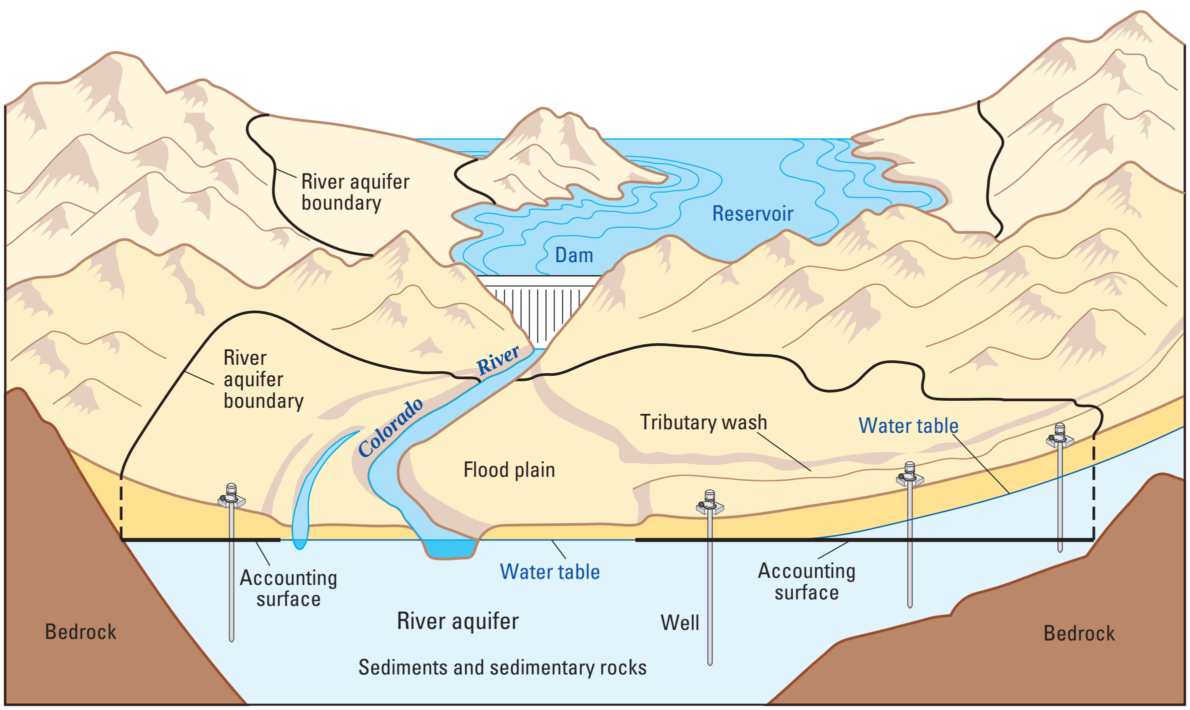
Prepared in cooperation with the Bureau of Reclamation

Application of Geographic Information System Methods to Identify Areas Yielding Water that will be Replaced by Water from the Colorado River in the Vidal and Chemehuevi Areas, California, and the Mohave Mesa Area, Arizona



Modified from Wilson and Owen-Joyce (1994)

Scientific Investigations Report 2007–5284

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

Cover: Schematic diagram showing river aquifer and accounting surface along the lower Colorado River, California and Arizona.

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Conversion Factors and Datums

Multiply	By	To obtain
gallon per minute (gal/min)	0.0631	liter per second
inch per year (in/yr)	25.4	millimeter per year
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32.$$

Datums

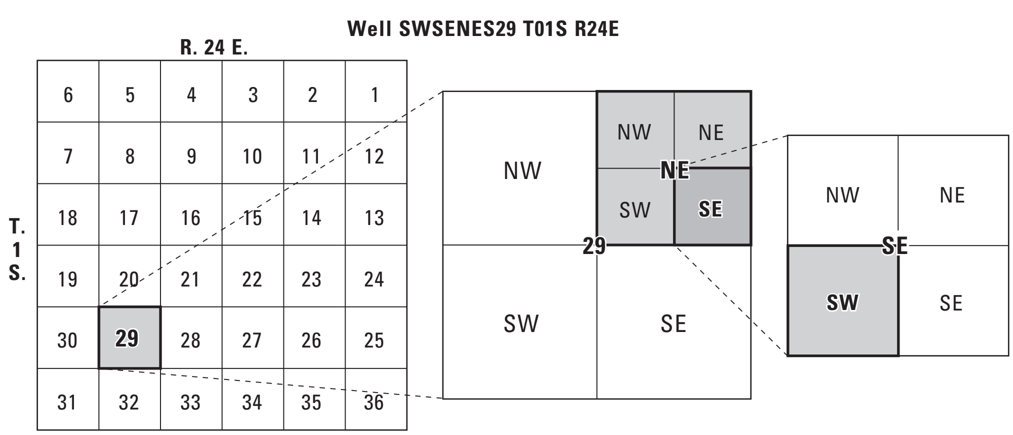
Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

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

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

Land-Net Numbering System for Wells in the Vidal, Chemehuevi, and Mohave Mesa Study Areas

The land-net numbering system for wells in the Vidal, Chemehuevi, and Mohave Mesa study areas is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the site, describes its position in the land net. The land-survey system divides a section of land within a township into four quadrants or quarter sections that are designated in counterclockwise order by the uppercase letters NE, NW, SW, and SE, which indicate, respectively, the northeast, northwest, southwest, and southeast quadrants. Each quadrant is further subdivided into quarter-quarter and quarter-quarter-quarter sections, equivalent to a 10-acre tract, using the same designation. Numbers that designate the section, township, and range, in that order, follow the third-level quadrant designation. Thus, a well in the Vidal area with a land-net designation of SWSENES29 T01S R24E identifies its location in the SW ¼ of the SE ¼ of the NE ¼ of Section 29, Township 1 South, Range 24 East.



Land-net location system for Vidal, Chemehuevi, and Mohave Mesa study areas.

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By Lawrence E. Spangler, Cory E. Angeroth, and Sarah J. Walton

Abstract

Relations between the elevation of the static water level in wells and the elevation of the accounting surface within the Colorado River aquifer in the vicinity of Vidal, California, the Chemehuevi Indian Reservation, California, and on Mohave Mesa, Arizona, were used to determine which wells outside the flood plain of the Colorado River are presumed to yield water that will be replaced by water from the Colorado River. Wells that have a static water-level elevation equal to or below the elevation of the accounting surface are presumed to yield water that will be replaced by water from the Colorado River. Geographic Information System (GIS) interpolation tools were used to produce maps of areas where water levels are above, below, and near (within ± 0.84 foot) the accounting surface.

Calculated water-level elevations and interpolated accounting-surface elevations were determined for 33 wells in the vicinity of Vidal, 16 wells in the Chemehuevi area, and 35 wells on Mohave Mesa. Water-level measurements generally were taken in the last 10 years with steel and electrical tapes accurate to within hundredths of a foot. A Differential Global Positioning System (DGPS) was used to determine land-surface elevations to within an operational accuracy of ± 0.43 foot, resulting in calculated water-level elevations having a 95-percent confidence interval of ± 0.84 foot.

In the Vidal area, differences in elevation between the accounting surface and measured water levels range from -2.7 feet below to as much as 17.6 feet above the accounting surface. Relative differences between the elevation of the water level and the elevation of the accounting surface decrease from west to east and from north to south. In the Chemehuevi area, differences in elevation range from -3.7 feet below to as much as 8.7 feet above the accounting surface, which is established at 449.6 feet in the vicinity of Lake Havasu. In all of the Mohave Mesa area, the water-level elevation is near or below the elevation of the accounting surface. Differences in elevation between water levels and the accounting surface range from -0.2 to -11.3 feet, with most values exceeding -7.0 feet.

In general, the ArcGIS Triangulated Irregular Network (TIN) Contour and Natural Neighbor tools reasonably represent areas where the elevation of water levels in wells is above, below, and near (within ± 0.84 foot) the elevation of the accounting surface in the Vidal and Chemehuevi study areas and accurately delineate areas around outlying wells and where anomalies exist. The TIN Contour tool provides a strict linear interpolation while the Natural Neighbor tool provides a smoothed interpolation. Using the default options in ArcGIS, the Inverse Distance Weighted (IDW) and Spline tools also reasonably represent areas above, below, and near the accounting surface in the Vidal and Chemehuevi areas. However, spatial extent of and boundaries between areas above, below, and near the accounting surface vary among the GIS methods, which results largely from the fundamentally different mathematical approaches used by these tools. The limited number and spatial distribution of wells in comparison to the size of the areas, and the locations and relative differences in elevation between water levels and the accounting surface of wells with anomalous water levels also influence the contouring by each of these methods. Qualitatively, the Natural Neighbor tool appears to provide the best representation of the difference between water-level and accounting-surface elevations in the study areas, on the basis of available well data.

Introduction

A cooperative effort by the Bureau of Reclamation (Reclamation) and the U.S. Geological Survey (USGS) has been under way since the early 1990s to inventory all wells located within the river aquifer along the lower Colorado River from the area surrounding Lake Mead to the Mexican border. Information obtained from the well inventory will be used by Reclamation to determine if wells located within the river aquifer outside of the flood plain are pumping water that will be replaced by water from the Colorado River. Initial attempts to identify these wells by using well inventory and water-level data have encountered several problems, including substantial water-level differences in adjacent wells, long time spans between water-level measurements, and the precision with which water levels and elevations are measured. In addition, the data often include a range of natural and anthropogenic-induced variations that must be considered when determining static water levels under current hydrologic conditions.

Accounting for use of water from the Colorado River is decreed by the Consolidated Decree of the United States Supreme Court in *Arizona v. California* (United States Supreme Court, 2006). Water pumped from wells located within the flood plain of the river is presumed to be river water and is accounted for as Colorado River water. Water pumped from wells outside the flood plain of the river but still within the bounds of the river aquifer, however, may or may not be accounted for as Colorado River water. A method for identifying which wells outside the flood plain of the river will yield water that will be replaced by water from the Colorado River by determining the relation between the elevation of the static water level in wells and the elevation of the accounting surface is documented in Wilson and Owen-Joyce (1994) and Owen-Joyce and others (2000). Wells that have a static water-level elevation equal to or below the elevation of the accounting surface at the location of the well are presumed to yield water that will be replaced by water from the Colorado River. Wells that have a static water-level elevation above the elevation of the accounting surface are presumed to yield water that will be replaced by water from precipitation and inflow from tributary valleys.

Purpose and Scope

This report describes the application of selected Geographic Information System (GIS) methods to determine differences between water-level and accounting-surface elevations and to identify areas that yield water that will be replaced by water from the Colorado River. The report (1) evaluates the well-inventory data set in three test basins along the lower Colorado River, (2) compares water-level elevations in selected wells with the elevation of the accounting surface in these areas, and (3) examines selected interpolation tools that can be used to identify areas that yield water that will be replaced by water from the Colorado River. Data from wells in the Vidal, California; Chemehuevi Indian Reservation, California; and Mohave Mesa, Arizona areas are stored in the USGS National Water Information System (NWIS) database.

Description of Study Areas

Three areas along the lower Colorado River downstream from Davis Dam were selected to determine the relation between static water levels in wells and the accounting surface: the area in the vicinity of Vidal, California; the area that includes the Chemehuevi Indian Reservation (herein termed Chemehuevi), California; and the area in the vicinity of Bullhead City, Arizona, and to the south on Mohave Mesa (fig. 1). These areas were selected on the basis of having a sufficient number of wells for analysis, had static water levels that had been measured within the last 10 years, and had land-surface elevations that had been determined by a Differential Global Positioning System (DGPS).

Vidal, California

The Vidal study area is located along the western side of the Colorado River, in San Bernardino and Riverside Counties, California, and east of the small community of Vidal (fig. 1). The area lies roughly between lat 34°02' and 34°13' and long 114°21' and 114°31' and includes about 45 mi^2 of the Colorado River aquifer. The area is situated on an alluviated terrace that slopes toward the river at an elevation ranging from about 325 ft along the river to 530 ft in the western part of the area, about 3 mi from the river. Land use primarily consists of residential areas interspersed with undeveloped areas. The area is sparsely populated and most water use is for domestic purposes. Reported well yields in the Vidal area range from 10 to 1,800 gal/min, and depth to water below land surface ranges from about 14 ft along the Colorado River to 184 ft in the western part of the area (U.S. Geological Survey, unpub. data, 2006). No perennial surface streams cross the study area. Precipitation in the vicinity of Vidal averages 5.3 in/yr and mean temperature is 22.8°C, calculated on the basis of monthly normals for 1971–2000 at Parker, Arizona (Western Regional Climate Center, 2007).

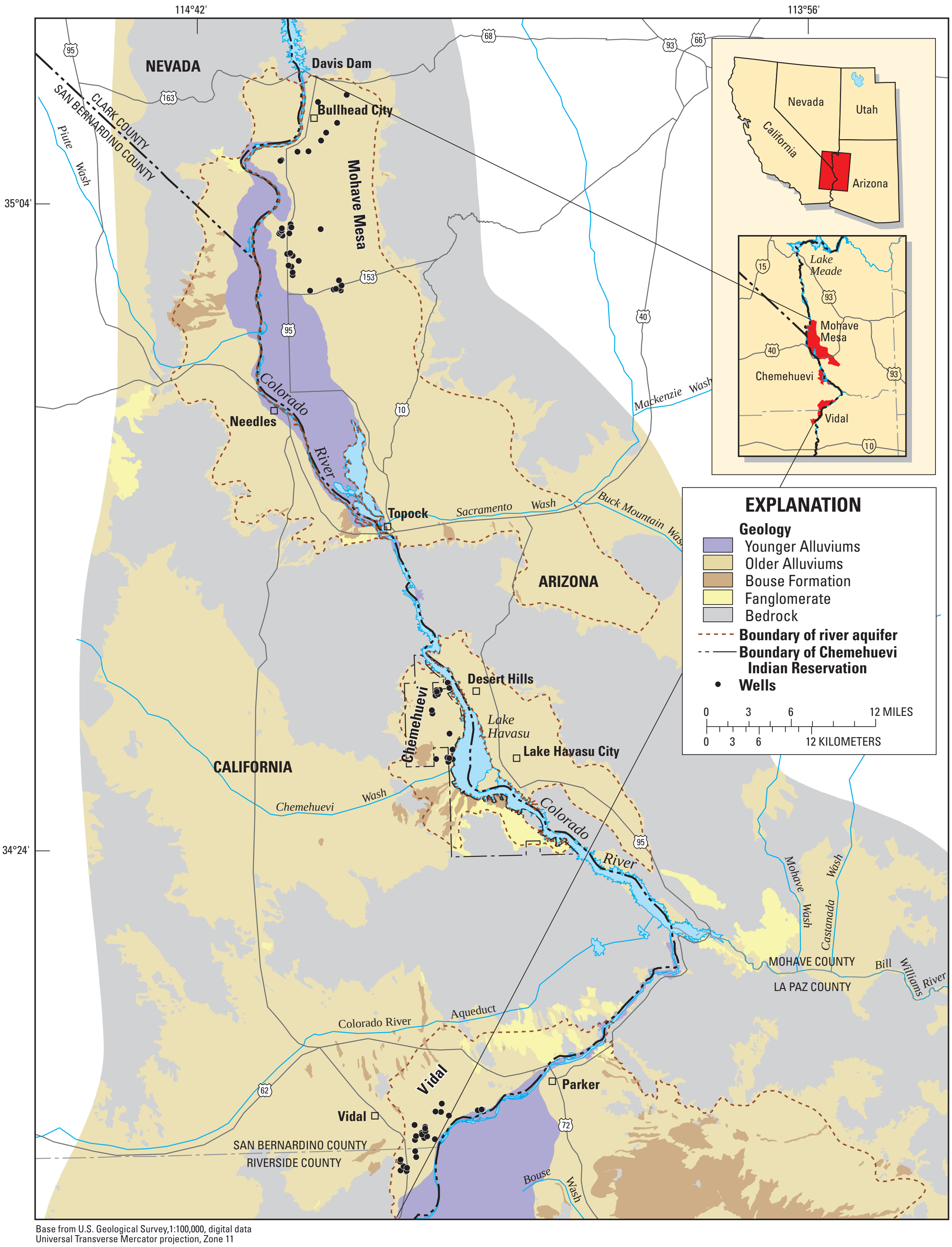


Figure 1. Location and geology of the Vidal, Chemehuevi, and Mohave Mesa study areas along the lower Colorado River, California and Arizona (modified from Wilson and Owen-Joyce, 1994).

Chemehuevi, California

The Chemehuevi study area is located along the western side of the Colorado River (Lake Havasu), in San Bernardino County, California, and across the river from Lake Havasu City, Arizona (fig. 1). The area lies roughly between lat 34°25' and 34°37' and long 114°17' and 114°29' and includes about 50 mi^2 of the river aquifer. Elevation ranges from about 450 ft along the river to about 625 ft in the northern part of the area. Land that is developed in the area primarily is for residential use. The area is sparsely populated and most water use is for domestic purposes. Reported well yields in the Chemehuevi area range from 15 to 550 gal/min, and depth to water below land surface ranges from about 3 ft along the Colorado River to 180 ft in higher-elevation areas west of the river (U.S. Geological Survey, unpub. data, 2006). No perennial surface streams cross the study area, but Chemehuevi Wash forms the southern boundary of the area. Precipitation in the vicinity of Chemehuevi averages 2.9 in/yr and mean temperature is 24.7°C, calculated on the basis of monthly normals for 1971-2000 at Lake Havasu City, Arizona (Western Regional Climate Center, 2007).

Mohave Mesa, Arizona

The Mohave Mesa study area is located along the eastern side of the Colorado River, in Mohave County, Arizona, south of Bullhead City (fig. 1). The area lies roughly between lat 34°55' and 35°13' and long 114°25' and 114°44' and includes about 111 mi^2. Elevation ranges from about 1,225 ft northeast of Bullhead City to 530 ft in the southern part of the area, near the river. Land use primarily consists of residential areas among undeveloped areas. The area is sparsely populated and most water use is for domestic purposes. Reported well yields in the Mohave Mesa area range from 12.5 to 650 gal/min, and depth to water below land surface ranges from about 71 ft near the Colorado River to 731 ft in the northeastern part of the area, near Bullhead City (U.S. Geological Survey, unpub. data, 2006). No perennial surface streams cross the study area. Precipitation in the vicinity of Mohave Mesa averages 6.6 in/yr and mean temperature is 23.4°C, calculated on the basis of monthly normals for 1971-2000 at Bullhead City, Arizona (Western Regional Climate Center, 2007).

The Colorado River Aquifer and Accounting Surface

The Colorado River aquifer consists of permeable, partly saturated sediments and sedimentary rocks that are hydrologically connected to the Colorado River (fig. 2). These sediments consist of unconsolidated to semi-consolidated sands, silts, gravels, and clays that interfinger with similar materials that make up the adjacent alluvial slopes. These materials have highly variable transmissivity values and serve as the principal aquifer in this region. In the Vidal, Chemehuevi, and Mohave Mesa study areas, the river aquifer generally includes younger and older alluviums of Miocene to Holocene age; Pliocene-age sediments of the Bouse Formation; and a Miocene- to Pliocene-age fanglomerate unit (Metzger and others, 1973; Wilson and Owen-Joyce, 1994) (fig. 1). The river aquifer is bounded by relatively impermeable bedrock along the bottom and margins of the basins that underlie the valley of the Colorado River (fig. 2). Total thickness of the river aquifer is as much as 5,000 ft in some areas.

Water levels in the Colorado River aquifer respond to changes in elevation of the Colorado River, withdrawals from the aquifer, and runoff from precipitation that infiltrates downward to the aquifer from the river channel, tributary washes, canals, and reservoirs. Nearly all of the water in the river aquifer is derived from the Colorado River. The accounting surface represents the elevation and slope of the unconfined static water table in the river aquifer outside the flood plain of the Colorado River that would exist assuming the only source of water to the aquifer is the Colorado River. This surface was generated by using profiles of the Colorado River or the water-surface elevation of agricultural drains near the outer edge of the flood plain where available, or in the case of reservoirs, the annual high water-surface elevation used by Reclamation to operate reservoirs under normal flow conditions. Water-surface profiles were computed for the highest median monthly projected discharge in the river for 1992-2001 and were determined by using hydraulic routing and step-backwater methods (Bureau of Reclamation, 1989a, 1989b, and 1990). The accounting surface extends outward from the edge of the flood plain to the subsurface boundary of the river aquifer along the margins of the basins (fig. 2). Accounting-surface contours generally are perpendicular to the Colorado River and increase in elevation from south to north. Contour intervals are variable along the lower Colorado River; accounting-surface contours are established at 4-ft intervals in the Vidal area and 2-ft intervals in the Mohave Mesa area. Because the Colorado River has been impounded to form Lake Havasu in the Chemehuevi area, the accounting surface is presumed to be essentially level and thus is represented by a single elevation value.

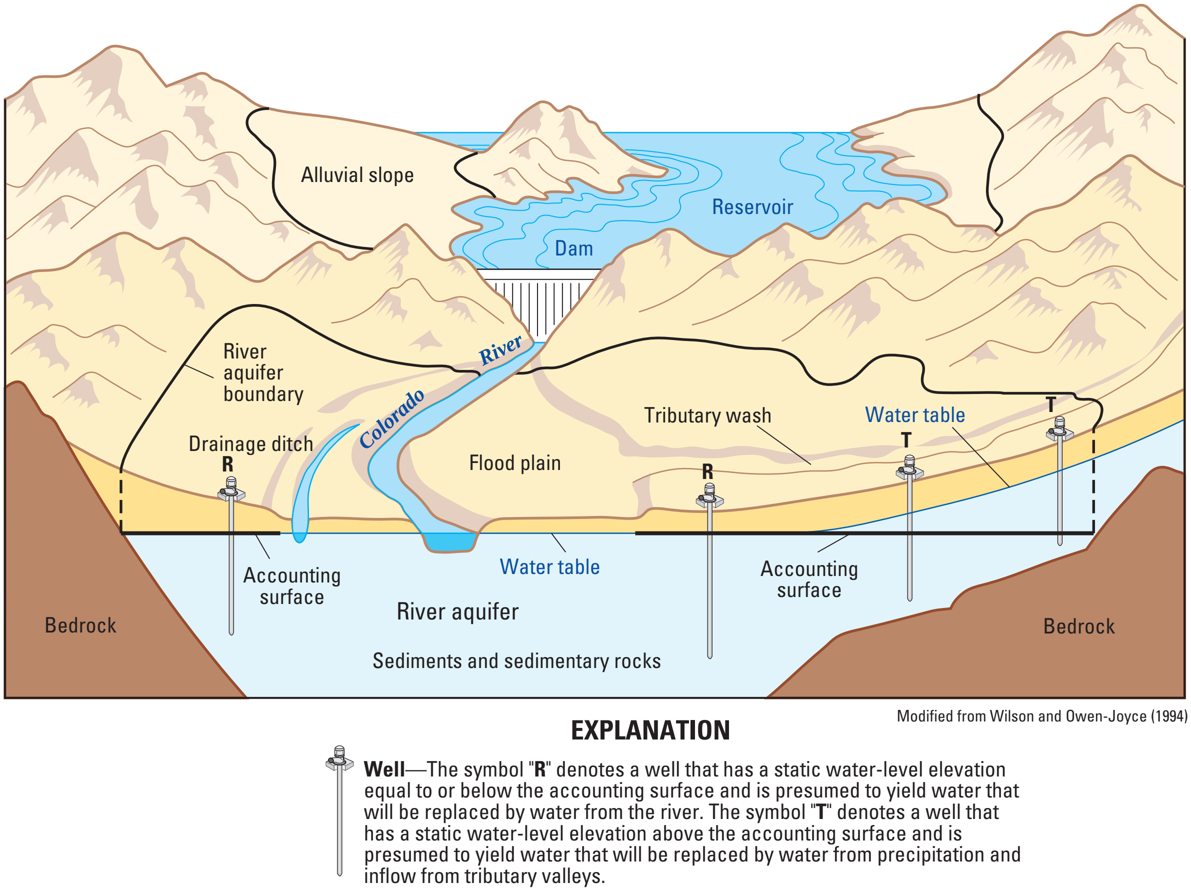


Figure 2. River aquifer and accounting surface along the lower Colorado River, California and Arizona.

Methods

Measured depths to water in feet below land surface were subtracted from land-surface elevations to determine water-level elevations for selected wells in the Vidal, Chemehuevi, and Mohave Mesa study areas. These water-level elevations were then compared with the elevation of the accounting surface at each of the wells. On the basis of relations between the water-level and accounting-surface elevations, ArcGIS Triangulated Irregular Network (TIN) Contour, Natural Neighbor, Inverse Distance Weighted (IDW), and Spline interpolation tools were used to delineate areas where water-level elevations are presumed to be above, below, and near (within ± 0.84 ft) the elevation of the accounting surface in the study areas.

Water Levels and Land-Surface Elevations

Data for inventoried wells in the study areas were obtained from the USGS (Arizona Water Science Center) NWIS database. Information that was obtained included elevation of the land surface at the well, depth to water below land surface, pumping status of the well at the time of measurement, date of measurement, and elevation and water-level measurement methods and accuracies. These data were used to determine water-level elevations that could then be compared with one another to evaluate anomalies. Historical examinations of water levels for selected wells also were done to evaluate variability in water levels over time in comparison to water levels measured during the study period and used for analysis.

Land-surface elevations for wells stored in the NWIS database were determined by several different methods. For this project, only those wells for which the land-surface elevation was determined by DGPS were used. The DGPS unit used to determine the land-surface elevation at each of the wells has a manufacturers' reported accuracy of ± 0.10 ft. This accuracy results in a 95-percent confidence interval of about ± 0.20 ft. In practice, the accuracy of the DGPS unit was determined to be ± 0.43 ft (Sandra Owen-Joyce, U.S. Geological Survey, written commun., 2006), resulting in a 95-percent confidence interval of ± 0.84 ft with respect to land-surface elevation. Thus, with 95-percent confidence, wells with a difference between the water-level elevation and accounting-surface elevation of greater than ± 0.84 ft have water levels that are either above or below the accounting surface, and wells with a difference of less than ± 0.84 ft have water levels that may be either above or below (cannot be distinguished from) the accounting surface.

Geographic Information System Methods

Interpolation tools available within the ArcGIS 3D and Spatial Analyst tool box include TIN Contour, Natural Neighbor, IDW, and Spline (Environmental Systems Research Institute, 2007a and b). These tools commonly are used to determine values of points at locations where no data are available by mathematically interpolating between points with known values. All of the tools are designed to work best where data sets are sufficiently large (dense) and where data are evenly distributed. Limited and irregularly distributed data sets may substantially affect the usefulness of the tools to be able to generate accurate interpolations.

TIN Contour is a linear interpolation tool that represents a surface as a network of triangles (Environmental Systems Research Institute, 2007a). A TIN can be constructed by triangulating a set of vertices with x, y, and z values. The vertices are connected with a series of edges to form a network of triangles, where each triangle is treated as a plane. The edges of a TIN form contiguous, nonoverlapping triangular facets. The resulting triangulation ensures that no vertex lies within the interior of any of the triangles in the network. Contours are generated directly from the TIN within its zone of interpolation. Portions of individual contours generated by the tool within a triangle are straight. Any change in direction occurs only when a contour passes from one triangle into another. As a result, the resulting contours are not smooth. This type of contouring produces an exact linear interpretation of the surface, which may not be realistic.

Natural Neighbor is an exact triangulation interpolation tool for multivariate datasets. The value for an interpolation point is estimated by using weighted values of the closest surrounding points in a triangulation rather than distances between points (Sibson, 1981). These points, termed the natural neighbors, are connected to the interpolation point when inserted into the triangulation. The Natural Neighbor tool can efficiently handle large numbers of input points and works equally well with regularly and irregularly distributed data sets (Watson, 1992). The Natural Neighbor tool has been shown to consistently outperform other techniques both quantitatively and qualitatively when applied to generating surfaces (Owen, 1993; Abramov and McEwen, no date, accessed November 2007). No weighting or power options are available for the Natural Neighbor tool within ArcGIS.

The Natural Neighbor tool also was used to calculate the elevation of the accounting surface at each well location by using the principal contours established by Reclamation. Assuming a linear relation between the established accounting-surface contours, 10-meter grid cells were used to generate values of the elevation of the accounting surface between the principal contours and at each well location. The elevation of the accounting surface could then be compared with the water-level elevation at that location.

Inverse Distance Weighted is a method of interpolation that estimates cell values by averaging (weighting) the values of sample data points in the neighborhood of each cell. The weight is a function of inverse distance and is not affected by the spatial arrangement of the data. The closer a point is to the center of the cell being estimated, the more influence, or weight, it has in the averaging process; likewise, the farther a sampled point is from the cell being evaluated, the less weight it has in the calculation of the cell's value. IDW makes the assumption that values closer to the unsampled location are more representative of the value to be estimated than samples farther away (Collins, 1996). Distance-based weighting methods have been used to interpolate climatic data (Legates and Willmont, 1990).

The IDW tool tends to generate bull's eye patterns. In addition, all interpolated values lie within the range of the data point values and may not accurately represent valleys and peaks in the surface (de Smith, Goodchild, and Longley, 2007). The choice of power option in the IDW tool also can substantially affect the interpolation results. As the power option is increased, the interpolated value takes on the value of the closest sample point. Thus, nearby points will have the most influence, and the surface will have more detail (be less smooth). Specifying a lower value for the power option provides more influence to surrounding points farther away. For this project, the default option (power of 2) was used to simplify and streamline the method for potential users.

The Spline tool uses a deterministic technique to represent two-dimensional curves on three-dimensional surfaces (Eckstein, 1989; Hutchinson and Gessler, 1994). The tool uses an interpolation method that estimates values by using a mathematical function that minimizes the total curvature of the surface, resulting in a smooth surface that passes exactly through the input points. Because rapid changes in gradient or slope may occur in the vicinity of the data points (edge effects), however, this tool is not suitable for estimating curvature. Splines can be used for generating gently varying surfaces such as the elevation of the water surface and have the advantage of creating curves and contour lines that are visually appealing. Some of the disadvantages of using Spline are that no estimates of error are given and that splines may mask uncertainty present in the data (Collins, 1996). Splines are typically used for creating contour lines from dense regularly spaced data, but may be used for interpolation of irregularly spaced data. The basic (regularized) interpolation tool within ArcGIS can be applied by assigning a weight value of 0 to 0.5 in the Spline function, with higher values of weight resulting in smoother surfaces. For this project, the default option (weight of 0.1) was used to simplify and streamline the method for potential users.

Application of Geographic Information System Methods

Data from the USGS NWIS database were imported into ArcGIS to determine the relation between water-level elevations and the elevation of the accounting surface along the lower Colorado River. The elevation of the accounting surface was compared with the elevation of water levels in selected wells to determine which wells yield water that will be replaced by water from the Colorado River. Wells in areas in which the elevation of the water level is above the elevation of the accounting surface are presumed to pump water that will be replaced by water from precipitation or tributary inflow. Wells in areas in which the elevation of the water level is below the elevation of the accounting surface are presumed to pump water that will be replaced by water from the Colorado River. Wells in areas in which the elevation of the water level is within ± 0.84 ft of the accounting surface cannot be determined with sufficient confidence to be either above or below the accounting surface. These wells may or may not pump water that will be replaced by water from the Colorado River.

Maps for each of the study areas have been produced showing the contoured relations between areas where water-level elevations are above, below, and near the accounting surface using TIN Contour, Natural Neighbor, IDW, and Spline interpolation tools. Contour intervals were established at -2, -0.84, 0.84, 2, 4, and 8 ft to span the range of difference between water-level and accounting-surface elevations. The boundary of the river aquifer along the edge of the Colorado River in the Vidal and Mohave Mesa study areas and Lake Havasu in the Chemehuevi study area was represented by a series of points where the elevation of the river and the elevation of the water table in the river aquifer are assumed to be equal. For contouring purposes, these points were assigned a value of zero so that the interpolation tools could define more accurately the boundaries between areas above, below, and near the accounting surface between well locations and the river.

Vidal Area

Well Selection and Water-Level Measurements

Data for 81 wells completed in the river aquifer in the Vidal area were compiled from the NWIS database, of which 17 wells did not have a measured static water level because of well obstructions, well status such as pumping, or because a measurement was not possible (landowner restriction, well had been destroyed, etc.). Water-level measurements in the remaining 64 wells were further evaluated on the basis of the date of measurement and land-surface elevation accuracy. Most of the water levels in the data set were measured during 1961-64, 1972, 1990, 1995-97, and 2000-01. The number of measurements taken in each well ranged from 1 to 13; most wells had 5 or less measurements that were made throughout at least a 10-year period. Water levels in all wells were measured with calibrated steel or electrical tapes that are accurate to within tenths or hundredths of a foot. Water-level measurements that were reported only to within 1-ft accuracy were not used. Water-level measurements that were determined to be substantially influenced by the effects of pumping of the well or a nearby well were not used. All elevation measurement accuracies in the 1972 data set (which included 12 wells) were 10 ft, as determined from topographic map contour intervals, and none of these wells were included in the analysis. The selection process yielded 33 wells with water levels that were measured during 2000-01.

Calculated water-level elevations and interpolated accounting-surface elevations for the 33 selected wells in the Vidal area are shown in table 1; at back of report. Water levels measured from November 2000 through March 2001 were used to calculate elevations to maintain consistency in method of measurement of water levels and elevations, and minimize variations resulting from natural (climatic) and anthropogenic effects over time. Nonetheless, in some locations, such as at wells 7 and 8, water-level elevations in adjacent wells were substantially different and no apparent explanation for these discrepancies could be determined. In some areas where wells are sparse or recent water-level data are not available, older water-level data were used to help evaluate relations between the elevation surfaces. For example, water-level and accounting-surface elevation differences determined for several wells for which only 1990 measurements are available were observed to be consistent with elevation differences determined for nearby wells measured in 2000-01. Water-level variations of more than 10 ft were noted for several wells in which multiple measurements had been taken over time (table 1). These large “apparent” water-level fluctuations, however, may be the result of measurements being made during or shortly after pumping of the well or pumping effects from nearby wells, rather than from natural variations, and thus, probably do not represent static water-level conditions.

Although not selected for use in analysis because an obstruction had prevented water levels from being measured since 1993, the water-level fluctuation in a well located at NESESES10 T01S R24E may be more representative of natural (seasonal) effects over time. Thirteen measurements made every 1 to 2 months from December 1961 through June 1963 showed a variation of only 1.59 ft between the highest and lowest values (standard deviation of 0.46 ft). Other wells with fewer measurements taken over longer time periods showed fluctuations of less than 1 ft (table 1).

Delineation of Areas

When the 95-percent confidence interval (± 0.84 ft) is taken into account, relative differences between water-level elevations and accounting-surface elevations for the selected wells show distinct areas where the elevation of the water level is above (higher than), below (lower than), and within the 95-percent confidence interval (within ± 0.84 ft) of the accounting surface. On the basis of the availability and distribution of wells within the river aquifer, these generalized areas were delineated between the accounting-surface elevation contours of 320 and 336 ft by using the TIN Contour, Natural Neighbor, IDW, and Spline tools (figs. 3-6).

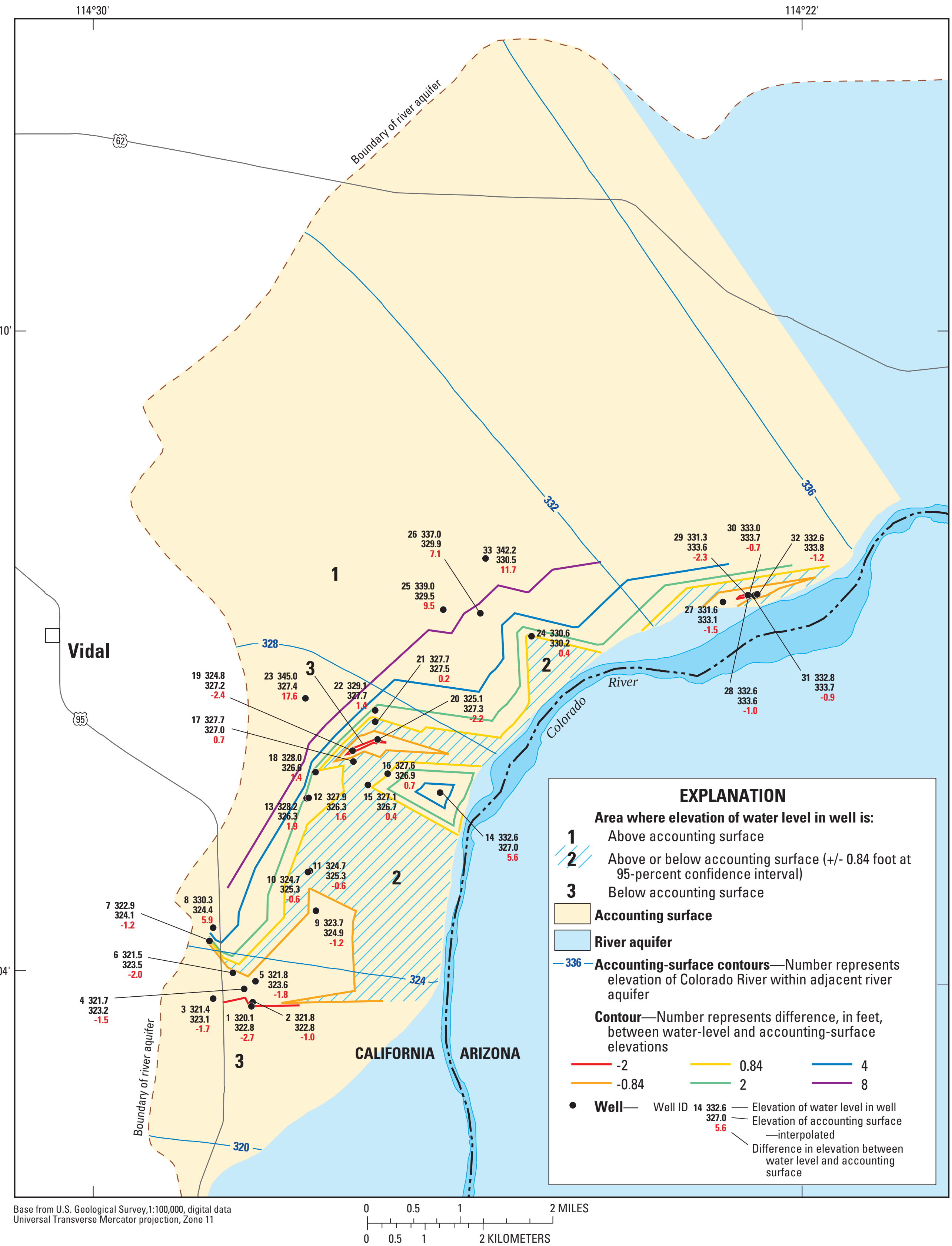
The area where the elevation of the water level is above the elevation of the accounting surface generally lies more than 1 mi from the river and between the 324- and 332-ft elevation contours of the accounting surface. Differences in elevation range from 1.4 to 17.6 ft above the accounting surface, with a substantial increase in difference and thus, gradient toward the northwest. This area likely extends past the 332-ft contour interval to the east, but relations to areas where water-level elevations are lower than accounting-surface elevations between the 332 and 336-ft intervals are uncertain. An area where the water-level elevation also is substantially above the accounting-surface elevation (5.6 ft) appears to be localized around well 14. Although wells along the river generally have water-level elevations near or below the accounting surface, calculated elevation differences for wells with older water-level data in the vicinity of this well (not shown) also indicate that an elevated water-table surface may exist in this area.

The area where the water-level elevation is below the elevation of the accounting surface lies in the southern part of the study area where the accounting-surface elevation is lower than about 325 ft and also along the river in the eastern part of the area between the 332- and 336-ft contours. Differences in elevation range from -0.9 to -2.7 ft below the accounting surface. A small area where the water-level elevation is also below the elevation of the accounting surface is localized around wells 19 and 20. Water-level elevations in this area are more than 2 ft below the elevation of the accounting surface whereas elevations in surrounding wells are slightly above the accounting-surface elevation of about 327 ft. The area where the elevation of the water level may be above or below the elevation of the accounting surface (on the basis of ± 0.84 ft at the 95-percent confidence interval) generally lies within 1.5 mi of the river and between the accounting-surface elevations of 324 and 328 ft, with localized areas to the northeast. The boundary defining this area will change over time as additional information becomes available. Overall, in the Vidal area, relative differences between the elevation of the water level and the elevation of the accounting surface decrease from west to east (toward the river) and from north to south (along the river).

The TIN Contour and Natural Neighbor tools appear to reasonably portray areas where water-level elevations are above, below, and near (within ± 0.84 ft) the accounting surface, except in areas where well data are sparse, and adequately delineate areas where anomalies in the surface exist, such as in the vicinity of wells 19 and 20, and around well 14 (figs. 3 and 4). Boundaries between areas where water-level elevations may be above or below the elevation of the accounting surface (on the basis of ± 0.84 ft at the 95-percent confidence interval) and areas that are above (greater than 0.84 ft) and below (less than -0.84 ft) the accounting surface also appear to be reasonable, although contours delineated by Natural Neighbor are considerably smoother than those delineated by TIN Contour.

The default power option of 2 in the IDW tool was used to delineate areas where water-level elevations are above, below, and near the accounting surface and is shown in figure 5. In general, these areas are reasonably portrayed, although the area near (within ± 0.84 ft) the accounting surface is substantially larger than that delineated by either the TIN Contour or Natural Neighbor tool, and the area below the accounting surface in the vicinity of wells 27 to 32 is noticeably different.

The default weight option of 0.1 in the Spline tool was used to delineate areas above, below, and near the accounting surface as shown in figure 6. In general, the area near (within ± 0.84 ft) the accounting surface is considerably reduced in size from that delineated by the IDW tool and relations between the surfaces between about the 322 and 328-ft accounting-surface contours are substantially different. Anomalous areas around well 14 and wells 19 and 20 appear to be accurately represented. Although boundaries between all three areas are smooth, anomalies (inliers) within the area near (within ± 0.84 ft) the accounting surface are shown where well control is not available, such as that in the vicinity of well 15 (fig. 6).



Base from U.S. Geological Survey,1:100,000, digital data
Universal Transverse Mercator projection, Zone 11

Figure 3. Areas interpolated above, below, and near the accounting surface in the Vidal area of California by using the Triangulated Irregular Network Contour tool.

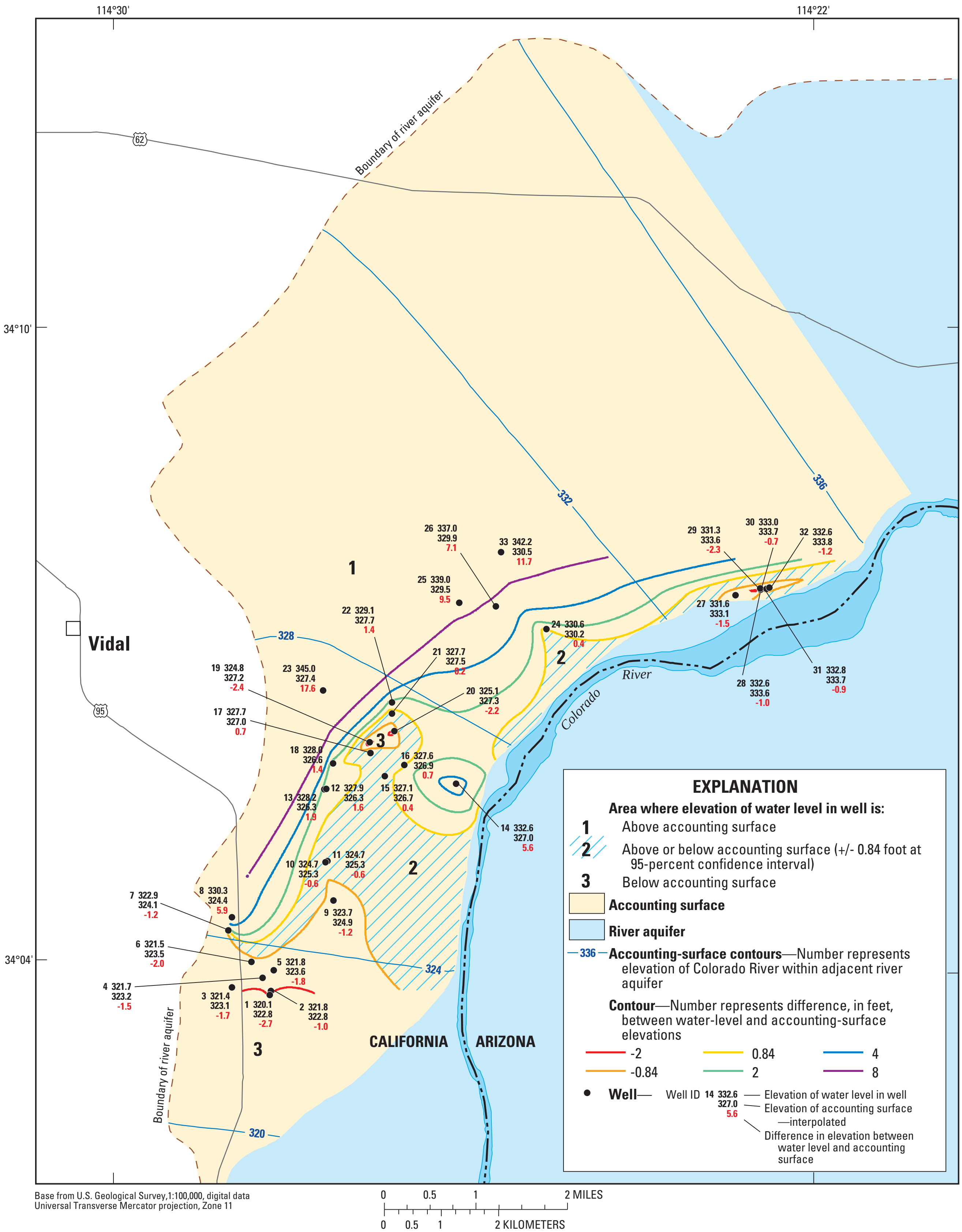


Figure 4. Areas interpolated above, below, and near the accounting surface in the Vidal area of California by using the Natural Neighbor tool.

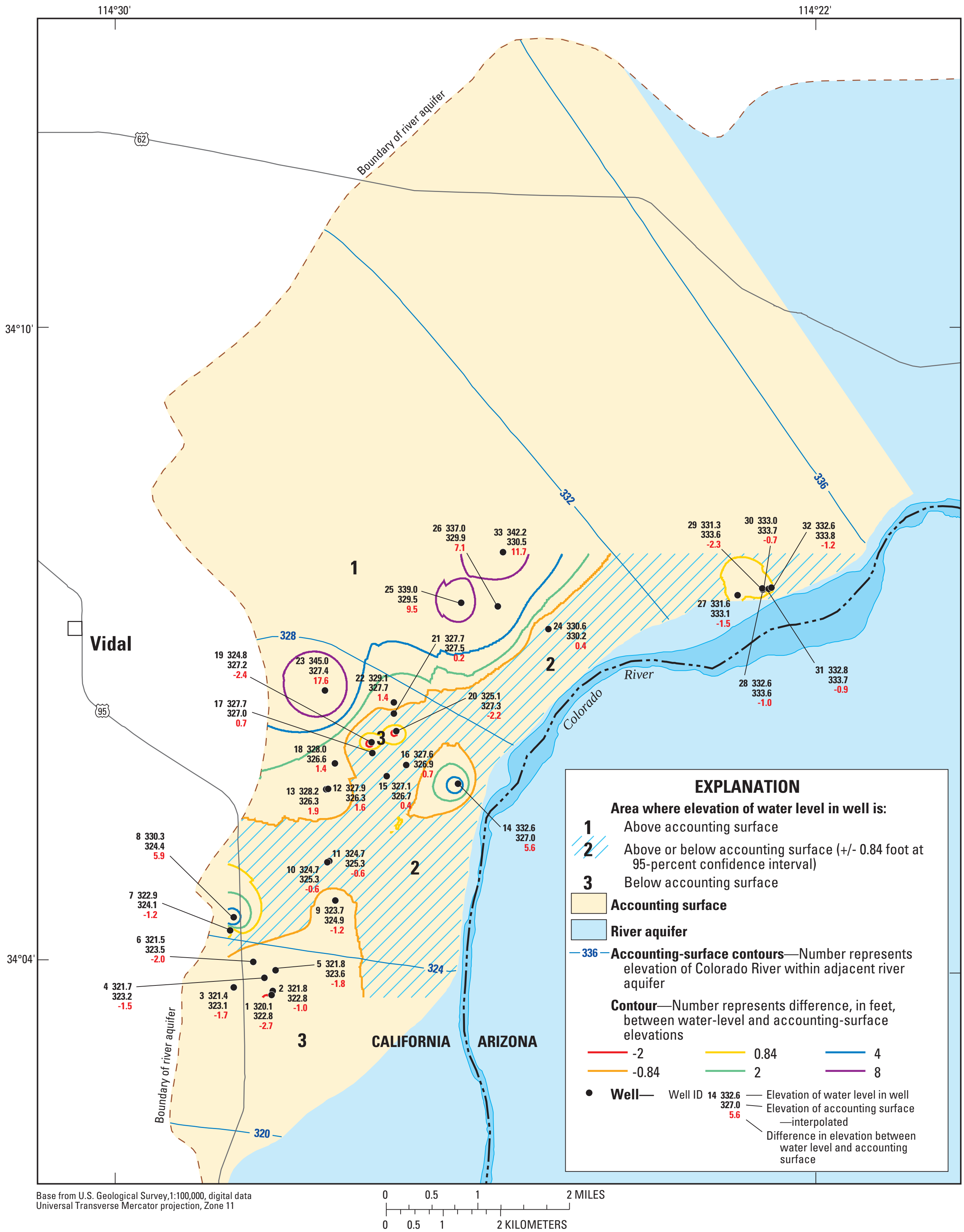


Figure 5. Areas interpolated above, below, and near the accounting surface in the Vidal area of California by using the Inverse Distance Weighted (power of 2) tool.

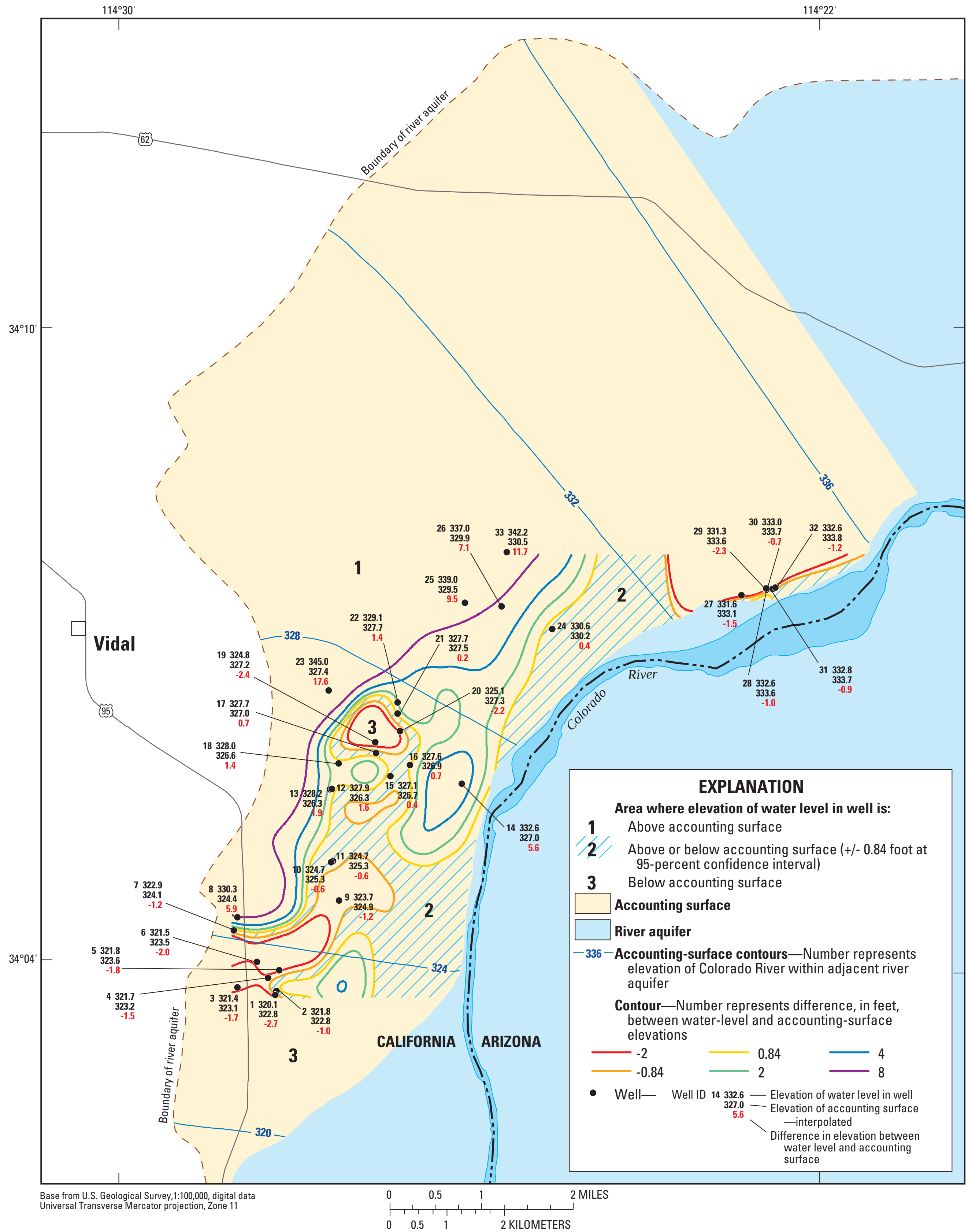


Figure 6. Areas interpolated above, below, and near the accounting surface in the Vidal area of California by using the Spline (weight of 0.1) tool.

Representations of areas above, below, and near (within ± 0.84 ft) the accounting surface in the Vidal area are substantially different among the Natural Neighbor, IDW, and Spline tools, and result largely from the fundamentally different mathematical approaches used by each of these tools. Variations in the representations of these surfaces by these tools also are likely influenced by the limited number of wells (interpolation points) in comparison to the size of the area, the spatial distribution of the wells, and the location of wells with anomalous water-level elevations. Although all of the tools portray an area along the Colorado River where water-level elevations may be above or below (within ± 0.84 ft) the accounting surface, as might be expected, well control is sparse or nonexistent. Qualitatively, the Natural Neighbor tool appears to provide the best representation of the difference between the water-level elevation and the accounting surface in the Vidal area.

Chemehuevi Area

Well Selection and Water-Level Measurements

Data for 39 wells in the Chemehuevi study area were compiled from the NWIS database, of which 6 wells did not have a measured static water level because of well obstructions, well status such as pumping, or because a measurement was not possible (landowner restriction, well had been destroyed, etc.). Water-level measurements in the remaining 33 wells were further evaluated on the basis of the date of the measurement and land-surface elevation accuracy. Most of the water levels in the data set were measured in 1996 and 2000-01, with the oldest but most recent measurements for two wells made in 1962. The number of measurements taken in each well ranged from one to four. Water levels in all wells were measured with calibrated steel or electrical tapes that are accurate to within tenths or hundredths of a foot. Water-level measurements that were reported only to within 1-ft accuracy were not used. Water-level measurements that were determined to be substantially influenced by the effects of pumping of the well or a nearby well were not used. Wells that were reported to be pumped recently however, were evaluated on a well by well basis. As a result, 16 wells with water levels that were measured in 1996 and 2000-01 were selected for analysis.

Calculated water-level elevations and interpolated accounting-surface elevations were determined for the 16 selected wells completed in the river aquifer north of Chemehuevi Wash (table 2; at back of report). Water levels were measured in 11 wells between November 2000 and March 2001; however, because of the scarcity of wells in the area and the absence of recent water-level data, older water-level data were used to help understand relations between the elevation surfaces. Therefore, water-level elevations in the remaining five wells were based on measurements taken in 1996. These water levels were observed to be consistent with elevation differences determined for nearby wells measured during 2000-01. Variations as large as 7 ft were noted for wells in which multiple measurements (at least three) had been taken, but variations for most wells generally were within about 2 ft over intervals of at least 10 years. Some fluctuations in water level may be the result of measurements being made shortly after pumping of the well or possibly from effects of pumping of nearby wells, and thus, may not represent static water-level conditions.

Delineation of Areas

When the 95-percent confidence interval (± 0.84 ft) is taken into account, relative differences between water-level elevations and the accounting surface for the selected wells show distinct areas where the elevation of the water level is below the elevation of the accounting surface and where the elevation of the water level may be above or below (within ± 0.84 ft) the elevation of the accounting surface. Areas where the elevation of the water level is above the elevation of the accounting surface appear to be localized. Because the accounting surface is presumed to be level in the vicinity of Lake Havasu, only one value, 449.6 ft, was used to represent the elevation of the accounting surface throughout the area (fig. 7). On the basis of the availability and distribution of wells within the river aquifer, these generalized areas were delineated between Chemehuevi Wash and the northern boundary of the river aquifer by using TIN Contour, Natural Neighbor, IDW, and Spline techniques (figs. 7-10).

The area where the water-level elevation is above the elevation of the accounting surface is based only on two wells that are located in the southern part of the study area, just north of Chemehuevi Wash. The difference in elevation between the water level in well 3 and the accounting surface is 8.7 ft; this relation between the surfaces probably extends to the west where land-surface elevation is higher. An area where the water-level elevation also is above the accounting surface appears to be localized around well 4 just west of Lake Havasu. Calculated elevation differences for wells in the vicinity of well 4 however, are substantially below the elevation of the accounting surface. No apparent reason could be found for this anomalous difference using the available data.

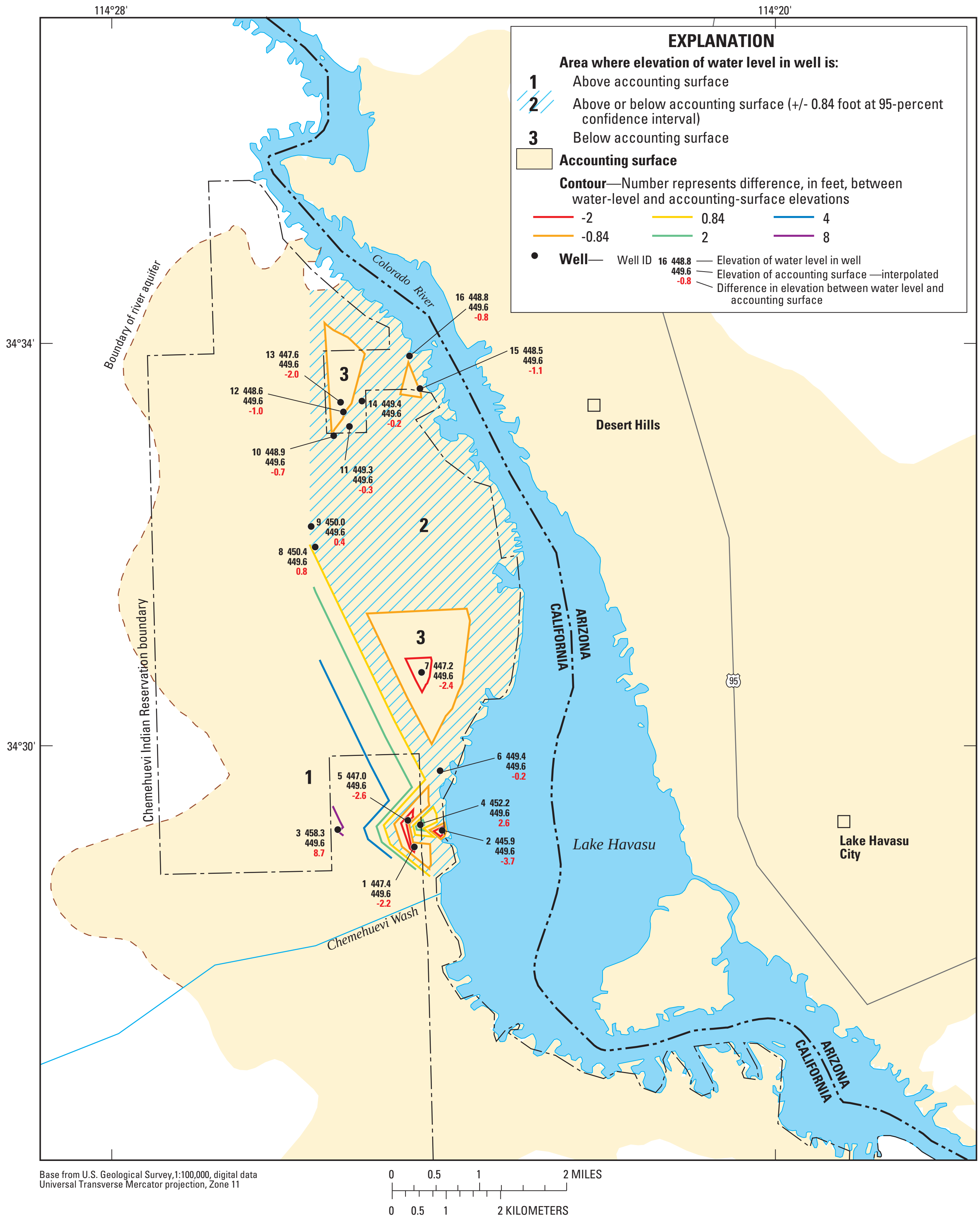


Figure 7. Areas interpolated above, below, and near the accounting surface in the Chemehuevi area of California by using the Triangulated Irregular Network Contour tool.

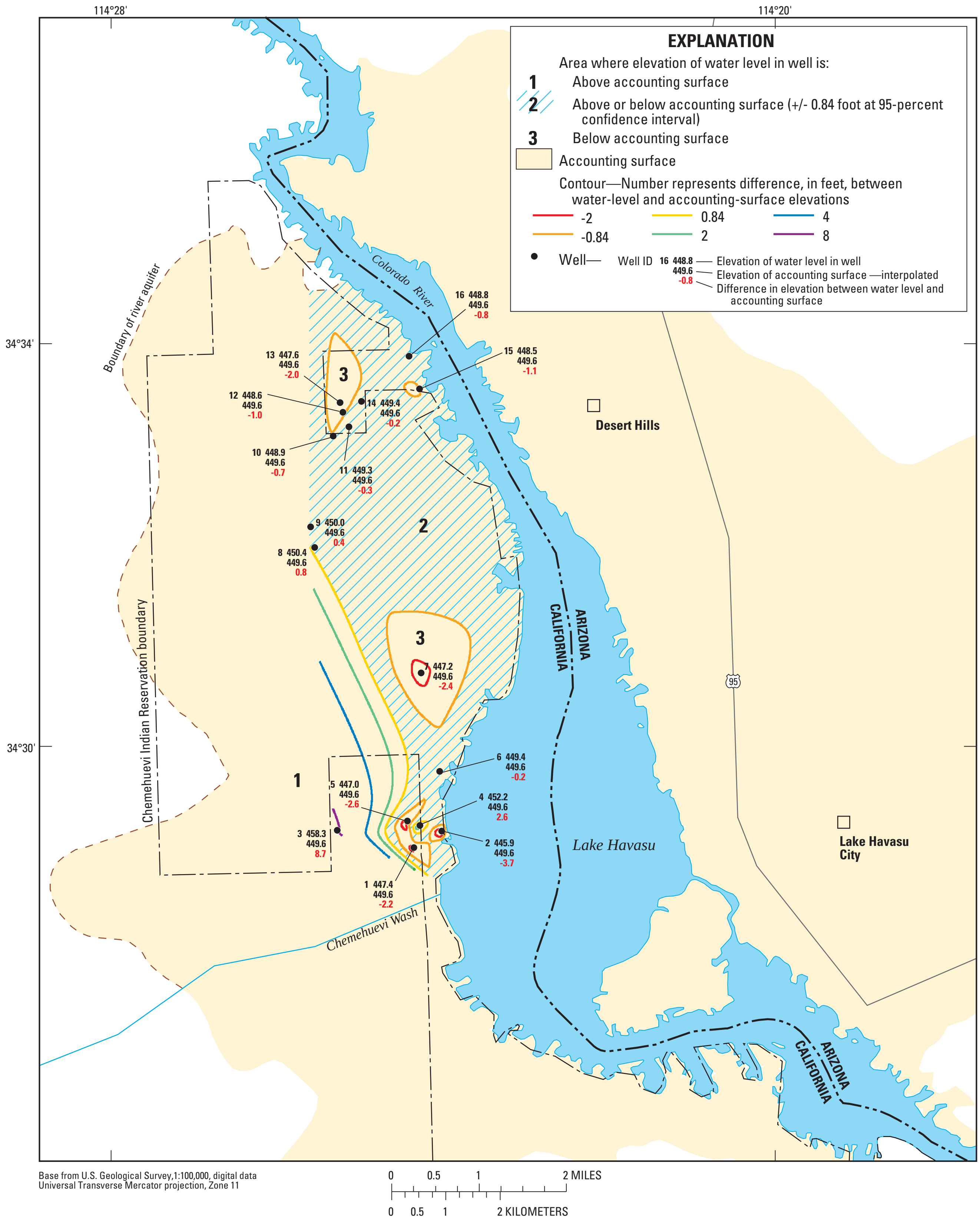


Figure 8. Areas interpolated above, below, and near the accounting surface in the Chemehuevi area of California by using the Natural Neighbor tool.

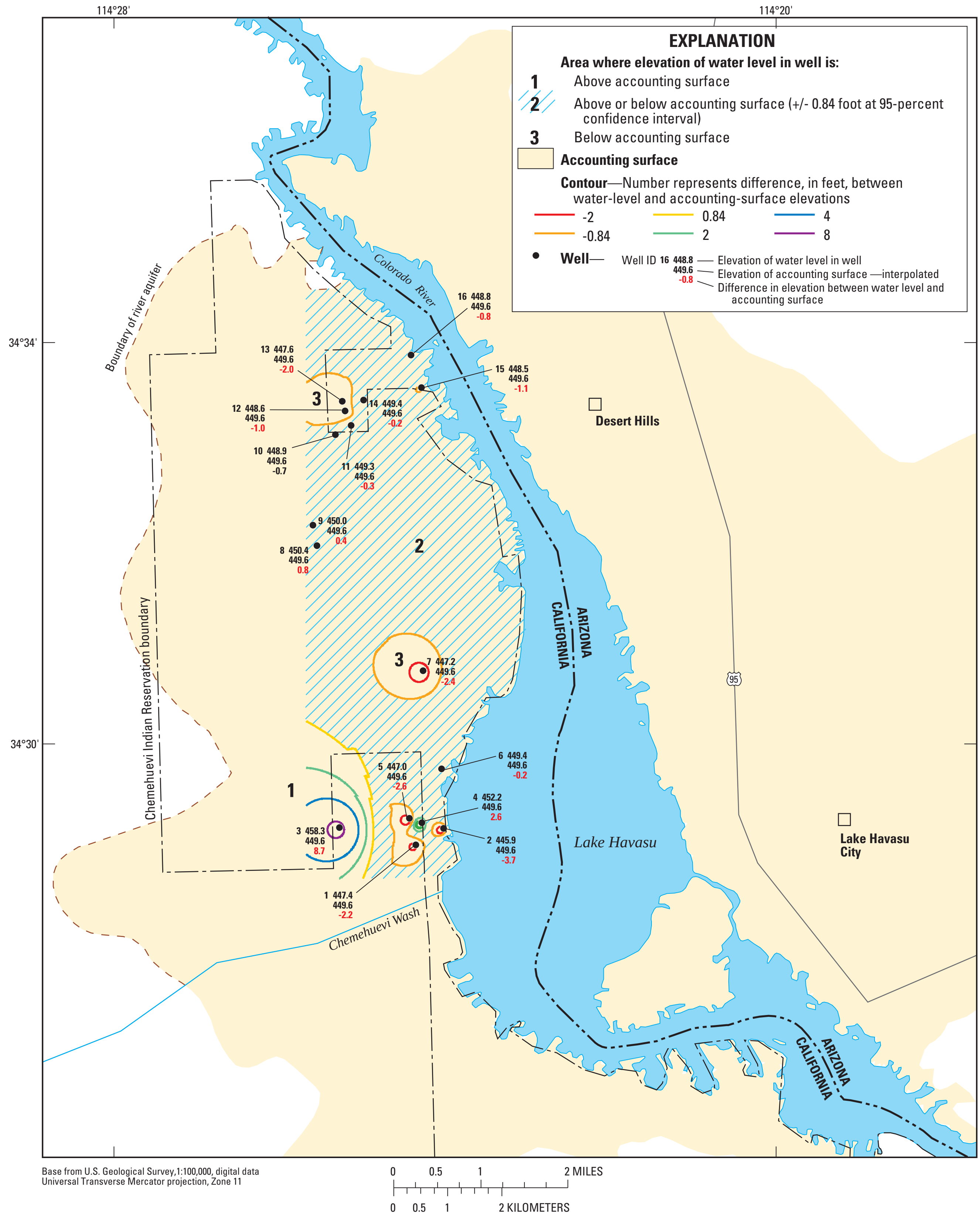


Figure 9. Areas interpolated above, below, and near the accounting surface in the Chemehuevi area of California by using the Inverse Distance Weighted (power of 2) tool.

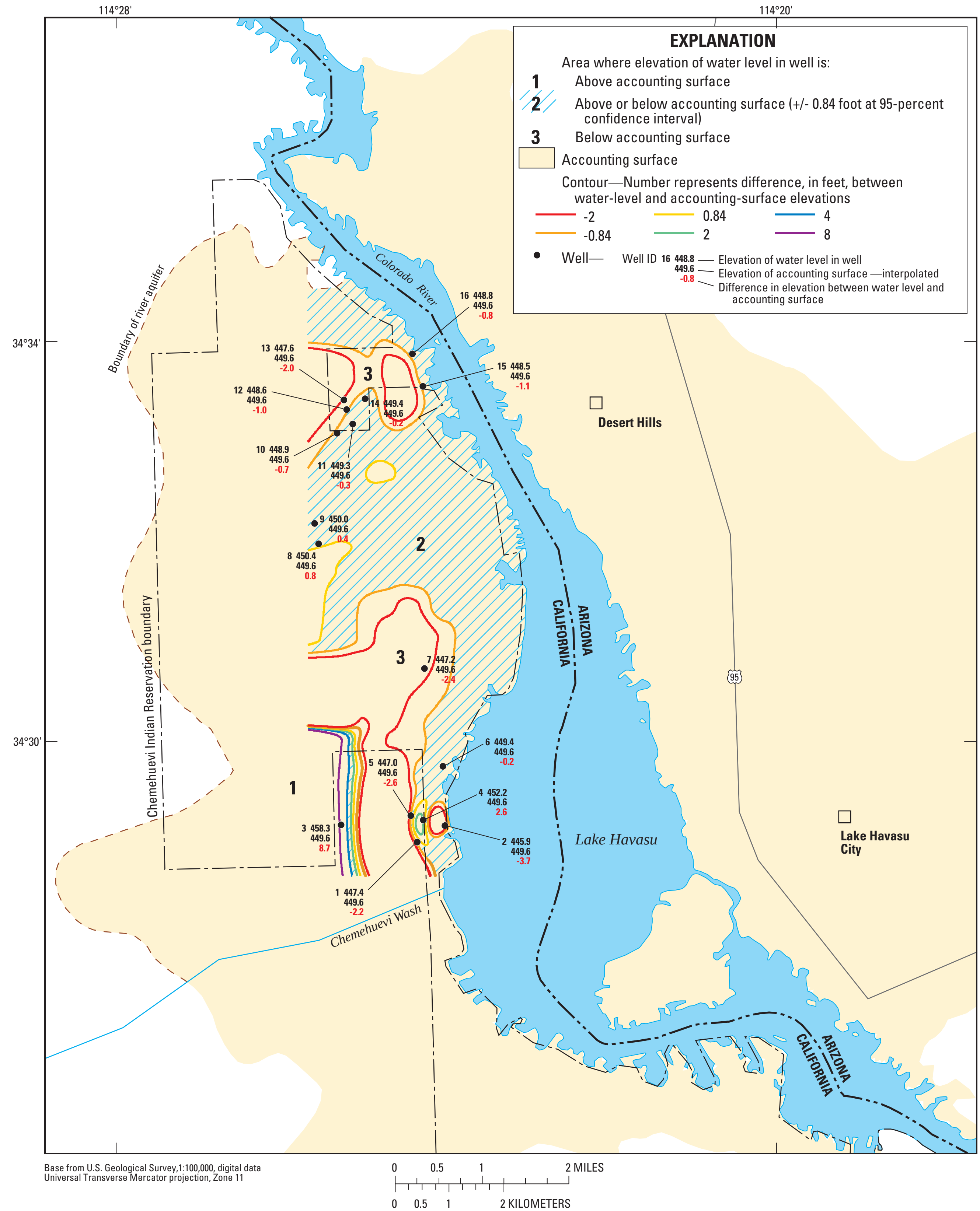


Figure 10. Areas interpolated above, below, and near the accounting surface in the Chemehuevi area of California by using the Spline (weight of 0.1) tool.

The area where the water-level elevation is below the elevation of the accounting surface is in the southeastern part of the study area just north of Chemehuevi Wash and adjacent to Lake Havasu, and also in the northern part of the area (fig. 7). Well 7 may also represent an area where the water level is substantially below the accounting surface. Differences in elevation range from about -1.0 to -3.7 ft in well 2; however, the large difference associated with this well may be attributed to its close proximity to the lake where water levels may be influenced by lake fluctuations. The area where the elevation of the water level may be above or below the elevation of the accounting surface (on the basis of ± 0.84 ft at the 95-percent confidence interval) is located primarily in the northern part of the study area and along the western margin of the delineated area, on the basis of available well data. The boundary defining this area will change or shift over time as water levels fluctuate. Overall, in the Chemehuevi study area, the elevation of the water level in most wells is below or near (within ± 0.84 ft) the elevation of the accounting surface.

The TIN Contour and Natural Neighbor tools appear to accurately portray areas where water-level elevations are above, below, and near (within ± 0.84 ft) the accounting surface, and delineate areas where anomalies in the surface exist, such as around well 4 (figs. 7 and 8). Boundaries between areas where the elevation of the water level may be above or below the elevation of the accounting surface (on the basis of ± 0.84 ft at the 95-percent confidence interval) and areas that are above (greater than 0.84 ft) and below (less than -0.84 ft) the accounting surface also appear to be reasonably defined, on the basis of the distribution of wells in this area. However, well data are insufficient in a large part of the area to accurately portray relations between these surfaces. Contours delineated by the Natural Neighbor tool are considerably smoother than those delineated by TIN Contour.

The IDW tool using the default power option of 2 is represented in figure 9. The area that may be above or below (within ± 0.84 ft) the accounting surface is portrayed as larger than that delineated by the TIN Contour or Natural Neighbor tools, with a consequent decrease in size of the area where water-level elevations are below (less than -0.84 ft) the accounting surface, especially in the vicinity of well 7. However, well data are insufficient to accurately portray relations between the surfaces in much of the area. The IDW tool delineates the anomalous area around well 4, but the area around well 15, with a water-level elevation below the accounting surface, is not well defined.

Boundaries delineated by the Spline tool using the default weight option (0.1) (fig. 10) are substantially different from those delineated by using the IDW, TIN, and Natural Neighbor tools, with a larger component of the area represented as where the water-level elevation is below (less than -0.84 ft) the accounting surface, with a consequent reduction in size of the area near (within ± 0.84 ft) the accounting surface. This substantial difference appears to be influenced by well 7, where the water-level elevation is 2.4 ft below the accounting surface. The Spline tool accurately delineates the anomalous area around well 4 and around wells in the northern part of the area where water-level elevations are below the accounting surface, but generates inliers (closed contours) in areas for which no well data are available.

Areas above, below, and near (within ± 0.84 ft) the accounting surface in the Chemehuevi area are represented differently among the TIN Contour, Natural Neighbor, IDW, and Spline tools. Although all of the tools portray a sizeable area where water-level elevations may be above or below (within ± 0.84 ft) the accounting surface, well control is sparse or nonexistent. Variations in the representations by each of these tools result in large part, from the fundamentally different mathematical approaches used by these tools. The relatively small number of wells (interpolation points) in comparison to the size of the area, the spatial distribution of the wells (most wells located in the northern and southern parts of the area), and the location of wells with anomalous water-level elevations also influence relations between the contoured surfaces. On the basis of the very limited data set, the Natural Neighbor tool appears to provide the best qualitative representation of the difference between the water-level elevation and the accounting surface in the Chemehuevi area.

Mohave Mesa Area

Well Selection and Water-Level Measurements

Data for 79 wells in the Mohave Mesa area were compiled from the NWIS database, of which 28 wells completed in the river aquifer did not have a measured static water level or else had a measured water level that was not static because of well obstructions or pumping effects. Four wells had anomalous water-level elevations that were substantially above or below calculated values for surrounding wells. Water-level measurements in the remaining 47 wells were further evaluated on the basis of the date of the measurement and land-surface elevation accuracy. In the Mohave Mesa area, the most recent water-level measurements were made in 2006 in 30 of the wells. All of the water-level measurements in the vicinity of Bullhead City were made in 1998. A few additional measurements were made in 1999, 2002, 2003, and 2005. Land-surface elevation accuracies for six wells ranged from 5 to 20 ft (one-half the topographic map contour interval) and were not used for determining water-level elevations. Water levels for an additional six wells were reported only to an accuracy of 1 ft and were not used. Water levels in the remaining 35 wells were measured by using calibrated steel or electrical tapes that are accurate to within tenths or hundredths of a foot.

Calculated water-level elevations and interpolated accounting-surface elevations were determined for the 35 selected wells completed in the river aquifer in the Mohave Mesa area (table 3; at back of report). Most of the water levels selected for analysis were measured in 2006 and in many instances, were the only values available. However, in some areas where recent water-level data are not available, such as in the vicinity of Bullhead City, older water-level data were used to help understand relations between the elevation surfaces. These data were observed to be consistent with measurements determined for nearby wells measured in 2006, or to be consistent with measurements taken in other wells in the area at the same time.

Water-level variations observed in some wells are likely the result of measurements being made during or shortly after pumping of the well or pumping effects from nearby wells, and thus, do not represent static water-level conditions. The significance of these effects on a well-by-well basis was used in evaluating whether a well was selected for analysis. Measurements made sequentially on August 30, 2006, in a well located at NESENWS14 T19N R22W that likely shows the effects of pumping of a nearby well indicated depth to water of 154.75, 156.65, and 158.12 ft, showing a steady decline in the water level (U.S. Geological Survey, unpub. data, 2006). Water levels measured in another well located at SWNWNES15 T19N R22W on August 31, 2006, also show the effects of pumping, with sequential values of 82.68, 83.72, and 85.96 ft. (U.S. Geological Survey, unpub. data, 2006). Because these values do not represent static water-level conditions, they were not used in the analysis.

Delineation of Areas

When the 95-percent confidence interval (± 0.84 ft) is taken into account, relative differences between water-level elevations and the accounting surface for the selected wells show that in virtually all of the study area, the elevation of the water level is below the elevation of the accounting surface. A small area is located near highway 153 where the elevation of the water level may be above or below (within ± 0.84 ft) the elevation of the accounting surface. Areas where the elevation of the water level is above the elevation of the accounting surface may not be present in the Mohave Mesa area. On the basis of the availability and distribution of wells within the river aquifer, these generalized areas were delineated between the accounting-surface elevations of 470 and 502 ft by using TIN Contour, Natural Neighbor, IDW, and Spline techniques (figs. 11-14).

In virtually all of the Mohave Mesa study area, the water-level elevation is below the elevation of the accounting surface. This includes the area near Bullhead City between the accounting-surface elevations of 488 and 502 ft and all wells between the accounting-surface elevations of 472 and 478 ft, which generally are within a short distance of the river. Water-level elevations for selected wells between the contour intervals of 470 and 472 ft and more than 5 mi east of the river also are below the accounting surface. Differences in elevation between water levels in wells and the accounting surface range from about -2.0 to -11.3 ft, with most values exceeding -7.0 ft. However, water levels in a number of wells were reported to have been measured after the well had been recently pumped and therefore, may not represent static water-level conditions. Effects from nearby pumping wells may also result in differences between water-level elevations and the accounting surface that are considerably lower (more negative) than would exist under normal static conditions. The magnitude of the difference between elevations in this area indicates that water-level elevations in many wells may still be below the accounting surface when pumping effects are neglected.

An area where the elevation of the water level may be above or below the elevation of the accounting surface (on the basis of ± 0.84 ft at the 95-percent confidence interval) occurs between the 470- and 472-ft accounting-surface contours in the southern part of Mohave Mesa (fig. 11). This localized area is represented by wells 4 and 5, which have differences in elevation of -0.2 and -0.4 ft, respectively. An area where the elevation of the water level is above the elevation of the accounting surface may be present immediately to the north of these wells. A reported water-level measurement (1-ft accuracy) made in 1999 in one well in this area (not shown) results in a difference in elevation of about 6.0 ft, substantially higher than the 472-ft accounting-surface contour. The close proximity of wells in this area, and hence, potential interference between wells during pumping, may explain the range in variability (-0.1 to -7.9 ft) of differences between water-level and accounting-surface elevations.

The TIN Contour and Natural Neighbor tools accurately delineate the small area where water-level elevations may be above or below (within ± 0.84 ft) the elevation of the accounting surface and also delineate a narrow area along the Colorado River west of Bullhead City (figs. 11 and 12). Power option 2 (default) in the IDW tool shows a considerably larger (wider) area along the Colorado River where the water-level elevation may be above or below the elevation of the accounting surface (fig. 13). This delineated area along the river likely results from the interpolation between the boundary of the river aquifer along the edge of the river (where the elevation of the river and the elevation of the water table in the river aquifer are assumed to be equal) and the considerably lower (more negative) water-level elevations in wells east of the river. However, no well data exist in this area to substantiate whether water-level elevations are near (within ± 0.84 ft) the accounting surface.

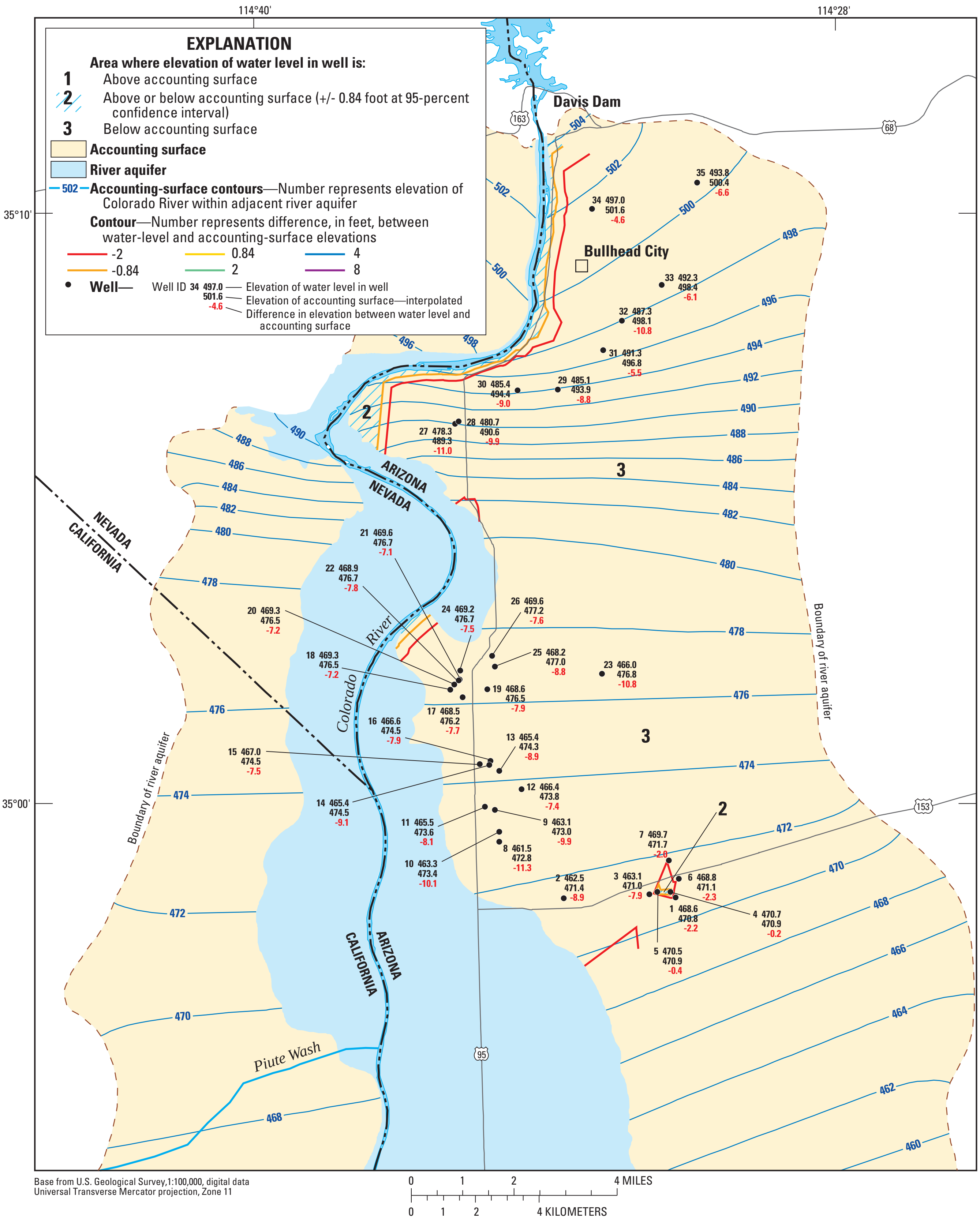


Figure 11. Areas interpolated above, below, and near the accounting surface in the Mohave Mesa area of Arizona by using the Triangulated Irregular Network Contour tool.

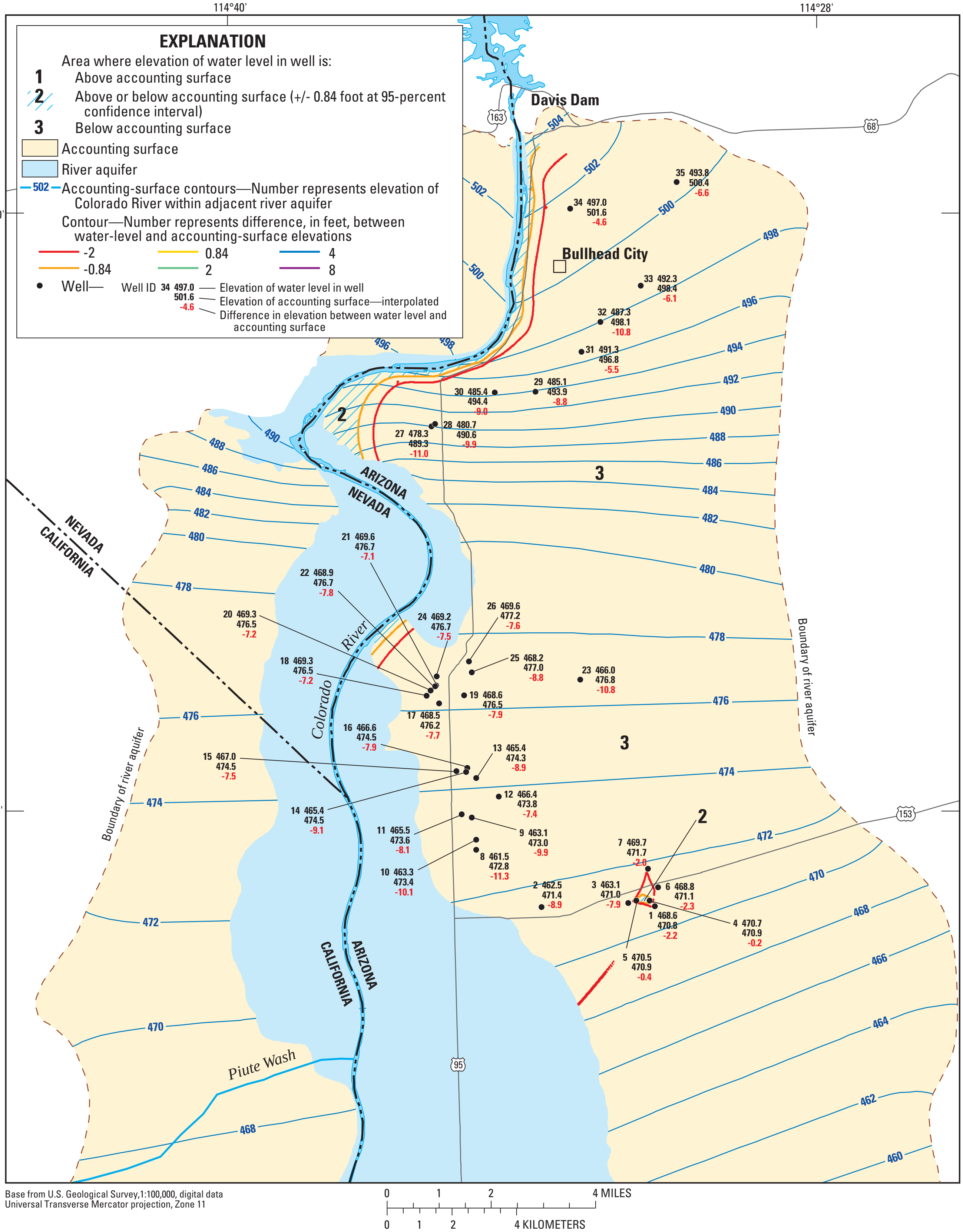


Figure 12. Areas interpolated above, below, and near the accounting surface in the Mohave Mesa area of Arizona by using the Natural Neighbor tool.

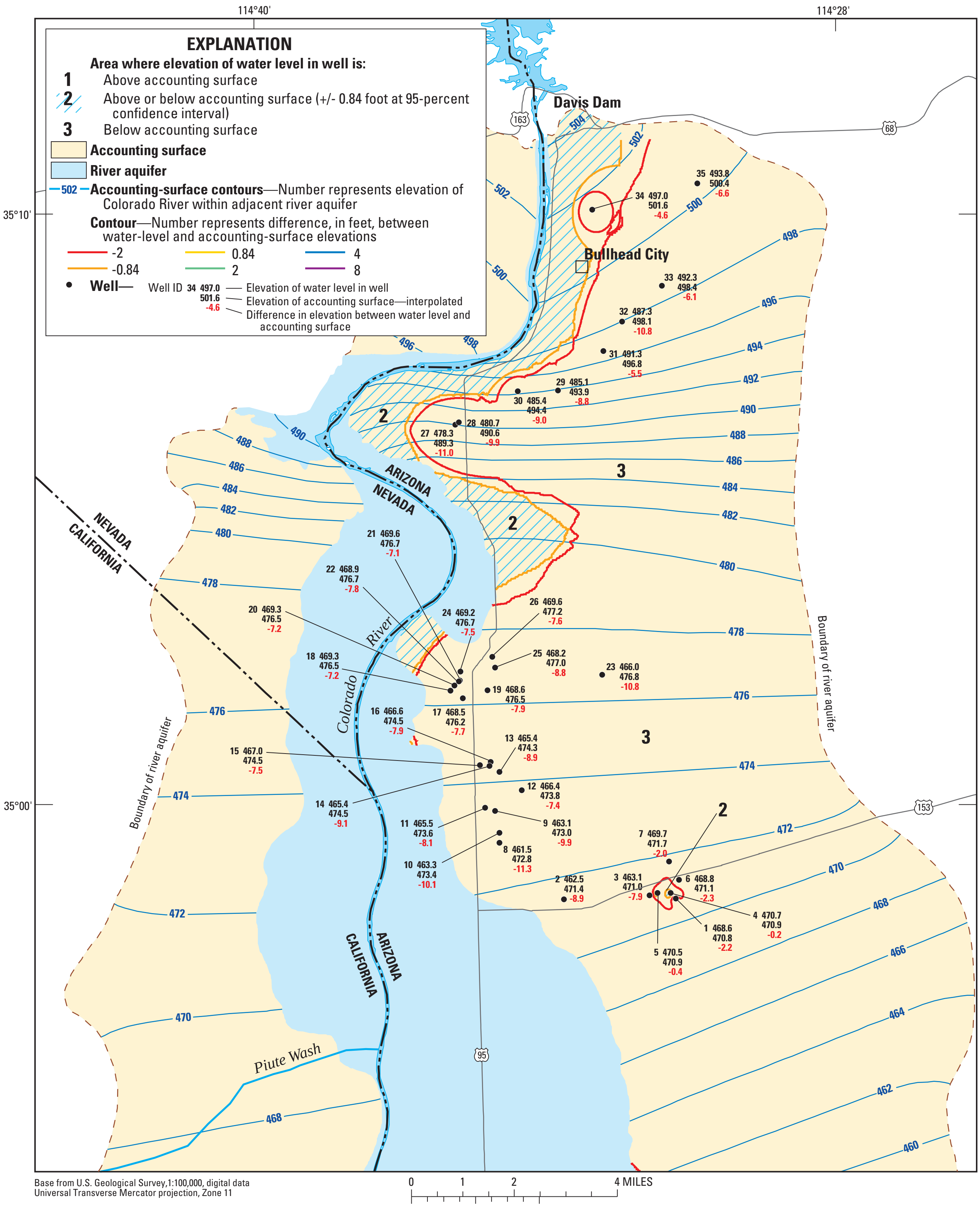


Figure 13. Areas interpolated above, below, and near the accounting surface in the Mohave Mesa area of Arizona by using the Inverse Distance Weighted (power of 2) tool.

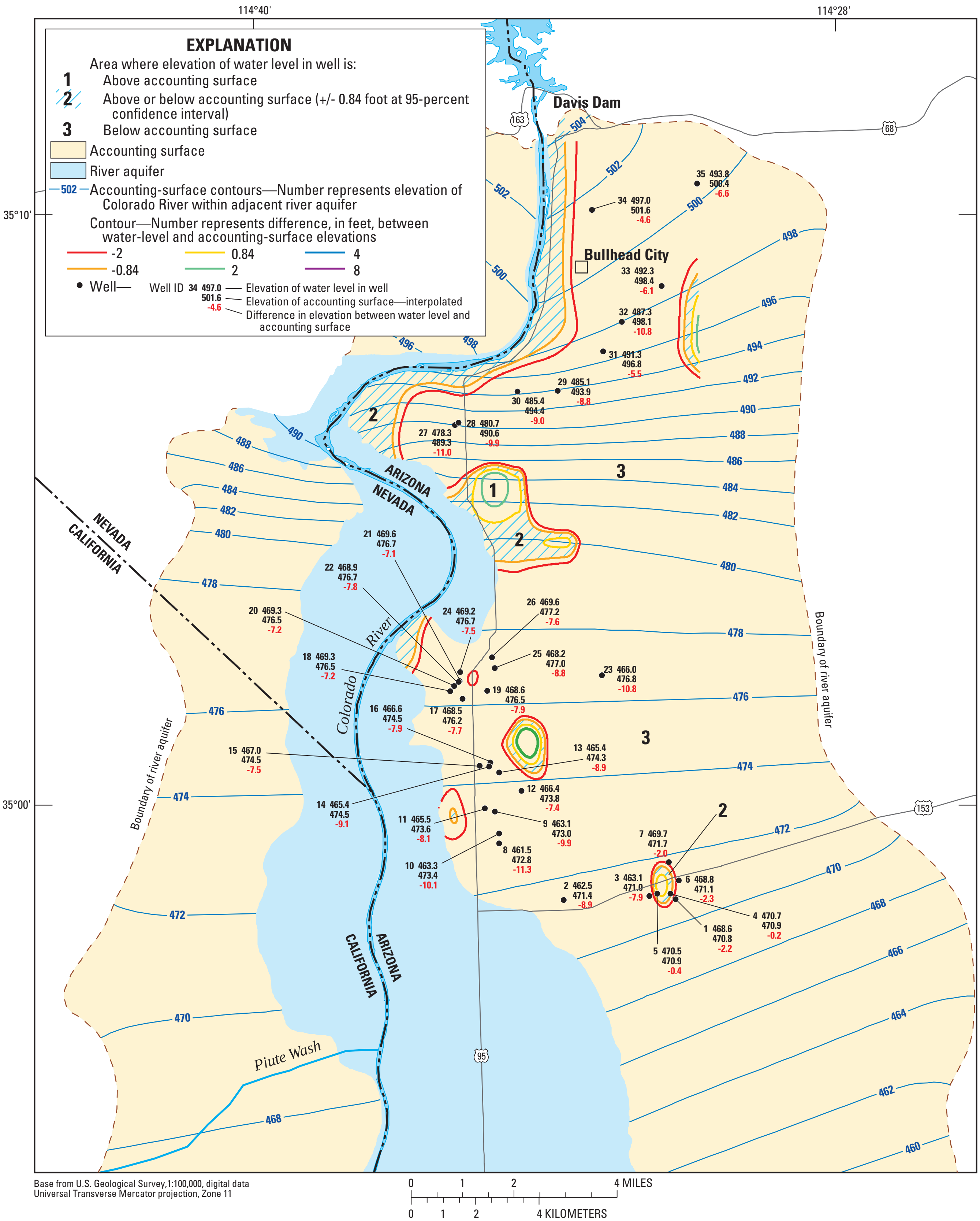


Figure 14. Areas interpolated above, below, and near the accounting surface in the Mohave Mesa area of Arizona by using the Spline (weight of 0.1) tool.

Areas delineated along the river where the water-level elevation may be above or below (within ± 0.84 ft) the accounting surface by using the default weight option (0.1) in the Spline tool are similar to those delineated by the IDW tool (fig. 14). The Spline tool also delineates the area between the 470- and 472-ft accounting-surface contours where the water-level elevation may be above or below the accounting surface. However, several other areas on Mohave Mesa, such as between the 474- and 476-ft and 482- and 484-ft accounting-surface contours, are delineated by the Spline tool as where the water-level elevation may be above (greater than 0.84 ft) the accounting surface, but for which no well data exist (fig. 14).

The observed patterns resulting from the application of the TIN Contour, Natural Neighbor, IDW, and Spline tools to delineate areas below the accounting surface in the Mohave Mesa area result largely from the fundamentally different mathematical approaches used by these tools. The spatial distribution of the wells, particularly the lack of well control in the area between the 478- and 488-ft accounting-surface contours, and the considerable range in difference in elevations between the water-level and accounting surfaces, also may contribute to the observed anomalies and variation in contouring among the interpolation tools. Qualitatively, the Natural Neighbor tool appears to provide the best representation of the difference between the water-level elevation and the accounting surface in the Mohave Mesa area.

Summary and Conclusions

The U.S. Geological Survey, in cooperation with the Bureau of Reclamation, began this study to determine if wells located within the Colorado River aquifer outside the flood plain are pumping water that will be replaced by water from the Colorado River. Water pumped from wells along the flood plain of the river is presumed to be river water and is accounted for as Colorado River water. Water pumped from wells outside the flood plain of the river may or may not be accounted for as Colorado River water. Relations between the elevation of the static water level in wells and the elevation of the accounting surface within the Colorado River aquifer were used to determine which wells outside the flood plain of the river will yield water that will be replaced by water from the Colorado River. Wells that have a static water-level elevation equal to or below the elevation of the accounting surface are presumed to yield water that will be replaced by water from the Colorado River.

Calculated water-level elevations and interpolated accounting-surface elevations were determined for 33 wells completed in the river aquifer in the vicinity of Vidal, California, 16 wells on and adjacent to the Chemehuevi Indian Reservation, California, and 35 wells on Mohave Mesa, Arizona. Well data were obtained from the U.S. Geological Survey NWIS database. Water-level measurements generally were taken during the last 10 years with steel and electrical tapes accurate to within tenths or hundredths of a foot. A Differential Global Positioning System (DGPS) was used to determine land-surface elevations to within an operational accuracy of ± 0.43 ft, resulting in calculated water-level elevations having a 95-percent confidence interval of ± 0.84 ft. Thus, wells with a difference between the water-level elevation and accounting-surface elevation of greater than ± 0.84 ft have water levels that are either above or below the accounting surface, and wells with a difference of less than ± 0.84 ft have water levels that cannot be determined with at least 95-percent confidence, to be either above or below the accounting surface. ArcGIS Triangulated Irregular Network (TIN) Contour, Natural Neighbor, Inverse Distance Weighted (IDW), and Spline interpolation tools were used to create contours of the difference between the water-level and accounting-surface elevations. The contours delineate areas where water-level elevations are above, below, and near (within ± 0.84 ft at the 95-percent confidence interval) the elevation of the accounting surface, on the basis of available well data.

In the Vidal area, differences in elevation range from 1.4 to 17.6 ft above the accounting surface and range from -0.9 to -2.7 ft below the accounting surface. Relative differences between water-level elevations and the elevation of the accounting surface decrease from west to east (toward the river) and from north to south (along the river). In the Chemehuevi area just north of Chemehuevi Wash, differences in elevation in the area where the water-level elevation is below the elevation of the accounting surface range from about -1.0 to -3.7 ft. In the vicinity of Lake Havasu, the accounting surface is established at 449.6 ft. In most of the Mohave Mesa study area, the water-level elevation is below the elevation of the accounting surface. Differences in elevation between water levels and the accounting surface range from about -2.0 to -11.3 ft, with most values exceeding -7.0 ft.

The TIN Contour and Natural Neighbor tools reasonably represent areas where the elevation of water levels in wells is above, below, and near (within ± 0.84 ft) the elevation of the accounting surface in the Vidal and Chemehuevi study areas and accurately delineate areas around outlying wells and where anomalous differences between water-level and accounting-surface elevations exist. Using the default options in ArcGIS, the IDW and Spline tools also reasonably represent areas above, below, and near the accounting surface in the Vidal and Chemehuevi areas. However, spatial extent of and boundaries between areas above, below, and near the accounting surface vary substantially between the IDW and Spline tools and those delineated by the TIN Contour and Natural Neighbor tools. Variations in the representations by the TIN Contour, Natural Neighbor, IDW, and Spline tools result largely from the fundamentally different mathematical approaches used by each of these tools. The limited number of wells selected for analysis, and hence interpolation points, in comparison to the size of the areas, the spatial distribution of the wells, and the locations and relative differences in elevation between water levels and the accounting surface of wells with anomalous water levels also influence the contouring variations observed among the methods.

Qualitatively, the Natural Neighbor tool appears to provide the best representation of the difference between water-level and accounting-surface elevations in the study areas when compared with the TIN Contour, IDW, and Spline tools in ArcGIS. Additional work to determine quantitatively which tool provides the best representation could be done and should include other tools available in ArcGIS as well as interpolation methods not available in ArcGIS. Semi-variograms or sensitivity analysis on residuals also could be done for each of the study areas using geostatistical methods such as kriging.

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Table 1. Data for selected wells in the Vidal area, California.

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; U, unknown; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Latitude	Longitude	Land-net location (Section-Township-Range)	Elevation of land surface (feet above sea level)	Well depth (feet below land surface)	Water-level measurement date (year/month/day)
1	340330114282801	340329.73	1142828.79	SWSENES29 T01S R24E	415.6	110	19900919 20010213
2	340332114282801	340331.92	1142827.85	SWSENES29 T01S R24E	418		19900918 20010213
3	340335114285301	340334.58	1142854.37	SESENWS29 T01S R24E	426.8		20010208
4	340340114283301	340339.65	1142833.16	NWSENES29 T01S R24E	426.2	132	20010213
5	340342114282701	340343.7	1142825.65	SENENES29 T01S R24E	426.9	166	19900918 20010208
6	340347114284301	340348.86	1142840.7	NENWNES29 T01S R24E	438.9		19900920 20010215
7	340406114285301	340406.96	1142855.9	NESESWS20 T01S R24E	473.8		19900918 20010208
8	340414114285301	340414.52	1142853.14	SENESWS20 T01S R24E	488	185	19920731 19920731 20010208
9	340422114274301	340422.46	1142743.63	SWSWNES21 T01S R24E	438.7	142	19900921 19970425 20010125
10	340443114274901	340444.41	1142748.37	NENENWS21 T01S R24E	456.1	154.8	19900921 19970425 20010125
11	340445114274701	340445.03	1142747.05	NWNWNES21 T01S R24E	455.2		20010125
12	340525114274701	340525.99	1142746.62	NWSWNES16 T01S R24E	469.8	225	19640616 19900921 20001129 20001129
13	340526114274801	340525.76	1142747.86	NESENWS16 T01S R24E	470.8	224	20001129 20001129
14	340529114261601	340527.15	1142617.72	SENENES15 T01S R24E	418		19870917 19900921 19970425 20001116
15	340533114270601	340532.5	1142706.44	NENWNWS15 T01S R24E	448.4	234	19900922 19970425 20001114
16	340538114265301	340538.59	1142652.71	NWNENWS15 T01S R24E	444.2	205	19611214 19620223 19620329 19620523 19900915 19970610 20001114

Table 1. Data for selected wells in the Vidal area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; U, unknown; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Water level (feet below land surface)	Water-level accuracy	Water-level status	Water-level method	Water-level elevation (feet above sea level)	Elevation of accounting surface (feet above sea level)	Difference in elevation (feet)
1	340330114282801	95.79	2		S			
		95.53	2	R	V	320.1	322.8	-2.7
2	340332114282801	110.26	2		S			
		96.22	2		V	321.8	322.8	-1.0
3	340335114285301	105.43	2		V	321.4	323.1	-1.7
4	340340114283301	104.47	2		V	321.7	323.2	-1.5
5	340342114282701	105.11	2		S			
		105.13	2		V	321.8	323.6	-1.8
6	340347114284301	117.33	2		S			
		117.37	2		S	321.5	323.5	-2.0
7	340406114285301	155.69	2	R	S			
		150.89	2		V	322.9	324.1	-1.2
8	340414114285301	157.02	2		S			
		157.03	2		S			
		157.67	2		V	330.3	324.4	5.9
9	340422114274301	114.73	2		S			
		113.86	2		V			
		115	2		V	323.7	324.9	-1.2
10	340443114274901	130.85	2		S			
		130.28	2		V			
		131.42	2		V	324.7	325.3	-0.6
11	340445114274701	130.51	2		V	324.7	325.3	-0.6
12	340525114274701	141.5	1		S			
		141.9	1		V			
		141.87	2	R	S			
		141.87	2	R	S	327.9	326.3	1.6
13	340526114274801	142.59	2	R	S			
		142.61	2	R	S	328.2	326.3	1.9
14	340529114261601	86.7	2		S			
		85.21	2		S			
		84.15	2		V			
		85.38	2		V	332.6	327.0	5.6
15	340533114270601	120.56	2		S			
		120.3	2		V			
		121.35	2		V	327.1	326.7	0.4
16	340538114265301	115.28	2		S			
		115.53	2		S			
		118.42	2	P	S			
		121.36	2		S			
		115.57	2		S			
		115.35	2		V			
		116.6	2		V	327.6	326.9	0.7

Table 1. Data for selected wells in the Vidal area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; U, unknown; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Latitude	Longitude	Land-net location (Section-Township-Range)	Elevation of land surface (feet above sea level)	Well depth (feet below land surface)	Water-level measurement date (year/month/day)
17	340546114271501	340545.72	1142715.83	NWSWSWS10 T01S R24E	462.3	306	19611214
							19620223
							19620329
							19620523
							19621107
							19630104
							19900922
							20001104
18	340541114273801	340540.44	1142741.62	SWSWSES09 T01S R24E	467.5		19900922
							19970612
							20001129
19	340551114271501	340552.1	1142715.64	NWSWSWS10 T01S R24E	461.6		19620223
							19620329
							19620523
							19620718
							19900922
							20001114
20	340559114270001	340558.18	1142659.61	SWNESWS10 T01S R24E	448.7		19870917
							19900915
							19950412
							19950412
							19970610
							20001115
21	340608114264901	340607.87	1142700.25	SESWNWS10 T01S R24E	460.6	241.5	19900917
							20001115
							20001115
22	340614114270001	340614.23	1142700.24	NWSENWS10 T01S R24E	465.4	224	19610524
							19611213
							19640617
							19870917
							19900914
							19950412
							19970610
							20001115
							20001115
23	340625114274301	340622.05	1142747.17	SWNWNES09 T01S R24E	502.8	365	19611213
							19900922
							20001129
24	340654114251301	340653.65	1142513.14	NENESES02 T01S R24E	430.6	174	20001130
							20001130
25	340706114261501	340709.89	1142612.33	NWSWNWS02 T01S R24E	480.3		20010213
26	340707114254801	340707.46	1142547.53	NESENWS02 T01S R24E	457.9	202	20000211
							20010207
27	340712114230201	340710.25	1142303.38	NESENES06 T01S R25E	350.4		19900914
							19950406
							20010207

Table 1. Data for selected wells in the Vidal area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; U, unknown; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Water level (feet below land surface)	Water-level accuracy	Water-level status	Water-level method	Water-level elevation (feet above sea level)	Elevation of accounting surface (feet above sea level)	Difference in elevation (feet)
17	340546114271501	135.14	2		S			
		135.5	2		S			
		143.14	2	P	S			
		152.58	2	P	S			
		138.58	2		S			
		138.98	2		S			
		134.54	2		S			
		134.58	2		V	327.7	327.0	0.7
18	340541114273801	139.46	2		S			
		143.2	1		V			
		139.5	2		V	328.0	326.6	1.4
19	340551114271501	137.69	2		S			
		144.57	2	P	S			
		149.02	2	P	S			
		153.79	2		S			
		136.78	2		S			
		136.84	2		V	324.8	327.2	-2.4
20	340559114270001	121.6	1	V	S			
		123.93	2		S			
		131.9	2	V	S			
		132.8	2	V	S			
		124.4	1	V	V			
		123.59	2	V	S	325.1	327.3	-2.2
21	340608114264901	133.03	2		S			
		132.92	2		S	327.7	327.5	0.2
		132.97	2		V			
22	340614114270001	148.14	2		S			
		138.61	2		S			
		141.6	1		S			
		134.9	2		S			
		136.51	2		S			
		138.67	2		S			
		136.35	2		V			
		136.06	2		S			
		136.26	2		S	329.1	327.7	1.4
23	340625114274301	159.32	2		S			
		158.14	2		S			
		157.77	2		V	345.0	327.4	17.6
24	340654114251301	99.95	2		S			
		99.96	2		S	330.6	330.2	0.4
25	340706114261501	141.31	2		V	339.0	329.5	9.5
26	340707114254801	123	0		U			
		120.86	2		V	337.0	329.9	7.1
27	340712114230201	16.91	2		S			
		16.36	2		S			
		18.78	2		S	331.6	333.1	-1.5

Table 1. Data for selected wells in the Vidal area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; U, unknown; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Latitude	Longitude	Land-net location (Section-Township-Range)	Elevation of land surface (feet above sea level)	Well depth (feet below land surface)	Water-level measurement date (year/month/day)
28	340713114224601	340713.01	1142246.06	SWNENWS05 T01S R25E	350.8		19900914
							19950406
							20010207
29	340713114224602	340713.84	1142246.17	SWNENWS05 T01S R25E	351.1		19900914
							20010207
30	340714114224201	340713.46	1142242.72	SWNENWS05 T01S R25E	347.8	100	20010207
31	340714114224301	340713.39	1142242.02	SWNENWS05 T01S R25E	347.5		20010207
32	340714114224001	340714.16	1142240.13	SWNENWS05 T01S R25E	347.8	90	20010207
33	340738114254301	340738.23	1142543.00	SENESWS35 T01N R24E	476	218	19611213
							19661018
							19900907
							19900924
							19950412
							20010206

Table 1. Data for selected wells in the Vidal area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; U, unknown; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Water level (feet below land surface)	Water-level accuracy	Water-level status	Water-level method	Water-level elevation (feet above sea level)	Elevation of accounting surface (feet above sea level)	Difference in elevation (feet)
28	340713114224601	17.64	2		S			
		18.79	2		S			
		18.21	2	X	V	332.6	333.6	-1.0
29	340713114224602	17.75	2		S			
		19.80	2	X	V	331.3	333.6	-2.3
30	340714114224201	14.85	2	X	V	333.0	333.7	-0.7
31	340714114224301	14.74	2	X	V	332.8	333.7	-0.9
32	340714114224001	15.23	2	X	V	332.6	333.8	-1.2
33	340738114254301	132.83	2		S			
		145.35	2		S			
		133.65	2		S			
		133.69	2		S			
		133.79	2		S			
		133.83	2		V	342.2	330.5	11.7

Table 2. Data for selected wells in the Chemehuevi area, California.

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; R, reported; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** For all wells, based on average stage of Lake Havasu; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Latitude	Longitude	Land-net location (Section-Township-Range)	Elevation of land surface (feet above sea level)	Well depth (feet below land surface)	Water-level measurement date (year/month/day)
1	342846114243601	342845.83	1142435.29	SESESES36 T05N R24E	554.8		20010510
2	342855114241501	342855.10	1142414.73	SENWSWS31 T05N R25E	457.4		19960313
3	342857114253001	342857.17	1142530.22	SWNWSWS36 T05N R24E	612	400	19910130
							19910130
							19960314
							20010425
							20010425
4	342859114243101	342858.82	1142430.37	SENESES36 T05N R24E	479.6		19960327
							20010522
5	342902114244001	342901.65	1142439.46	NWNESES36 T05N R24E	520.1		19910202
							19910202
							19910202
							19960328
							20010522
6	342931114241501	342930.98	1142415.18	NENWNWS31 T05N R25E	458.4		19960313
							20010508
7	343030114242701	343029.87	1142426.81	SWSWSWS19 T05N R25E	512.4		19960312
							20000607
8	343146114254101	343146.46	1142541.34	SWSENES14 T05N R24E	613	350	19960312
							20010524
							20010524
							20010524
9	343159114254401	343158.76	1142543.79	SWNENES14 T05N R24E	618.2	300	19960206
							20000607
10	343253114252601	343252.66	1142525.65	SWNWNWS12 T05N R24E	603.5	369	19950418
							19960206
							19960329
							20000606
11	343258114251401	343257.92	1142514.30	NWNENWS12 T05N R24E	589.5	310	19950331
							19950418
							19960206
							19960315
12	343307114251901	343306.76	1142518.40	SESWSWS01 T05N R24E	597.2	220	19910202
							19910202
							19960314
							20010508
							20010508
13	343312114252101	343312.67	1142520.21	NESWSWS01 T05N R24E	604.1	198	19910202
							19910202
							19960313
							20010424
							20010424

Table 2. Data for selected wells in the Chemehuevi area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; R, reported; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** For all wells, based on average stage of Lake Havasu; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Water level (feet below land surface)	Water-level accuracy	Water-level status	Water-level method	Water-level elevation (feet above sea level)	Elevation of accounting surface (feet above sea level)	Difference in elevation (feet)
1	342846114243601	107.44	2		V	447.4	449.6	-2.2
2	342855114241501	11.47	2		V	445.9	449.6	-3.7
3	342857114253001	146.74	2		V	465.3		
		146.87	2		S	465.1		
		146.86	2		V	465.1		
		153.5	2		S	458.5		
		153.7	2		S	458.3	449.6	8.7
4	342859114243101	27.9	1		V	451.7		
		27.42	2	R	V	452.2	449.6	2.6
5	342902114244001	74.96	2		V	445.1		
		75.07	2		S	445.0		
		75.07	2		S	445.0		
		74.01	2		V	446.1		
		73.15	2		V	447.0	449.6	-2.6
6	342931114241501	11.48	2		V	446.9		
		9.04	2		V	449.4	449.6	-0.2
7	343030114242701	64.67	2		V	447.7		
		65.21	2		S	447.2	449.6	-2.4
8	343146114254101	161.56	2		V	451.4		
		162.63	2		S	450.4		
		162.63	2		S	450.4	449.6	0.8
		162.65	2		V	450.4		
9	343159114254401	167.39	2		V	450.8		
		168.19	2		V	450.0	449.6	0.4
10	343253114252601	154.5	1		R	449.0		
		154.2	2		S	449.3		
		154.6	2		S	448.9	449.6	-0.7
		158.35	2	V	V	445.2		
11	343258114251401	142	0		R	447.5		
		140	1		R	449.5		
		139.88	2		S	449.6		
		140.25	2		V	449.3	449.6	-0.3
12	343307114251901	148.97	2		V	448.2		
		149	2		S	448.2		
		148.65	2		V	448.6	449.6	-1.0
		149.95	2	R	S	447.3		
		149.97	2	R	S	447.2		
13	343312114252101	155.68	2		V	448.4		
		155.73	2		S	448.4		
		155.22	2		V	448.9		
		156.5	2		S	447.6		
		156.5	2		S	447.6	449.6	-2.0

Table 2. Data for selected wells in the Chemehuevi area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; R, reported; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** For all wells, based on average stage of Lake Havasu; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Latitude	Longitude	Land-net location (Section-Township-Range)	Elevation of land surface (feet above sea level)	Well depth (feet below land surface)	Water-level measurement date (year/month/day)
14	343312114250501	343312.86	1142504.88	NESESWS01 T05N R24E	572	200	19910202
							19910202
							19960328
15	343320114242301	343319.53	1142422.58	SWNWSWS06 T05N R25E	466.5	250	19960312
							20010424
							20010424
							20010424
16	343339114243001	343339.21	1142429.51	NESENES01 T05N R24E	467.4	88	20010425
							20010425

Table 2. Data for selected wells in the Chemehuevi area, California.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; X, affected by surface-water site; V, foreign matter; P, pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; R, reported; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** For all wells, based on average stage of Lake Havasu; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Water level (feet below land surface)	Water-level accuracy	Water-level status	Water-level method	Water-level elevation (feet above sea level)	Elevation of accounting surface (feet above sea level)	Difference in elevation (feet)
14	343312114250501	123.23	2		V	448.8		
		123.28	2		S	448.7		
		122.57	2		V	449.4	449.6	-0.2
15	343320114242301	18.27	2	X	V	448.2		
		17.97	2	R	S	448.5	449.6	-1.1
		18.06	2	R	S	448.4		
		18.4	2	R	S	448.1		
16	343339114243001	18.62	2		S	448.8		
		18.63	2		S	448.8	449.6	-0.8

Table 3. Data for selected wells in the Mohave Mesa area, Arizona.

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; T, nearby recently pumped; S, nearby pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; R, reported; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Latitude	Longitude	Land-net location (Section-Township-Range)	Elevation of land surface (feet above sea level)	Well depth (feet below land surface)	Water-level measurement date (year/month/day)
1	345810114314801	345810.42	1143147.92	SWSESES05 T18N R21W	860.1		20060927
2	345812114340601	345812.35	1143405.83	NESWSES01 T18N R22W	573.2	260	19980409
3	345815114322001	345814.59	1143219.88	NWSESWS05 T18N R21W	802.1	400	20060926
4	345816114315401	345816.4	1143153.74	NESWSES05 T18N R21W	851.2		20060927
							20040115
5	345817114321001	345816.8	1143209.96	NESESWS05 T18N R21W	820.1		20060926
6	345829114314301	345829.42	1143143.42	NENESES05 T18N R21W	883.1	487	20060928
					883.1		20051207
7	345848114315501	345848.41	1143154.88	SENWNES05 T18N R21W	865.9	537	20060927
							20051226
8	345911114352401	345911.33	1143523.62	SENESWS35 T19N R22W	532.9	150	20060802
9	345922114352301	345921.6	1143523.17	NENESWS35 T19N R22W	538.6	126	20060804
10	345944114352801	345943.88	1143528.15	NWNENWS35 T19N R22W	538.9		20060718
11	345948114354001	345947.57	1143540.32	NENWNWS35 T19N R22W	538.6	160	20060718
12	350004114345501	350004.2	1143454.59	SENESES26 T19N R22W	569.3	120	20060615
13	350023114352101	350023.42	1143521.24	NESENWS26 T19N R22W	561.2	120	20060614
14	350030114353301	350029.96	1143533.48	SWNENWS26 T19N R22W	553.3		20060126
					553.3		20060126
15	350031114354601	350030.68	1143545.57	SWNWNWS26 T19N R22W	545.2	100	20060125
16	350034114353201	350033.64	1143531.94	SWNENWS26 T19N R22W	556.1		20060222
17	350139114360401	350139.02	1143604.4	SWSESES15 T19N R22W	552.6		20060915
18	350147114362001	350147.31	1143619.52	SWNWSES15 T19N R22W	545.6	108	20060912
19	350148114355101	350146.69	1143533.62	NWSESWS14 T19N R22W	594	230	19690611
							19900626
							20060112
20	350152114361401	350152.44	1143614.46	SWNWSES15 T19N R22W	549.6	125	20060913
							20020913
21	350157114360801	350157.08	1143607.84	NENWSES15 T19N R22W	554.9	125	20060913
22	350157114360802	350156.73	1143608.18	NENWSES15 T19N R22W	554.2	115	20060915
23	350200114331201	350159.64	1143311.76	NWNWSWS18 T19N R21W	845.1	450	19980604
24	350206114360701	350206.41	1143606.68	SESWNES15 T19N R22W	555.7	120	20060823
25	350210114352401	350209.63	1143523.79	NESENWS14 T19N R22W	635.3	220	20060830
					635.3		20060830
26	350220114352701	350220.46	1143526.94	NENENWS14 T19S R22W	630.6	185	20060810
27	350618114360501	350617.08	1143605.92	SWNENES20 T20N R22W	588.1	390	19980604
28	350618114360301	350619.38	1143601.43	SWNENES20 T20N R22W	602.9		19980604
29	350649114340001	350649.35	1143357.89	SWSESES13 T20N R22W	714.2	340	19980529
30	350649114344901	350649.52	1143447.52	NWNESES16 T20N R22W	701.0	600	19980529
31	350728114330001	350728.35	1143300.33	NESWNES18 T20N R21W	830.8	450	19980528
32	350758114323601	350757.68	1143236.38	SWNWSWS08 T20N R21W	860.6	900	19980603
33	350833114314601	350832.92	1143145.96	SWSESES05 T20N R21W	1,121.4	1,212	19980528
34	350951114331001	350952	1143310	NESENES31 T21N R21W	696.1	405	19980527
35	351015114305901	351016	1143059	NWSWSWS27 T21N R21W	1,225.1	1,080	19980515

Table 3. Data for selected wells in the Mohave Mesa area, Arizona.—Continued

[**Site ID:** 15-digit numeric identifier in U.S. Geological Survey National Water Information System (NWIS) database. Number is based on latitude-longitude and sequence number; **Latitude and Longitude:** Expressed in degrees, minutes, and decimal seconds; **Land-net location:** Refer to description in text; **Water-level accuracy:** 0, feet; 1, 0.1 foot; 2, 0.01 foot; **Water-level status:** R, recently pumped; T, nearby recently pumped; S, nearby pumping; **Water-level method:** S, steel tape; V, calibrated electric tape; R, reported; **Water-level elevation:** Determined by difference between land-surface elevation at well and depth to water below land surface; **Elevation of accounting surface:** Refer to description in text; **Difference in elevation:** Determined by subtracting elevation of accounting surface from water-level elevation at each well]

Map ID	Site ID	Water level (feet below land surface)	Water-level accuracy	Water-level status	Water-level method	Water-level elevation (feet above sea level)	Elevation of accounting surface (feet above sea level)	Difference in elevation (feet)
1	345810114314801	391.55	2		V	468.6	470.8	-2.2
2	345812114340601	110.7	1		R	462.5	471.4	-8.9
3	345815114322001	339	2		V	463.1	471.0	-7.9
4	345816114315401	380.46	2		V	470.7	470.9	-.2
		380	0		R			
5	345817114321001	349.6	2		V	470.5	470.9	-.4
6	345829114314301	414.31	2	T	V	468.8	471.1	-2.3
		410	0		R			
7	345848114315501	396.16	2		V	469.7	471.7	-2.0
		411	0		R			
8	345911114352401	71.41	2		V	461.5	472.8	-11.3
9	345922114352301	75.51	2		V	463.1	473.0	-9.9
10	345944114352801	75.64	2		V	463.3	473.4	-10.1
11	345948114354001	73.08	2		V	465.5	473.6	-8.1
12	350004114345501	102.9	2	R	V	466.4	473.8	-7.4
13	350023114352101	95.85	2	R	V	465.4	474.3	-8.9
14	350030114353301	87.89	2		S			
		87.9	2		S	465.4	474.5	-9.1
15	350031114354601	78.16	2		V	467.0	474.5	-7.5
16	350034114353201	89.48	2		V	466.6	474.5	-7.9
17	350139114360401	84.12	2	S	V	468.5	476.2	-7.7
18	350147114362001	76.35	2		V	469.3	476.5	-7.2
19	350148114355101	123.5	2		S			
		122.49	2		V			
		125.45	2		V	468.6	476.5	-7.9
20	350152114361401	80.31	2		V	469.3	476.5	-7.2
		78	0		R			
21	350157114360801	85.34	2	R	V	469.6	476.7	-7.1
22	350157114360802	85.34	2	R	V	468.9	476.7	-7.8
23	350200114331201	379.06	2		V	466.0	476.8	-10.8
24	350206114360701	86.47	2	R	V	469.2	476.7	-7.5
25	350210114352401	167.08	2	R	S			
		167.1	2	R	S	468.2	477.0	-8.8
26	350220114352701	160.98	2		V	469.6	477.2	-7.6
27	350618114360501	109.89	2		S	478.3	489.3	-11.0
28	350618114360301	122.25	2		V	480.7	490.6	-9.9
29	350649114340001	229.1	2		V	485.1	493.9	-8.8
30	350649114344901	215.58	2		V	485.4	494.4	-9.0
31	350728114330001	339.51	2		S	491.3	496.8	-5.5
32	350758114323601	373.31	2		V	487.3	498.1	-10.8
33	350833114314601	629.07	2		V	492.3	498.4	-6.1
34	350951114331001	199.18	2		V	497.0	501.6	-4.6
35	351015114305901	731.28	2		V	493.8	500.4	-6.6

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Spangler and others—**Geographic Information System Methods, Colorado River, Vidal and Chemehuevi, California, and Mohave Mesa, Arizona**—Scientific Investigations Report 2007–5284