Water Availability and Use Science Program

Altitude of the Potentiometric Surface in the Mississippi River Valley Alluvial Aquifer, Spring 2020

Pamphlet to accompany

Scientific Investigations Map 3478

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

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By Virginia L. McGuire, Ronald C. Seanor, William H. Asquith, Kellan R. Strauch, Anna M. Nottmeier, Judith C. Thomas, Roland W. Tollett, and Wade H. Kress

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
section (640 acres or 1 square mile)	259.0	square hectometer (hm^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Datum

Horizontal coordinate information is referenced to the World Geodetic Survey of 1984 (WGS 84). Historical data collected and stored as North American Datum of 1927 (NAD 27) or the North American Datum of 1983 (NAD 83) have been converted to WGS 84 for use in this publication.

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88). Historical data collected and stored as National Geodetic Vertical Datum of 1929 (NGVD 29) have been converted to NAVD 88 for use in this publication.

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

Abbreviations

GIS	geographic information system
MAP	Mississippi Alluvial Plain
MRVA	Mississippi River Valley alluvial aquifer
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
RMSE	root mean square error
USGS	U.S. Geological Survey

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Introduction

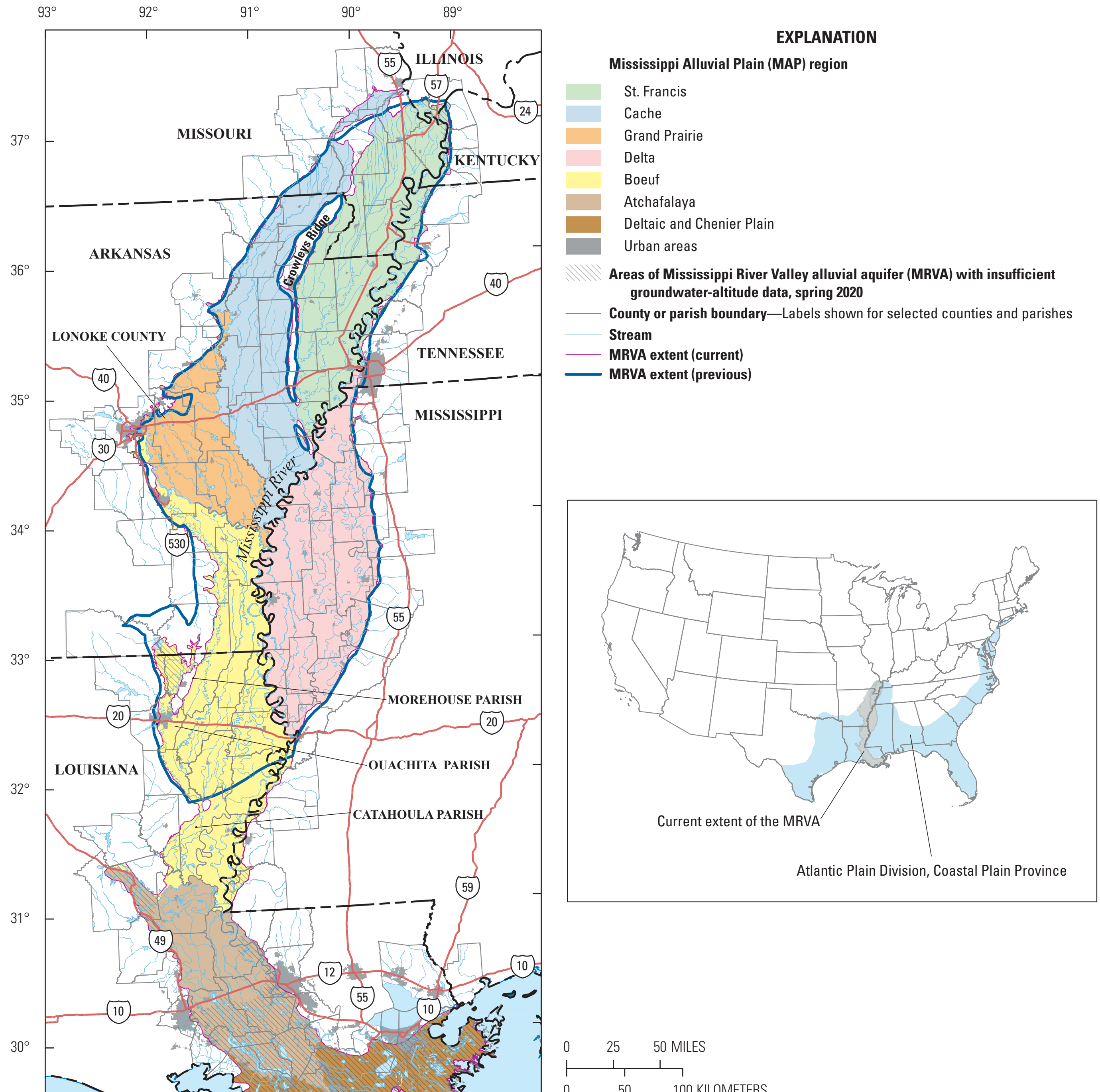
The Mississippi River Valley alluvial aquifer (MRVA) is an important surficial aquifer in the Mississippi Alluvial Plain (MAP) area (fig. 1). The aquifer is generally considered to be an unconfined aquifer (Clark and others, 2011), and withdrawals are primarily used for irrigation (Lovelace and others, 2020). These groundwater withdrawals have resulted in substantial areas of water-level decline in parts of the aquifer. Concerns about water-level declines and the sustainability of the MRVA have prompted the U.S. Geological Survey (USGS), as part of the USGS Water Availability and Use Science Program and with assistance from other Federal, State, and local agencies, to undertake a regional water-availability study to assess the characteristics of the MRVA, including creation of a map of the potentiometric surface of the MRVA for spring 2020, and to provide information to water managers to inform their decisions about resource allocations and aquifer sustainability.

The purpose of this report is to present a potentiometric-surface map for the MRVA. The source data for the map were groundwater-altitude data from wells measured manually or continuously generally in spring 2020 and from the altitude of the top of the water surface (hereinafter referred to as "surface-water altitude") measured generally on April 9, 2020, in rivers in the area.

The term "potentiometric surface" is applicable for maps of the groundwater-altitude surface in unconfined, semiconfined, and confined aquifers (Lohman, 1972). The MRVA generally exhibits characteristics of unconfined conditions, where surface-water features may or may not be hydraulically connected to the aquifer, but it also exhibits characteristics of confined or semiconfined conditions in some areas at least during part of the year. The location of these areas, where the aquifer is confined or semiconfined, have been assessed by various authors in parts of the MRVA but applicable datasets, suitable for use in this potentiometric surface map, were not found and therefore were not included in this study.

Previously published potentiometric-surface maps for a large part of the MRVA include maps from water levels measured from 1953 to 1961 (Krinitzsky and Wire, 1964), for 1964 (Boswell and others, 1968), and for 2016 and 2018 (McGuire and others, 2019, 2020). Previously published potentiometric-surface maps for parts of the MRVA include maps for the Grand Prairie region in Arkansas in 1929, 1939, and 1959 (Engler and others, 1963) and selected counties in northeast and central Arkansas in 1965 and 1966 (Albin and others, 1967; Plebuch and Hines, 1967); the entire aquifer area in Arkansas for 1972, 1980, 1983, 1984, 1985, 1986, 1987, 1989, 1992, 1994, 1996, 1998, 2000, 2002, 2004, 2006, 2008, and 2012 (Ackerman, 1989; Edds and Fitzpatrick, 1984; Joseph, 1999; Plafcan and Edds, 1986; Plafcan and Fugitt, 1987; Plafcan and Remsing, 1989; Reed, 2004; Schrader, 2001, 2006, 2008, 2010, 2015; Stanton and others, 1998; Westerfield, 1990; Westerfield and Gonthier, 1993; Westerfield and Poynter, 1994); the aquifer area in northwestern Mississippi for various years including 1976, 1980, 1981, 1982, and 1983 (Dalsin, 1978; Darden, 1981, 1982a, 1982b, 1983; James Hoffmann, Mississippi Department of Environmental Quality, written commun., 2018; Sumner, 1984, 1985; Wasson, 1980); the entire aquifer area in Missouri for 1976 (Miller and Appel, 1997); and the part of the aquifer in northeastern Louisiana for 1990 (Seanor and Smoot, 1995). The previously published potentiometric-surface maps that were used in this study were McGuire and others (2019, 2020), Miller and Appel (1997), Seanor and Smoot (1995), and Schrader (2015).

To best reflect hydrologic conditions in the MRVA, the groundwater altitudes used to create the 2020 potentiometric-surface map would be measured in a short timeframe of days or 1 or 2 week(s) and there would be available data (for example, from sets of wells, with short [5 to 10 feet (ft)] screens, installed near the top, in the middle, and near the bottom of the aquifer) to indicate vertical flow components (Fetter, 2001; Freeze and Cherry, 1979). However, the measurement timing for many wells was determined by the needs and schedules of the entities doing the measurements instead of the preferred schedule for a regional potentiometric-surface map. Many of the measured wells also have longer (greater than 10 ft) screens, so these water-level measurements tend to represent a mean hydraulic head in the aquifer for that location (Fetter, 2001). For this report, recognizing the limitations of the available data, it was decided to assess all available groundwater-altitude data from wells measured from January 21 to June 17,



Previous extent of the MRVA (U.S. Geological Survey, 2015)
Current extent of the MRVA (Painter and Westerman, 2018)
Physiographic divisions (Fenneman and Johnson, 1946; U.S. Geological Survey, 2004)
MAP regions (Ladd and Travers, 2019)

Base from U.S. Geological Survey digital data, 1:1,000,000 and 1:2,000,000, variously dated
Highways from National Highway Planning Network, various scales, 2014
Urban areas from U.S. Census Bureau, 1:500,000, 2016
Albers National Hydrogeologic Grid projection
Standard parallels 45°30′ N. and 29°30′ N., central meridian 96°00′ W.
World Geodetic Survey of 1984

Figure 1. Previous and current extent of the Mississippi River Valley alluvial aquifer (MRVA) and areas with insufficient groundwater-altitude data to map the potentiometric surface for spring 2020.

2020, for use in the potentiometric-surface map for spring 2020. The resultant potentiometric-surface map would then represent the generalized central tendency for spring 2020, but it would not be useful for some purposes, such as for calibration of a groundwater-flow model for early April 2020 or for some local scale assessments.

Study Area Description

The current (2020) extent of the MRVA is defined to be the same as the boundary of the MAP physiographic division, which is a revision of the aquifer extent used in previous studies (fig. 1; Ackerman, 1996; Clark and others, 2011; Painter and Westerman, 2018; and U.S. Geological Survey, 2015). The MRVA underlies an area of approximately 43,800 square miles (mi^2) in parts of seven States—Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee (fig. 1; Painter and Westerman, 2018).

The MRVA primarily underlies the MAP section within the Atlantic Plain Division, Coastal Plain Physiographic Province (fig. 1; Fenneman and Johnson, 1946; U.S. Geological Survey, 2004). The MRVA extends about 560 miles (mi) north to south from southeastern Missouri and Illinois and southwestern Kentucky to the southern boundary of Louisiana. The width of the MRVA ranges from about 35 mi in northeast Louisiana and southwest Mississippi to 134 mi in southern Louisiana. The Mississippi River (fig. 1) is within the MRVA boundary except in southeast Louisiana, where the river is north of the MRVA boundary and instead overlies aquifers in Pleistocene-aged deposits (Smoot, 1986). Where the Mississippi River is within the MRVA boundary, the river is along the eastern boundary of the northern and southern part of the aquifer; in the central part of the MRVA, the Mississippi River curves toward the middle of the aquifer at the northwest boundary of Mississippi before curving back toward the eastern boundary of the aquifer about 50 mi south of the northeast boundary of Louisiana (fig. 1).

The MRVA is contained in Quaternary-age sand, gravel, silt, and clay deposits overlying Tertiary-age units (Clark and others, 2011; Hosman and Weiss, 1991; Saucier, 1994). In some areas, the MRVA is overlain by a Quaternary-age confining unit of silt and clay; where present, this confining unit impedes recharge to the MRVA (Ackerman, 1989; Boswell and others, 1968; Kleiss and others, 2000). There are four areas within the MAP extent where the MRVA is not present (fig. 1; Painter and Westerman, 2018). The two northernmost areas, in northeastern Arkansas and southeastern Missouri, which are termed "Crowleys Ridge," are erosional remnants of Tertiary-age deposits of clay, silt, sand, and lignite, overlaid by Quaternary-age sand and gravel, and capped by Quaternary-age loess (fig. 1; Guccione and others, 1986; McFarland, 2004). The combined area of the two Crowleys Ridge parts is about 1,053 mi^2; the combined length of the two parts of Crowleys Ridge is about 185 mi and the width ranges from less than a mile to about 21 mi. Crowleys Ridge forms a physical barrier to groundwater flow in the MRVA (Kresse and others, 2014; Schrader, 2008, 2010, 2015). Two other areas where the aquifer is not present are an upland area of about 128 mi^2 in northeastern Louisiana in the center of Morehouse Parish and the northeastern part of Ouachita Parish, and an upland area of about 21 mi^2 in the north-central part of Catahoula Parish (fig. 1; Saucier, 1994).

Groundwater withdrawals from the MRVA in 2015 were 12,100 million gallons per day, making it the second most heavily pumped aquifer in the Nation. Ninety-seven percent of total withdrawals in 2015 were for irrigation (Lovelace and others, 2020).

Data and Methods

The 2020 potentiometric-surface raster and associated contours were created by interpolating the groundwater-altitude data from wells and surface-water-altitude data from streamgages into a raster dataset (grid with a uniform cell size and hereinafter referred to as a "raster"), converting the resultant raster to contours, manually modifying some of the contours, conducting spatial analysis, and generating outputs using a geographic information system (GIS) software (Esri® ArcMap, version 10.7; Esri, 2018). The GIS tool, topo to raster (Esri, 2021a), was used to interpolate the water-level altitude data from selected wells and streamgages (McGuire and others, 2021), which is the same method used for the 2016 and 2018 potentiometric-surface maps (McGuire and others, 2019, 2020). The topo to raster tool is an interpolation method designed for the creation of hydrologically correct digital elevation models. The topo to raster tool (Esri, 2021b) is based on the ANUDEM program, version 5.3 (Hutchinson, 1988, 1989, 1996, and 2000; Hutchinson and others, 2011). The GIS tool, point density, was used to designate areas with estimated contours for the 2020 potentiometric-surface map (Esri, 2021a); this is not the same method used to identify estimated contours in the 2016 and 2018 potentiometric-surface maps (McGuire and others, 2019, 2020). For the 2016 and 2018 potentiometric-surface maps, the estimated contours were identified manually by qualitatively assessing the amount of available groundwater and surface-water data in the vicinity of the contour. For spring 2020, the point shapefiles of groundwater- and surface-water-altitude data, raster files of the potentiometric-surface map, and shapefile of the potentiometric-surface-altitude contours are available in a USGS data release (McGuire and others, 2021).

Water-Level Data

Groundwater-altitude data were compiled by the USGS (table 1; McGuire and others, 2021; U.S. Geological Survey, 2020a) from 1,237 wells completed in the MRVA and measured either manually in the time period from January 21 to

Table 1. Total number of wells that were completed in the Mississippi River Valley alluvial aquifer and measured manually one or more times or continually for spring 2020, and the subset of these wells whose groundwater-altitude data were used to generate the potentiometric-surface map for the Mississippi River Valley alluvial aquifer, spring 2020, by Mississippi Alluvial Plain region (Ladd and Travers, 2019; U.S. Geological Survey, 2020a).

[MAP, Mississippi Alluvial Plain; MRVA, Mississippi River Valley alluvial aquifer; --, no data]

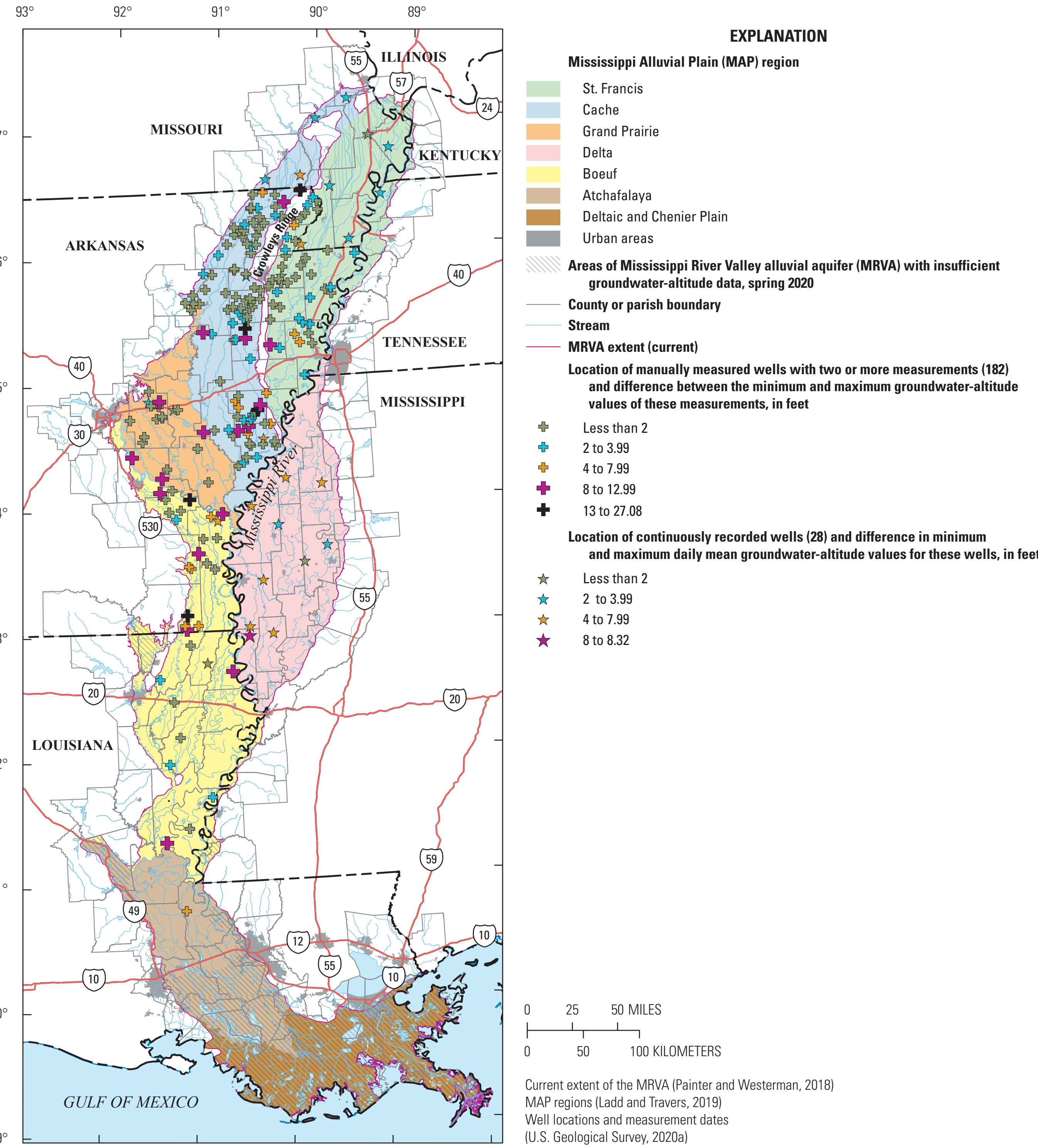
MAP Region	Total number of wells measured manually, pre-irrigation season, 2020	Total number of wells measured continually, pre-irrigation season, 2020	Number of wells measured manually and used in the potentiometric-surface map, MRVA, spring 2020	Number of wells measured continually and used in the potentiometric-surface map, MRVA, spring 2020	Total number of wells used to generate the potentiometric-surface map, MRVA, spring 2020
St. Francis	163	7	156	7	163
Cache	249	7	244	7	251
Grand Prairie	134	2	132	2	134
Delta	455	11	455	10	465
Boeuf	205	2	202	2	204
Atchafalaya	22	--	20	--	20
Deltaic and Chenier Plain	--	--	--	--	--
MRVA	1,228	29	1,209	28	1,237

June 17, 2020, or continually during all or part of the time period from January 1 to May 31, 2020. The groundwater-altitude data in wells that were manually measured one or more times are hereinafter referred to as “manually measured.” The groundwater-altitude data in wells that were measured continually for all or part of the time period are hereinafter referred to as “continually measured.” The wells were measured as part of a regular water-level monitoring program by the Arkansas Natural Resources Commission, Missouri Department of Natural Resources, U.S. Department of Agriculture Natural Resources Conservation Service, USGS, and Yazoo Mississippi Delta Joint Water Management District. Wells measured by drillers in Missouri were included in the data used to map the potentiometric surface for the MRVA in 2016 (McGuire and others, 2019) but were not included for the 2020 potentiometric-surface map because the data from 2020 were not yet available (September 2020).

The manually and continually measured water levels for wells screened in the MRVA were stored in the USGS National Water Information System database (U.S. Geological Survey, 2020a) as depth to water below land surface. For the manually and continually measured wells, the land-surface altitude, in feet, and associated vertical datum (National Geodetic Vertical Datum of 1929 [NGVD 29] or North American Vertical Datum of 1988 [NAVD 88]) were retrieved or determined for each well. If the stored land-surface altitude datum was NGVD 29, the land-surface altitude was converted to NAVD 88 using the National Geodetic Survey’s VERTCON computer program (Miller, 1999), and the measured groundwater altitude or daily mean groundwater altitude with respect to NAVD 88 was calculated for each well. Groundwater altitudes from the well’s measuring point for manually and continually measured wells are assumed to be accurate to the hundredths of a foot.

All groundwater-altitude data from manually and continually measured wells were reviewed to identify and exclude groundwater-altitude values that appeared to be affected by current or recent pumping and that were substantially different from the groundwater altitudes in nearby wells, possibly because of local or seasonal conditions. Other considerations for rejecting a well’s groundwater altitude were apparent discrepancies between the spatial location of the well and the well’s legal description or identifier and suspected inaccuracy in the land-surface altitude value. In addition, groundwater-altitude data from wells were not used for (1) wells that were flowing and could not be measured or (2) wells that were dry.

For manually measured wells with one measurement, the only available measurement was selected as the groundwater altitude to consider for use to create the potentiometric-surface map. For the 182 manually measured wells with more than one measurement and used in the 2020 potentiometric surface map, the maximum (highest) groundwater altitude for each well was selected; the difference between the maximum and minimum groundwater-altitude values ranged from 0.02 to 27.08 ft, with a median difference of 1.34 ft (fig. 2). Only two wells, in the Boeuf region in Louisiana, had three measurements; the remaining 180 wells had two measurements. The number of wells with more than one measurement by region were Cache (90 wells), St. Francis (41 wells), Boeuf (29 wells), Grand Prairie (21 wells), and Atchafalaya (1 well); the number of wells with more than one measurements by State were Arkansas (172 wells) and Louisiana (10 wells). For the



Current extent of the MRVA (Painter and Westerman, 2018)
MAP regions (Ladd and Travers, 2019)
Well locations and measurement dates
(U.S. Geological Survey, 2020a)

Base from U.S. Geological Survey digital data, 1:1,000,000 and 1:2,000,000, variously dated
Highways from National Highway Planning Network, various scales, 2014
Urban areas from U.S. Census Bureau, 1:500,000, 2016
Albers National Hydrogeologic Grid projection
Standard parallels 45°30′ N. and 29°30′ N., central meridian 96°00′ W.
World Geodetic Survey of 1984

Figure 2. Location of manually and continuously measured wells screened in the Mississippi River Valley alluvial aquifer (MRVA) with two or more groundwater-altitude values for spring 2020 and the difference between the minimum and maximum groundwater-altitude values for these wells in this time period.

wells with more than one manual measurement, the minimum and maximum measurement dates and range of groundwater-altitude values are described as follows:

- The multiple measurements for 11 wells were on the same day and the differences between the minimum and maximum groundwater altitudes were from 0.02 to 4.34 ft.

- The multiple measurements for 88 wells were less than 10 days apart, but not on the same day, and the differences between the minimum and maximum groundwater altitudes were from 0.04 to 27.08 ft.

- The multiple measurements for 83 wells were 10 days to 106 days apart and the differences between the minimum and maximum groundwater altitudes were from 0.04 to 22.05 ft.

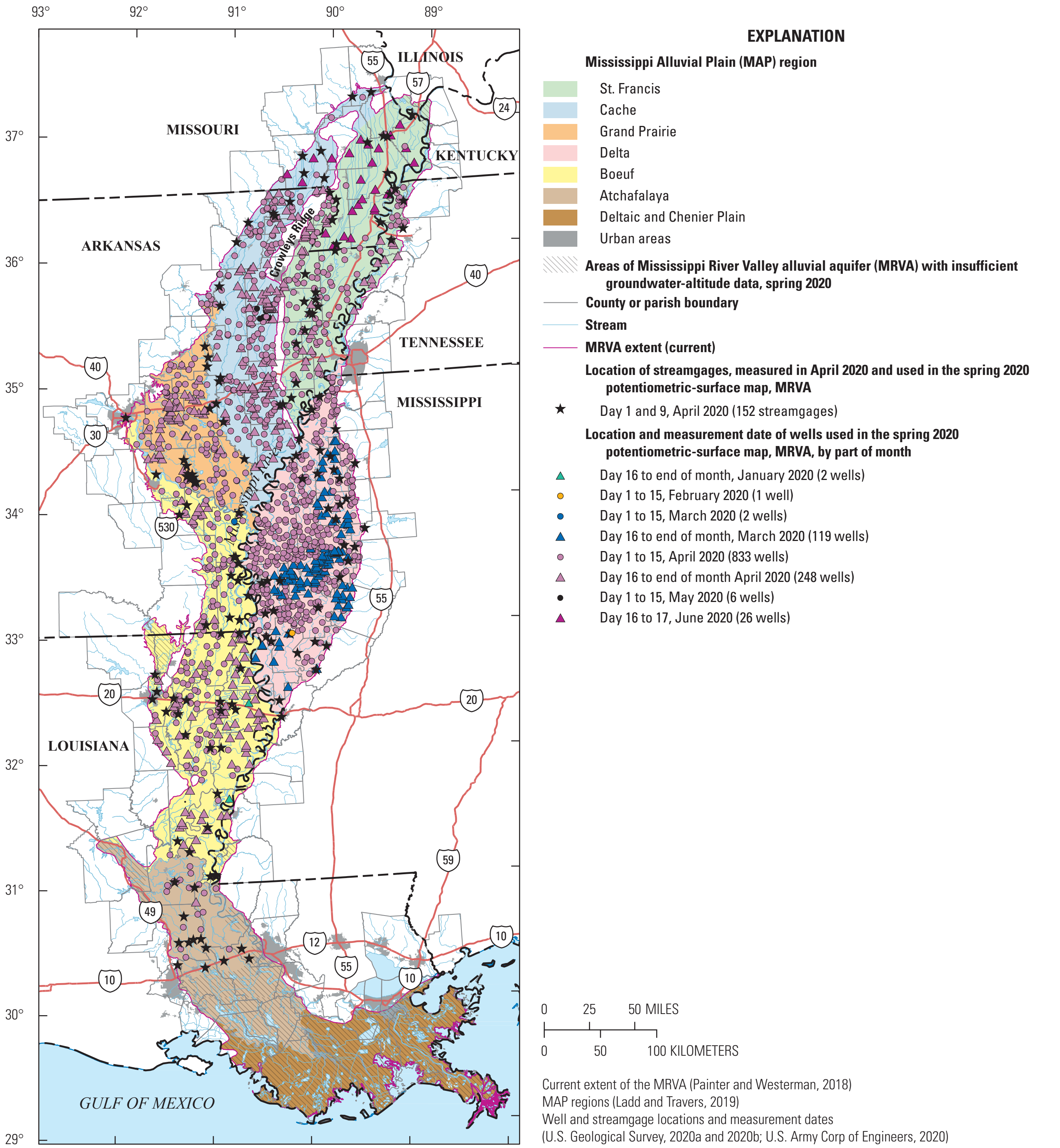
Measurement data for 29 continuously measured wells screened in the MRVA were retrieved (McGuire and others, 2021). The location and number of continuously measured wells by region were St. Francis (7 wells), Cache (7 wells), Grand Prairie (2 wells), Delta (11 wells), and Boeuf (2 wells); and by State were Arkansas (7 wells), Louisiana (1 well), Mississippi (11 wells), Missouri (9 wells), and Tennessee (1 well). One of the continuously measured wells in the Delta region in Mississippi was not used in the 2020 potentiometric surface map because the water-level altitude in this well was much higher than the water-level altitude in nearby wells. For 28 continually measured wells that were used in the 2020 potentiometric surface map, the difference between the maximum and minimum available groundwater altitude from January 1 to May 31, 2020 was from 0.90 to 8.32 ft (fig. 2; McGuire and others, 2021). The date of the minimum measurement ranged from January 1 to May 31, 2020; the date of the maximum measurement ranged from January 13 to May 31, 2020. The number of days between the minimum and maximum measurement for each well ranged from 3 to 151 days.

Groundwater-altitude data from 1,237 wells were used in the spring 2020 potentiometric-surface map (table 1; fig. 3). The minimum, maximum, mean, and median distances between the 1,237 wells were 7.2 ft, 20.5 mi, 2.5 mi, and 2.1 mi, respectively. These wells included 1,027 manually measured wells, which were measured one time; 182 manually measured wells, which were measured two or three times; and 28 continually measured wells (McGuire and others, 2021). The median measurement date for the selected manually and continually measured water levels was April 9, 2020 (table 2). When groundwater-altitude data were not available for a continually measured well on April 9, 2020, the first available daily mean groundwater altitude for that well prior to April 9, 2020, was used. For continually measured wells, the mean, and not the maximum, groundwater-altitude values were selected or calculated because that was the daily statistic that was publicly available for most continually measured wells (U.S. Geological Survey, 2020a). Following review of the data, groundwater-altitude data from 19 of 1,228 manually measured wells and 1 of 29 continually measured wells were not used in the 2020 potentiometric-surface map; in the USGS data release, these wells have the USE2020 field set to −1 and the USECMT2020 field contains the reason the groundwater-altitude data were not used (table 1; fig. 4; McGuire and others, 2021).

The distribution of measurement dates for the selected groundwater-altitude values ranged from 0 wells for the first 15 days in January 2020 to 833 wells in the first 15 days of April 2020 (fig. 3). The areas of insufficient groundwater data were assessed qualitatively using the distance between wells and by visually examining aquifer areas not included in buffers of various sizes around the wells; for this report, the area with insufficient groundwater data was defined as no wells within 12.4 mi of the center of a given cell. This distribution indicates that if only wells measured in a short timeframe, such as the first 15 days in April 2020, were used to create the 2020 potentiometric-surface map, there would be larger areas with insufficient groundwater-altitude data.

Daily mean surface-water-altitude data were assembled for 310 streamgages routinely operated by the U.S. Army Corps of Engineers and the USGS in the MRVA area (table 3; U.S. Geological Survey, 2020b; U.S. Army Corps of Engineers, 2020; McGuire and others, 2021). For this study, the streamgage altitude, in feet; the associated vertical datum (NGVD 29 or NAVD 88); and the daily mean river stage on April 9, 2020, if available or the first available value prior to April 9, 2020, were retrieved for each streamgage. If the vertical datum associated with the streamgage altitude was NGVD 29, the streamgage altitude was converted to NAVD 88 using National Geodetic Survey’s VERTCON program (Miller, 1999) for possible use to create the potentiometric-surface map.

Of the 310 streamgages considered for use in the potentiometric-surface map (table 3), a total of 158 streamgages were not used for the 2020 potentiometric-surface map (fig. 4; McGuire and others, 2021). These 158 streamgages were not used because 98 were in areas with insufficient groundwater data to substantiate that the surface-water altitude was representative of the groundwater altitude in the area; 47 had surface-water altitudes that were much higher than the nearby wells screened in the MRVA, likely either because the surface-water altitude was affected by precipitation events or the MRVA is not connected to the surface water at these locations; 6 had surface-water altitude values that seemed problematic; 6 had surface-water altitudes that possibly were substantially affected by control structures, and 1 was a duplicate site. There were 152 streamgages in areas with nearby groundwater-altitude data for 2020 that were used to create the 2020 potentiometric-surface map (fig. 3; McGuire and others, 2021). The surface-water-altitude values were considered approximations of the groundwater altitude at the river location because the altitude of the connection between groundwater and surface water at this location is not known.



Base from U.S. Geological Survey digital data, 1:1,000,000 and 1:2,000,000, variously dated
Highways from National Highway Planning Network, various scales, 2014
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Standard parallels 45°30′ N. and 29°30′ N., central meridian 96°00′ W.
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Figure 3. Location of wells with groundwater-altitude values and streamgages with surface-water-altitude values used to create the potentiometric-surface map of the Mississippi River Valley alluvial aquifer (MRVA), spring 2020, and the part of the measurement month for the selected water-level-altitude value.

Table 2. Summary statistics for water-level measurement dates of water levels used in the spring 2020 potentiometric-surface map for wells that were completed in the Mississippi River Valley alluvial aquifer and measured manually one or more times or continually as part of groundwater monitoring networks for spring 2020, by Mississippi Alluvial Plain region (Ladd and Travers, 2019; U.S. Geological Survey, 2020a).

[Minimum, maximum, and median columns are shown in YYYYMMDD format; YYYY, year; MM, month; DD, day; MAP, Mississippi Alluvial Plain; MRVA, Mississippi River Valley alluvial aquifer; --, no data]

MAP Region	Summary statistics for water-level measurement dates of water levels used in the potentiometric-surface map, MRVA, spring 2020								
	Manually measured wells in groundwater monitoring networks			Continuously measured wells			All wells		
	Minimum	Maximum	Median	Minimum	Maximum	Median	Minimum	Maximum	Median
St. Francis	20200406	20200617	20200414	20200409	20200409	20200409	20200406	20200617	20200414
Cache	20200406	20200616	20200414	20200409	20200409	20200409	20200406	20200616	20200414
Grand Prairie	20200406	20200430	20200414	20200409	20200409	20200409	20200406	20200430	20200414
Delta	20200316	20200423	20200402	20200210	20200409	20200409	20200210	20200423	20200402
Boeuf	20200121	20200427	20200415	20200308	20200409	20200324	20200121	20200427	20200415
Atchafalaya	20200413	20200417	20200414	--	--	--	20200413	20200417	20200414
Deltaic and Chenier Plain	--	--	--	--	--	--	--	--	--
MRVA	20200121	20200617	20200409	20200210	20200409	20200409	20200121	20200617	20200409

Characterizing the 2020 Potentiometric-Surface Raster and Contours

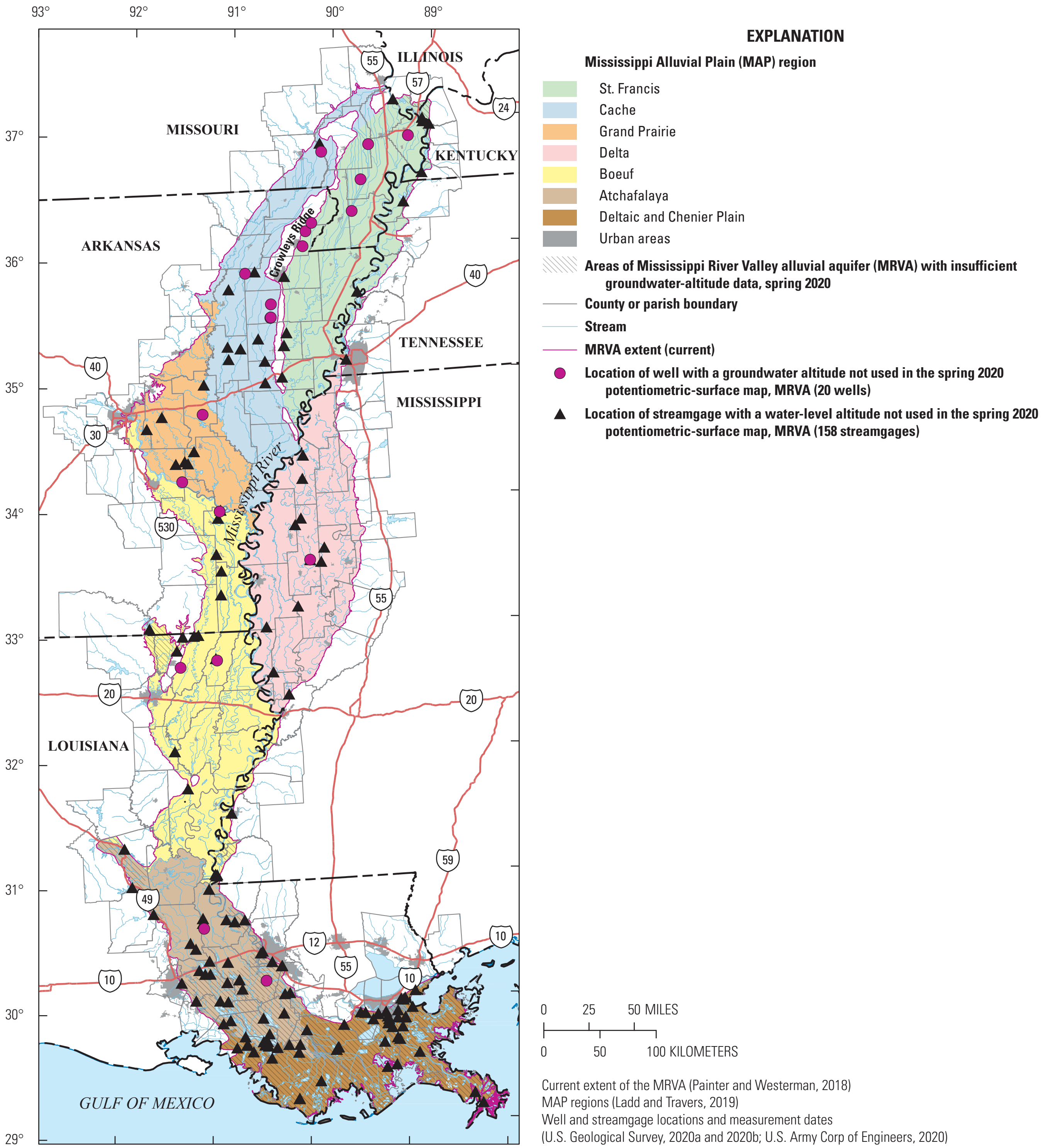
The potentiometric-surface raster and contours were generated using source files of selected groundwater- and surface-water-altitude data for spring 2020 (tables 1, 3; McGuire and others, 2021). About 81 percent of the aquifer area had sufficient groundwater data for 2020 (fig. 1) to create a potentiometric-surface map for spring 2020. The resultant spatial files are in Albers equal-area conic projection in meters using the World Geodetic Survey of 1984 and the potentiometric-surface altitude is expressed relative to the NAVD 88 datum. The rasters have a cell size of about 0.386 mi^2 and are aligned with the National Hydrologic Grid (Clark and others, 2018).

The potentiometric-surface raster was compared to a raster of the aquifer base (Torak and Painter, 2019) to identify where the potentiometric-surface raster was below the aquifer-base raster. The potentiometric-surface raster was as much as 11 ft below the aquifer base only in an approximate 19-mi^2 area in the south-central part of Lonoke County, Arkansas (fig. 1). In this area, there are five wells with water-level altitudes used to generate the potentiometric-surface raster. The well identification code for these wells (termed “site badge” in the related data file; McGuire and others, 2021) and, for each well, the depth of the water-level altitude below the aquifer base are USGS:344249091493201 (6.86 ft), USSCS:344253091483101 (7.03 ft), AR008:344405091503701 (6.15 ft), AR008:344355091451501 (3.75 ft), and USGS:344648091494601 (0.73 ft). No changes were made to the potentiometric-surface raster as a result of this comparison.

A total of five potentiometric maps were created—one for the entire MRVA, and one each for the St. Francis and Cache MAP regions in the north, Boeuf and Grand Prairie MAP regions in the west-central area, Delta MAP region in the east-central area, and Atchafalaya, Deltaic, and Chenier Plains MAP regions in the south. The maps are at a reduced, regional scale of 1:625,000 to allow for the display of control-point values.

The interpolation process, which was used to generate the rasters, can result in cell values for cells collocated with a measured well that are generally similar to, but commonly not equal to, the corresponding groundwater- and surface-water-altitude values based on measurements. This difference is partly because the cell values represent the value for the cell area, and the measured values are values at specific locations within the area represented by the cell.

To assess the uncertainty in the final raster and contours, the water-level altitude values for the 1,237 wells used in the potentiometric-surface map and the 20 wells not used to generate the potentiometric-surface raster were compared, if possible, to the final potentiometric-surface raster value in the cell where the well or streamgage is located (McGuire and others, 2021). For each well, the root mean square error (RMSE) and bias were calculated for the difference between the manually measured water-level altitude and the value extracted from the potentiometric-surface raster generated using the contours and point values (Helsel and others, 2020).



Base from U.S. Geological Survey digital data, 1:1,000,000 and 1:2,000,000, variously dated
Highways from National Highway Planning Network, various scales, 2014
Urban areas from U.S. Census Bureau, 1:500,000, 2016
Albers National Hydrogeologic Grid projection
Standard parallels 45°30′ N. and 29°30′ N., central meridian 96°00′ W.
World Geodetic Survey of 1984

Figure 4. Location of wells with groundwater-altitude values and streamgages with surface-water-altitude values for spring 2020 that were not used to create the potentiometric-surface map of the Mississippi River Valley alluvial aquifer (MRVA), spring 2020.

Table 3. Total number of streamgages in the Mississippi Alluvial Plain with surface-water-altitude values for spring 2020, and number of surface-water-altitude values, generally for April 9, 2020, used to generate the potentiometric-surface map, spring 2020, for the Mississippi River Valley alluvial aquifer by Mississippi Alluvial Plain region (Ladd and Travers, 2019; U.S. Army Corps of Engineers, 2020; U.S. Geological Survey, 2020b).

[MAP, Mississippi Alluvial Plain; MRVA, Mississippi River Valley alluvial aquifer; --, no data]

MAP Region	Number of streamgages with surface-water-altitude values, generally for April 9, 2020, in the MAP area	Number of surface-water-altitude values, generally for April 9, 2020, used to generate the potentiometric-surface map, MRVA, spring 2020
St. Francis	42	30
Cache	30	20
Grand Prairie	23	17
Delta	47	34
Boeuf	55	38
Atchafalaya	65	13
Deltaic and Chenier Plain	48	--
MRVA	310	152

Potentiometric-Surface Map, Spring 2020

The spring 2020 potentiometric-surface contours ranged from 10 to 340 ft above NAVD 88, and the regional direction of groundwater flow was to the south-southwest, except in areas of groundwater-altitude depressions (sheet 1), where groundwater flowed into the depression, and near rivers, where flow was generally parallel to the rivers. However, in some areas, flow was from the aquifer into the river or from the river into the aquifer. The lowest measured groundwater altitude was in Saint Landry Parish, Louisiana, and the highest was in Bollinger County, Missouri; the lowest measured surface-water altitude was in West Baton Rouge Parish, La., and the highest was in Cape Girardeau, Mo. (McGuire and others, 2021). Based on groundwater- and surface-water-altitude measurements for spring, 2020, the MRVA is connected to surface-water features in some areas and disconnected in other areas at least during part of the year; however, the extent of the degree of connectivity of these areas cannot be derived from these data.

The RMSE and bias for the differences between the measured water-level altitude and potentiometric-surface raster value for the 19 manually and 1 continually measured wells, which were not used in the potentiometric-surface map and were located in a raster cell with a potentiometric-surface value, were 51.42 and 15.2 ft, respectively. One of the manually measured wells not used in the 2020 potentiometric-surface map was in a raster cell where the potentiometric-surface value was not defined.

The RMSE for the difference between the measured water-level altitude for the 1,209 manually and 28 continually measured wells, which were used in the potentiometric-surface map and were located in a raster cell with a potentiometric-surface value, was 1.71 ft with a bias of 0.07 ft. Two of the manually measured wells used in the 2020 potentiometric-surface map were in raster cells where the potentiometric-surface value was not defined.

The spring 2020 potentiometric contours in the Cache region ranged from 120 to 340 ft above NAVD 88 and show a large depression in the lower one-half of the Cache region (sheet 2). The lowest measured groundwater altitude was 110.89 ft in a depression in Poinsett County, Ark., and the highest measured groundwater altitude was 340.27 ft in Bollinger County, Mo.; the lowest measured surface-water altitude was 168.67 ft in Monroe County, Ark., and the highest was 344.16 ft in Cape Girardeau County, Mo. (McGuire and others, 2021). Flow in the Cache region generally is to the south-southwest or into the depression in the southern part of the region.

The spring 2020 potentiometric contours in the St. Francis region ranged from 160 to 320 ft above NAVD 88 (sheet 2). The lowest measured groundwater altitude was 158.22 ft in St. Francis County, Ark., and the highest measured groundwater altitude was 316.51 ft in Mississippi County, Mo.; the lowest measured surface-water altitude was 178.74 ft in Lee County, Ark., and the highest was 325.13 ft in Mississippi County, Mo. (McGuire and others, 2021). Flow in the St. Francis region generally is to the south-southwest.

The spring 2020 potentiometric contours in the Boeuf region ranged from 40 to 230 ft above NAVD 88 (sheet 3). The lowest measured groundwater altitude was 33.10 ft in Concordia Parish, La., and the highest measured groundwater altitude was 218.00 ft in Pulaski County, Ark.; the lowest measured surface-water altitude was 36.64 ft in Concordia Parish, La., and the highest was 236.02 ft in Pulaski County, Ark. (McGuire and others, 2021). Flow in the Boeuf region is to the southeast, southwest, south, and into the depressions.

The spring 2020 potentiometric contours in the Grand Prairie region ranged from 90 to 230 ft above NAVD 88; there is a large depression in the potentiometric surface within the region (sheet 3). The lowest measured groundwater altitude was 82.91 ft in Lonoke County, Ark., and the highest measured groundwater altitude was 230.04 ft in Pulaski County, Ark.; the lowest measured surface-water altitude was 158.57 ft in Arkansas County, Ark., and the highest was 200.60 ft in White County, Ark. (McGuire and others, 2021). Flow in the Grand Prairie region generally is into the depression that encompasses most of the region.

The spring 2020 potentiometric contours in the Delta region ranged from 60 to 210 ft above NAVD 88; there is a large depression in the potentiometric surface within the central part of the region (sheet 4). The lowest measured groundwater altitude was 54.36 ft in Leflore County, Mississippi, and the highest measured groundwater altitude was 208.42 ft in DeSoto County, Miss.; the lowest measured surface-water altitude was 95.76 ft in Issaquena County, Miss., and the highest was 203.04 ft in Tunica County, Miss. (McGuire and others, 2021). Flow in the Delta region generally is into the large depression at the center of the region.

For most of the Atchafalaya region and all the Deltaic and Chenier Plains region, a spring 2020 potentiometric-surface map could not be created because of insufficient groundwater-altitude data (sheet 5). In the part of the Atchafalaya region included in the 2020 potentiometric-surface map, potentiometric contours ranged from 10 to 40 ft above NAVD 88 (sheet 5). The lowest measured groundwater altitude was 4.46 ft in Saint Landry Parish, La., and the highest measured groundwater altitude was 48.86 ft in Avoyelles Parish, La.; the lowest measured surface-water altitude was 3.49 ft in West Baton Rouge Pariah, La., and the highest was 39.46 ft in Avoyelles Parish, La. (McGuire and others, 2021). Groundwater flow in the mapped area is generally toward the south and southwest.

Summary

A potentiometric-surface map for spring 2020 was created for the Mississippi River Valley alluvial aquifer (MRVA) using available groundwater-altitude data from 1,237 wells completed in the MRVA and from the altitude of the top of the water surface in area rivers from 152 streamgages. Personnel from local, State, and Federal entities routinely collect groundwater-level data from wells screened in the MRVA. The U.S. Geological Survey and the U.S. Army Corps of Engineers routinely collect data on river stage and streamflow for the rivers overlying the MRVA area. The potentiometric-surface map for 2020 was created utilizing existing groundwater and surface-water altitudes to support investigations to characterize the MRVA as part of the U.S. Geological Survey Water Availability and Use Science Program.

Sufficient data were available to map the potentiometric surface of the MRVA for spring 2020 for about 81 percent of the aquifer area. The lowest measured groundwater altitude was 4.46 feet (ft) in Saint Landry Parish, Louisiana, and the highest was 340.27 ft in Bollinger County, Missouri; the lowest measured surface-water altitude was 3.49 ft in West Baton Rouge Parish, La., and the highest was 344.16 ft in Cape Girardeau County, Mo. The potentiometric contours ranged from 10 to 340 ft above the North American Vertical Datum of 1988. The regional direction of groundwater flow was generally to the south-southwest, except in areas of groundwater-altitude depressions, where groundwater flowed into the depression, and near rivers, where flow can be parallel to the river, from the aquifer to the river, or from the river into the aquifer. There are large depressions in the potentiometric-surface map in the lower one-half of the Cache region and in most of the Grand Prairie and Delta regions.

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