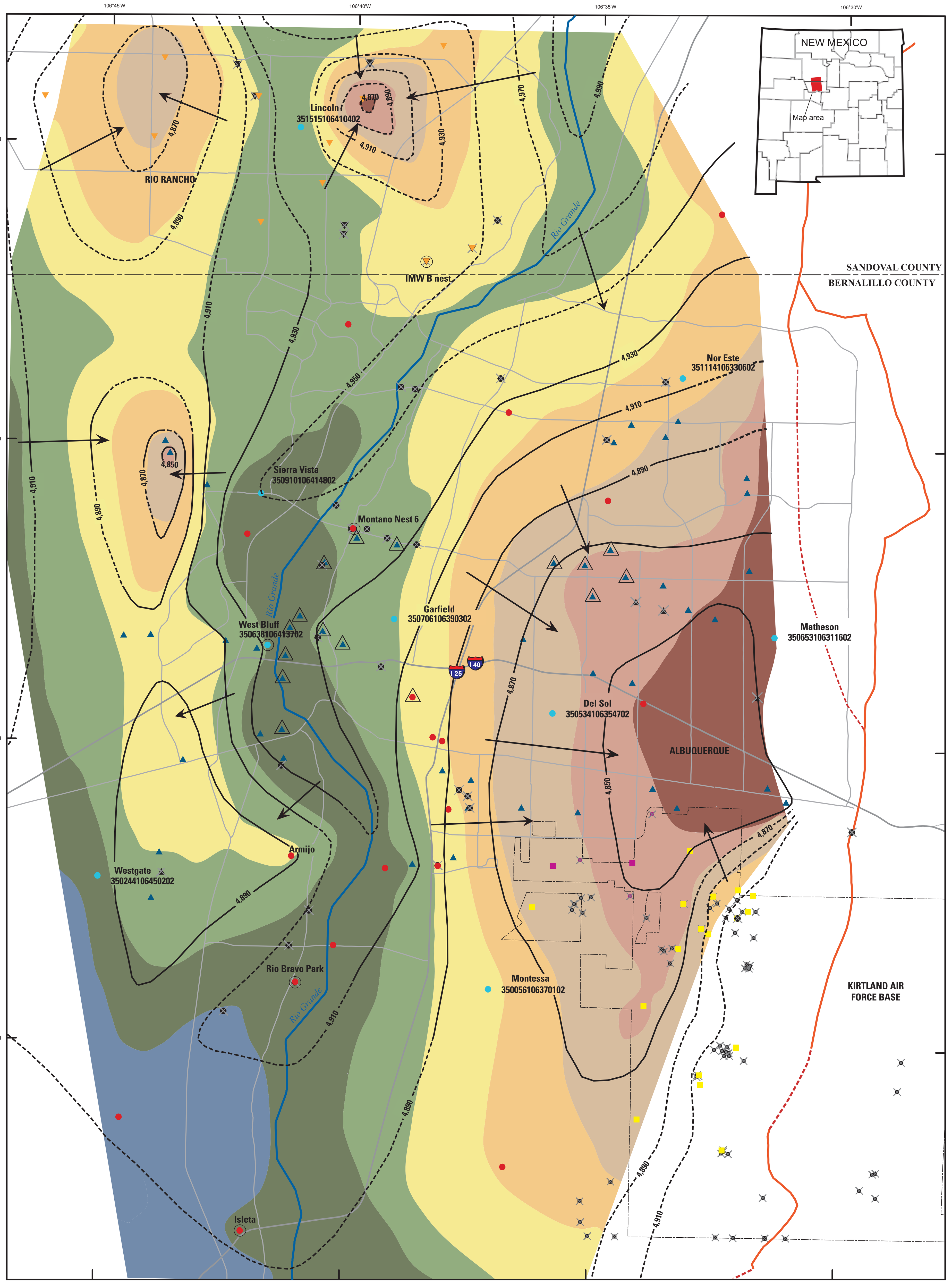
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
Albuquerque Bernalillo County Water Utility Authority

Scientific Investigations Map 3162



Base from ESRI Data and Maps, 2008 World, Europe, United States, Canada, and Mexico (2008). Redlands, CA: ESRI, digital data, 1:50,000
Faults modified from Mark Hudson and Scott Minor, U.S. Geological Survey, written communication, 1999
Streams, military base, and Indian reservation boundaries from the U.S. Department of Commerce, Bureau of the Census, various years, TIGER/Line files, digital data, 1:100,000
Universal Transverse Mercator Zone 13N projection
North American Datum of 1983 and North American Vertical Datum of 1988

0 3 6 MILES
0 3 6 KILOMETERS

EXPLANATION

Estimated water-level change, in feet, predevelopment to 2008. Areas underlying dashed contour are approximate.

No decline

Declines
- 0 to 20
- 21 to 40
- 41 to 60
- 61 to 80
- 81 to 100
- 101 to 120
- More than 120

4,850 Potentiometric contour, 2008—Shows altitude at which water level would have stood in tightly cased wells, estimated 2008, interval 20 feet. Dashed where inferred. Datum is the North American Vertical Datum of 1988 (NAVD 88).

Area of apparent hydraulic discontinuity, not near a known fault, as identified by Bexfield and Anderholm (2000).

Basin-bounding fault in the area of a large hydraulic discontinuity, as identified by Bexfield and Anderholm (2000).

Approximate direction of groundwater flow.

Well used to verify the groundwater-level change.

Piezometer used to determine the difference in water level between the shallow aquifer and the production zone along the Rio Grande.

U.S. Geological Survey (USGS) water-level measurement (by steel tape or electric tape) in USGS piezometer, 2006–8.

351515106410402 Piezometer for which hydrograph is shown for period of record and USGS site identifier.

Not used in constructing the potentiometric surface: USGS water-level measurement (by steel tape or electric tape) in USGS piezometer, 2006–8.

USGS water-level measurement (by steel tape or electric tape) in Albuquerque Bernalillo County Water Utility Authority supply well, 2006–8.

Not used in constructing the potentiometric surface: USGS water-level measurement (by steel tape or electric tape) in Albuquerque Bernalillo County Water Utility Authority supply well, 2006–8.

City of Rio Rancho water-level measurement (by airline) in City of Rio Rancho supply well, 2008.

Not used in constructing the potentiometric surface: City of Rio Rancho water-level measurement (by airline) in City of Rio Rancho supply well, 2008.

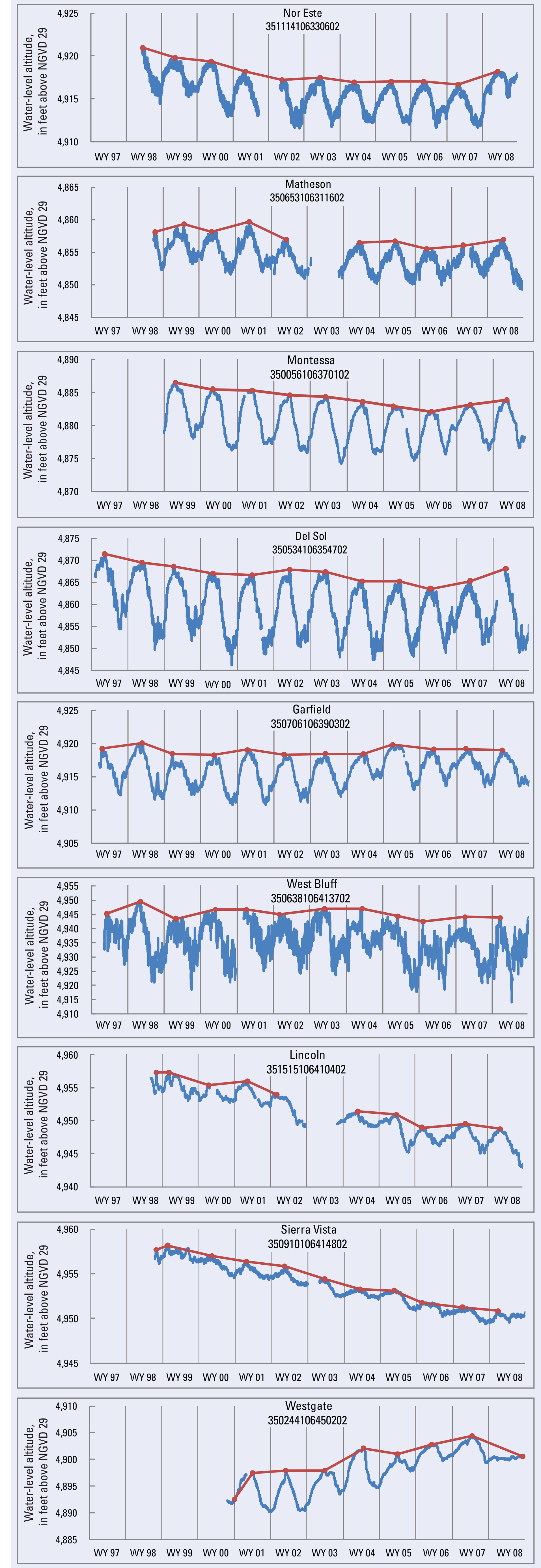
Sandia National Laboratories (SNL) or Kirtland Air Force Base (KAFB) water-level measurement (by steel tape or electric tape) in SNL and KAFB piezometer.

Not used in constructing the potentiometric surface: SNL or KAFB water-level measurement (by steel tape or electric tape) in SNL and KAFB piezometer.

KAFB water-level measurement (by airline) in KAFB supply well.

Not used in constructing the potentiometric surface: KAFB water-level measurement (by airline) in KAFB supply well.

Figure 1. Map showing estimated 2008 potentiometric surface and water-level change, predevelopment to 2008.



EXPLANATION

Altitude of the annual highest water level, in feet above National Geodetic Vertical Datum of 1929 (NGVD 29).

Daily mean water-level altitude, in feet above NGVD 29.

U.S. Geological Survey site identifier is shown with piezometer nest name.

WY, water year.

Figure 2. Hydrographs for selected piezometers (locations shown on fig. 1).

Abstract

The water-supply requirements of the Albuquerque metropolitan area of central New Mexico have historically been met almost exclusively by groundwater withdrawal from the Santa Fe Group aquifer system. Previous studies have indicated that the large quantity of groundwater withdrawal relative to recharge has resulted in water-level declines in the aquifer system throughout the metropolitan area. Analysis of the magnitude and pattern of water-level change can help improve understanding of how the groundwater system responds to withdrawals and variations in the management of the water supply and can support water-management agencies' efforts to minimize future water-level declines and improve sustainability. This report, prepared by the U.S. Geological Survey in cooperation with the Albuquerque Bernalillo County Water Utility Authority, presents the estimated groundwater potentiometric surface during winter (from December to March) of the 2008 water year (WY 08) and the estimated changes in water levels between predevelopment and WY 08 for the production zone of the Santa Fe Group aquifer system in the Albuquerque and surrounding metropolitan and military areas. Hydrographs from selected wells are included to provide details of historical water-level changes.

In general, water-level measurements used for this report were measured in small-diameter observation wells screened over short intervals and were considered to best represent the potentiometric head in the production zone—the interval of the aquifer, about 300 feet below land surface to 1,100 feet or more below land surface, in which production wells generally are screened. Water-level measurements were collected by various local and Federal agencies. The WY 08 potentiometric surface map was created in a geographic information system, and the change in water-level elevation from predevelopment to WY 08 was calculated. The 2008 water-level contours indicate that the general direction of groundwater flow is from the Rio Grande towards clusters of production wells in the east, north, and west. Water-level changes from predevelopment to 2008 are variable across the area. Hydrographs from piezometers on the east side of the river generally indicate a trend of decline in the annual highest water level through most of the period of record. Hydrographs from piezometers in the valley near the river and on the west side of the river indicate spatial variability in water-level trends.

Introduction

The water-supply requirements of the Albuquerque metropolitan area of central New Mexico have historically been met almost exclusively by groundwater withdrawal from the Santa Fe Group aquifer system. The large quantity of groundwater withdrawal relative to recharge has resulted in water-level declines in the aquifer system throughout the metropolitan area (Bexfield and Anderholm, 2002a). Analysis of the magnitude and pattern of water-level change can help improve understanding of how the groundwater system responds to withdrawals and variations in the management of the water supply and can support water-management agencies' efforts to minimize future water-level declines and improve sustainability.

In response to groundwater declines, the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) has implemented a strategy to obtain and develop sustainable sources of water for municipal use (ABCWUA, 2007). The principal components of this strategy include development of renewable surface-water allocations as the primary municipal supply, establishment of a groundwater reserve for times of drought, increased use of water-conservation measures to reduce water consumption, and regional water-resource planning and management. The ABCWUA started treatment and distribution of surface water for municipal supply after completion of the San Juan-Chama Drinking Water Project in December 2008. Groundwater withdrawal will gradually be reduced by increasing distribution and use of treated surface water to provide 90 percent of the municipal supply (ABCWUA, 2009).

Purpose and Scope

This report, prepared by the U.S. Geological Survey (USGS) in cooperation with the ABCWUA, presents the estimated groundwater potentiometric surface during winter (from December to March) of the 2008 water year (WY; a water year is the 12-month period of October 1 through September 30 designated by the calendar year in which it ends) and the estimated changes in water levels between predevelopment (as could best be judged by Bexfield and Anderholm [2000] on the basis of pre-1961 water levels in the Albuquerque area) and WY 08 for the production zone of the Santa Fe Group aquifer system in the Albuquerque and surrounding metropolitan and military areas. Hydrographs from selected wells are included to provide details of historical water-level changes.

Acknowledgments

The authors thank John Stomp of the ABCWUA for guidance and support of this investigation to improve understanding of the water resources of the Albuquerque area. Various Federal and local agencies are acknowledged for providing data for this report. Specifically, Mick Jakymiw with the City of Rio Rancho Department of Public Works Utilities Operation Division provided water-level data for production and monitoring wells; the data were collected by personnel of the City of Rio Rancho. Harold Greear, Daniel Garcia, and Bagher Dayyani with the ABCWUA provided assistance with access to wells. Mark Dazell with Kirtland Air Force Base (KAFB) provided water-level data for the production wells at KAFB; the data were collected by personnel of KAFB. Franz Lauffer with Sandia National Laboratories (SNL) provided water-level data for monitoring wells located at KAFB; the data were collected by personnel of SNL and KAFB.

The authors thank Joseph Beman of the USGS for making measurements of water levels in the ABCWUA production wells and the USGS piezometers.

Data Sources

The accuracy of water-level elevations used in this report is related to the methods used to determine the elevation of land surface and to measure the depth to water in the well. Water-level elevations are calculated as the difference between the land-surface elevation and the measured depth to water. Land-surface elevations were determined by the USGS by estimating from 7.5-minute topographic quadrangle maps or Global Positioning System methods or were determined by the agency reporting the water level. All elevations were assumed to be accurate to within plus or minus 5 feet (ft), the accuracy of the likely least accurate method (estimation from 10-ft land-surface elevation contours from 7.5-minute topographic quadrangle maps).

Depths to water in wells were measured by using a steel tape, an electric tape, or an airline. The standard USGS procedure for water-level measurement is done by using a steel tape (Sweet and others, 1990), which is generally considered accurate to plus or minus 0.01 ft (Sweet and others, 1990; Dalton and others, 1991). Thermal expansion and stretching of the steel tape at depths greater than 1,000 ft can reduce the accuracy (Garber and Koopman, 1968). Electric-tape measurements of shallow water levels conducted with a well-maintained probe are accurate to within plus or minus 0.02 ft (Dalton and others, 1991). Wear of the tape and the probe, kinks in the tape, and stretching of the tape with increased depth can reduce the accuracy to plus or minus 0.1 ft (Barcelona and others, 1985; Dalton and others, 1991). Airline measurements of water level by determination of the pressure required to displace the water from a known length of submerged tubing are accurate to as much as plus or minus 0.25 ft (Garber and Koopman, 1968; Dalton and others, 1991). The accuracy of airline measurements can be decreased by numerous factors including inaccuracies in measuring the length of the airline, gage errors, leaks, decreased water density at higher temperature, and increased water density with increased salinity (Garber and Koopman, 1968; Dalton and others, 1991). For this report, steel-tape and electric-tape measurements were considered accurate to within 1 ft. Airline measurements were considered accurate to within 5 ft and were used only when other data were not available, when the water levels were comparable to data for nearby wells, and when water levels from the well did not show erratic variation over the period of record.

Water-level elevations from wells and piezometers screened in the middle of the production zone (the interval of the aquifer, about 300 ft below land surface to 1,100 ft or more below land surface, in which production wells generally are screened) were considered to best represent the potentiometric head in the production zone. (The potentiometric head is the elevation at which water stands in a tightly cased well.) The water level measured at the water table can differ as much as 25 ft or more from the water level measured in deeper parts of the aquifer; generally the potentiometric-head gradient is downward in the central and western parts of Albuquerque and upward in the eastern part of Albuquerque (Bexfield and Anderholm, 2002a). In general, piezometers used for this report were small-diameter observation wells screened over short intervals (5–20 ft) and screened near the middle of the production zone (except for piezometers located at KAFB, described later in this section).

Water-level measurements used for this report, collected from WY 06 to WY 09, were determined to be comparable despite the span of time between measurements because errors caused by comparing water-level measurements collected over approximately 4 years are nearly equivalent to the variation in measured water levels for the same year in wells having long screened intervals. The water levels measured in nested piezometers that span the length of long screened intervals in nearby production wells can vary by 10 ft or more (Bexfield and Anderholm, 2002a). Additionally, water-level measurements in piezometers in the production zone generally vary 1–2 ft per year.

Water-level measurements for ABCWUA production wells were made by USGS personnel as part of a program to monitor near-static water levels during times of low water demand for each well. Water levels were measured primarily in winter (a minimal number of water levels were measured in October, November, or April) and after the well had not been pumped for at least 2 weeks and the water level in the well had stabilized. Water levels were measured with a steel or electric tape. The most recently available winter water level for each well, either WY 07 or WY 08, was used in this report.

Water-level measurements for City of Rio Rancho production and monitoring wells were made by City of Rio Rancho personnel and were provided to the USGS by the City of Rio Rancho Department of Public Works Utilities Operation Division (Mick Jakymiw, City of Rio Rancho, written commun., 2008). Water levels in production wells were measured monthly after the well had not been pumped for several hours and in some cases days to months. Water levels in monitoring wells were measured monthly. Water-level measurements were made with either an airline or an electric tape. City of Rio Rancho water-level data used in this report were selected from measurements made primarily in February or March during WY 06, WY 07, or WY 08. Water-level measurements obtained with an electric tape and water-level measurements obtained after the well had not been pumped for at least a week were considered to be more accurate and representative of aquifer conditions and were given preference in the selection process.

Water-level measurements for 26 piezometer nests (4 nests are outside the area shown on the map), part of a water-level network maintained by the USGS in cooperation with the ABCWUA, were made by USGS personnel. The piezometer nests generally are located at least 1 mile (mi) from production wells to reduce the short-term effects of pumping on measured water levels. The piezometers are installed as nested wells, usually three piezometers per nest, and in most cases the screen lengths are 5−10 ft. Typically one piezometer is near the water table, one is near the middle of the production zone, and one is near the bottom of or below the production zone. Data used in this report generally were from piezometers screened near the middle of the production zone. Water-level measurements were made with an electric or steel tape. Water-level data were selected from measurements made in winter months during WY 07 or WY 08.

Continuous water-level data were collected by using pressure transducers at piezometer nests as part of the monitoring network (Beman, 2009). Continuous water-level data for the period of record through WY 08 (Beman, 2009) are used in this report to evaluate trends in groundwater levels. The data were collected hourly by using differential pressure transducers and dataloggers and following USGS guidelines described in Freeman and others (2004; Joe E. Beman, oral commun., 2010). The piezometer nests were visited every 4–8 weeks, at which times water-level data were downloaded from the dataloggers and check measurements of water level were obtained (Joe E. Beman, written commun., 2010).

Water-level measurements for 18 piezometers located on KAFB were made by KAFB or SNL personnel and were provided to the USGS by SNL (Franz Lauffer, SNL, written commun., 2009). The piezometers installed by SNL generally are screened near the water table in the upper part of the aquifer. Water levels were usually measured three or four times a year and were measured with an electric or steel tape. Water-level data were selected from measurements made in winter months during WY 07, WY 08, or WY 09.

Water-level measurements for two supply wells located on KAFB were made by KAFB personnel and were provided to the USGS by KAFB (Mark Dazell, KAFB, written commun., 2009). Water levels were measured monthly with an airline after the well had not been pumped for approximately 3 days. Water-level data were selected from measurements made in winter WY 08.

For areas near the Rio Grande, few water-level measurements were available in the production zone; therefore, riverbed elevations and water-level differences at five nested piezometer sites located near the river (Isleta, Rio Bravo Park, West Bluff, Montano Nest 6, and IMW B nest) were used to estimate water-level elevations. Water-level measurements from a piezometer screened across the shallow aquifer and another screened across the production zone were compared to estimate the difference in potentiometric head between the shallow aquifer and the production zone. The potentiometric-head difference between the shallow aquifer and the production zones was then linearly interpolated along the length of the river at 1-mi intervals. Potentiometric heads in the shallow aquifer were 6 ft to more than 25 ft higher than hydraulic heads in the production zone (Beman, 2009). Assuming that the river and the shallow aquifer have a good hydraulic connection and that the altitude of the riverbed is representative of the potentiometric head in the shallow aquifer, an estimated altitude of the water level in the production zone was calculated as the difference between the riverbed elevation and the production-zone groundwater-head elevation along the river.

Methods for Estimating Water-Level Contours and Water-Level Change

The WY 08 potentiometric-surface map (fig. 1) was created in a geographic information system (GIS). Well locations were plotted, and the water-level elevation data were hand contoured in the GIS. Water-level contours were converted to a gridded surface by using a spline interpolation technique that requires the surface to exactly match the water-level elevation along the contour and to have minimum curvature; the technique was modified to better constrain the surface to the sample data range (Environmental Systems Research Institute, Inc., 2009). Water-level elevations from the WY 08 estimated potentiometric surface and the predevelopment potentiometric surface of Bexfield and Anderholm (2000) were interpolated onto a grid of points spaced at 1,640-ft intervals. The change in water-level elevation from predevelopment to WY 08 was then calculated for each grid point. A surface of the calculated change in water level was generated from the gridded points by using the spline interpolator technique. Paired predevelopment and WY 08 water-level measurements from 16 wells were used to verify the calculated water-level change. The areas for which the potentiometric surface and the estimated water-level change are shown on the map were selected to focus on areas where the most data were available, and in general, boundaries were selected to exclude areas where water-level measurements were too sparse. The eastern edge of the contoured area was selected with the intent of excluding the area east of where Bexfield and Anderholm (2000) indicated the existence of hydraulic discontinuities, probably associated with major faults, where water levels would not be representative of the production zone.

The areas of water-level change presented on this map (fig. 1) are intended to provide only reasonable estimates of the general magnitude, extent, and areal pattern of water-level change in the production zone of the Santa Fe Group aquifer system. Because of the degree of variability and accuracy of the data and the error introduced by the comparison of interpolated values on a discrete grid, the boundaries shown between intervals of water-level change are not precisely located. Therefore, it is not appropriate to use this map to estimate the exact water-level change at an individual location.

Hydrographs

Hydrographs for the period of record from selected piezometers (fig. 2) were examined visually for trends in groundwater levels. Hydrographs from the selected piezometers indicate seasonal variation in water levels that is related to withdrawals from nearby production wells; in general, water levels decline during summer months when withdrawals are larger and increase during winter months when withdrawals are smaller.

Hydrographs from piezometers on the east side of the river (Nor Este, Matheson, Montessa, and Del Sol) generally indicate a decline in the annual highest water level (AHWL) through most of the period of record. The hydrograph from the Nor Este piezometer indicates an increase in AHWL starting in WY 08, and hydrographs from the other selected piezometers indicate an increase in AHWL starting in WY 07.

Hydrographs from piezometers in the valley near the river (Garfield and West Bluff) and on the west side of the river (Lincoln, Sierra Vista, and Westgate) indicate spatial variability in water-level trends. Hydrographs from the Garfield and West Bluff piezometers indicate no consistent trends in the AHWL, with intervals of increasing and declining AHWL; Garfield indicates less variability in AHWL than West Bluff. Hydrographs from the Lincoln and Sierra Vista piezometers indicate a trend of almost steady decline in AHWL; Lincoln indicates small increase in WY 01 and WY 07. The hydrographs from the Westgate piezometer indicate an increase in AHWL for the period of record except for WY 05 and WY 08.

Groundwater Flow and Water-Level Changes

The 2008 water-level contours indicate that the general direction of groundwater flow is from the Rio Grande towards clusters of production wells in the east, north, and west. Steep hydraulic gradients are present along the eastern margin of the Albuquerque metropolitan area (as much as 0.036 ft/ft), near production wells in the northwest (as much as 0.028 ft/ft), and west of the river between the Armijo and Sierra Vista monitoring wells (as much as 0.027 ft/ft). Historically, groundwater in the mapped area flowed from north to south-southwest on the east side of the Rio Grande and from northeast to southwest on the west side of the Rio Grande (Bexfield and Anderholm, 2000). Predevelopment hydraulic gradients were as much as 0.028 ft/ft in the northwest and as much as 0.0025 ft/ft in the valley along the river (calculated from Bexfield and Anderholm, 2000) Water-level changes from predevelopment to 2008 are variable across the basin. Water-level changes are smallest in the southwestern part of the study area, where groundwater withdrawals are minimal, and along the Rio Grande, where recharge from the river is occurring. Water-level changes are largest along the eastern margin of the study area (decline of more than 120 ft) and in the northwest (decline of more than 100 ft). Groundwater declines along the eastern margin of the study area are likely amplified by the proximity of clusters of production wells to basin-bounding faults that are the boundary between the large thickness of the higher permeability basin-fill sediments and the reduced thickness of basin-fill sediments overlying bedrock along the margin of the basin (Connell, 2006). Groundwater declines in the western and northwestern part of the basin are likely the effect of pumping stresses; however, faulting and the resulting juxtaposition of lithologic units with different hydrologic properties likely increase the declines in water levels from withdrawals (Heywood and others, 2002, p. 15–16; McAda and Barroll, 2002, p. 38–46). Water-level declines along the river north of the Sierra Vista piezometer likely result from greater groundwater withdrawals in the north and propagation of water-level declines outward from clusters of production wells.

Similar to predevelopment to WY 08 water-level changes, changes in groundwater levels from 2000 (mapped by Bexfield and Anderholm, 2002b) to 2008 indicate continued declines in water level in most areas across the basin. Areas of greater declines west of the Rio Grande are primarily in the north coincident with clusters of production wells and are in accord with the hydrographs from piezometers located in the area (Lincoln and Sierra Vista). Areas of decline east of the river are primarily along the eastern basin margin and are in accord with hydrographs indicating a decline from 2000 to 2008; however, hydrographs from wells east of the river also indicate recent rises in water level that possibly represent a reversal in the trend of declining water levels. Some minor differences in mapped groundwater conditions from 2000 to 2008 are the result of mapping techniques and changes in the availability of water-level data.

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Estimated 2008 Groundwater Potentiometric Surface and Predevelopment to 2008 Water-Level Change in the Santa Fe Group Aquifer System in the Albuquerque Area, Central New Mexico

By
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2011

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