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Water-Level Database Update for the Death Valley Regional Groundwater Flow System, Nevada and California, 1907–2007

Data Series 519

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

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By Michael T. Pavelko

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Conversion Factors, Datums, and Acronyms and Abbreviations

Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)

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).

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

Acronyms and Abbreviations

DOE	Department of Energy
DVRFS	Death Valley regional groundwater flow system
HGU	hydrogeologic units
NDWR	Nevada Division of Water Resources
NWIS	National Water Information System
OCRWM	Office of Civilian Radioactive Waste Management
USGS	U.S. Geological Survey

Water-Level Database Update for the Death Valley Regional Groundwater Flow System, Nevada and California, 1907–2007

By Michael T. Pavelko

Abstract

The water-level database for the Death Valley regional groundwater flow system in Nevada and California was updated. The database includes more than 54,000 water levels collected from 1907 to 2007, from more than 1,800 wells. Water levels were assigned a primary flag and multiple secondary flags that describe hydrologic conditions and trends at the time of the measurement and identify pertinent information about the well or water-level measurement. The flags provide a subjective measure of the relative accuracy of the measurements and are used to identify which water levels are appropriate for calculating head observations in a regional transient groundwater flow model. Included in the report appendix are all water-level data and their flags, selected well data, and an interactive spreadsheet for viewing hydrographs and well locations.

Introduction

The Death Valley regional groundwater flow system (DVRFS) of southern Nevada and southeastern California (fig. 1) encompasses about 3,900 mi^2 and is geologically and hydrologically complex. The U.S. Geological Survey (USGS), in cooperation with the Department of Energy (DOE), developed a regional transient groundwater flow model of the DVRFS to support National Nuclear Security Administration/Nevada Site Operations and Office of Civilian Radioactive Waste Management (OCRWM) programs at the Nevada Test Site (Belcher, 2004). In 2005, OCRWM requested an update to the transient DVRFS model to reflect newly acquired geologic and hydrologic data. As part of that effort, databases that support the model were updated to 2007. This report is an update to the original DVRFS water-level database (San Juan and others, 2004).

The purpose of the DVRFS water-level database is to identify water-level measurements that are appropriate and beneficial for calculating head observations for the regional, transient groundwater flow model. The DVRFS model includes 27 hydrogeologic units (HGU). Although a water level is not available for every HGU, water levels were compiled for as many HGUs as possible. However, when constructing a regional, long-term, and hydrogeologically complex model with large cell sizes, such as DVRFS, all known water levels do not have to be included, especially for areas with a high density of shallow alluvial domestic wells, such as Pahrump Valley and Amargosa Desert, Nevada and California. For this reason, all known water levels were not included in the database.

The well and water-level data in the database are stored in the USGS National Water Information System (NWIS) database for Nevada, at http://waterdata.usgs.gov/nv/nwis/nwis, and were retrieved for use in the model-specific water-level database. During construction of the original database, each water level was examined and assigned a detailed condition indicating the relative quality of the measurement as a steady-state or transient head observation for the model. In addition, multiple general conditions were assigned to each water level, providing supplementary information about the measurement, the well, or the hydrologic conditions at the time of the measurement. These conditions were assigned based on hydrologic trends, land- and water-use history, and geologic setting.

The water-level data are compiled from Federal, State, and local agencies, private industries, citizens, and published reports and therefore vary in accuracy and precision. The number of significant figures for depth-to-water values should not be considered a metric of accuracy or precision but rather is a byproduct of the reporting criteria from the various sources. In this database, the accuracy of measured depth-to-water ranges from 0.01 to 1 ft and the accuracy of measurement dates ranges from 1 minute to 1 year. Typically, data reported with less accuracy are from old reports or non USGS databases. During calibration of the numerical model, weights are assigned to head observations, which are derived

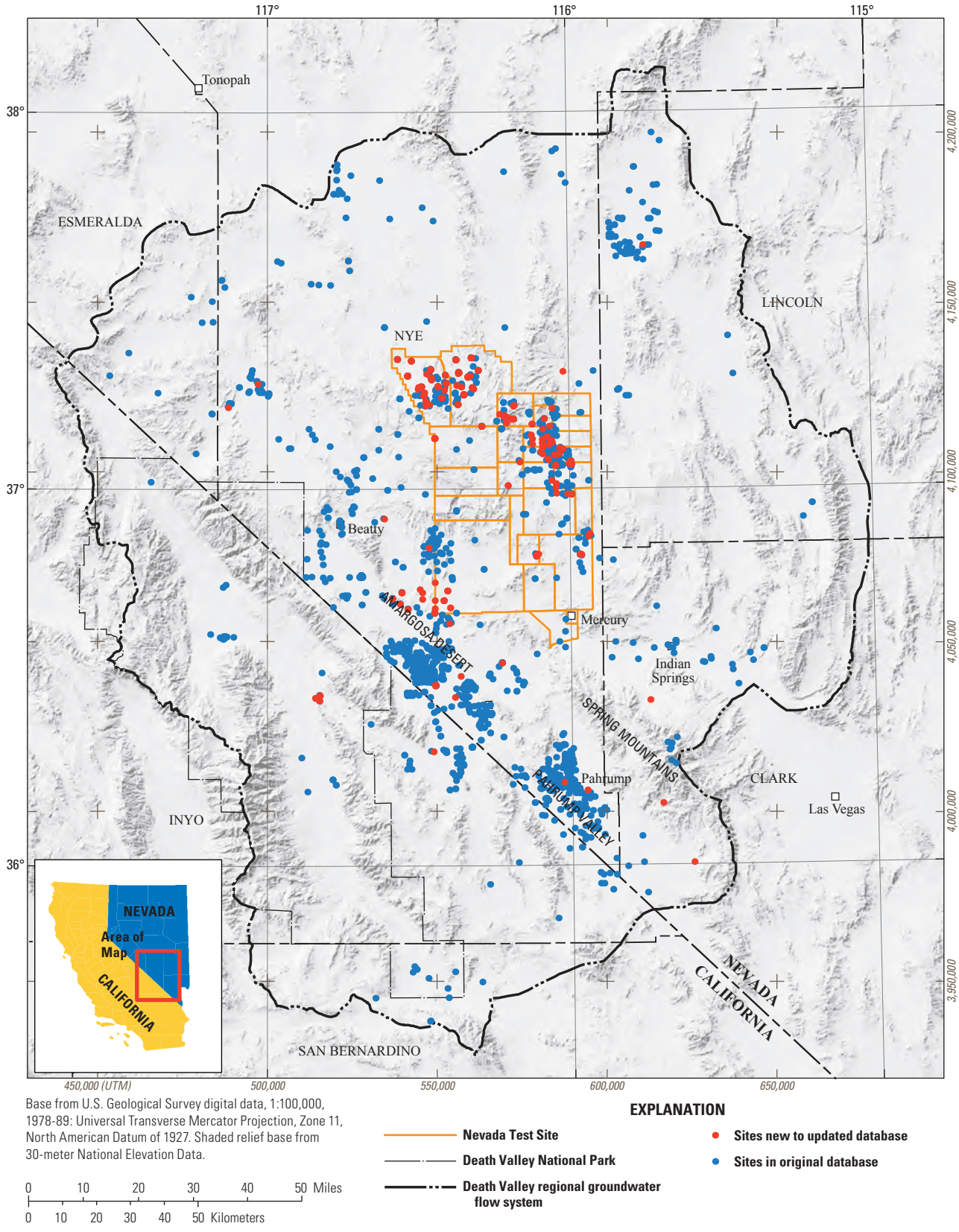

Figure 1. Areal distribution of wells in the original and updated water-level databases for the Death Valley regional groundwater flow system, Nevada and California.

from one or more water-level measurement; lower weights reflect less accurate data. Since the accuracy of the reported dates and water levels are reflected in the observation weights used in the model, the reported values included in the database are considered sufficiently accurate for a regional-scale model such as the DVRFS model.

The original DVRFS water-level database contains 38,313 water levels from 2,145 wells collected from 1900 to 2003 (San Juan and others, 2004), including data from wells located as far as 40 mi outside the DVRFS model area. The database includes 35,567 water levels from 1,386 wells within the DVRFS model area.

Water-Level Database Update

The updated water-level database includes 54,026 water levels, collected from 1907 to 2007, from 1,813 wells within the DVRFS model area. Development of the updated water-level database included a search for new wells and water levels, entering the new data into NWIS, revaluating the assigned detailed and general conditions from the original database in light of newly acquired water-level, well-construction, or other hydrogeologic data, and flagging the newly acquired water levels. In the updated database, detailed and general conditions from the original database are replaced by primary and secondary flags, respectively. For the DVRFS model area, the updated database has 427 more wells (fig. 1) and 18,459 more water levels than the original database. Of the 427 wells, 16 were drilled after the original database was developed and the rest are preexisting wells that were not in NWIS. The appendix of this report contains the updated database.

Well data in the database are agency code, site number, station name (well name), well altitude, hole depth, well depth, the number of open intervals, and the highest and lowest open interval (appendix A). Values are not available for each data parameter for every well in the database. Well data were verified with well logs from the Nevada Division of Water Resources (NDWR), driller's logs, or both.

Water-level data in the database are time and date of measurement, depth to water, water-level altitude, and NWIS water-level status code. Water-level altitudes were calculated by subtracting depths to water from well altitudes. Water-level data were verified using historical field notes and published and unpublished data from various Federal, State, and local agencies, or well owners. The updated database includes 1,097 records without water-level data, but they were included because they each have an NWIS water-level status code that provides additional information about the condition of the well or surrounding hydrologic conditions at the time of the attempted measurement (table 1). NWIS water-level status codes associated with no water-level measurements are D (dry), F (flowing), N (measurement discontinued), O (obstruction above water surface), P (pumping), W (well destroyed), and Z (other).

Table 1. Definitions and summary of National Water Inventory System water-level status codes used in the water-level database for the Death Valley regional groundwater flow system, Nevada and California, 1907–2007.

[NWIS, National Water Inventory System]

NWIS water-level status code	Site status at time of water-level measurement	Number of water levels with this code	Number of wells with this code
D	Dry	332	97
F	Flowing	216	33
I	Injection of water	5,210	266
N	Measurement discontinued	10	10
O	Obstruction above water surface	152	77
P	Pumping	1,297	115
R	Recently pumping	1,313	206
S	Nearby site pumping	243	38
T	Nearby site recently pumping	96	15
V	Foreign substance on water surface	13	6
W	Well destroyed	27	23
Z	Other [Sometimes documented in NWIS remarks fields]	1,018	267

Well and water-level data from NWIS were retrieved and entered into a Microsoft© Excel 2007 workbook for analysis and flag assignment. Primary and secondary water-level flags were determined by visual inspection of hydrographs for the well and surrounding wells, evaluating available data for the well and water level, evaluating the well location relative to pumping areas and underground nuclear tests, and researching unpublished and published materials. Unpublished resources primarily were field notes, NDWR well logs, and well data stored in NWIS, such as well construction and borehole lithology. Published resources primarily included regional hydrologic reports, such as Winograd and Thordarson (1975), Kilroy (1991), Laczniak and others (1996), and Belcher (2004).

Primary flags indicate whether or not a water level should be used to calculate a head observation in the model (table 2). Two primary flag types, steady state (regional scale) and transient (regional scale), are acceptable for regional models. Steady state (regional scale) primary flags are assigned to water levels considered representative of a regional groundwater system unaffected by human activities, such as pumping, artificial recharge, aquifer testing, or underground nuclear testing. Transient (regional scale) primary flags are assigned to water levels considered representative of a regional groundwater system affected by groundwater pumping. As many as six secondary flags for each water level provide additional information about the measurement, the well, or the hydrologic conditions at the time of data collection.

Water levels assigned insufficient data, localized, none, non-static level, steady state (local scale), suspect, and transient (local scale) primary flags are not suitable for calculating head observations in the DVRFS model. All primary flags describe hydrologic conditions except insufficient data. Insufficient data primary flags are assigned to water levels that do not have enough supporting documentation to confidently assign another flag; typically, a water level flagged with insufficient data was kept because it was one of a few measurements available for the time or location. Secondary flags support the primary flag and provide additional information about the well, water-level measurement, or the hydrologic conditions and trends at the time of the measurement (table 3). The application of some of the primary and secondary flags used in the database are shown on an annotated hydrograph for well 162 S19 E53 15DB 1 in Pahrump, Nevada (fig. 2).

Table 2. Definitions and summary of primary water-level flags used in the water-level database for the Death Valley regional groundwater flow system, Nevada and California, 1907–2007.

[NWIS, National Water Inventory System]

Flag	Definition	Number of water levels with this flag	Number of wells with this flag	Is flag appropriate for model?
Insufficient data	Water level is one of a limited number or supporting information, such as well data, is limited.	341	199	No
Localized	Water level represents localized hydrologic conditions.	5,012	150	No
None	Water level was not measured typically because well was dry, obstructed, or destroyed.	1,096	284	No
Non-static level	Water level is affected by sampling, testing, construction, or some other local activity.	9,216	610	No
Steady state (local scale)	Water level represents prepumped, equilibrium conditions in a local groundwater flow system.	598	52	No
Steady state (regional scale)	Water level represents prepumped, equilibrium conditions in regional groundwater flow system.	17,385	859	Yes
Suspect	Water-level measurement may be erroneous or affected by unnatural conditions.	1,206	256	No
Transient (local scale)	Water level represents transient conditions in the well or a local groundwater flow system.	1,268	53	No
Transient (regional scale)	Water level represents transient conditions caused by pumping from a regional groundwater flow system.	17,887	405	Yes

Table 3. Definitions and summary of secondary water-level flags used in the water-level database for the Death Valley regional groundwater flow system, Nevada and California, 1907–2007.

[ET, evapotranspiration; SSR, steady state (regional scale); TRR, transient (regional scale); DVRFS, Death Valley regional groundwater flow system]

Flag	Definition	Number of water levels with this flag	Number of wells with this flag
Abrupt change	Water level represents a rapid shift or change from previous measurements.	392	185
Anomalous – high	Water level is unusually high relative to other water levels at the well or nearby wells.	945	166
Anomalous – low	Water level is unusually low relative to other water levels at the well or nearby wells.	464	160
Borehole deviation	Water level is corrected for borehole deviation.	710	21
Consistent	Water level is part of a reasonably consistent trend representative of general water-level conditions in the area.	16,840	796
Declining trend	Water level is part of a discernible downward trend. Possible causes include nearby pumping, decreased recharge, equilibration following drilling, or depressurization after a nuclear test.	20,131	745
Destroyed	Water level was not measured because well was destroyed.	26	22
Dry	Water level was not measured because well was dry.	333	98
Earthquake response	Water level is significantly different than previous measurement and the change is associated with an earthquake.	97	10
Elevated	Water level is elevated appreciably above the regional groundwater system, probably because of natural conditions.	1,579	74
Equilibration	Water level is part of a discernible trend that is approaching an equilibrium level, either higher or lower than the initial measurement. Equilibration commonly occurs following well construction, pumping, or nearby nuclear testing.	10,811	582
Erratic	Water level is erratic relative to previous and/or subsequent water levels.	1,081	88
ET response	Water level may be affected by evapotranspiration.	4,572	89
Floating oil	Water level represents the top of a layer of oil floating on the water surface; water level is not corrected for density effects.	88	2
Flowing	Water level is above land surface. In some cases, an accurate water level could not be measured due to flowing conditions.	519	35
Injection/Recovery	Water level may be affected by recent injection of water, mud, or other fluid into the well or a nearby well.	5,473	267
Limited data	Water level is one of a limited number, therefore the primary flag assigned to the water level is tentative.	467	292
Local Infiltration	Water level is responding to locally derived infiltration of water.	241	6
Maximum estimate	Water level, or depth to bottom of well (when well is dry), represents a maximum estimate of the equilibrated water-level altitude in the monitored hydrologic unit.	42	41
Minimum estimate	Water level represents a minimum estimate of the equilibrated water-level altitude in the monitored hydrologic unit.	50	37
Not SSR for DVRFS	Water level initially had a primary flag of steady state (regional scale) for the original DVRFS model but the flag was removed before calibration.	107	6
Not TRR for DVRFS	Water level initially had a primary flag of transient (regional scale) for the original DVRFS model but the flag was removed before calibration.	23	1
Nuclear test effect	Water level may be affected by nearby nuclear tests, not necessarily concurrent with water-level measurement.	1,542	45
Obstruction	Water level was not measured because of an obstruction in the well above the water surface.	150	77
Packer Test	Water level was measured during a packer test.	6,621	288

Table 3. Definitions and summary of secondary water-level flags used in the water-level database for the Death Valley regional groundwater flow system, Nevada and California, 1907–2007.—Continued

[ET, evapotranspiration; SSR, steady state (regional scale); TRR, transient (regional scale); DVRFS, Death Valley regional groundwater flow system]

Flag	Definition	Number of water levels with this flag	Number of wells with this flag
Precipitation	Water level may be affected by a recent precipitation event.	245	24
Pumping area	Water level may be affected by groundwater withdrawals at a nearby well or wells.	10,534	489
Pumping/Recovery	Water level may be affected by current or past pumping at the well or at a nearby well or wells. If the water level was not measured, the well was actively pumping.	18,277	383
Questionable accuracy	Water level may have been measured with poor technique or measurement documentation is erroneous.	1,787	78
Rising trend	Water level is part of a discernible rising trend. Possible causes include a decrease in nearby pumping, equilibration following drilling, or above-normal precipitation.	12,553	353
Seasonal pumping	Water level is part of a seasonally fluctuating trend that is attributed to nearby seasonal pumping.	4,357	17
Suspected perched water	Water level may represent perched-water conditions.	1,443	62
Temperature effect	Water level may be affected by anomalously high or low water temperature; reported water level is not adjusted for temperature effects.	174	4
Testing area	Water level may be affected by one or more underground nuclear tests in the area.	4,563	236
Uncertain	Water level is difficult to interpret and therefore the primary water-level flag is tentative.	2,872	134
Undeveloped	Water level may not represent hydrologic conditions because the well was poorly developed or not developed.	551	181
Well construction	Water level may be equilibrating from well construction, well development, or both.	1,359	145

The periods of water-level record for wells in the updated database range from a single measurement (one day) to about 65 years of measurements; water-level measurements for 328 wells span 20 years or more. There are 870 wells with a combined total of 17,835 water levels with steady state (regional scale) primary flags, 411 wells with a combined total of 18,033 water levels with transient (regional scale) primary flags, and 117 wells that have at least one steady state (regional scale) and one transient (regional scale) water level (fig. 3). The annual distribution of steady state (regional scale) and transient (regional scale) primary flags, which represent the water levels appropriate for the model, is shown in figure 4. The altitudes of steady-state (regional scale) water levels range from about 280 ft below sea level in Death Valley National Park to about 8,200 ft above sea level in the Spring Mountains. By well, the largest difference between the highest and lowest transient (regional scale) water levels is about 167 ft, 268 wells have a difference less than 10 ft, 109 wells have a difference between 10 and 50 ft, and 33 wells have a difference greater than 50 ft.

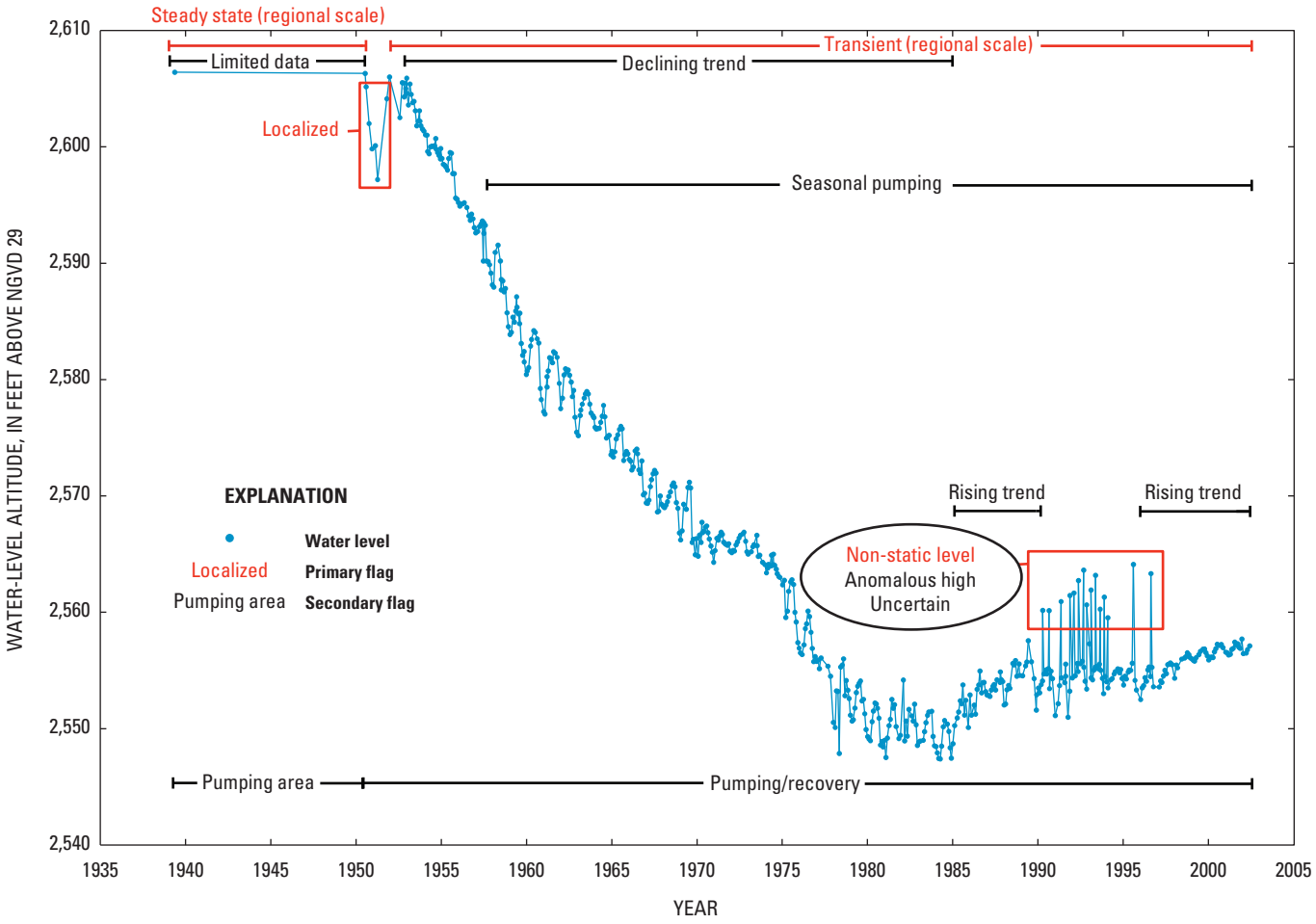

Figure 2. Hydrograph with annotation showing primary and secondary flags assigned to water levels from well 162 S19 E53 15DB 1, in Pahrump, Nevada.

The updated water-level database is provided as appendix A of this report. The appendix, a Microsoft© Excel 2007 workbook, also includes supplemental tables that describe the NWIS water-level status codes and primary and secondary flags. In the workbook, the "Water-Level Database" worksheet is interactive, allowing the user to select a well of interest from a drop-down menu. When a well is selected, the well and water-level data and primary and secondary flags are displayed at the bottom of the worksheet, the location of the well is displayed on a map in the upper left, and the hydrograph for the well is displayed in the upper right. Figure 5 is a screenshot from the "Water-Level Database" worksheet that shows well 162 S19 E53 28BAA 1, which was selected from the Station Name column using the AutoFilter feature in Microsoft© Excel 2007. The "Data" worksheet only contains the well and water-level data and primary and secondary flags and can be used to import the data into other software packages.

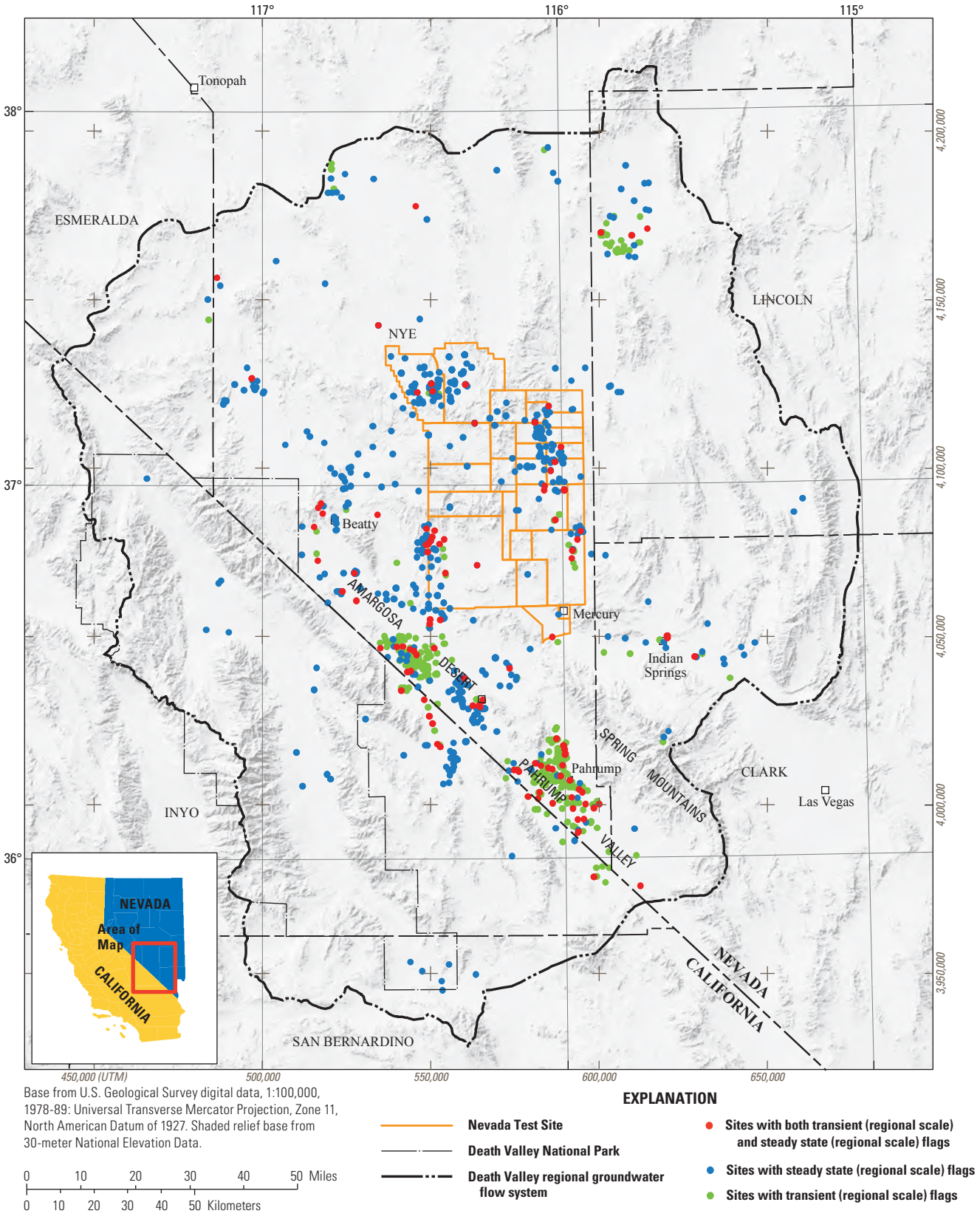

Figure 3. Areal distribution of wells included in the updated water-level database for the Death Valley regional groundwater flow system with steady state (regional scale), transient (regional scale), or both primary flags, Nevada and California.

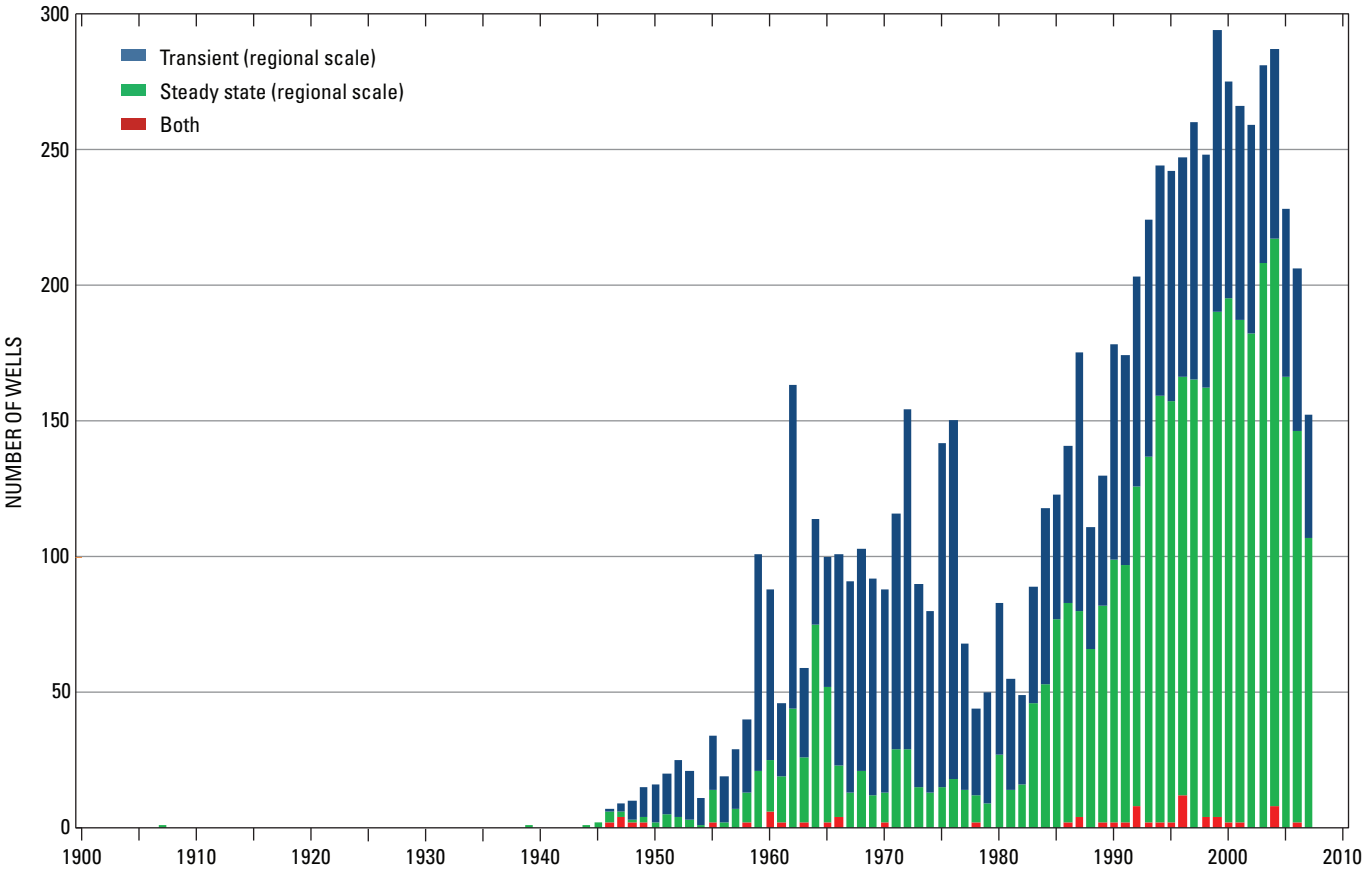

Figure 4. Annual distribution of steady state (regional scale) and transient (regional scale) primary flags from the Death Valley regional groundwater flow system, Nevada and California.

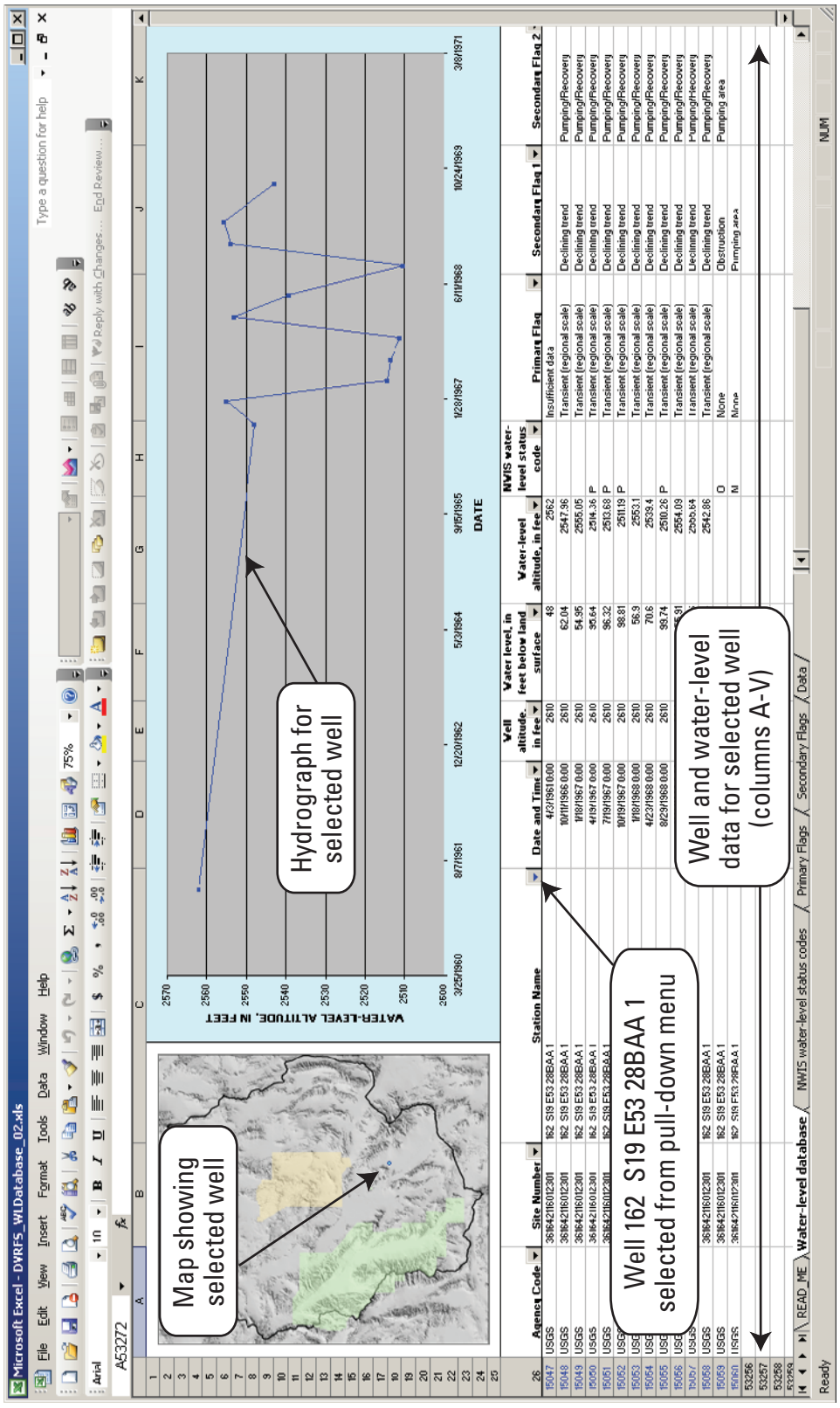

Figure 5. Annotated screen shot showing features of the "Water-Level Database" worksheet in appendix A.

Summary

An update to the DVRFS regional, transient groundwater flow model, to reflect newly acquired geologic and hydrologic data, requires an update to all supporting databases, including the water-level database. The purpose of the DVRFS water-level database is to identify water-level measurements that are appropriate and beneficial for calculating head observations for the model. The DVRFS water-level database was updated with NWIS well and water-level data from 2003 to 2007 and now includes 54,026 water levels measured from 1907 to 2007 in 1,813 wells. For the DVRFS model area, the updated database includes 427 more wells and 18,459 more water levels than the original database. Sixteen wells were drilled after 2003 and the other wells new to the database were not in NWIS when the original database was developed.

Each water level was assigned a primary flag that describes the general hydrologic conditions at the time of the measurement and as many as six secondary flags that provide additional information that support the primary flag, qualify the hydrologic conditions and trends at the time of the measurement, and identify important information about the well or water-level measurement.

A primary flag of steady state (regional scale) or transient (regional scale) indicates that water levels are appropriate for consideration as a head observation in a regional groundwater flow model. Approximately one-third of the water levels from almost one-half of the wells are steady state (regional scale) and approximately one third of the water levels from about 20 percent of the wells are transient (regional scale). Almost 30 percent of the primary water-level flags indicate a non-static level resulting from local activity, localized hydrologic conditions, or a local steady-state or transient groundwater flow system. Approximately 5 percent of the primary flags indicate that there was insufficient or suspect data, or no water level was measured.

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Appendix A. Water-Level Database for the Death Valley Regional Groundwater Flow System, Nevada and California, 1907–2007

The database distributed with this report is in a Microsoft© Excel 2007 workbook that contains six worksheets. The "READ_ME" worksheet describes the contents of the other sheets in the workbook. The "Water-Level Database" worksheet contains all well and water-level data, water-level flags, a map, and a hydrograph. The worksheet is interactive and formatted to show well and water-level data for individual wells, the location of the well, and its hydrograph. Using Excel's AutoFilter feature, individual wells can be selected from a dropdown menu in the Station Name field (spreadsheet cell C26). When a well is selected, the map in the upper left of the worksheet shows the location of the well and the hydrograph in the upper right of the worksheet shows all water levels for that well. Note that the solid lines that connect the water-level measurements are shown only to identify trends and do not imply interpolated water levels between measurements. The "NWIS Water-Level Status Codes," "Primary Flags," and "Secondary Flags" worksheets correspond to tables 1, 2, and 3, respectively, and define the various cdes and flags used in the database. The "Data" worksheet only contains the well and water-level data and primary and secondary flags and can be used to export the data into other applications or files.

The electronic database available in this report can be accessed and downloaded at URL http://pubs.usgs.gov/ds/519/.

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