Prepared in cooperation with the Mississippi Department of Environmental Quality

Simulation of Water-Management Scenarios for the Mississippi Delta

Scientific Investigations Report 2019–5116

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

Cover photograph: First day of irrigation on a rice field, 2019, Humphreys County, Mississippi. U.S. Geological Survey water-use site 331136090390001 B0331 HUMPHREYS WU (https://waterdata.usgs.gov/nwis/inventory/?site_no=331136090390001&agency_cd=USGS, accessed December 18, 2019). Photograph by Shane J. Stocks, U.S. Geological Survey.

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DAVID BERNHARDT, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

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Suggested citation:
Haugh, C.J., Killian, C.D., and Barlow, J.R.B., 2020, Simulation of water-management scenarios for the Mississippi Delta: U.S. Geological Survey Scientific Investigations Report 2019–5116, 15 p., https://doi.org/10.3133/sir20195116.

Associated data for this publication:
Haugh, C.J., Killian, C.D., and Barlow, J.R.B., 2020, MODFLOW-2005 model used to evaluate water-management scenarios for the Mississippi Delta: U.S. Geological Survey data release, https://doi.org/10.5066/P9906VM5.

ISSN 2328-031X (print)
ISSN 2328-0328 (online)

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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	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
gallon (gal)	3.785	cubic decimeter (dm^3)
million gallons (Mgal)	3,785	cubic meter (m^3)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow rate	
acre-foot per day (acre-ft/d)	0.01427	cubic meter per second (m^3/s)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallons per minute (gal/min)	0.06308	liters per second
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)

Datum

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

Simulation of Water-Management Scenarios for the Mississippi Delta

By Connor J. Haugh, Courtney D. Killian, and Jeannie R.B. Barlow

Abstract

To compare the effectiveness of proposed alternative water-supply scenarios on future water availability in the Mississippi Delta, the U.S. Geological Survey and the Mississippi Department of Environmental Quality are collaborating on the update and enhancement of an existing regional groundwater-flow model of the area. Through this collaboration, the model has been updated to include boundary conditions through March 2014 with the most recent water-use data, precipitation and recharge data, and streamflow and water-level observation data. The updated model has been used to evaluate selected alternative water-supply scenarios to determine relative effects on the Mississippi River Valley alluvial aquifer. Alternative water-supply options evaluated in this report include: (1) irrigation efficiency, (2) on-farm storage and tailwater recovery, (3) instream weirs to increase surface-water availability, (4) intrabasin transfer of surface water, and (5) groundwater transfer and injection. A relative comparison approach was used to calculate the simulated water-level response caused by each scenario. Water-level response is the difference between water levels simulated by the alternative water-supply scenario and those simulated by a base or "no action" scenario. Water-level response in the alluvial aquifer varied for each scenario based on the location, magnitude, and (or) adoption rates of the simulated alternative water-supply option. The groundwater transfer and injection scenario showed the largest water-level response.

Introduction

The largest agricultural region within Mississippi is the northwestern Mississippi River alluvial plain, locally referred to as the "Delta" (Economic Research Service, U.S. Department of Agriculture, 2010) (fig. 1). Approximately 9,290 million gallons per day (Mgal/d) of water are withdrawn from the Mississippi River Valley alluvial aquifer in Mississippi (alluvial aquifer), which makes it the most used aquifer in the State (Maupin and Barber, 2005) (fig. 1). Although the alluvial aquifer has a large reserve, it is finite, and evidence indicates declining water levels with the largest declines in the central Delta area (Arthur, 2001; Barlow and Clark, 2011). Water-level declines also have resulted in decreases in baseflow in many Delta streams, most notably in the Big Sunflower River (Barlow and Clark, 2011, p. 6) to the extent that in the absence of rainfall or irrigation return flow, some stream reaches are dry during the summer months (Barlow and Clark, 2011, p. 6).

Agriculture, the dominant land use in the Delta, is an integral economic contributor and is the major category of water use. Presently (2019), the Delta relies primarily on groundwater from the alluvial aquifer for irrigation; historically, surface water also was used as a source of irrigation. Several alternative water-supply scenarios have been proposed to address sustainability of water resources in the Delta.

To compare the effectiveness of proposed alternative water-supply scenarios on future water availability in the Mississippi Delta, an existing regional groundwater-flow model of the area developed by Clark and Hart (2009) was updated and enhanced. Simulation models of the hydrologic system are useful decision-support tools that assist planners in evaluating water-management scenarios and optimizing monitoring efforts to provide data where and when they are most needed.

Purpose and Scope

Using an existing calibrated regional groundwater-flow model (Clark and Hart, 2009), the U.S. Geological Survey (USGS), in cooperation with the Mississippi Department of Environmental Quality (MDEQ), evaluated five primary water-management scenarios for the alluvial aquifer underlying the Delta in northwestern Mississippi. The five scenarios are (1) irrigation efficiency, (2) on-farm storage and tailwater recovery, (3) instream weirs to increase surface-water availability, (4) intrabasin transfer of surface water to increase surface-water availability, and (5) groundwater transfer and injection. Each scenario was analyzed by simulating the effects on aquifer water levels over a 50-year period and comparing the water-level response relative to a base scenario. Water-level response is the difference between water levels simulated by the alternative-supply scenario and those simulated by a base-case or "no action" scenario. The purpose of this report is

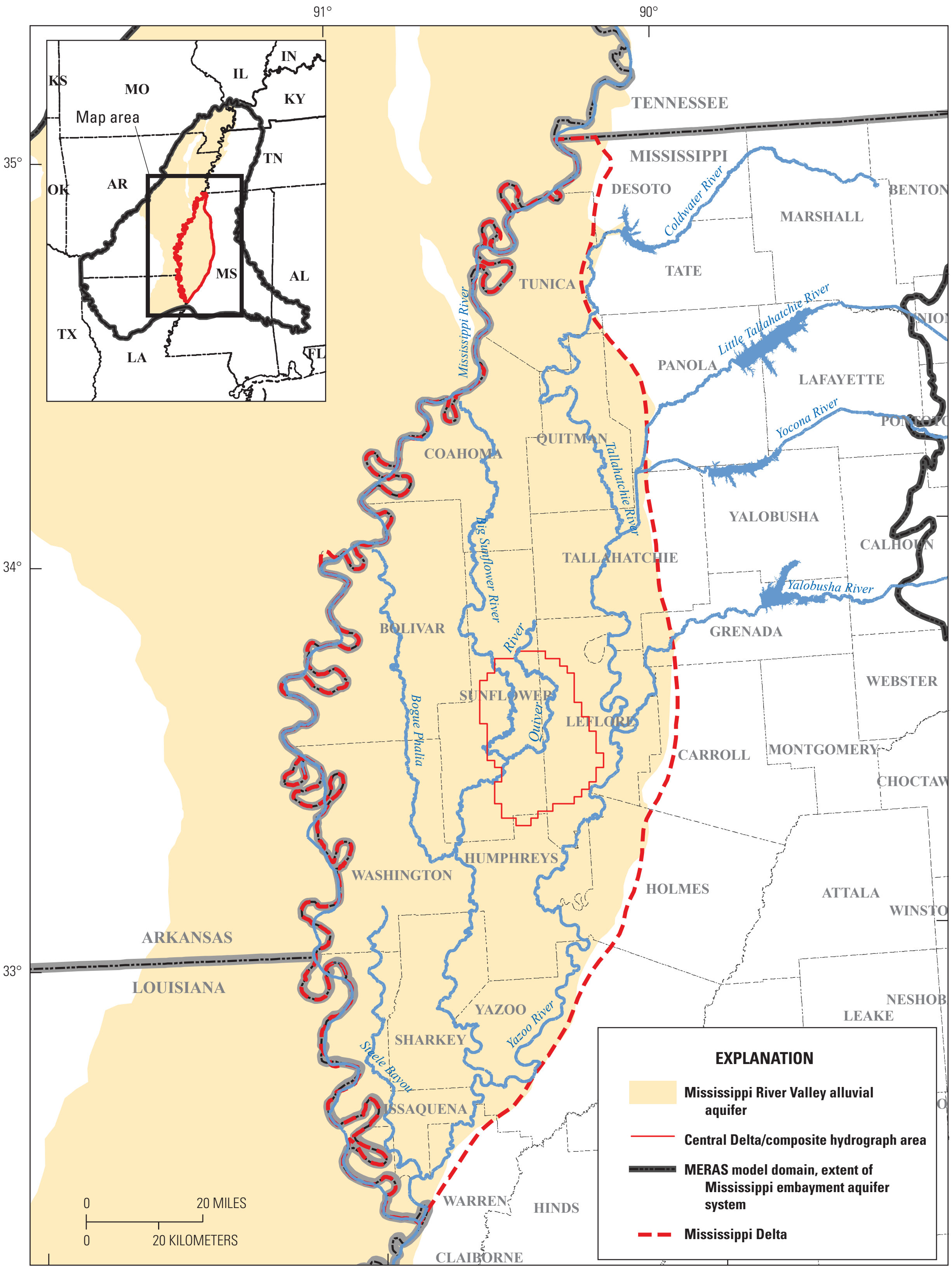

Figure 1. Location of the Mississippi Delta study area.

to document updates to the model and the results of the model simulations to aid MDEQ in the better understanding of the effects of the various water-management scenarios proposed for the Delta. All data and files used to support the updated model are available from Haugh and others (2020).

Updates to the Regional Groundwater-Flow Model

As part of the Mississippi Embayment Regional Aquifer Study (MERAS), the USGS developed a large-scale regional groundwater-flow model covering the entire Mississippi embayment and extending through the primary drinking-water aquifers of the embayment (figs. 1 and 2). This model was constructed using MODFLOW-2005, a software package developed by the USGS (Harbaugh, 2005). The construction and calibration of the original MERAS model (version 1.0) is documented in Clark and Hart (2009). The model calibration period extends from January 1, 1870, to April 1, 2007, for a total of 137 years and 69 stress periods. The first stress period is simulated as steady state to represent predevelopment conditions. Stress periods 2 through 27 are variable in length to reflect embayment-wide changes in groundwater withdrawals. Stress periods 28 (beginning in 1986) through 69 are each 6 months in length to reflect spring–summer (April–September) and fall–winter (October–March) conditions related to irrigation (Clark and Hart, 2009). The MERAS model was further enhanced in 2013 (MERAS model version 2.0) with some modifications to water-use estimates and refined parameter estimation of select aquifer properties by use of pilot points (Clark and others, 2013).

Several updates were made to the MERAS flow model for this study (MERAS model version 2.1), including adding additional stress periods to extend the model through March 31, 2014, and a refinement of agricultural water use in the Delta. Fourteen additional stress periods, each 6 months in length (stress periods 70 through 83), were added to continue the seasonal stresses related to irrigation and extend the simulation period.

Recharge

Recharge for the additional stress periods was estimated from monthly precipitation data (PRISM Climate Group, 2015) summed for the stress periods. Recharge was estimated from the precipitation data by using the same zones and multipliers from the original MERAS model (Clark and Hart, 2009).

Water Use

Agricultural water-use values for the Delta were updated and refined for stress periods 60 (beginning April 1, 2002) through 83 (March 31, 2014). The update includes the last 10 stress periods from the previous MERAS model (version 2.0) plus the 14 stress periods added with this update. The previous model used a county-wide average value estimated every 5 years for agricultural water-use data (fig. 3*A*). The updated MERAS model (version 2.1) uses agricultural water-use data estimated at the same scale as the model, a 1-mile (mi) by 1-mi grid cell, on a seasonal basis (seasonal water-use data furnished by Yazoo Mississippi Delta Joint Water Management District [2016; Massey and others, 2017; fig. 3*B*]). Water use for the added stress periods (70–83) for wells outside the Delta were assumed to continue at the 2006–07 rates as represented by stress periods 68 and 69.

Streambed Hydraulic Conductivity

Streambed hydraulic-conductivity values in version 2.1 of the model remained mostly unchanged from those in version 2.0 of the model, except for one reach of the Tallahatchie River in Leflore County, Miss. Streambed hydraulic conductivity, specifically the streambed hydraulic conductivity of the Tallahatchie River, is an important parameter in the groundwater transfer and injection scenario because groundwater is pumped from wells adjacent to the Tallahatchie River in that scenario. If the streambed hydraulic conductivity is high enough such that the Tallahatchie River is well connected with the aquifer, then streambed leakage of water from the river would provide a source of water to the aquifer and therefore to pumping wells adjacent to the river.

Streambed hydraulic conductivity was treated as a regional parameter within large river basins during the MERAS model calibration (Clark and Hart, 2009; Clark and others, 2013). Few data on streambed hydraulic conductivity were available at the time of the initial MERAS model development. The calibrated value of streambed hydraulic conductivity for the Tallahatchie River in MERAS model (version 2.0) is 0.2458 foot per day (ft/d). To investigate the effect of streambed hydraulic conductivity on streambed leakage and aquifer water levels in the groundwater transfer and injection scenario, three model (version 2.1) simulations were run, assuming the streambed hydraulic conductivity in the reach of the Tallahatchie River near Leflore County, Miss., is 0.2458 ft/d, 2.2458 ft/d, and 24.58 ft/d. The output at a model cell (layer 2, row 261, column 218) that contains the Tallahatchie River and a proposed pumping well indicates that streambed leakage increases with higher streambed hydraulic conductivity. At the end of a 50-year simulation period, streambed leakage varied from about 3.9 cubic feet per second (ft^3/s) to about 23 ft^3/s with streambed hydraulic-conductivity values of 0.2485 ft/d and 24.85 ft/d, respectively (fig. 4*A*). Additionally, simulations with higher streambed leakage

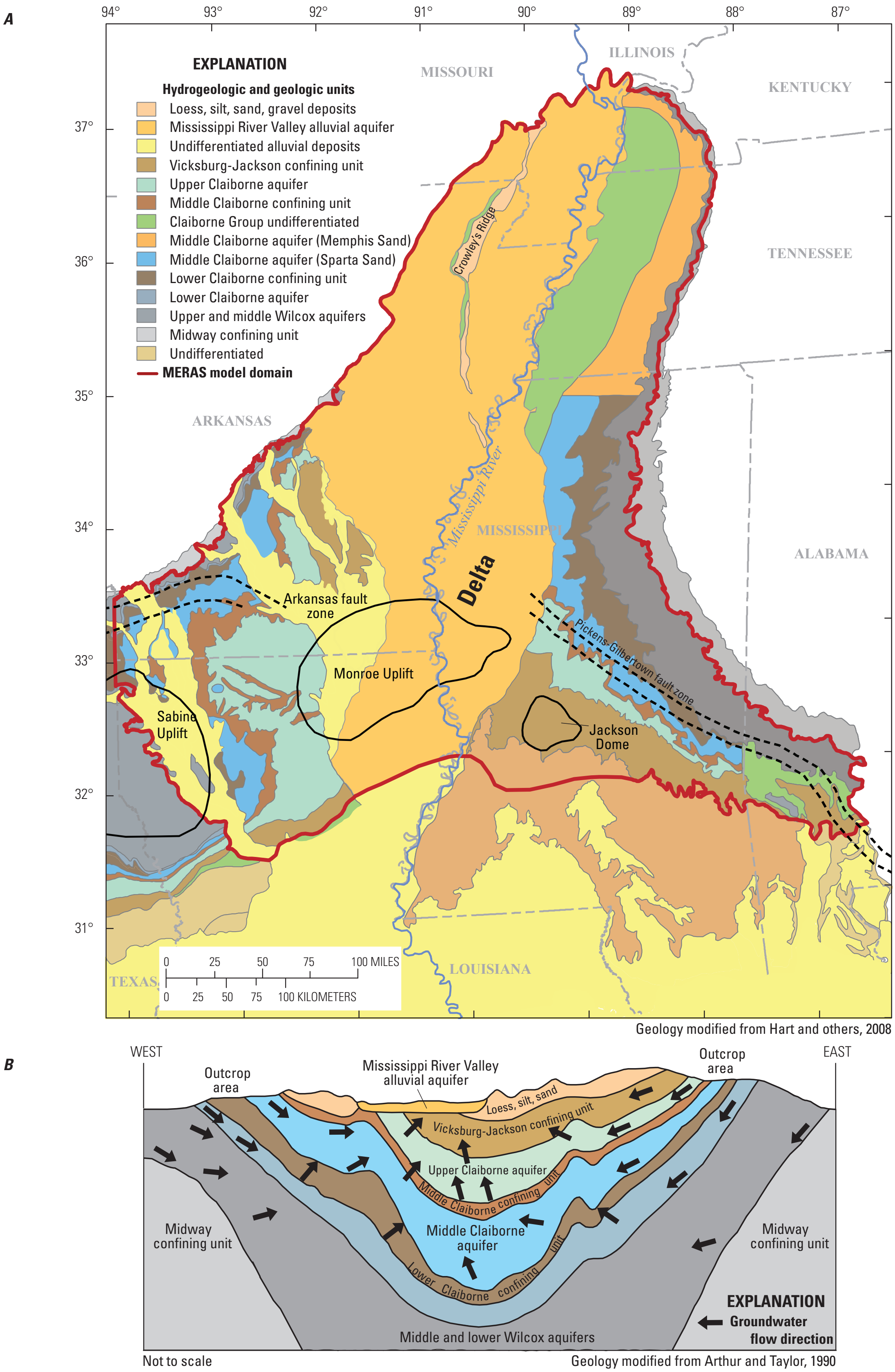

Figure 2. *A*, Mississippi Embayment Regional Aquifer Study (MERAS) model domain and surficial geology of the study area and *B*, hydrogeologic and geologic units.

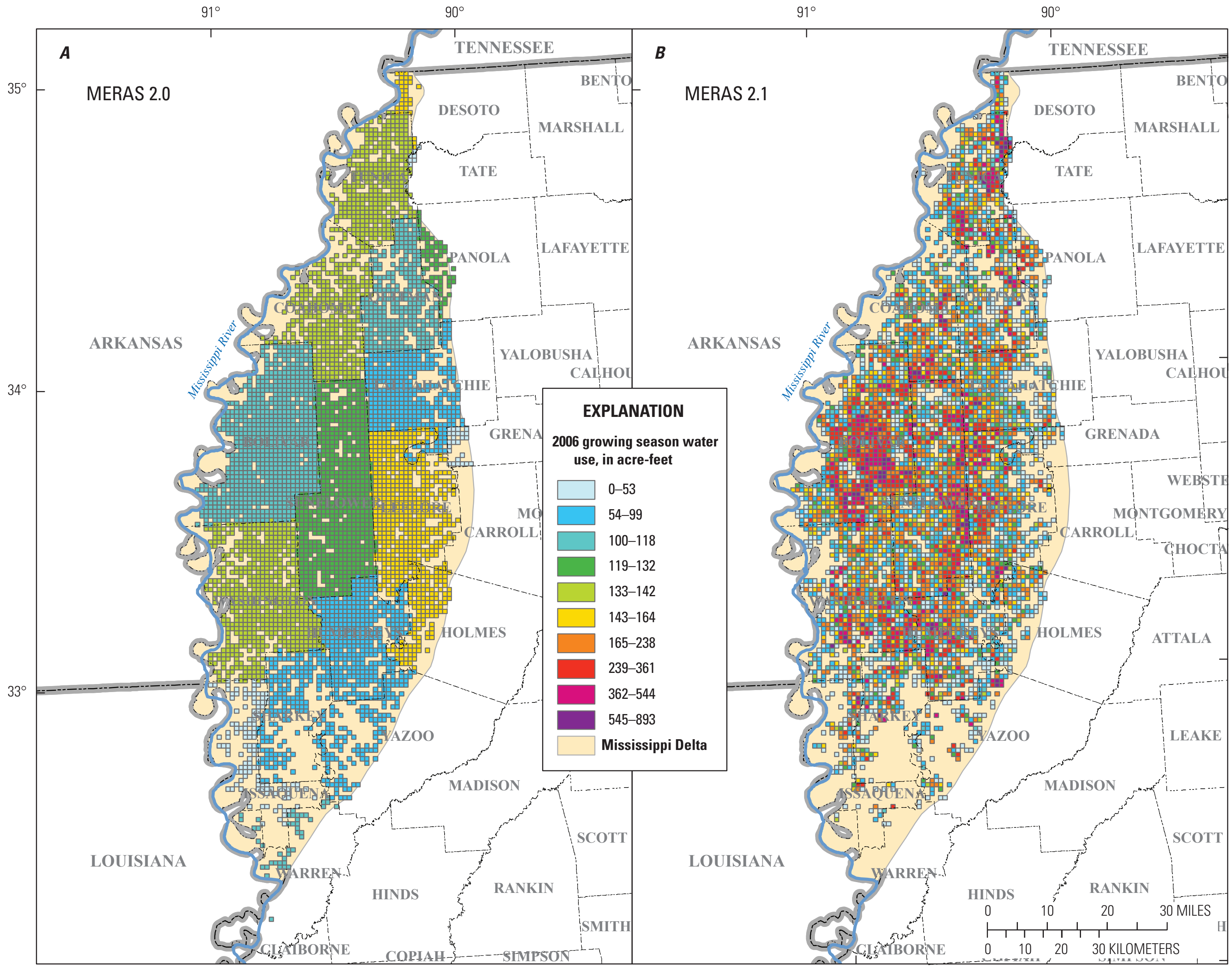

Figure 3. *A*, Water-use distribution in version 2.0 of the Mississippi Embayment Regional Aquifer Study (MERAS) model (Clark and Hart, 2009) and *B*, water-use distribution in version 2.1 of the MERAS model for the 2006 growing season.

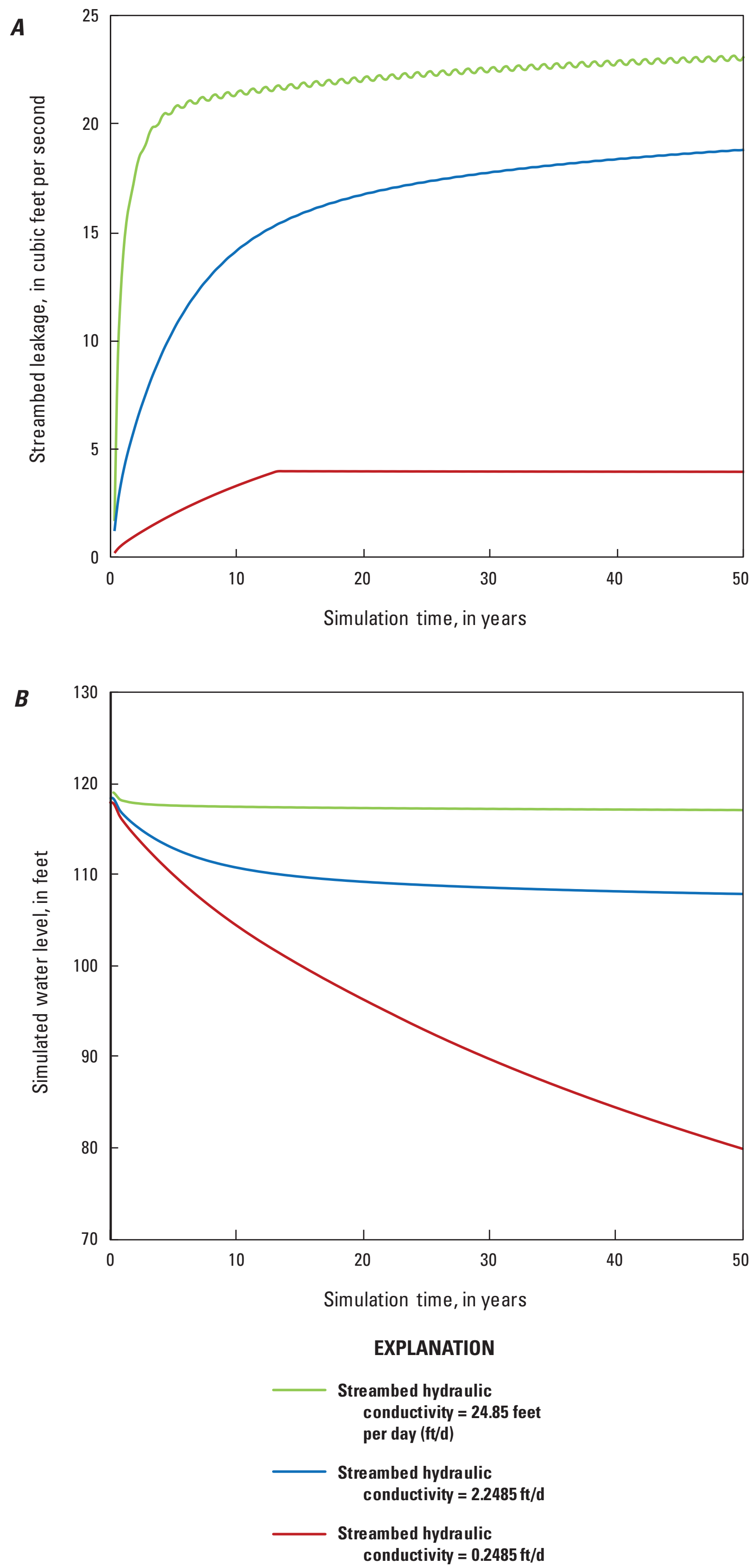

Figure 4. The effects of varying streambed hydraulic conductivity on *A*, simulated streambed leakage and *B*, simulated water levels.

indicate less water-level decline in the aquifer as the river provides a source of water to the wells, thus reducing the water removed from aquifer storage (fig. 4*B*).

Recent waterborne geophysical data-collection efforts along the Tallahatchie River indicate variations in the streambed material that can affect the streambed hydraulic conductivity (Miller and others, 2016a, b). The geophysical data indicate that the apparent streambed hydraulic conductivities within the area where the groundwater transfer and injection scenario is simulated are relatively higher than those in the rest of the Tallahatchie River (Miller and others, 2016a, b). Therefore, streambed hydraulic conductivity for the reach of the Tallahatchie River where the groundwater transfer and injection scenario is simulated was increased from the calibrated value of 0.2458 ft/d to 2.2458 ft/d in the MERAS model version 2.1.

Model Evaluation

To evaluate if the updates to the model, particularly the agricultural water-use updates for the Delta, improved the model calibration, water-level fit statistics were calculated. The average residual, root mean square error (RMSE), and the sum of squares between the observed and simulated water levels in the Delta for the stress periods that were updated and common to version 2.0 and 2.1 (stress periods 60–69) were calculated (table 1). For these stress periods, there were 1,291 water-level observations from 295 wells (fig. 5). The average water-level residual from the previous MERAS model (version 2.0) to the updated MERAS model (version 2.1) decreased 0.90 foot (ft) from 5.92 ft to 5.02 ft, and the RMSE decreased 0.76 ft, indicating that the updated water-use values improved the model fit.

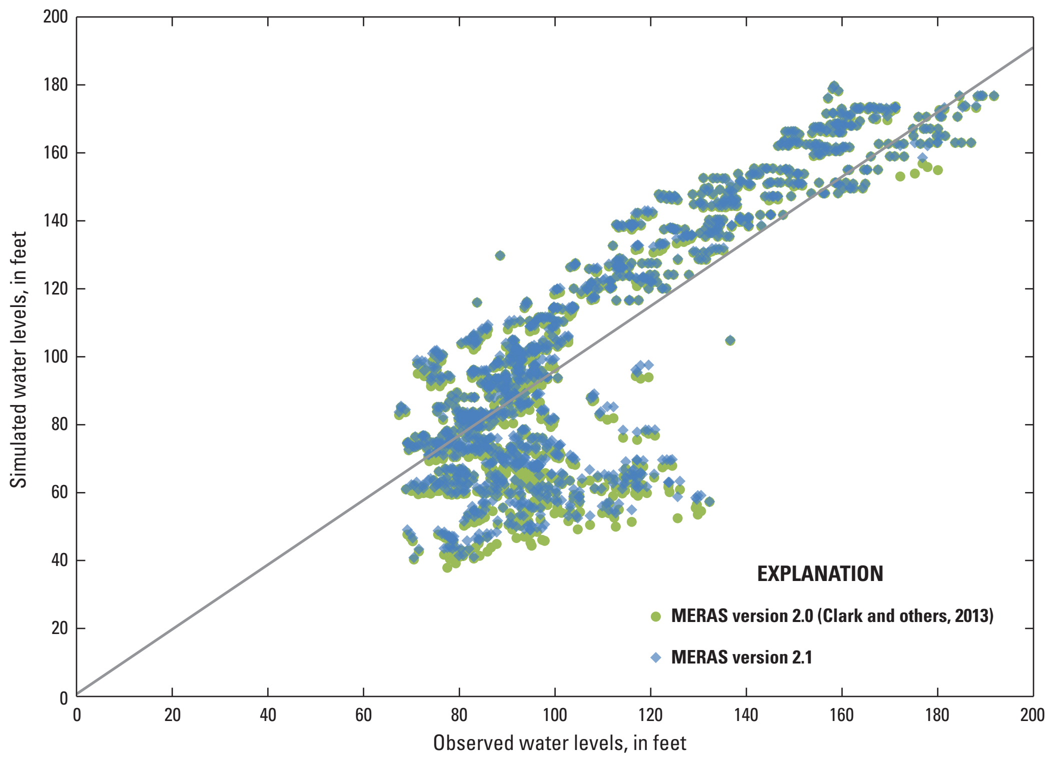

Figure 5. Observed versus simulated water levels for Mississippi Embayment Regional Aquifer Study (MERAS) model versions 2.0 and 2.1.

Water-Management Scenarios

Five water-management scenarios, each with several sub-scenarios, were analyzed. The five scenarios are (1) irrigation efficiency, (2) on-farm storage and tailwater recovery, (3) instream weirs to increase surface-water availability, (4) intrabasin transfer of surface water to increase surface-water availability, and (5) groundwater transfer and injection. The locations of operation for each scenario are shown in figure 6. The first four scenarios decrease groundwater withdrawals through either irrigation efficiency or by providing or enhancing a surface-water resource (figs. 6*A*–6*D*). The last scenario increases groundwater availability through groundwater transfer (fig. 6*E*). For the purpose of computing an average water-level change over time, a "composite hydrograph area" encompassing 283 square miles (mi^2) was defined near the center of the Delta in an area most affected by water-level declines (fig. 1), hereafter referred to as the central Delta area. Within the central Delta area, the average water level was calculated for each stress period and reported as a single hydrograph showing the average water level over time.

Information for each scenario was aggregated and assessed by using a participatory model development approach. An initial workshop on March 19, 2015, brought together stakeholders and technical experts with respect to irrigation and alternative water-supply options in the Delta to assess all known alternative water-supply options and the amount of data or information available for each option. Alternative water-supply options were selected for model scenario development if enough information or data were available to develop a scenario and if the model was sufficient for representing the scenario. Selected scenarios were then developed through several iterative meetings with the respective technical experts. Once the technical experts approved of the inputs and outputs for their respective scenario, the results from each scenario were shared with various stakeholder groups in the Delta to solicit feedback. The scenarios and results presented in the following sections are the outcome of this participatory model development process.

Table 1. Changes in water-level residual statistics between Mississippi Embayment Regional Aquifer Study (MERAS) model versions 2.0 and 2.1.

Model version	Minimum observed water level (feet)	Maximum observed water level (feet)	Range in observed water levels (feet)	Average residual (feet)	Root mean square error (feet)	Sum of squares (square feet)
MERAS 2.0	67.40	191.75	124.35	5.92	21.48	595,458
MERAS 2.1	67.40	191.75	124.35	5.02	20.71	553,825
Change	not applicable	not applicable	not applicable	−0.90	−0.76	−41,633

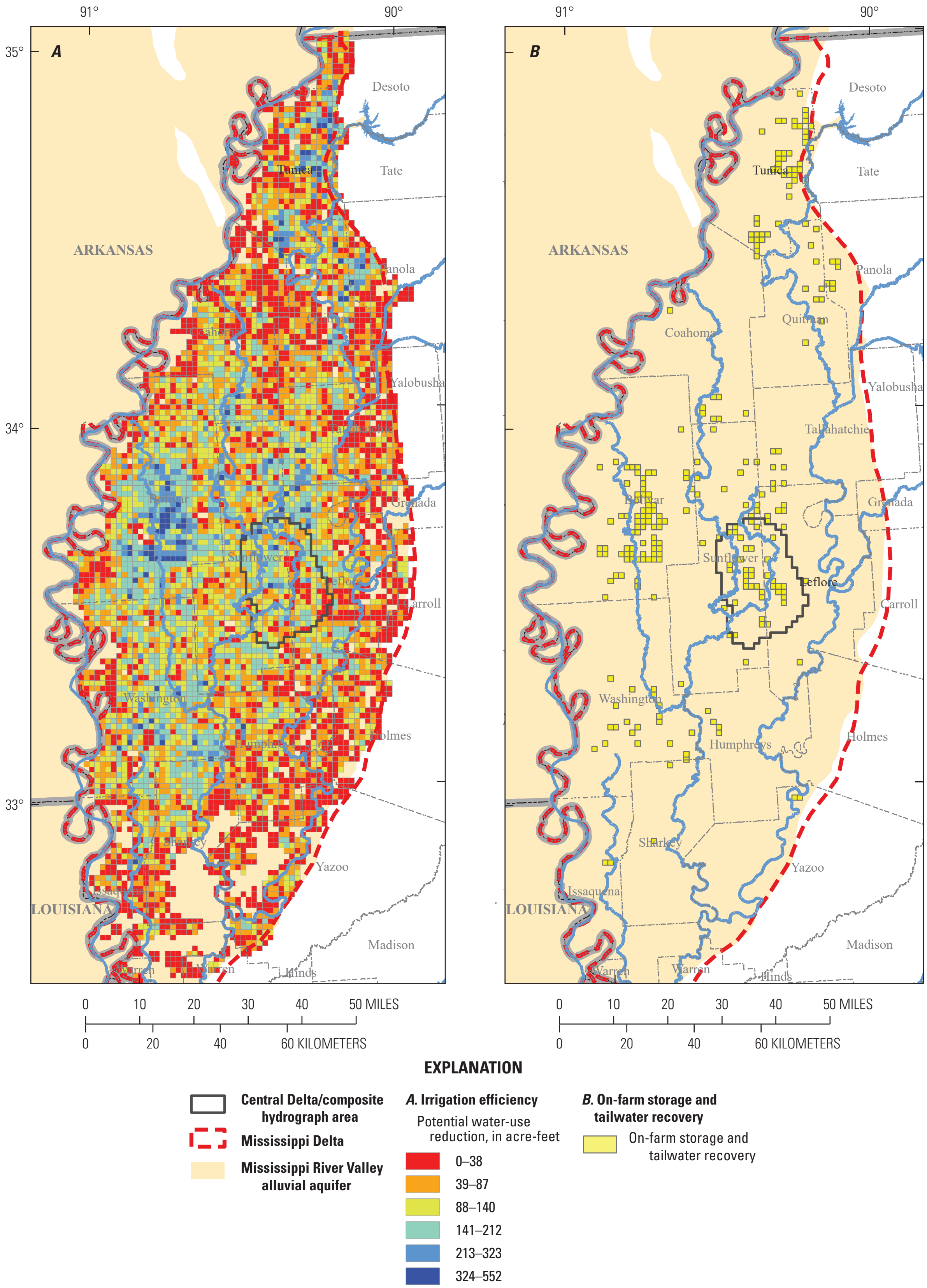

Figure 6. Locations of the water-management scenarios: *A*, irrigation efficiency, *B*, on-farm storage and tailwater recovery, *C*, instream weirs, *D*, surface-water transfer, and *E*, groundwater transfer and injection.

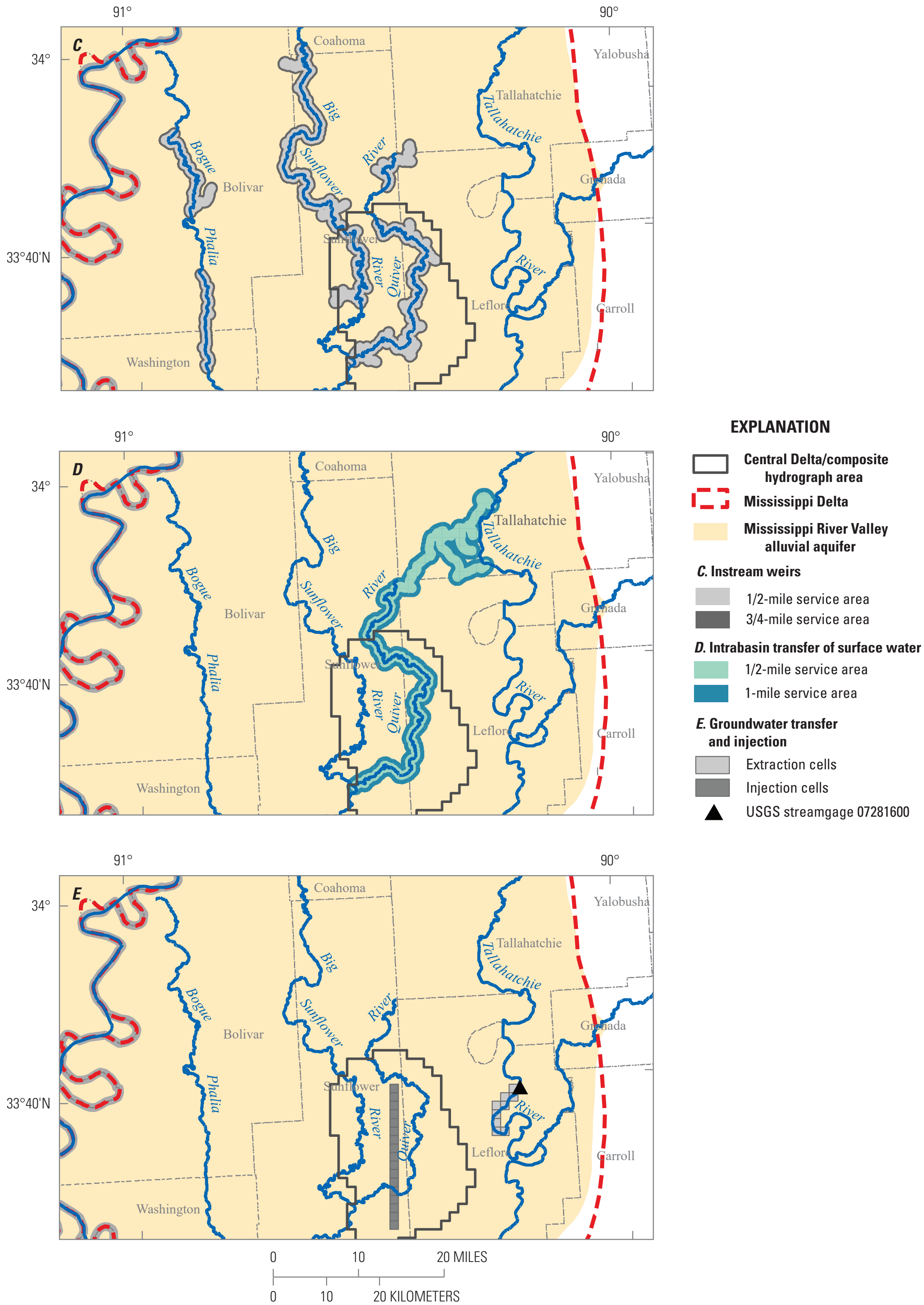

Figure 6. —Continued

Base Scenario

The base scenario simulates 50 years by using seasonal 6-month stress periods. The water-use stresses are assumed to remain unchanged from 2013 rates as represented by stress periods 82 and 83. The recharge rate is set at a constant average annual value. The primary purpose of the base scenario is not to predict future conditions in the aquifer but to provide a standard scenario against which alternate water-management scenarios can be compared.

Figure 7 shows the simulated water-level changes over the central Delta area for the 50-year simulation period. The total change or decline in the average water level over the 50-year simulation is about 35 ft (fig. 7). Seasonal fluctuations in the water levels related to groundwater withdrawals for irrigation can be noted in the hydrographs.

Irrigation Efficiency Scenario

The irrigation efficiency scenario assumes that adopting more efficient irrigation techniques will reduce water use. This scenario assumes a 28-percent reduction in water use for rice and soybean irrigation, a 40-percent reduction for corn irrigation, and no reduction for cotton irrigation (fig. 6*A*). The percentage of reduction in irrigation of crops was recommended by Jason Krutz, Mississippi State University Delta Research and Extension Center (written commun., 2016). This scenario was analyzed with two sub-scenarios—one where the irrigation efficiency was applied throughout the Delta and one where the irrigation efficiency was only applied to the central area of the Delta. The total change or decline in the average water level over the 50-year simulation for the scenario in which irrigation efficiency was applied throughout the Delta is about 20 ft, or 15 ft less than the water-level decline of 35 ft for the base scenario (fig. 7*A*; table 2). The total change or decline in the average water level over the 50-year simulation for the scenario in which irrigation efficiency was applied only to the central area of the Delta is about 24 ft, or 11 ft less than the water-level decline of 35 ft for the base scenario (fig. 7*A*; table 2).

On-Farm Storage and Tailwater-Recovery Scenario

The on-farm storage and tailwater-recovery scenario assumes reduction in water use by reusing water captured through tailwater recovery systems or using water from on-farm storage ponds. Tailwater recovery systems catch irrigation runoff and rainfall runoff from the fields and return it to be used for irrigation. The scenario assumes these practices would be implemented at 250 sites, each serving an area of 0.25 mi^2 (fig. 6*B*). Model grid locations were chosen by ordering all Delta grid cells by water use and selecting the 250 grid cells with the highest water use.

This scenario is analyzed with three sub-scenarios depending on the level of water-use reduction assumed. For a given ¼-mi^2 location, water-use reductions are assumed to be 25 percent with only tailwater recovery, 50 percent with a mix of tailwater recovery and on-farm storage, and 75 percent if tailwater recovery and on-farm storage are fully implemented at a site. The percentage of reduction in water use was recommended by Paul Rodrigue (U.S. Department of Agriculture, Natural Resources Conservation Service, written commun., 2016). The total decline in the average water level over the 50-year simulation for this scenario ranges from about 32 to 34 ft, or 1 to 3 ft less than the decline of 35 ft for the base scenario, depending on the level of water-use reduction assumed (fig. 7*B*; table 2).

Instream Weirs Scenario

The instream weirs scenario assumes that 10 weirs can be built on the Bogue Phalia, Big Sunflower River, and Quiver River to increase the amount of available surface water, thus decreasing the need for groundwater pumping (Dave Johnson, U.S. Army Corps of Engineers, Vicksburg District, written commun., 2016; fig. 6*C*). This scenario was analyzed with six sub-scenarios representing three different rates of adoption and two different areas of availability adjacent to the impounded stream reach. The rates of adoption were assumed to be either 100, 66, or 33 percent. The impounded surface-water source was assumed to be available within either a ½-mi or ¾-mi buffer around the impounded stream reach. A sufficient supply of water was assumed for all sub-scenarios.

The total change or decline in the average water level over the 50-year simulation for this scenario, assuming availability within a half mile of an impoundment, ranges from about 23 to 31 ft, or 4 to 12 ft less than the decline of 35 ft for the base scenario, depending on the adoption rate assumed (fig. 7*C*; table 2). The total change or decline in the average water level over the 50-year simulation for the scenario, assuming availability within ¾ of a mile of an impoundment, ranges from about 18 to 29 ft, or 6 to 17 ft less than the decline of 35 ft for the base scenario, depending on the rate of adoption (fig. 7*C*; table 2).

Intrabasin Transfer of Surface-Water Scenario

The intrabasin transfer of surface-water scenario assumes that water can be diverted from the Tallahatchie River to the Quiver River to increase the amount of surface water available in the Quiver River, thus decreasing the need for groundwater pumping (fig. 6*D*). This scenario was analyzed with six sub-scenarios representing three different rates of adoption and two different areas of availability adjacent to the Quiver River. The rates of adoptions were assumed to be either 100, 66, or 33 percent. The Quiver River as an alternate source was

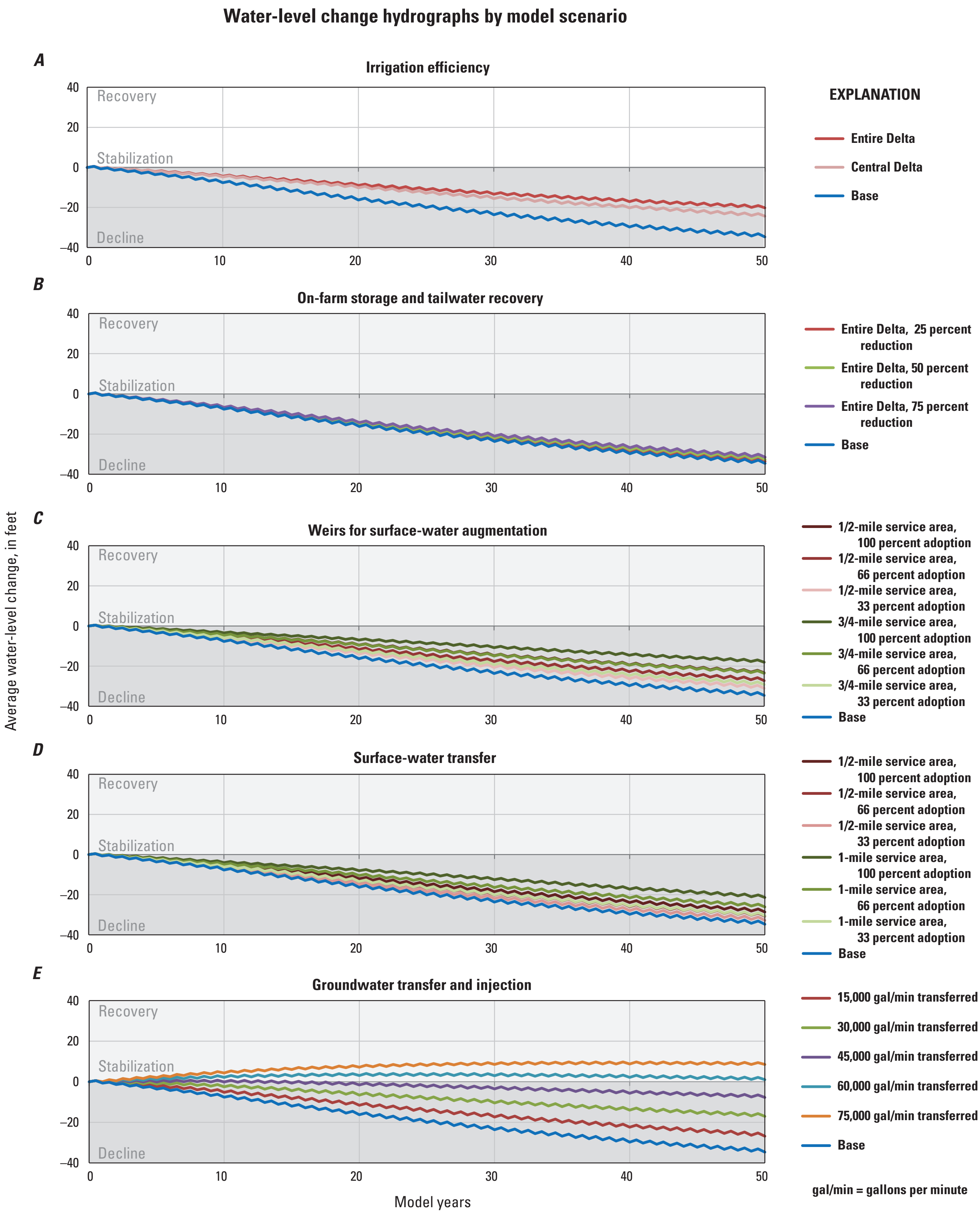

Figure 7. Water-level change for each scenario: *A*, irrigation efficiency, *B*, on-farm storage and tailwater recovery, *C*, instream weirs, *D*, surface-water transfer, and *E*, groundwater transfer and injection.

Table 2. Summary of selected alternative water-management scenario assumptions and results within area of interest[1] in the Mississippi Delta.

[%, percent; mi, mile; gal/min, gallon per minute]

Water-management scenario	Sub-scenario	Type of change	Volume of water not pumped or added directly, in acre-feet per year	Average increase in water level above base scenario within the central Delta area[1] at year 50, in feet	Average increase in water level above base scenario within the central Delta area[1] at year 50, in percent
Irrigation efficiency (specified reduction by crop)	Delta-wide	Decrease groundwater withdrawals	530,647	15	42
	Central Delta		36,710	11	30
On-farm storage and tailwater recovery	25% reduction (Tailwater recovery only)	Decrease groundwater withdrawals	18,432	1	3
	50% reduction (Mix of tailwater recovery with and without on-farm storage)		36,865	2	6
	75% reduction (Tailwater recovery and on-farm storage)		55,297	3	9
Instream weirs for surface-water availability	33% adoption (1/2-mi buffer area)	Decrease groundwater withdrawals	24,186	4	11
	66% adoption (1/2-mi buffer area)		48,372	7	21
	100% adoption (1/2-mi buffer area)		73,290	12	33
	33% adoption (3/4-mi buffer area)		35,923	6	16
	66% adoption (3/4-mi buffer area)		71,847	11	32
	100% adoption (3/4-mi buffer area)		108,859	17	48

Table 2. Summary of selected alternative water-management scenario assumptions and results within area of interest[1] in the Mississippi Delta.—Continued

[%, percent; mi, mile; gal/min, gallon per minute]

Water-management scenario	Sub-scenario	Type of change	Volume of water not pumped or added directly, in acre-feet per year	Average increase in water level above base scenario within the central Delta area[1] at year 50, in feet	Average increase in water level above base scenario within the central Delta area[1] at year 50, in percent
Surface-water transfer	33% adoption (1/2-mi buffer area)	Decrease groundwater withdrawals	11,975	2	6
	66% adoption (1/2-mi buffer area)		23,951	4	12
	100% adoption (1/2-mi buffer area)		36,289	6	18
	33% adoption (1-mi buffer area)		23,733	4	12
	66% adoption (1-mi buffer area)		47,465	9	25
	100% adoption (1-mi buffer area)		71,917	14	38
Groundwater transfer and injection	15,000 gal/min	Increase recharge to alluvial aquifer	24,195	8	23
	30,000 gal/min		48,390	18	51
	45,000 gal/min		72,586	27	78
	60,000 gal/min		96,781	36	103
	75,000 gal/min		120,976	43	124

[1]See figure 6 for location of central Delta/composite hydrograph area.

assumed to be available within either a ½-mi or 1-mi buffer area adjacent to the affected reach of the Quiver River. A sufficient supply of water was assumed for all sub-scenarios.

The total change or decline in the average water level over the 50-year simulation for this scenario, assuming availability within ½ mile of the Quiver River, ranges from about 29 to 33 ft, or 2 to 6 ft less than the decline of 35 ft for the base scenario, depending on the adoption rate assumed (fig. 7*D*; table 2). The total change or decline in the average water level over the 50-year simulation for this scenario, assuming availability within 1 mi of the Quiver River, ranges from about 21 to 33 ft, or 4 to 14 ft less than the decline of 35 ft for the base scenario, depending on the adoption rate assumed (fig. 7*D*; table 2).

Groundwater-Transfer and Injection Scenario

The groundwater-transfer and injection scenario assumes withdrawal wells located along the Tallahatchie River can be used as a source of water that is then pumped to the central Delta area and injected into the alluvial aquifer (Dr. J.R. Rigby, U.S. Department of Agriculture, Agricultural Research Service, written commun., 2016; fig. 6*E*). This scenario was analyzed with five sub-scenarios representing different water-transfer rates. The rates of water transfer were assumed to be constant at 15,000 gallons per minute (gal/min), 30,000 gal/min, 45,000 gal/min, 60,000 gal/min, and 75,000 gal/min.

The maximum water transfer rate of 75,000 gal/min is a small percentage of the flow in the Tallahatchie River as measured by the USGS streamgage on the Tallahatchie River at Money, MS (USGS station no. 07281600), which has a drainage area of 5,221 mi^2 (USGS, 2018; fig. 6*E*). For water years 1996 through 2016, the annual mean flow on the Tallahatchie River at Money, MS (USGS station no. 07281600) ranged from 3,490 ft^3/s in 2000 to 12,830 ft^3/s in 2003. The maximum transfer rate of 75,000 gal/min (167 ft^3/s) ranges from 1.3 to 4.8 percent of the annual mean flow. For water years 1996 through 2016, the daily mean flows on the Tallahatchie River at Money, MS (07281600) ranged from 585 ft^3/s on September 6, 2007, to 20,600 ft^3/s on February 1, 2010. The maximum transfer rate of 75,000 gal/min (167 ft^3/s) ranges from 0.8 to 28.5 percent of the daily mean flow. There are no days when the maximum transfer rate exceeds the daily mean flow.

The total change in the average water level over the 50-year simulation for this scenario ranges from a decline of about 27 ft to an increase of about 8 ft, or 8 to 43 ft less decline than the 35-ft decline in the base scenario, depending on the water-transfer rate (fig. 7*E*; table 2).

Model Limitations

Models are simplifications of natural systems. Factors that affect how well a model represents a given natural system include the model scale, the accuracy and availability of hydrogeologic property data, the accuracy of withdrawal, water-level and streamflow data, and appropriately defined boundary conditions. The MERAS model, used for the analysis presented in this report, is consistent with the conceptual model and hydrologic data of the MERAS study area. The MERAS model uses a grid-cell size of 1 mi^2, and a model will not provide accurate prediction on a scale smaller than the grid resolution. The hydraulic-conductivity zones used in the MERAS model represent large-scale variation in hydraulic properties; the actual spatial variations of hydraulic properties of the aquifer system occur on a much smaller scale and are not defined in great detail. Further discussion of the limitations of the MERAS model are reported by Clark and Hart (2009, p. 56).

Summary

The U.S. Geological Survey and the Mississippi Department of Environmental Quality are collaborating on the update and enhancement of an existing regional groundwater-flow model to evaluate selected alternative water-supply scenarios and identify data needs for future water management and modeling efforts in the Mississippi Delta. Alternative water-supply options assessed to date include (1) irrigation efficiency; (2) on-farm storage and tailwater recovery; (3) instream weirs to increase surface-water availability; (4) intrabasin transfer of surface-water to increase surface-water availability; and (5) groundwater transfer and injection. A relative comparison approach was used in which the water-level response resulting from each scenario was calculated by taking the difference between water levels predicted by each alternative water-supply scenario and a base, or "no action," scenario. Although the calculated water-level response is positive for each scenario, it does not indicate that water levels are increasing relative to initial conditions, rather that the water levels in the alternative scenario are relatively higher than those in the base scenario. Water-level response in the alluvial aquifer varied for each scenario based on the location and adoption rate of the implemented alternative-supply option. These initial model results serve as a starting point to develop and assess conjunctive water-management-optimization scenarios, as well as to improve and enhance current and future monitoring activities within the Delta.

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Publishing support provided by
Lafayette Publishing Service Center

USGS

Haugh and others—**Simulation of Water-Management Scenarios for the Mississippi Delta**—SIR 2019–5116

ISSN 2328-031X (print)
ISSN 2328-0328 (online)
https://doi.org/10.3133/sir20195116