (M_d * 0.9954) + 5.42$	2.0
U-4u PS 2A	2	1,485 – 1,665	$V_d = (M_d * 0.94500) - 4.46$	98.1
U-7ba PS 1AS	⁵ 2	926 – 1,476	$V_d = (M_d * 0.92489) + 24.99$	68.4
U-19ad PS 1A	1	0 – 2,579	$V_d = M_d * 0.9310558$	154
U-19v PS 1D	1	0 – 3,885	$V_d = M_d * 0.9338$	186
U-20m PS 1DABCF	2	1,300 – 1,325	$V_d = (M_d * 0.9892) + 10.21$	4.0
		1,350 – 1,375	$V_d = (M_d * 0.986) + 14.49$	5.0
U-20n PS 1DD-H⁶	2	2,050 – 2,100	$V_d = (M_d * 0.9361) + 86.88$	46.8
		2,150 – 2,200	$V_d = (M_d * 0.9349) + 89.38$	52.2
UE-5 PW-1 ⁷	2	770 – 775	$V_d = (M_d * 0.998) + 1.27$	0.3
UE-5 PW-2 ⁷	2	835 – 845	$V_d = (M_d * 0.999) + 0.17$	0.7
UE-5 PW-3 ⁷	2	755 – 920	$V_d = M_d - 0.06$	0.06
UE-10j ⁸	2	2,100 – 2,200	$V_d = (M_d * 0.9927) + 13.32$	2.0
UE-25 WT 3 ⁹	2	984 ± 25	$V_d = M_d - 0.89$	0.89
UE-25 WT 13	2	950-1,000	$V_d = M_d - 0.04$	0.04
UE-25 WT 14 ⁹	2	1,135 ± 25	$V_d = M_d - 0.28$	0.28
UE-25 WT 15 ⁹	2	1,161 ± 25	$V_d = M_d - 0.62$	0.62
UE-25p 1 PTH ⁹	2	1,184 ± 25	$V_d = M_d - 0.07$	0.07
WW-2 ¹⁰	2	1,725 – 2,175	$V_d = M_d - 0.52$	0.5
WW-A ¹¹	2	1,575 – 1,850	$V_d = M_d - 3.00$	3.0
WW-C ¹²	¹³ 2	1,500 – 1,540	$V_d = (M_d * 0.99625) + 4.74$	1.0
		1,540 – 1,701	$V_d = (M_d * 0.96619) + 51.04$	1.0
WW-C-1	1, 2	1,525 – 1,550	$V_d = (M_d * 0.9848) + 19.21$	4.3
		1,550 – 1,575	$V_d = (M_d * 0.9772) + 30.99$	--
		1,575 – 1,600	$V_d = (M_d * 0.966) + 48.63$	5.7

¹ Source of data includes a borehole deviation survey completed to a depth of 3,926 ft, and an assumed constant angle of slant to 4,172 ft (bottom of borehole). The slant angle is based on the measured deviation at a depth of 3,926 ft.

² Includes wells *ER-20-12 m1*; *ER-20-12 p1*; *ER-20-12 p2*; *ER-20-12 p3*; and *ER-20-12 p4*.

³ Includes wells *ER-EC-12 deep*, *ER-EC-12 intermediate*, and *ER-EC-12 shallow*.

⁴ Includes wells *RNM-1*, *RNM-1 (Zone I perms)*, *RNM-1 (Zone IV perms)*, and *RNM-1 (Zone V perms)*.

⁵ Sporadic borehole-deviation measurements were obtained from drilling records.

⁶ Includes wells *U-20n PS 1DD-H (3025 ft)*, *U-20n PS 1DD-H (4309 ft)*, and *U-20n PS 1DD-H (4470 ft)*.

⁷ Borehole deviation information from National Security Technologies, LLC, 2011.

⁸ Includes wells *UE-10j (2232-2613 ft)*, *UE-10j (2232-2297 ft)*, and *UE-10j (2380 ft)*.

⁹ Borehole deviation information from Savard, 2001.

¹⁰ Includes wells *WW-2 (2045 ft)*, *WW-2 (2535 ft)*, *WW-2 (2896 ft)*, *WW-2 (3422 ft)*, and *WW-2 (3422 ft, uncased)*. Borehole deviation information from Moore and others, 1963.

¹¹ Includes wells *WW-A (1730 ft)* and *WW-A (1870 ft)*.

¹² Includes wells *WW-C (1373-1701 ft)* and *WW-C (recompleted)*.

¹³ Source of data includes a borehole deviation survey completed to a depth of 1,540 ft, and an assumed constant angle of slant to 1,701 ft (bottom of borehole). The slant angle is based on the measured deviation at a depth of 1,540 ft.

θ is angle of slant from the vertical.

When a borehole-deviation survey is available, water-level corrections for selected depth intervals are developed based on cumulative measured borehole deviations from the survey. The true vertical water-level depth for a selected depth interval is determined by using a linear equation of the form:

$$V_d = (M_d - M_{top}) * (\Delta V_{int} / \Delta M_{int}) + V_{top}, \quad (2)$$

where

- V_d is corrected vertical water-level depth, in feet below land surface;
- M_d is measured water-level depth, in feet below land surface;
- M_{top} is measured depth to top of depth interval over which correction applies, in feet below land surface;
- ΔV_{int} is difference in true vertical depths between top and bottom of depth interval over which correction applies, in feet below land surface;
- ΔM_{int} is difference in measured depths between top and bottom of depth interval over which correction applies, in feet below land surface; and
- V_{top} is true vertical depth to top of depth interval over which correction applies, in feet below land surface.

As an example, a borehole deviation survey for borehole UE-10j (USGS data files, Henderson, Nev.) shows that a measured depth interval of 2,100–2,200 ft below land surface can be used to bound historic water-level measurements for well completions in this borehole ([table 1](#)). The corresponding true-vertical depths from the deviation survey at the top and bottom of this interval are 2,097.99 and 2,197.26 ft, respectively. Substituting these values into equation 2 gives the linear water-level adjustment for the depth interval that bounds historic water levels:

$$V_d = (M_d - 2,100) * (99.27/100.00) + 2,097.99 \quad (3)$$

In reduced form, equation 3 becomes:

$$V_d = (M_d * 0.9927) + 13.32 \quad (4)$$

Water levels in 48 wells in 29 boreholes in the study area were corrected for borehole deviation ([table 1](#)). Ten of these boreholes are slant holes that were intentionally drilled at an angle. The average water-level adjustments for borehole deviation in the slant holes and in borehole ER-16-1 are greater than 45 ft, with the exception of borehole U-20m PS 1DABCF. In the remaining boreholes, the average water-level adjustments were less than about 6 ft.

Hydrologic conditions were used to describe the state of each water level that was measured in the study area. The conditions also describe the external factors that may have affected the measured depths-to-water. Hydrologic conditions were categorized as either general or detailed ([table 2](#)). General hydrologic conditions describe the state of a water level; examples are steady state, transient, and nonstatic. Detailed hydrologic conditions describe the effect that a factor may have on a water level, or denote the uncertainty of a water-level interpretation. Factors affecting water levels include pumping, recent well construction, and earthquake response. Water-level effects include abrupt change, equilibration, and rising trend. One general hydrologic condition and as many as six detailed hydrologic conditions were assigned to each water-level measurement in the study area.

The contributing units assigned to each well in the study area were based on subsurface hydrologic unit types as described in Fenelon and others (2010). A contributing unit represents the hydrologic unit at the open interval of the well that may contribute water to the well. A well may have been assigned more than one contributing unit code if multiple units are encountered by the open interval. All contributing unit codes are defined in [appendix A](#) in the Excel workbook named [ds533_NTS_hydrographs.xls](#).

The water-level history of each well is documented in a hydrograph narrative. The narrative consists of comments or explanations about the well or water-level data measured in the well. An interpretation of the hydrograph and its hydrologic significance also is provided for most wells as part of the narrative. The narrative may include information about the open interval, testing done in the well, well productivity, specific influences near the well that may have affected water levels, and other details that may provide additional information about the conditions affecting past water-level measurements in the well. Basic information included in the narratives was derived from published reports or from USGS data files stored in Henderson, Nev.

Table 2. Descriptions of general and detailed hydrologic conditions assigned to water levels in the Nevada Test Site area, Nye County, Nevada.

Condition name	Description
General condition	
Insufficient data	Water level does not have sufficient supporting information to determine its general condition.
Localized conditions	Water level represents non-steady, hydrologic conditions in a small part of the aquifer directly adjacent to the well; water level is affected by activities near or in the well such as a nuclear test or small-scale pumping.
None	No water level was recorded because well is dry or obstructed, or site was visited but water level was not measured.
Nonstatic	Water level represents non-steady hydrologic conditions in the well that are not representative of the surrounding aquifer; water level is affected by activities in the well, such as aquifer testing, well construction, or pumping.
Steady state	Water level approximates pre-development, steady-state, hydrologic conditions in the groundwater flow system. The flow system can be fully saturated or perched. Water level is in dynamic equilibrium and considered to be steady state relative to long-term (50–100 years) climatic conditions. Water-level changes occurring as a result of natural conditions are considered steady state.
Suspect	Water level is suspect or in error, and cannot be attributed to any known hydrologic cause.
Transient	Water level represents non-steady hydrologic conditions in the groundwater flow system that typically result from pumping in the well or a nearby well. The flow system can be fully saturated or perched.
Detailed condition	
Abrupt change	Water level rapidly shifted or changed from previous measurement.
Anomalous - high	Water-level altitude is unusually high relative to other measurements in the well or in nearby wells.
Anomalous - low	Water-level altitude is unusually low relative to other measurements in the well or in nearby wells.
Borehole deviation	Water level is corrected for borehole deviation.
Consistent	Water level appears to be part of a reasonably consistent trend representative of general water-level conditions in the area.
Declining trend	Water level appears to be part of a discernible, overall downward trend. Possible causes include nearby pumping, decreased recharge, equilibration following drilling, or depressurization after a nuclear test.
Destroyed	Well was destroyed during site visit; no water-level measurement was made.
Dry	No water level was recorded because well was dry at time of measurement.
Earthquake response	Water level appears to be responding to a recent earthquake.
Elevated	Water level is appreciably elevated relative to representative levels in the adjacent groundwater flow system. Elevated level is believed to result from naturally occurring, large vertical gradients in the area of the well. Representative levels in the adjacent flow system are based on Fenelon and others (2010) and Fenelon and others (2012).
Equilibration	Water level appears to be part of a discernible, overall trend that is approaching an equilibrium level, either higher or lower than the current measurement. Equilibration commonly occurs following well construction, pumping, or nearby nuclear testing.
Erratic/Unstable	Water level is erratic and unstable.
Evapotranspiration response	Water level appears to be responding to evapotranspiration.
Floating oil	Water-level measurement may be affected by floating oil in the well. Reported measurement is not corrected for variable density effects.
Injection recovery	Water level is equilibrating from an injection of water, mud, or other fluid into the well or hole.
Limited data	Water level is one of a limited number. Therefore, the general condition assigned to water level is tentative.
Local infiltration	Water level is responding to infiltration from a locally derived source of water, such as a nearby pond or stream channel.

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Table 2. Descriptions of general and detailed hydrologic conditions assigned to water levels in the Nevada Test Site area, Nye County, Nevada.—Continued.

Condition name	Description
Detailed condition—Continued	
Maximum estimate	Water level or depth of attempted measurement (when well is dry or obstructed) represents a maximum estimate of the equilibrated water-level altitude in the monitored hydrologic unit.
Minimum estimate	Water level represents a minimum estimate of the equilibrated water-level altitude in the monitored hydrologic unit.
NA	No flag assigned.
Nearby drilling effect	Water level is affected by drilling activities in a nearby hole.
Nuclear-test effect	Water level appears to be or is suspected of being affected by nearby nuclear tests.
Obstruction	Water-level measurement was attempted but could not be made because of an obstruction in the hole.
Packer test	Water level was measured during a packer test.
Perched/semi-perched	Water level appears to represent perched- or semi-perched conditions.
Precipitation response	Water level appears to be responding to recharge from a large precipitation event or a wet winter.
Pumping area	Well is in an area that may be impacted by groundwater withdrawals; however, no clear evidence of an impact on the water level was determined.
Pumping effect	Water level is affected by active or recent pumping or bailing in the well or a nearby well, and appears lower than pre-pumping or pre-bailing water levels. If water-level measurement is missing, well was pumping at time of site visit and a measurement was not made.
Questionable accuracy	Water level may not be accurate because of a poor measurement.
Rising trend	Water level appears to be part of a discernible, overall rising trend. Possible causes include a decrease in nearby pumping, equilibration following drilling, and above-normal precipitation.
Seasonal effect	Water level appears to be affected by a seasonal cycle. Seasonal cycles can be natural (evapotranspiration, atmospheric pressure) or anthropogenic (seasonal pumping).
Spring effect	Water level may be affected by modifications or changes to a nearby spring.
Suspected unsaturated	Water level is suspected to represent remnant fluid in the well. Hole is believed to be unsaturated.
Temperature effect	Water level likely is affected by anomalously high or low water temperature; reported level is not adjusted for temperature effects.
Testing area	Well is within one mile of one or more underground nuclear tests. Water level is not believed to be, but could be, affected by the testing.
Tunnel effect	Water level may be affected by nearby tunneling.
Uncertain	General condition assigned to water level is tentative because of uncertainty in interpreting water level or hydrograph.
Undeveloped	Water level may not accurately represent hydrologic conditions in the monitored hydrologic unit because of insufficient or no well development.
Well-construction effect	Water level appears to be equilibrating from, or is suspected of being affected by, prior well-construction and (or) development activities.

Description of Database

The water-level database (NTS_WL.accdb) in [appendix A](#) is comprised of 16 tables. Site, well-construction, and lithology information for the wells in the study area are stored in 9 tables, and water-level information, including water-level data, hydrologic conditions at the time of each water-level measurement, and a hydrograph narrative for each well are contained in 4 tables ([table 3](#)). A summary of selected well characteristics and water-level information retrieved from these tables is presented in 2 additional tables in the database: *Well_Characteristics* ([table A1](#)) and *Water_Level_Measurements_Summary* ([table A2](#)).

The structure of the water-level database is shown in [figure 2](#). Tables in the database are linked by the field USGS_site_no (USGS site number), a unique 15-digit number used to identify each well; three tables also are linked by the field Water_level_date_time (water-level date and time). An effort was made to maintain a database structure that is similar to the structure of the NWIS database outlined in U.S. Geological Survey (2005). For example, the five construction tables from the NWIS database are preserved in the water-level database.

Hydrographs and well locations in the study area are interactively presented in a Microsoft® Excel workbook ([ds533_NTS_hydrographs.xlsx](#) in [appendix A](#)). The workbook is designed to be an easy-to-use tool to obtain the water-level history for any well in the study area. It also can be used to filter water-level data by restricting the data to certain wells,

dates, or hydrologic conditions. [Figure 3](#) is an example of a worksheet from the workbook and shows well *ER-2-1 piezometer (deep)*, which was selected with the pull-down list using the Microsoft® Excel built-in AutoFilter. Selected site information, water-level information and conditions, and the contributing unit from the water-level database are shown for this well. Additional information provided includes a short narrative that describes the well and hydrograph, and a hyperlink to the NWISWeb site home page for the well.

Information for each water level shown in the example in [figure 3](#), and for all water levels in the water-level database, includes water-level source, status, method, and accuracy (which pertains to the depth-to-water measurement and not the water-level altitude), and hydrologic conditions at the time of the water-level measurement. Interpretations for individual water-level measurements and for the period of record for a well have been incorporated into the water-level remark, hydrologic conditions, or hydrograph narrative ([appendix A](#); [fig. 3](#)). Abrupt water-level changes and long-term water-level declines are examples of typical hydrologic conditions that were interpreted. The components of the water-level record, including those shown in [figure 3](#), are defined in table *NTS14_field_descriptions* in the water-level database, NTS_WL.accdb, in [appendix A](#). Revisions made during the previous year to water-level data, general hydrologic-condition flags, or major changes to hydrograph narratives, are documented in table *NTS16_revision_history* in the water-level database.

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Table 3. Descriptions of tables in the water-level database for the Nevada Test Site area, Nye County, Nevada.

[NA, not applicable]

Table name	Table grouping	Type of data	Remarks
NTS01_sitefile	Site record	Location and general information about a well	One unique record for each well
NTS02_construction	Construction record	General construction data for a well	May have multiple entries for each well that describe unique intervals of the hole
NTS03_hole	Construction record	Hole diameter and interval	
NTS04_casing	Construction record	Casing diameter, interval, and material	
NTS05_opening	Construction record	Open-interval diameter, interval, material, type, and size of opening	May have multiple entries for each well that describe unique open intervals of the hole and/or casing
NTS06_measuring_point	Construction record	Information about stable points on or near a well from which measurements of depth-to-water are made	Populated with wells actively or recently measured by USGS
NTS07_water_levels	Water-level record	Basic water-level measurement data	Detailed hydrologic conditions at the time of the water-level measurement that describe water-level trends, factors causing changes in water levels, or uncertainty of a water-level interpretation
NTS08_water_levels_gen_cond	Water-level record	General hydrologic condition at the time of the water-level measurement	
NTS09_water_levels_det_cond	Water-level record	Detailed hydrologic conditions at the time of the water-level measurement that describe water-level trends, factors causing changes in water levels, or uncertainty of a water-level interpretation	
NTS10_hydrograph_narrative	Water-level record	The hydrograph narrative documents the water-level history of each well including comments or explanations about the well, hydrograph, or specific water levels	Remarks derived from a variety of sources including published reports, drilling records, or field notes
NTS11_remarks	Miscellaneous record	Meaningful data about a well for which no specific field is available	
NTS12_lithology	Geohydrologic record	Detailed lithologic descriptions of cuttings, cores and sidewall samples, or from geophysical logs	
NTS13_aquifer	Geohydrologic record	Aquifer(s) or lithologic unit(s) contributing water to well	The designations for aquifers or water-bearing units are modified after the subsurface hydrologic unit types described in figure 3 and appendix 3 of Fenelon and others (2010)
NTS14_field_descriptions	NA	Metadata for database tables NTS01-NTS13	Descriptions of the components in each database table
NTS15_references	NA	References cited in the NTS10_hydrograph_narrative table	
NTS16_revision_history	NA	Documentation of revisions to water-level data, general condition flags, and major changes to hydrograph narratives	

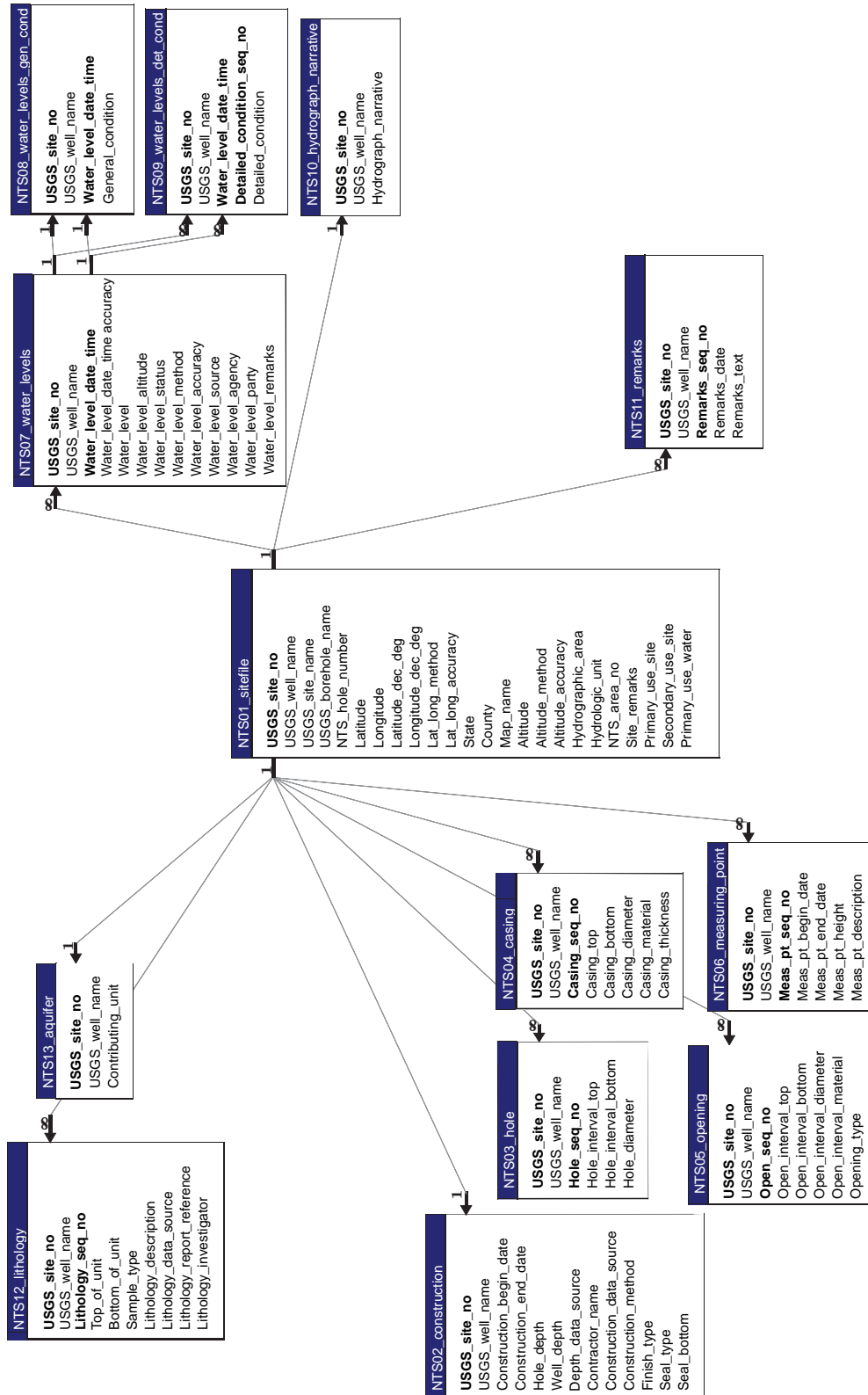


Figure 2. Relationships among data tables in the water-level database for the Nevada Test Site area, Nye County, Nevada.

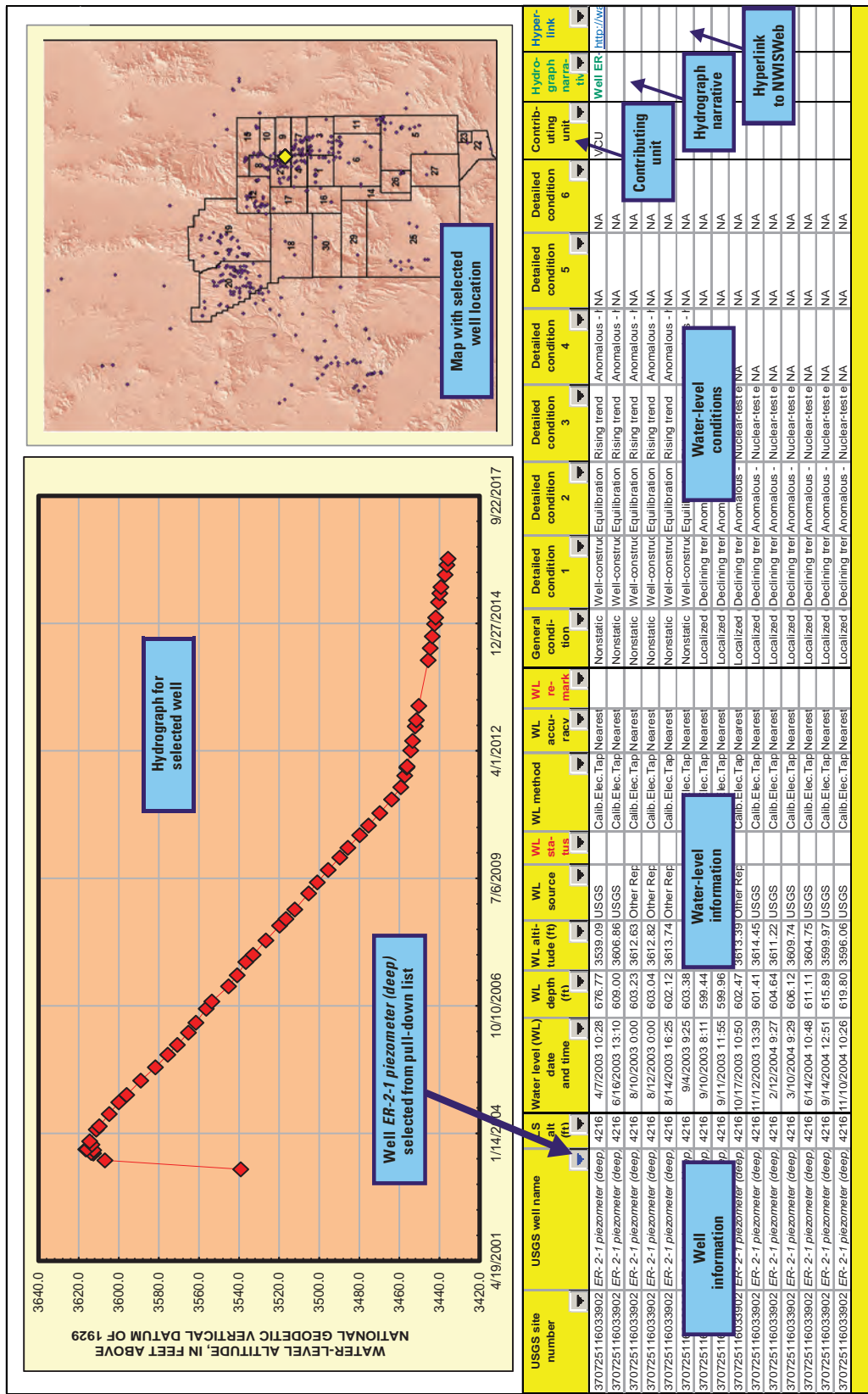


Figure 3. Example of a worksheet with a hydrograph and well information from the Microsoft® Excel workbook in [appendix A](#).

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Appendix A. Database of Groundwater Levels and Hydrograph Descriptions for the Nevada Test Site Area, Nye County, Nevada

The database distributed with this report (NTS_WL.accdb) is in Microsoft® Access format. It contains 13 tables with hydrologic information for wells in the study area ([fig. 2](#), [table 3](#)). The tables contain information on the wells including well construction, borehole lithology, contributing units, water levels, and information on the external conditions influencing each water level measured in the study area. A description of the information contained in each of the database tables is stored in the database in the table named *NTS14_field_descriptions*. A general description of each table (Table Properties) and query (Object Properties) can be read in the Access project window by opening the database, selecting “View By”, and then selecting “Details.” Descriptions of each table column can be made to appear at the bottom of the database window screen by opening a table and moving the cursor to the column of interest.

A summary of selected information from the 13 tables is presented in two additional tables in the appendix: *Well_Characteristics* and *Water_Level_Measurements_Summary*. The *Well_Characteristics* table ([table A1](#)) presents

characteristics for wells that have at least one water-level measurement through June 2016 in the study area, and the *Water_Level_Measurements_Summary* table ([table A2](#)) contains a summary of water-level measurements from wells in the study area. These tables were created from two queries named the same as the tables; the queries are saved in the database under the *Queries* tab. Descriptions of the information contained in these two tables are provided below.

A Microsoft® Excel workbook ([ds533_NTS_hydrographs.xlsx](#)) also is distributed with this report as an interface to the water-level database. Most of the water-level information from the database is provided in the spreadsheet. Different hydrographs from the study area can be selected using the Microsoft® Excel built-in AutoFilter.

Revisions made during the previous year to water-level data (table *NTS07_water_levels*), general condition flags (table *NTS08_water_levels_gen_cond*), or major changes to the hydrograph narratives (table *NTS10_hydrograph_narrative*), are documented in table *NTS16_revision_history* in the database.

Access table name	Column name	Description
<i>Table_A1_ Well_Characteristics</i>	USGS site number	Unique USGS site identification number
	USGS well name	Unique USGS well name that represents a discrete open interval in a borehole, mine, or tunnel site
	USGS borehole name	USGS borehole name at site
	NTS hole number	Official NTS hole name at site
	Latitude, in decimal degrees (NAD 83)	Latitude, in decimal degrees; datum is North American Datum of 1983
	Longitude, in decimal degrees (NAD 83)	Longitude, in decimal degrees; datum is North American Datum of 1983
	Land-surface altitude (ft) (NGVD 29)	Altitude of land surface at site, in feet; datum is National Geodetic Vertical Datum of 1929
	Date of completed construction	Date well construction was completed. A blank cell indicates construction date unknown
	Depth drilled (ft)	Depth of hole, in feet, that was drilled prior to establishing well. A blank cell indicates depth drilled is unknown or not applicable
	Top of open interval (ft)	Top of open interval in well, in feet below land surface. A blank cell indicates top of open interval is unknown or not applicable
	Bottom of open interval (ft)	Bottom of open interval in well, in feet below land surface. A blank cell indicates bottom of open interval is unknown or not applicable
	Contributing unit	Aquifer(s) or lithologic unit(s) contributing water to well. AAL, alluvial aquifer, local; AAR, alluvial aquifer, regional; AAQ, alluvial aquifer; ACU, alluvial confining unit; CAL, carbonate aquifer, local; CAR, carbonate aquifer, regional; CAQ, carbonate aquifer; SCU, siliceous confining unit; VAL, volcanic aquifer, local; VAR, volcanic aquifer, regional; VAQ, volcanic aquifer; VCM, volcanic composite unit; VCU, volcanic confining unit; None, there are no contributing units for the well. The contributing units are further defined using the following descriptors: (d), dry; (o), obstructed, and generally are used with generic aquifer codes AAQ, CAQ, and VAQ
<i>Table_A2_Water_ Level_Measurements_ Summary</i>	USGS site number	Unique USGS site identification number
	USGS well name	Unique USGS well name that represents a discrete open interval in a borehole, mine, or tunnel site
	First water-level measurement	Date of first water-level measurement made in well
	Last water-level measurement	Date of last water-level measurement made in well
	Number of measurements	The number of measurements made in the well including attempted measurements that were reported as dry or obstructed
	Minimum water-level depth (ft)	The shallowest of all water-level measurements made in the well; depth to water reported in feet below land surface and rounded to nearest foot. A blank cell indicates no water-level measurement available
	Maximum water-level depth (ft)	The deepest of all water-level measurements made in the well; depth to water reported in feet below land surface and rounded to nearest foot. A blank cell indicates no water-level measurement available

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