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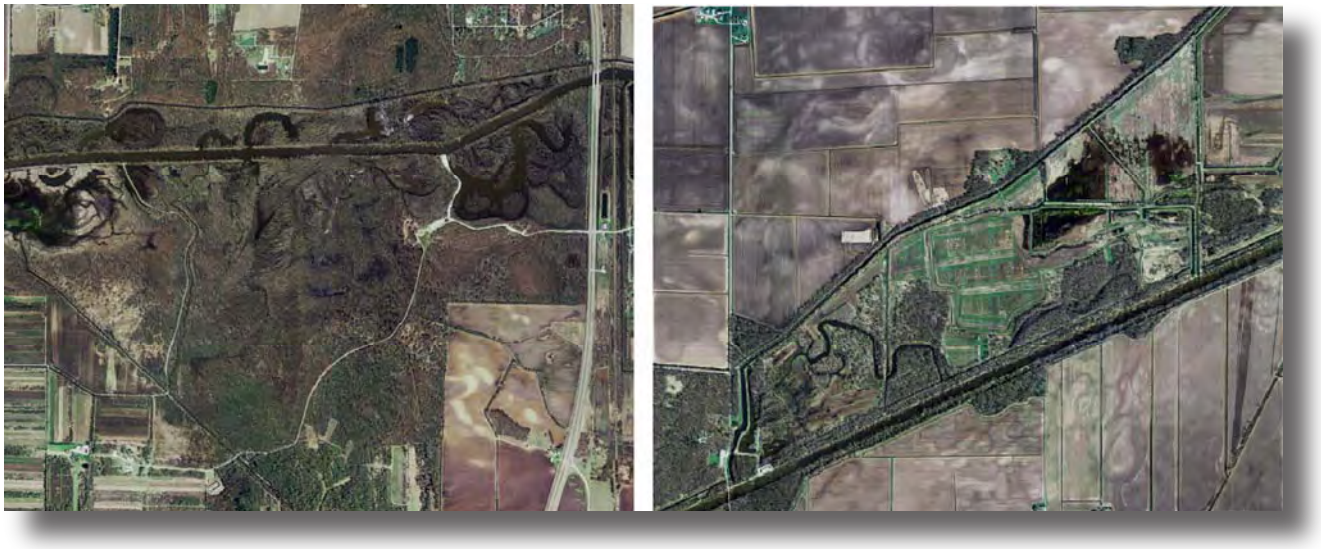
Hydrologic Characteristics of a Managed Wetland and a Natural Riverine Wetland along the Kankakee River in Northwestern Indiana



Scientific Investigations Report 2006-5222

U.S. Department of the Interior
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COVER. Digital color infrared orthophotographs taken March 2005, of the Hog Marsh managed wetland at the Grand Kankakee Marsh County Park, northwestern Indiana (right image) and a natural riverine wetland at LaSalle State Fish and Wildlife Area (left image). Photography accessed July 14, 2006, from *http://www.indiana.edu/~gisdata/05cir.html*

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Contents

Figures

Tables

Conversion Factors, Vertical Datum, and Acronyms

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
hectare (ha)	2.471	acre
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
cubic meter per second (m^3/s)	22.83	million gallons per day (Mgal/d)
liter per second (L/s)	15.85	gallon per minute (gal/min)
	Hydraulic conductivity	
meter per day (m/d)	3.281	foot per day (ft/d)
	Transmissivity	
meter squared per day (m^2/d)	10.76	foot squared per day (ft^2/d)

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

$$°F = (1.8 \times °C) + 32$$

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

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

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

Transmissivity: The standard unit for transmissivity is cubic meters per day per square meter multiplied by 1 meter of aquifer thickness [$(m^3/d)/m^2$]m. In this report, the mathematically reduced form, meter squared per day (m^2/d), is used for convenience.

Acronyms used in this report:

Acronym	*Description*
HM	Hog Marsh, prefix used in local well and site identifiers
IDNR-FW	Indiana Department of Natural Resources, Division of Fish and Wildlife
L	LaSalle Fish and Wildlife Area, prefix used in local well and site identifiers
PVC	Polyvinylchloride
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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Hydrologic Characteristics of a Managed Wetland and a Natural Riverine Wetland along the Kankakee River in Northwestern Indiana

By Leslie D. Arihood, E. Randall Bayless, and William C. Sidle[1]

Abstract

Characteristics of ground-water/surface-water interactions were identified at a managed wetland (Hog Marsh) and a natural riverine wetland (LaSalle) located on the north and south sides, respectively, of the Kankakee River in northwestern Indiana. Hog Marsh covers about 390 hectares of the Grand Kankakee Marsh County Park. LaSalle covers about 100 hectares of the LaSalle State Fish and Wildlife Area, and is about 20 kilometers downstream of Hog Marsh. Hydrologic characteristics of the two wetlands were investigated using data from 1997 to 1999 for 22 wells adjacent to the Kankakee River in northwestern Indiana. Surface-water levels at the managed wetland were controlled by a system of channels, levees, and managed flooding. Surface-water levels at the natural riverine wetland were not controlled.

Ground-water levels in the unconfined surficial aquifer beneath the two wetlands were analyzed by assessing water-level fluctuations. Fifteen wells at Hog Marsh and seven wells at LaSalle were monitored. The interquartile range in ground-water levels away from the river at Hog Marsh fluctuated less (from 0.4 to 0.7 meters) than all ground-water levels in the same aquifer beneath LaSalle (from 0.9 to 1.0 meters). The difference in the range of water-level fluctuation probably is attributable to the managed flooding of Hog Marsh units, which tends to maintain somewhat uniform water levels in that wetland.

Ground-water-flow directions along a vertical section through the unconfined surficial aquifer at the managed wetland were more variable than those at the natural riverine wetland. During winter and spring, when flow in the Kankakee River is high, flow is from the Kankakee River into the adjacent surficial aquifer and towards a 2-meter-wide Brown Ditch on the north side of Hog Marsh. Water levels in Brown Ditch remain lower than those in the Kankakee River during this period. From June to December, when flow in the Kankakee River is moderate to low, a flow divide developed near the center of the managed wetland. Ground-water flow south of the divide is to the Kankakee River; north of the divide, it is toward Brown Ditch. Slight ground-water mounding near the center of the managed wetland is accentuated by water-management practices that intentionally flood that area. Ground-water flow in the surficial aquifer at the natural riverine wetland was not impeded by ditches or managed flooding, and a simple flow-through system from areas south of the Kankakee River to the river was observed.

A ground-water flow model was constructed along a representative cross section through the surficial aquifer at the managed wetland and calibrated using data collected at the site. A no-flow boundary was used beneath the Kankakee River, and head-dependent boundaries were used along the north end of the model and at the base of the model. The model simulations indicated that artificial controls on the managed-wetland hydrology create sites of recharge to and discharge from the surficial aquifer that are absent at the natural riverine wetland. The steady-state flow simulation represented flow conditions following a 4-month period of no changes in hydrologic stresses. The simulation results indicated that flow paths originating from flooded areas near the center of the managed wetland are sources of aquifer recharge during the managed-flooding period. Brown Ditch captured almost all of the ground water north of the managed wetland. The simulated water budget along a well transect indicated that 88 percent of inflow to the surficial aquifer beneath the managed wetland was from a distribution channel and from flooding in the management units. These modeling results identify differences in flow patterns between the managed and natural riverine wetlands in addition to those identified by the water-level data. Results of transient simulations indicated that surface water from the Kankakee River penetrated only about 2 to 3 meters into the surficial aquifer beneath the managed wetland during the 5-month high-flow period.

The model simulations and the result of a flood-wave-response analysis also indicate that ground-water/surface-water interactions at natural riverine wetlands and at managed

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wetlands in riverine areas may be affected by variations in the hydraulic conductivity of adjacent streambeds. During a low-flow period in the Kankakee River, ground-water-flow simulations of the surficial aquifer at the managed wetland indicated a streambed hydraulic conductivity of 0.021 meters per day. A flood-wave-response analysis during a period of intermediate streamflow determined the streambed hydraulic conductivity to be 0.18 meters per day. A transient model simulation during a period of high streamflow indicated that the streambed hydraulic conductivity was 2.44 meters per day. The apparent relation between streamflow and hydraulic conductivity of the streambed may indicate that the quantity of ground-water/surface-water exchange varies seasonally.

Introduction

Wetland functions include flood-water storage, shoreline protection, wildlife habitat, ground-water recharge, and water-quality improvement (Carter, p. 43, 1996). Widespread recognition of the benefits of wetlands and acknowledgment of the more than 50-percent loss of wetland acreage in the United States since European settlement have resulted in the creation of Federal laws aimed at preventing additional losses of wetlands (U.S. Environmental Protection Agency, 1995). Wetland mitigation laws allow the destruction of natural wetlands if replacement wetlands are created elsewhere.

Replacement wetland programs designed to compensate for the destruction of natural wetlands through construction of new wetlands can be inequitable when the inherent wetland functions are not reproduced (Erwin, 1989). Because wetlands must have water to exist, the hydrology of a wetland potentially is a crucial element that affects the ecology of a replacement wetland. Water in wetlands is derived principally from ground-water flow, surface-water flow, and precipitation (Mitsch and Gosselink, 2000). Water in managed wetlands can be augmented by pumping or diverting ground water or surface water into the wetland to change the hydroperiod of the wetland (the seasonal pattern of the water levels) (Mitsch and Gosselink, 2000). Pumping or diversions of water, however, also can change the principal source of water to the wetland, the hydrologic inputs of nutrients to the wetland, and ultimately the productivity of the wetland for the growth of plants and the decomposition of plant material. For example, wetlands with long flooding periods have lower species diversity than those with shorter flooding periods (Mitsch and Gosselink, 2000). The ecology and functions of a wetland in a ground-water discharge area that received less-oxygenated ground water would not be the same as those in a wetland managed in a ground-water recharge area that received more-oxygenated flow from surface water or precipitation.

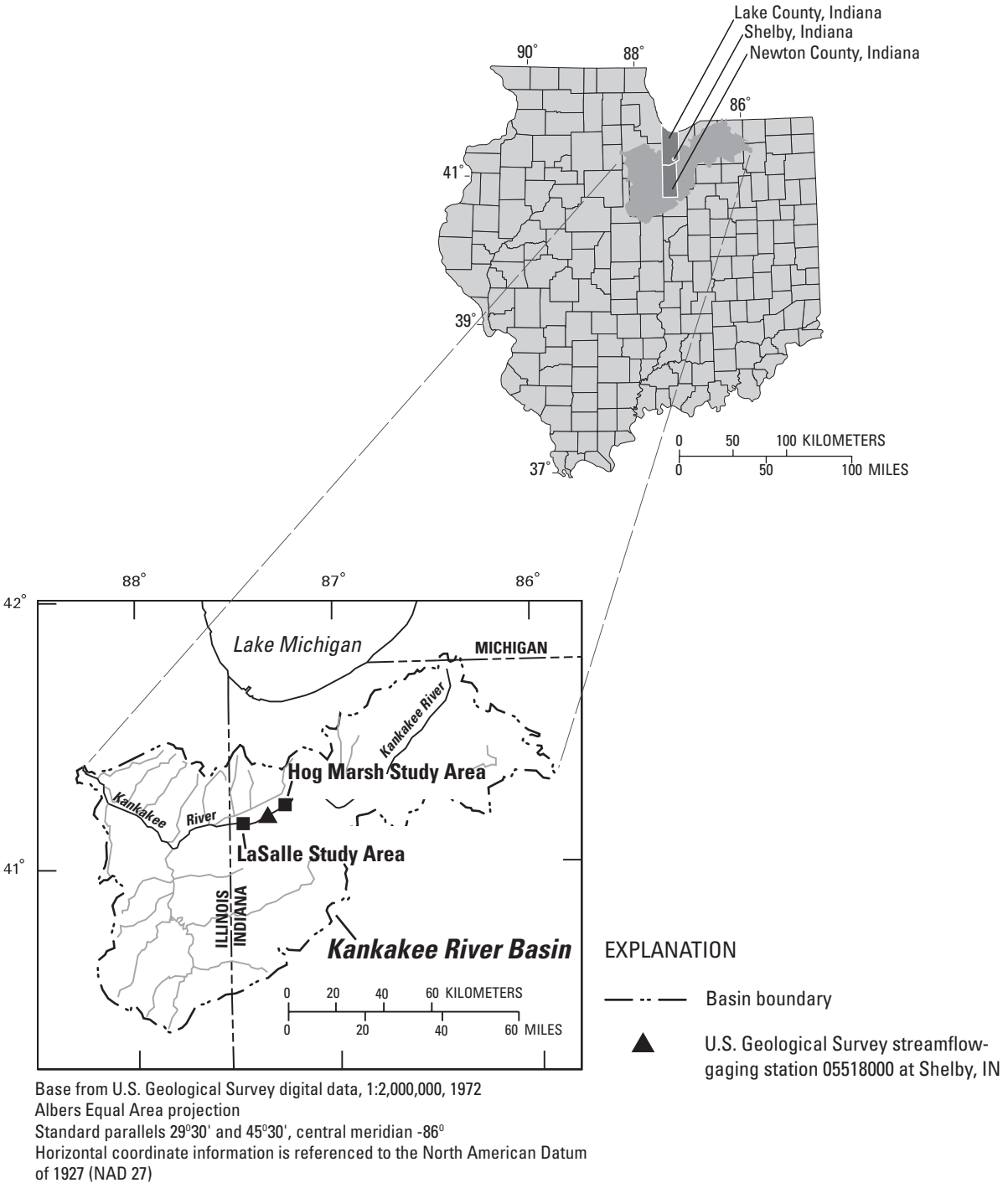
A hydrological analysis of a natural and managed riverine wetland along the Kankakee River was done by the U.S. Geological Survey (USGS) in cooperation with the U.S. Environmental Protection Agency (USEPA) from 1997 to 2000 to determine possible differences in hydrologic characteristics between the two wetlands. The study investigated ground- and surface-water interactions, sources of water, water-level fluctuations, and flow patterns in a managed wetland adjacent to the Kankakee River (Hog Marsh) and a natural riverine wetland (LaSalle) in the Kankakee River Basin (fig. 1). The Kankakee River Basin includes parts of northwestern Indiana and northeastern Illinois; the two study areas are in Indiana. Although the wetland at Hog Marsh is managed to maintain waterfowl habitat rather than to recreate a natural riverine wetland, it still provides a suitable managed wetland for purposes of comparison to the LaSalle wetland.

Purpose and Scope

This report presents the results of a 1997 to 2000 study that characterized the hydrology at a managed wetland (constructed channels, levees, and managed water levels) at Hog Marsh (subsequently called Hog Marsh) and a natural riverine wetland at LaSalle State Fish and Wildlife Area (subsequently called LaSalle) in the Kankakee River Basin, northwestern Indiana. The report describes hydrologic similarities and differences between the wetlands based on interpretation of hydrologic data and ground-water-flow simulations. The study compares a natural wetland to a wetland with managed water levels.

The hydrologic data set included monthly ground-water-level measurements in a network of 22 wells (15 at Hog Marsh and 7 at LaSalle), 20 aquifer tests to estimate hydraulic conductivity, continuous ground-water level measurements in 3 wells at Hog Marsh, and continuous surface-water-level measurements at two Hog Marsh sites, and at one USGS streamflow-gaging station at Shelby, Indiana. A single ground-water-flow transect was instrumented at the Hog Marsh site and another at the LaSalle site. Measurements were collected during the 3-year period from 1997 to 2000, and data were used as a basis for ground-water-flow simulations at Hog Marsh.

The field-measured data were used in aquifer tests, flood-wave response analyses, and computer simulations of ground-water flow. Aquifer tests provided estimates of aquifer hydraulic properties, and flood-wave response analyses were used to compute the hydraulic conductivity of bed sediments in adjacent streams and ditches. Numerical simulations were completed to examine two-dimensional flow along the instrumented transect at Hog Marsh and to evaluate the effect of artificial controls and natural hydrologic processes on the underlying aquifer system.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal Area projection
Standard parallels 29°30' and 45°30', central meridian -86°
Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27)

Figure 1. Location of the Kankakee River Basin, northwestern Indiana and northeastern Illinois, and Hog Marsh and LaSalle study areas, northwestern Indiana.

Description of Study Areas

The managed and natural riverine wetlands examined in this study are in the Kankakee River Basin, approximately 13,000 km^2 (1.3 million ha) in northwestern Indiana and northeastern Illinois (Mitsch and Gosselink, 2000; fig.1). Prior to European settlement, much of the basin was a continuous wetland ecosystem, which is now known as the Kankakee wetlands. The Kankakee wetlands extended from north-central Indiana to northeastern Illinois and included an area of approximately 2,000 km^2 (200,000 ha). At that time, the Kankakee wetlands were the largest in the midwestern United States (Meyer, 1935). The agrarian culture that accompanied European settlement, however, identified the area adjacent to the Kankakee River as fertile and desirable farmland. A vast tile and ditch network was developed to lower ground-water levels, and an extensive levee system was built to reduce flooding near the river (Mitsch and Gosselink, 2000). The drainage practices and resultant cultivation eliminated most of the Kankakee wetlands (Mitsch and Gosselink, 2000).

Background Information on the Wetland Sites

Hog Marsh is a 390 ha wetland restoration project contained within the 770 ha Grand Kankakee Marsh County Park managed by the Lake County (Ind.) Parks Department (fig. 2). With the exception of small wooded tracts and wooded lanes along Brown Ditch and the Kankakee River, Hog Marsh is a flat, open area with a cover of grasses and wetland vegetation. Wetland restoration began in 1979 with the installation of a network of pumps, drains, dikes, and ditches to facilitate water-level management in the park. Managed water levels are necessary to ensure that habitat for waterfowl is maintained during periods of peak migration. Prior to construction, the park property was used to grow row crops; the areas surrounding both LaSalle and Grand Kankakee Marsh County Park largely were cultivated with corn and soybeans.

The instrumented area of Hog Marsh is in the east end of the Park and is bounded on the north by a 2-meter-wide channel named Brown Ditch and on the south by the Kankakee River (fig. 2). A majority of the land surface in Hog Marsh is flooded seasonally. Water is pumped from the Kankakee River through a distribution channel to four managed wetland units (B, C, D, and E, fig. 2).

The 100 ha LaSalle study area, a remnant of the original Kankakee wetlands, is about 20 km downstream of Hog Marsh. LaSalle is bounded on the north by the Kankakee River and includes a cutoff meander that usually contains ponded water (fig. 3). The LaSalle study area is within the LaSalle State Fish and Wildlife Area, which is used as a recreation area for hunting and fishing and includes approximately 1,500 ha of sloughs and sedge meadows in a matrix of upland oak savannas. The LaSalle study area does not contain ditches.

Geohydrology of the Study Area

The study areas are in the Kankakee Outwash and Lacustrine Plain of the Northern Lake and Moraine area of Indiana (Schneider, 1966). Surface topography is characterized as a vast sand plain with occasional dunal and reworked dunal features. Surficial deposits are Wisconsinan outwash deposits of sand and gravel that have been highly reworked by eolian processes (fig. 4). Sand-and-gravel and dune-sand deposits constitute the surficial aquifer (fig. 5) that extends beneath both the Hog Marsh and LaSalle wetland areas. The surficial aquifer is about 14 m thick at Hog Marsh and about 7 m thick at LaSalle and is under water-table (unconfined) conditions. The surficial aquifer is considered equivalent to the aquifer 2 unit described for this area by Bergeron (1981). Average hydraulic conductivity of the aquifer is 76 m/d (Bergeron, 1981).

Till and lacustrine sediments constitute the confining unit that underlies the surficial aquifer (fig. 5). The confining unit is approximately 6 m thick at Hog Marsh and about 15 m thick at LaSalle. Vertical hydraulic conductivity of the confining unit is estimated to range from 3×10^{-5} to 5.5×10^{-7} m/d (Arihood and Basch, 1994).

The confining unit is underlain by a carbonate bedrock aquifer (fig. 5) that comprises Silurian and Devonian argillaceous dolostones and limestones that are about 6 and 150 m thick beneath the study area, respectively (Arihood, 1994). Fracturing is most prevalent in the uppermost 15 m of the carbonate bedrock aquifer (Arihood, 1994). Transmissivity of the bedrock aquifer typically ranges from 93 to 460 m^2/d (Arihood and Basch, 1994).

The study area has a temperate continental climate. Annual precipitation is approximately 94 cm/yr (Bergeron, 1981). Ground-water recharge rates have been estimated to range from 30 to 36 cm/yr (Arihood and Basch, 1994). Most precipitation infiltrates through the highly permeable soils into the surficial aquifer or continues to flow downward through the confining unit to recharge the bedrock aquifer (Arihood and Basch, 1994). Ground water from the unconsolidated deposits and bedrock eventually discharges to a stream or drainage ditch (Arihood and Basch, 1994).

The Kankakee River at the Shelby stream gage has a drainage area of 4,608 km^2 and an average width of 51.8 m. The average flow at the gage since 1922 is 48.0 m^3/s, and average monthly flow ranges from 16.1 m^3/s in September to 117 m^3/s in January.

Bergeron (1981) described the regional water-table altitude in the surficial aquifer using ground-water-level contours calculated by a steady-state model of the area. The contours were used to identify the regional direction of ground-water flow relative to the Hog Marsh and LaSalle sites (figs. 6 and 7). The contours should be representative of current conditions in that no major pumping centers have been introduced near the wetlands since Bergeron's report.

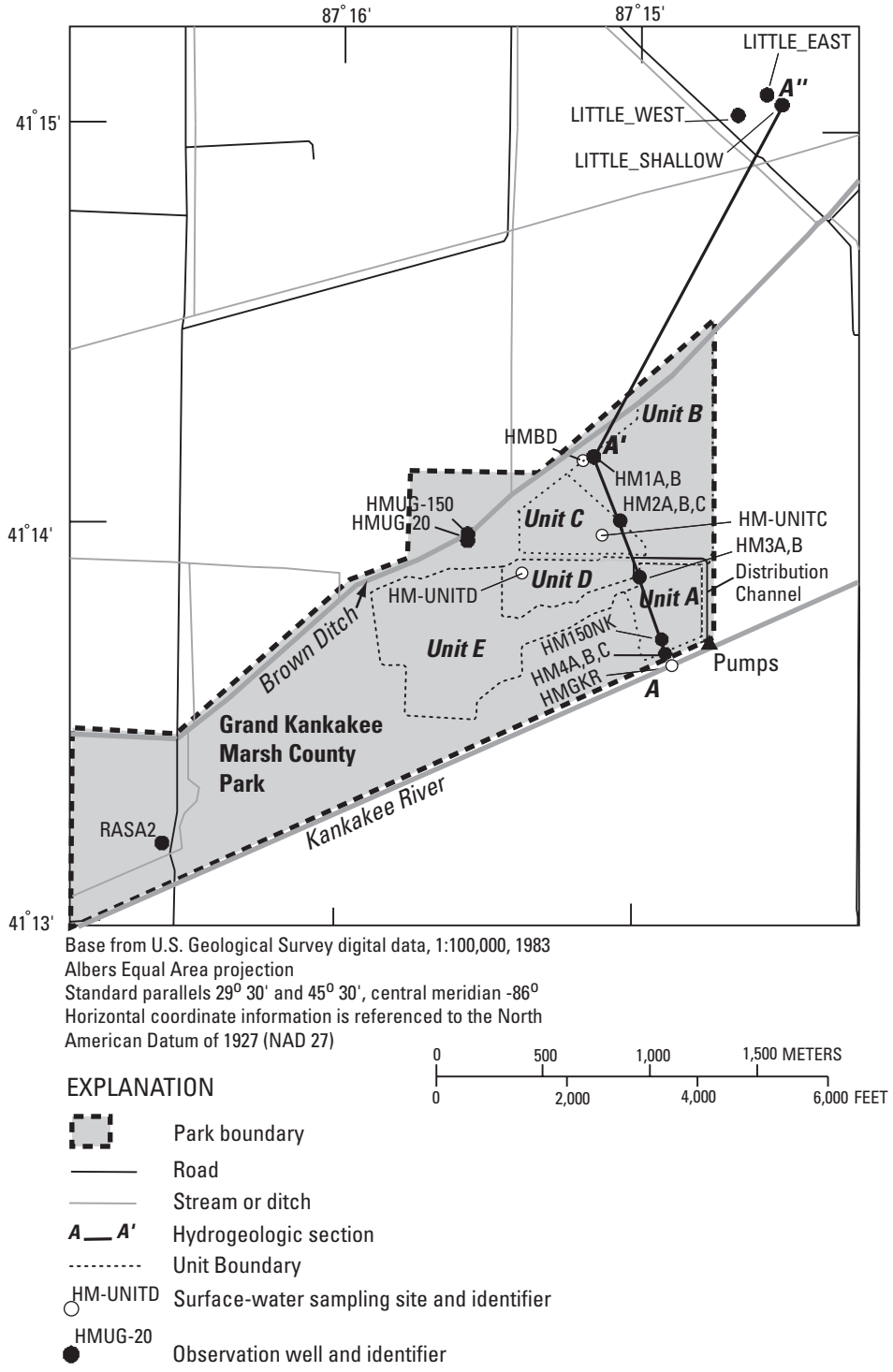


Figure 2. Location of hydrogeologic section A-A'-A", with wetland units and sampling sites at Hog Marsh, northwestern Indiana.

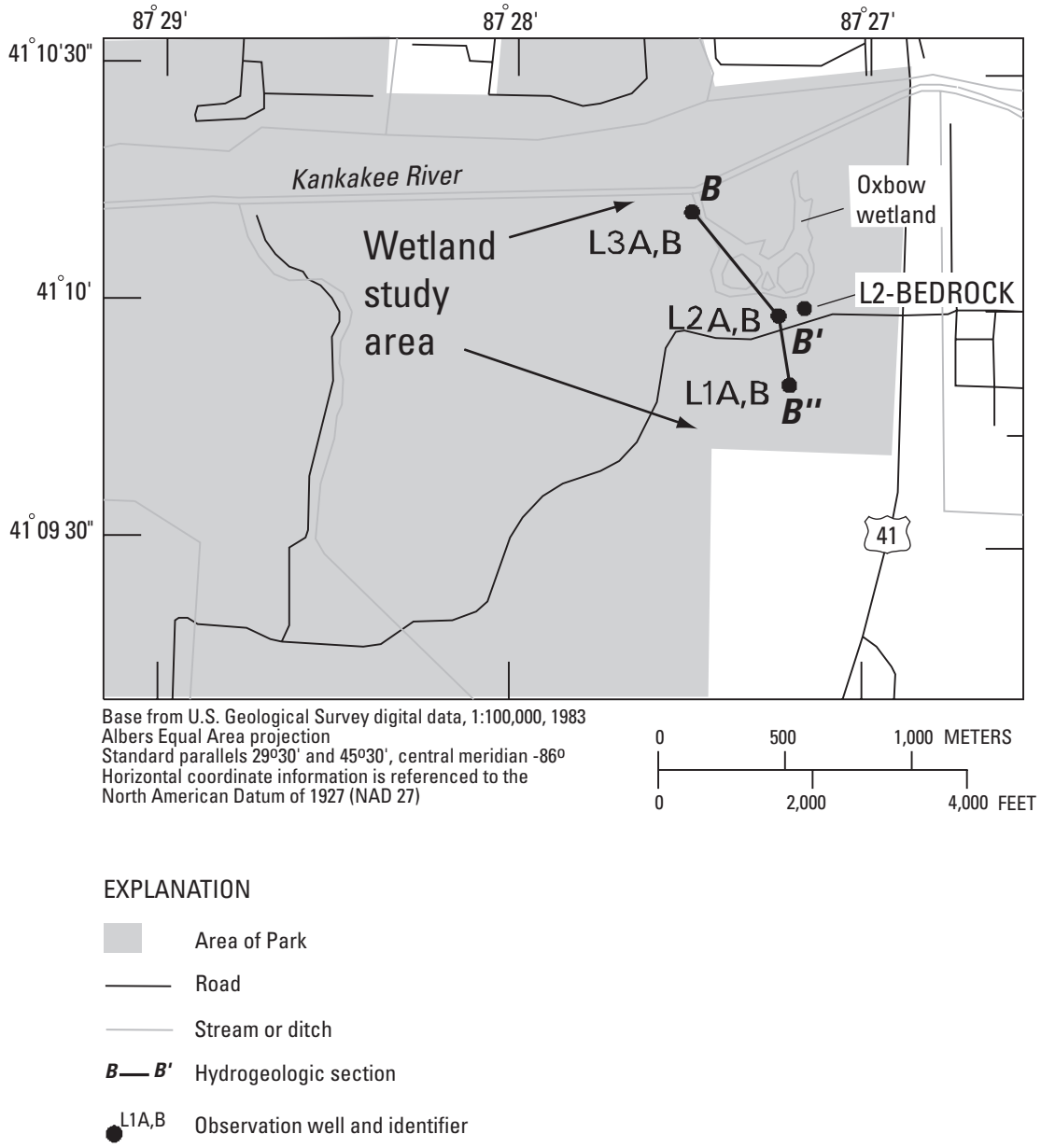


Figure 3. Location of hydrogeologic section B-B'-B", and sampling sites at LaSalle State Fish and Wildlife Area, northwestern Indiana.

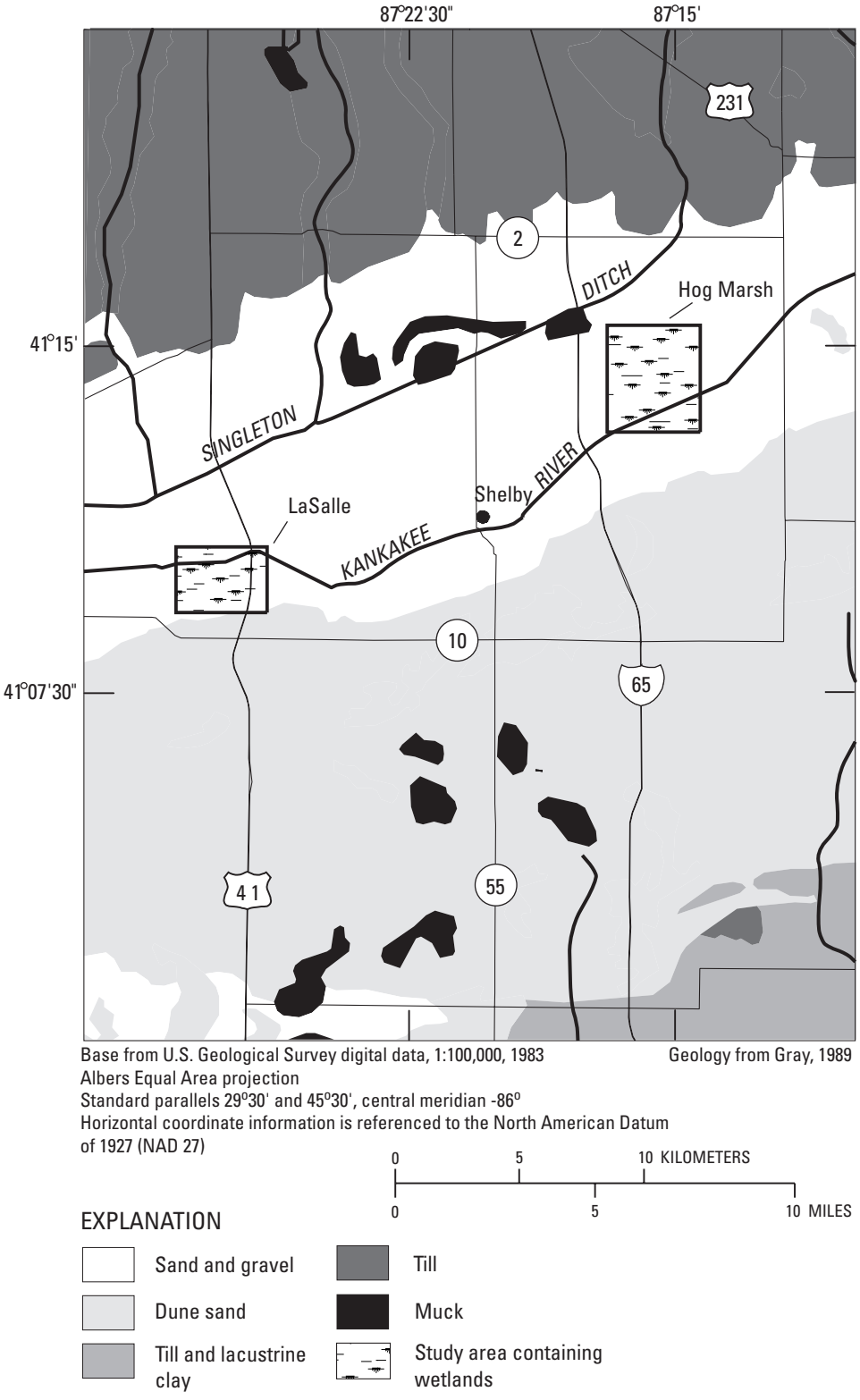


Figure 4. Surficial geology around LaSalle and Hog Marsh, near Shelby, Indiana, northwestern Indiana.

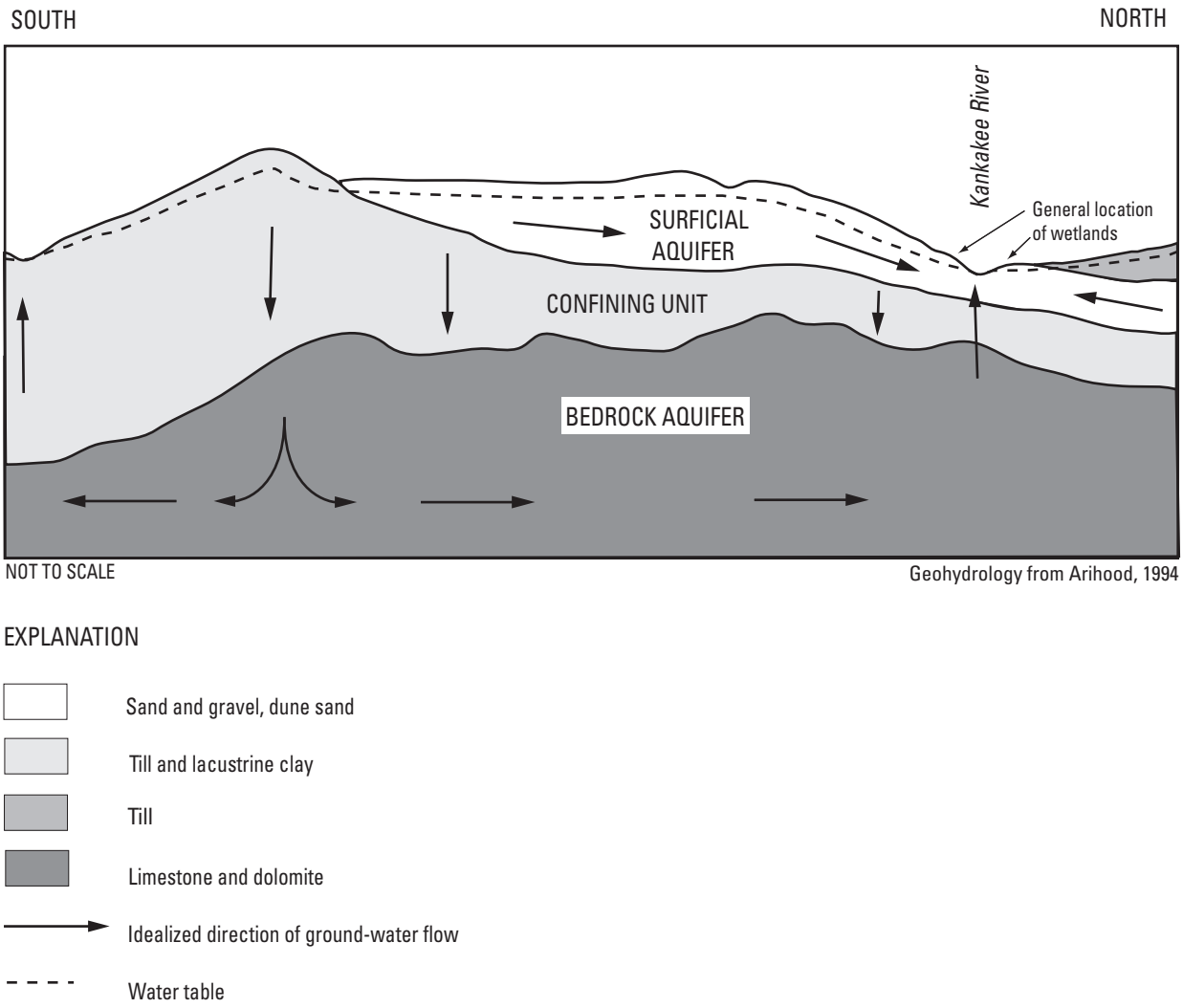


Figure 5. Major geohydrologic units and typical directions of ground-water flow in the study areas, northwestern Indiana.

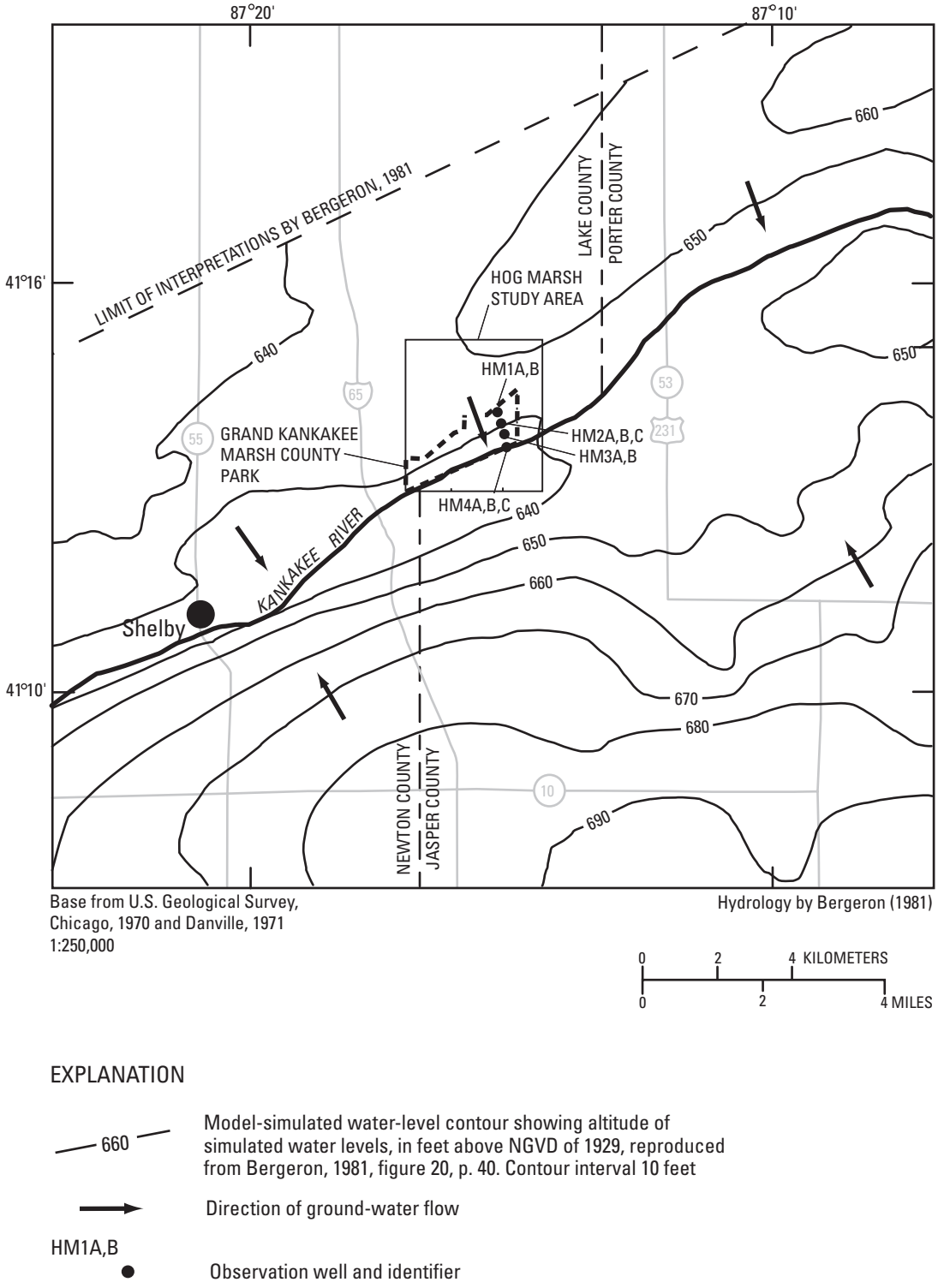


Figure 6. Location of observation wells installed at Hog Marsh relative to steady-state, model-simulated contours of the water-table altitude in the surficial aquifer near Shelby, Indiana, northwestern Indiana, 1981.

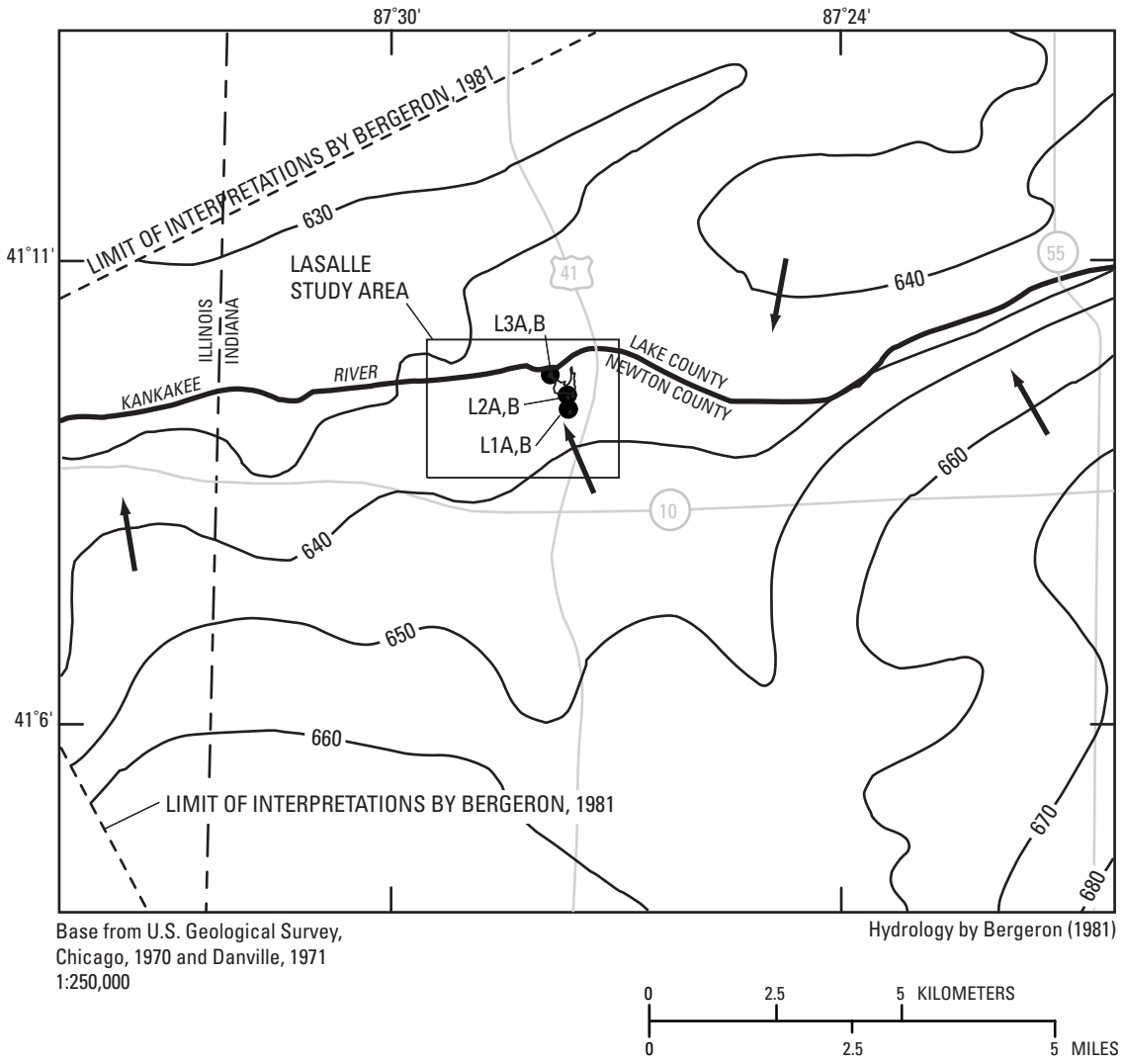


Figure 7. Location of observation wells installed at LaSalle relative to steady-state, model-simulated contours of the water-table altitude in the surficial aquifer near Shelby, Indiana, northwestern Indiana, 1981.

Ground water in the surficial aquifer (referred to as the outwash aquifer by Arihood and Basch, 1994) flows laterally in the aquifer to local streams, ditches, and the Kankakee River (Arihood and Basch, 1994). A water-table divide exists to the northwest of Hog Marsh, as indicated by the 650 feet above NGVD contour (fig. 6). Ground water flows approximately southward from the divide toward the Kankakee River in the immediate area of Hog Marsh. At the LaSalle site, ground water flows regionally to the north-northwest toward the Kankakee River. The direction of flow is approximately perpendicular to the Kankakee River at both sites. In general, regional ground water flow is from recharge areas of higher elevations to regional discharge points along the Kankakee River or to major ditches, such as Singleton Ditch (fig. 4). Local differences in flow directions result from differences in local drainage and topography.

Recharge from the surficial aquifer also may flow downward through the confining unit to the bedrock aquifer (fig. 5). At the Kankakee River, ground water discharges from the bedrock aquifer (through the confining unit) and the surficial aquifer into the river.

Methods of Investigation

Well transects were installed and water-level data were collected. The water- level data were used in hydraulic analyses and a ground-water model to investigate the hydrologic differences between a managed and a natural riverine wetland.

Well Transects

The hydrologic analyses were based on data collected along instrumented well transects at the Hog Marsh and LaSalle wetlands from 1997 to 1999 (figs. 2 and 3). The well transects were oriented approximately perpendicular to the Kankakee River and approximately parallel to the regional ground-water-flow directions in the surficial aquifer (figs. 6 and 7). The well sites at Hog Marsh were selected to parallel this regional flow direction and to pass beneath the center of the managed wetland units, given limitations in the drilling-rig access because of road and levee locations. The Hog Marsh well network consisted of 14 monitoring wells finished in the surficial aquifer and 3 wells finished in the underlying bedrock aquifer (fig. 2; table 1, at back of report). Three wells were nested at the HM2 and HM4 sites and were finished near the top, middle, and base of the surficial aquifer (fig. 8A). Two wells were nested at the HM1 and HM3 sites and finished near the top and base of the surficial aquifer. Single wells also finished in the surficial aquifer but not located along the transect are HM150NK, HMUG-20, HMUG-150, and LITTLE_SHALLOW (fig. 2; construction information in table 1, at back of report).

Installation of the three wells in the bedrock aquifer predated this study (Arihood, 1994). The bedrock well RASA2 is 2.4 km west of the Hog Marsh and is cased through 21 m of unconsolidated surficial material and open to 185 m of mixed-lithology Silurian and Devonian formations (fig. 2; geologic information in table 1, at back of report). The bedrock wells LITTLE_EAST and LITTLE_WEST are 1.8 km northeast of Hog Marsh and are open to Silurian and Devonian carbonate rocks from about 30 to 76 m and from about 25 to 26 m below land surface, respectively (fig. 2; well-construction data in table 1, at back of report).

The well network at the LaSalle wetland consisted of six wells finished in the surficial aquifer and one well finished in the bedrock aquifer (fig. 3; well-construction information in table 1, at back of report). Two wells were nested at each of the L1, L2, and L3 sites and finished near the middle and base of the surficial aquifer (fig. 8B). The well finished in bedrock at LaSalle (L2-BEDROCK) predated this study. Well L2-BEDROCK was cased through unconsolidated surficial material and open to mixed-lithology Silurian and Devonian formations from about 21 to 39 m. The well nest at L3 was as close to the regional flow path as possible, given limitations in drilling-rig access because of the location of roads and an oxbow (shown in fig. 3).

Wells at Hog Marsh and LaSalle that were finished in the surficial aquifer were installed with the hollow-stem auger method. Wells were constructed of 50.8-mm inner-diameter polyvinylchloride (PVC) casing and screens. The bottom 1.5 m of each well was screened in the surficial aquifer. After drilling, a log of natural-gamma radiation was made to assist with geologic descriptions. One well, L1A, was constructed of 5-cm inner-diameter galvanized pipe and a 1-m long stainless-steel screen that was hand driven into the surficial aquifer.

Surface-water-stage measurements at Hog Marsh were collected at four sites (table 2). Stage measurements were collected once a month during 9 of 12 months from August 1998 through August 1999 in Brown Ditch (HMBD) and during 12 of 13 months from July 1998 through August 1999 in the Kankakee River (HMGKR) at Hog Marsh (fig. 2). Continuous measurements of stage at sites HMBD and HMGKR also were recorded during the study; data from the continuous measurements were used to evaluate streambed hydraulic conductivity. A staff gage was installed in unit D (HM-UNITD, fig. 2) and water-level measurements were recorded during December 1998 and in February, March, June, and July 1999. USGS streamflow-gaging station Kankakee River at Shelby, IN. (05518000, fig. 1) provided continuous stage and discharge measurements near LaSalle (Stewart and others, 1999, 2000).

Water levels in all wells at LaSalle and Hog Marsh were measured monthly with an electric tape. Data from these wells during the period of record are shown in table 3 (at back of report). Continuous water-level data were acquired hourly in wells HM4A, HMUG-20, and HMUG-150 and at stage sites HMBD and HMGKR to evaluate streambed conductivity. The continuous ground-water- and surface-water-level data used for these analyses were from July 5 to August 23, 1998, and are shown in table 4 (at back of report).

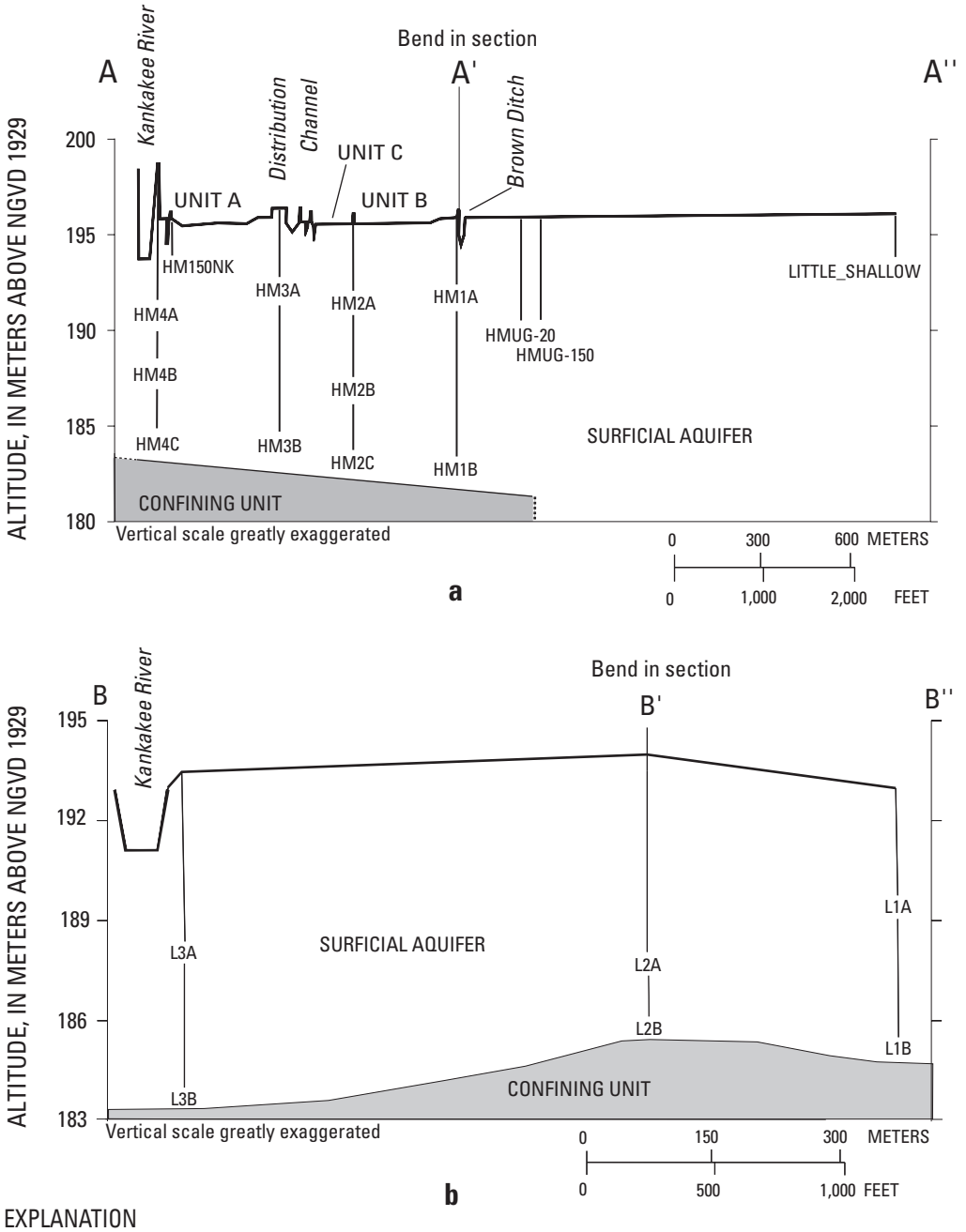


Figure 8. Vertical location of wells at (a) Hog Marsh and (b) LaSalle, northwestern Indiana (see figures 2 and 3, respectively, for transect locations).

Table 2. Selected characteristics for surface-water-stage measurement sites at Hog Marsh, northwestern Indiana.

[mm/yyyy, month/year]

Local surface-water site identifier	Latitude[a]	Longitude[a]	Date installed (mm/yyyy)	Type of site
HMBD	41˚14’08”	087˚15’25”	06/1998	Staff gage in ditch
HMGKR	41˚13’40”	087˚14’57”	06/1998	Staff gage in river
HM-UNITC	41˚13’59”	087˚15’07”	06/1998	Staff gage in wetland unit
HM-UNITD	41˚13’54”	087˚15’30”	06/1998	Staff gage in wetland unit

[a]Horizontal datum is referenced to North American Datum of 1927.

Hydraulic Tests

The first analysis of the hydraulic characteristics of the surficial aquifer consisted of a set of aquifer tests done in the surficial aquifer during October 1998 in the nested observation wells along the two transects. At a single well nest, the shallow well was pumped; drawdown in the deep well, typically about 3 m horizontally from the shallow well, was recorded. The pumping rate in the shallow well was about 0.57 L/s. Pumping continued at a steady rate for about 30 minutes. A greater pumping time would have been more informative, but pumping time was limited because of the number of wells to be tested. Continuous drawdown measurements were made in the pumped and observation wells with a pressure transducer and were recorded with a data logger. After ground-water levels in both wells recovered to pre-test levels, the deep well of the nest was pumped while drawdown was measured in the shallow well. The second test was conducted, using the same pumping rates and measurement practices as in the first test.

The time/drawdown data from the aquifer tests were analyzed for aquifer transmissivity, horizontal hydraulic conductivity, anisotropy ratio, specific storage, and specific yield; analytical solutions provided by Moench (1997) for unsteady flow in an unconfined (water-table) aquifer were used. The Moench solution was applied using the software package AQTESOLV (HydroSOLVE, Inc., 1998). The solution accounts for the effects on drawdowns from delayed gravity drainage, well-bore storage, well-screen skin, and partial penetration of pumping and observation wells. The observation and pumping wells in the Hog Marsh and LaSalle networks only partially penetrated the surficial aquifer; they were assumed to have no clogging-skin effects because they had been rigorously developed after installation. Because the tests lasted only about 30 minutes, the data were assumed to represent “early time” drawdown information. Early time data are fit to the first part of the curve, representing time versus drawdown in a water-table aquifer; curves developed from the analytical solutions of Moench (1997) were used. Although computed specific-yield values internally were consistent, early time data generally represent response to the specific storage of the surficial aquifer rather than to the specific yield. For this reason, the specific-yield values computed from the aquifer-test data only are considered qualitative.

The second hydraulic analysis estimated surficial-aquifer and streambed-hydraulic properties by using the rise and fall in ground-water levels caused by the rise and fall in a nearby stream (Barlow and Moench, 1998; DeSimone and Barlow, 1999). The technique, called the flood-wave-response analysis, can be applied to water-table (unconfined) or confined finite and semi-infinite aquifers. The water-table solution of the method was selected to analyze data from the surficial aquifer at Hog Marsh. Values of horizontal and vertical hydraulic conductivity, specific yield, and specific storage of the surficial aquifer were computed with the analysis. The hydraulic conductivity of the streambed also was computed with the analysis by matching simulated hydrographs to measured ones.

The resulting estimate of streambed hydraulic conductivity is an estimated average value for an approximately 15 m reach of streambed near the stream and ground-water instrumentation. For this reason, the flood-wave-response analysis does not have the limitations of seepage meters or permeameters where only local values of streambed hydraulic conductivity are measured.

Numerical Modeling

A cross-sectional, numerical ground-water flow model was used to simulate the geohydrologic conditions and ground-water flow at Hog Marsh. The ground-water-flow simulations were done for Hog Marsh to assist the conceptual understanding of the effect of managed flooding on vertical flow in the surficial aquifer. Simulating flow along the transect of wells was considered an appropriate representation of the total aquifer system underlying Hog Marsh. Data indicated a simple flow-through system at the LaSalle wetland and

no model was needed as a demonstration. The finite-difference numerical code developed by Harbaugh and McDonald (1996), commonly referred to as MODFLOW, was used to simulate ground-water flow at Hog Marsh. An iterative procedure is used in MODFLOW to solve the continuity equation for steady flow in a water table (unconfined), anisotropic, homogenous, ground-water-flow system. The programs MODPATH and MODTOOLS were used to compute and plot the advective flow paths of select ground-water parcels (Pollock, 1994; Orzol, 1997). These flow paths began at a model boundary cell and continued to a simulated discharge point.

Hydrologic Characteristics of the Hog Marsh and LaSalle Wetlands

Wetland development is affected by the range in fluctuation of the water table, directions of ground-water flow relative to the wetlands and adjacent hydrologic boundaries, and the hydraulic properties of the aquifer and adjacent streambeds. These characteristics were found to differ between the two wetlands.

Ground-Water Levels and Flow Directions

Ground-water levels in the unconfined surficial aquifer beneath the two wetlands were analyzed by observing the interquartile range of water levels, as shown by boxplots (fig. 9). The interquartile range (the middle 50 percent of the water levels) was chosen for analysis because the data set represents the most commonly occurring water-level values that have the most influence on the soil-moisture condition. Ground-water levels fluctuated the most in wells at Hog Marsh adjacent to the Kankakee River (about 1.2 m) because of large fluctuations in the stage of the river. Ground-water levels away from the river at Hog Marsh fluctuated less (from 0.4 to 0.7 m) than all ground-water levels in the same aquifer beneath LaSalle (from 0.9 to 1.0 m) (fig. 9). The difference in the range of water-level fluctuation probably is attributable to the managed flooding of Hog Marsh units, which tends to maintain similar water levels in that wetland. Ground-water levels were lowest during summer and fall and highest in the winter and spring at Hog Marsh and LaSalle.

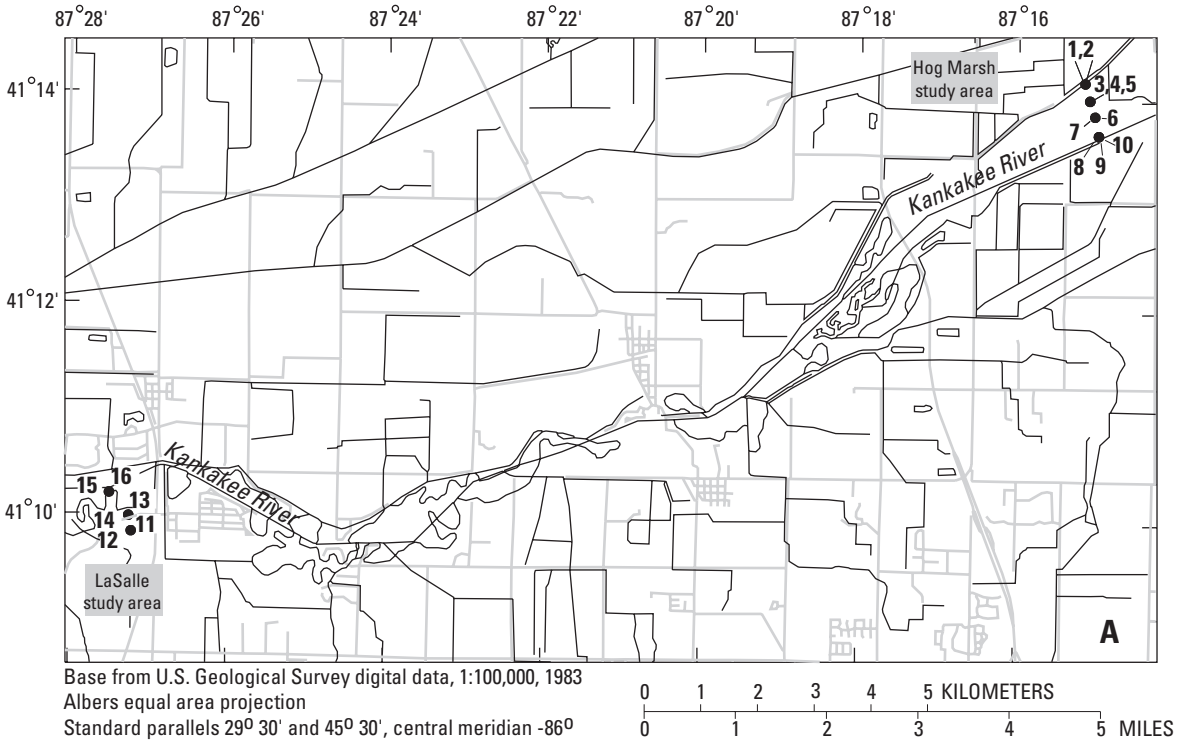
Contours of water levels at Hog Marsh indicated the development of two flow patterns during the year. During winter and spring, when flow in the Kankakee River is high, flow is from the Kankakee River into the adjacent surficial aquifer and towards Brown Ditch (fig. 10). Water levels in Brown Ditch remain lower than those in the Kankakee River during this period. During this same time, water-level altitudes in the river are greater than those in the bedrock aquifer and water from the surficial aquifer beneath the river flows into the bedrock aquifer (Arihood, 1994). During summer and fall, when flow in the Kankakee River is moderate to low, a flow divide develops at Hog Marsh between well sites HM2 and HM3. During this period, ground-water flow south of the flow divide is to the Kankakee River; north of the divide, it is toward Brown Ditch (fig. 11). The slight ground-water mounding near the center of Hog Marsh is accentuated by water-management practices that flood the center of the Hog Marsh. These water-management practices include pumping water from the Kankakee River and Brown Ditch into the distribution channel and distributing that water into adjacent units to maintain water in those units. Temporary reversals of the summer/fall flow pattern can occur near the Kankakee River and Brown Ditch during large rain storms. During these storms, river-water levels are elevated temporarily relative to water levels in the shallow aquifer, and river water infiltrates into the shallow aquifer.

In contrast to the ground-water-flow patterns observed at Hog Marsh, water levels measured across LaSalle generally indicated persistent flow from sites L1 and L2 to the Kankakee River (figs. 10 and 11). Water-level information indicates some infiltration from the river to the surficial aquifer beneath LaSalle during periods of high streamflow in the Kankakee River; the ground-water-flow reversals, however, generally last less than 1 month. The consistent flow of ground water from LaSalle toward the Kankakee River may be attributable to the absence of drainage ditches south of the well transect.

Ground-water levels near site L2 indicated that flow was consistently from the surficial aquifer to the underlying bedrock aquifer. Near site L1, however, ground-water levels indicated a tendency for upward flow from L1B to L1A (fig. 11); evapotranspiration in the sedge meadow that surrounds site L1 may be a causative factor.

Hydraulic Properties

Horizontal hydraulic conductivity (hereafter referred to as hydraulic conductivity) values for the surficial aquifer underlying Hog Marsh computed from aquifer-test data ranged from 18 to 37 m/d; the hydraulic conductivity at the one successfully tested LaSalle well was 7.9 m/d (table 5). Although one test cannot represent the entire LaSalle wetland area, hydraulic conductivity generally may be lower there than at Hog Marsh. A natural-gamma log of well L3B indicated a fining downward sequence in the unconsolidated sediments, but natural-gamma logs for the Hog Marsh area indicated sand and gravel at depth. Not all drawdown data could be used to calculate aquifer parameters because problems were encountered in some tests (such as the pumped well dewatered or drawdowns were affected by surging in the pumped well). Hydraulic conductivity data from the aquifer tests for the Hog Marsh area are from one-fourth to one-half the model-calibrated value by Bergeron (1981). The reason for lower values from the aquifer tests could be that the tests were done in alluvial sediments next to the river; the sediments may be more fine-grained than in the outwash deposits that constituted most of Bergeron's model area.



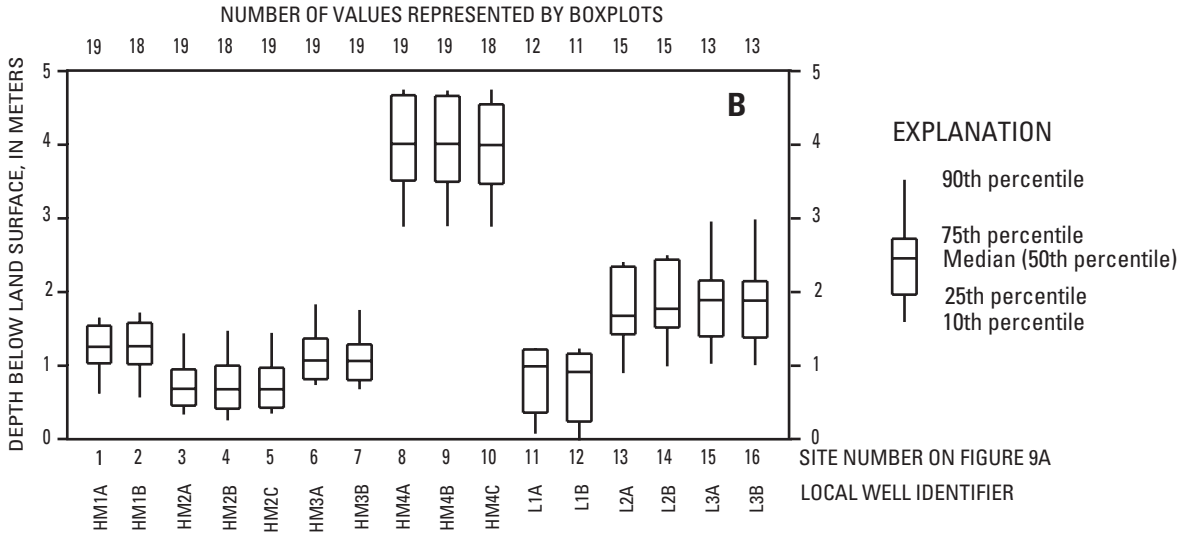
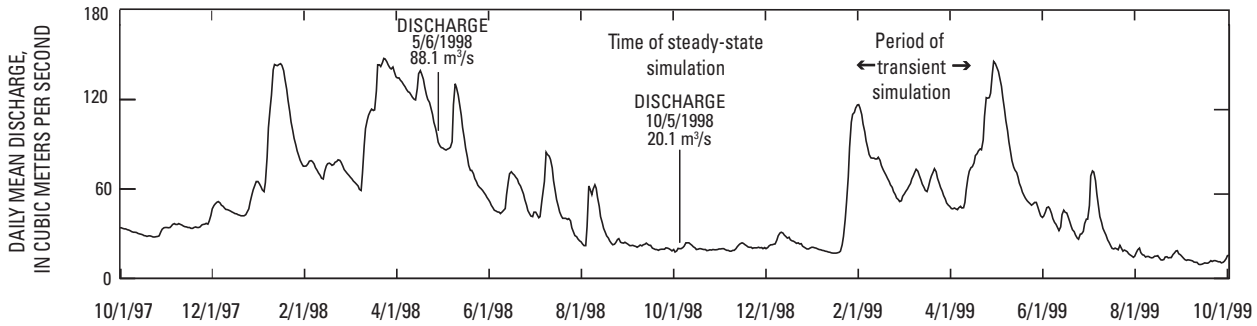
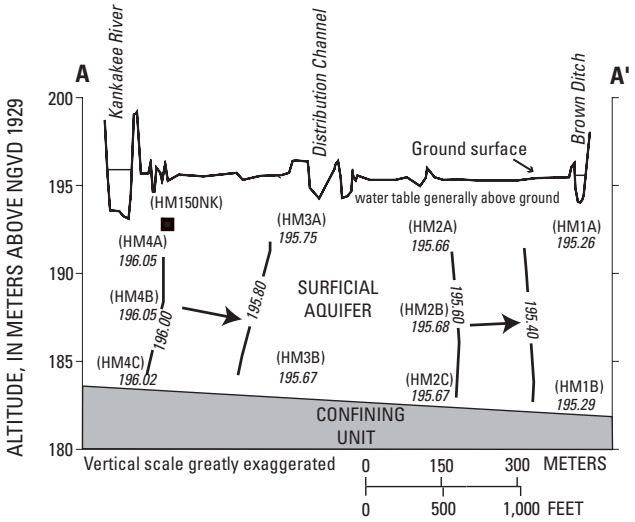


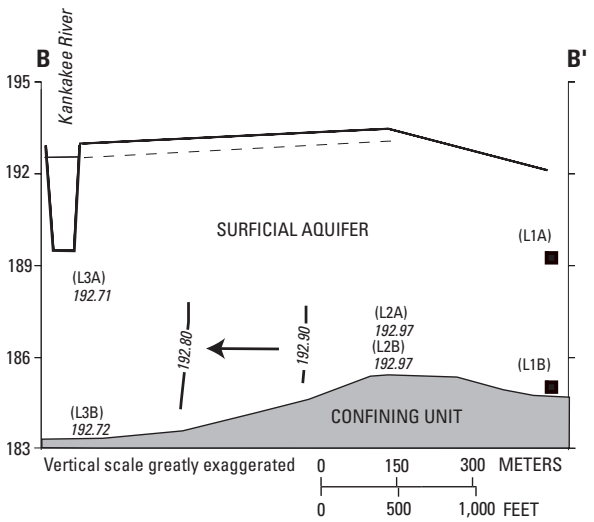
Figure 9. (A) location of observation wells and (B) truncated boxplots of depth to water level below land surface at Hog Marsh and LaSalle, northwestern Indiana, October 1997—August 1999. Truncated boxplots show the whisker end at the 10th and 90th percentiles, respectively.



DISCHARGE FOR THE U.S. GEOLOGICAL SURVEY STREAMFLOW-GAGING STATION KANKAKEE RIVER AT SHELBY, INDIANA



WATER-LEVEL CONTOURS AT HOG MARSH FOR MAY 6, 1998

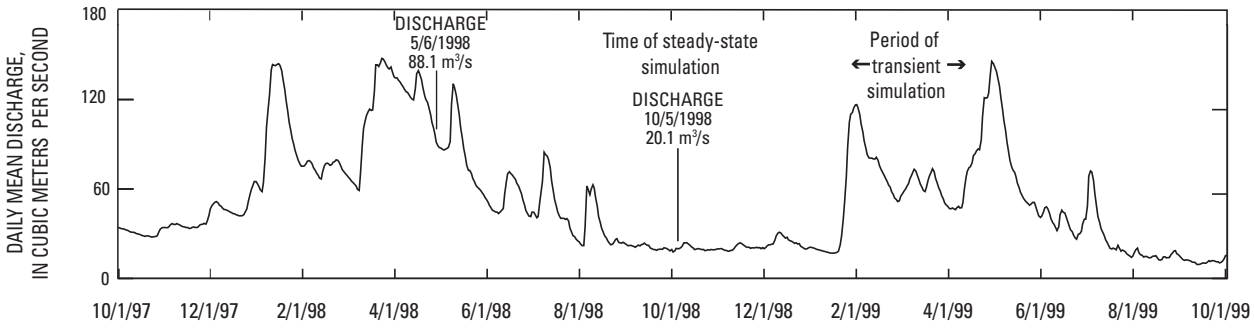


WATER-LEVEL CONTOURS AT LASALLE FOR MAY 6, 1998

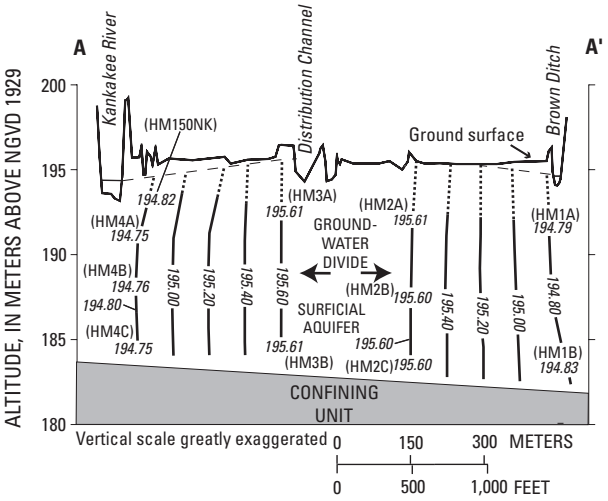
EXPLANATION

195.80	WATER-LEVEL ALTITUDE CONTOUR—Shows altitude of ground-water level in a tightly cased well. Contour interval is 0.2 meter for Hog Marsh data and 0.1 meter for LaSalle data. Datum is NGVD 1929
	Approximate water-table surface
	Generalized ground-water-flow direction
(HM1A) 195.26	Water-level altitude, in meters, with well name in parentheses
	Location of well screen without data

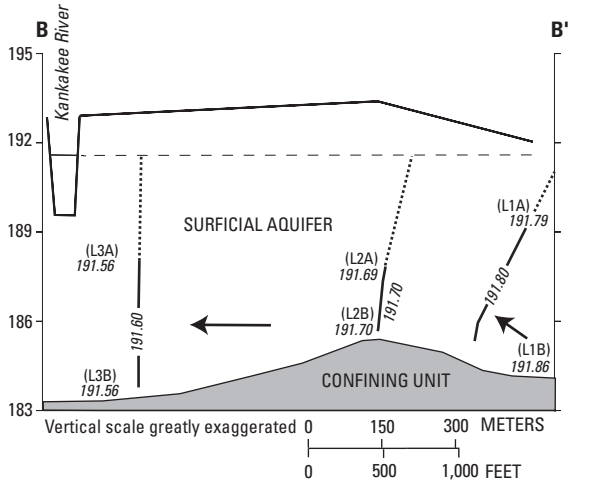
Figure 10. Relation between streamflow hydrograph for the Kankakee River, October 1, 1997—October 1, 1999, and cross-sectional water-level contours at Hog Marsh and LaSalle, northwestern Indiana, May 6, 1998.



MEAN DAILY DISCHARGE FOR U.S. GEOLOGICAL SURVEY STREAMFLOW-GAGING STATION
KANKAKEE RIVER AT SHELBY, INDIANA



WATER-LEVEL CONTOURS AT HOG MARSH FOR OCTOBER 5, 1998



WATER-LEVEL CONTOURS AT LASALLE FOR OCTOBER 5, 1998

EXPLANATION

191.60	WATER-LEVEL ALTITUDE CONTOUR—Shows altitude of ground-water level in a tightly cased well. Contour interval is 0.2 meter for Hog Marsh data and 0.1 meter for LaSalle data. Datum is NGVD 1929
	Approximate water-table surface
	Generalized ground-water-flow direction
(HM1A) 194.79	Water-level altitude, in meters, with well name in parentheses

Figure 11. Relation between streamflow hydrograph for the Kankakee River, October 1, 1997—October 1, 1999, and cross-sectional water-level contours at Hog Marsh and LaSalle, northwestern Indiana, October 5, 1998.

Table 5. Hydraulic characteristics computed from aquifer-test data collected at Hog Marsh and LaSalle, northwestern Indiana, October 1998.

[m, meter; m^2/d, square meter per day; m/d, meter per day; 1/m, unit in reciprocal meter]

Well tested	Observation well	Transmissivity (m^2/d)	Horizontal hydraulic conductivity (m/d)	Anisotropy ratio	Storage coefficient	Specific storage (1/m)	Saturated thickness (m)
HM1A	HM1B	270	21.0	0.28	0.0052	0.00039	13
HM1B	HM1A	340	27.0	.062	.0016	.00012	13
HM2B	HM2A	300	23.0	.13	.0068	.00052	13
HM3B	HM3A	210	18.0	.38	.0093	.00079	12
HM4A	HM4C	370	37.0	.035	.00085	.0026	11
HM4C	HM4A	360	34.0	.12	.0027	.00026	11
L1B	L1A	33	7.9	.07	.0020	.00046	4.3

Values for specific yield determined by the aquifer tests are not shown in table 5 because specific yields are based on early time/drawdown data and are subject to error. The values range from 0.0037 to 0.071, and the median value is 0.032. Examples of the measured and computed time/drawdown relations for Hog Marsh are shown in figure 12.

Hourly measurements of ground-water- and surface-water-level data were used in flood-wave-response analyses to simulate measured hydrographs in selected wells adjacent to the Kankakee River (HM4A) and Brown Ditch (HMUG-20 and HMUG-150; table 4 at back of report). The flood-wave-response analysis was applied to data from HMUG-20 and HMUG-150 near Brown Ditch and HM4A near the Kankakee River during two storms in July and August 1998. Initially, all surficial aquifer and streambed parameters were varied to obtain a match between the simulated and measured hydrographs; multiple solutions could be obtained with different sets of parameters. All surficial-aquifer parameter values subsequently were given a constant value, based on the previously completed aquifer-test analyses. A set of average aquifer parameter values considered representative of all the wells was chosen for the flood-wave-response analyses. The set of surficial-aquifer parameter values are given below:

Horizontal hydraulic conductivity	=	24.4 m/d at all wells
Vertical hydraulic conductivity	=	2.44 m/d at all wells
Specific storage	=	3 x 10^{-4} m^{-1} at all wells
Specific yield	=	0.03 at HM4A and 0.01 at HMUG-15 and HMUG-150

The only remaining undefined parameter, streambed hydraulic conductivity, was adjusted until the simulated hydrograph closely matched the measured hydrograph.

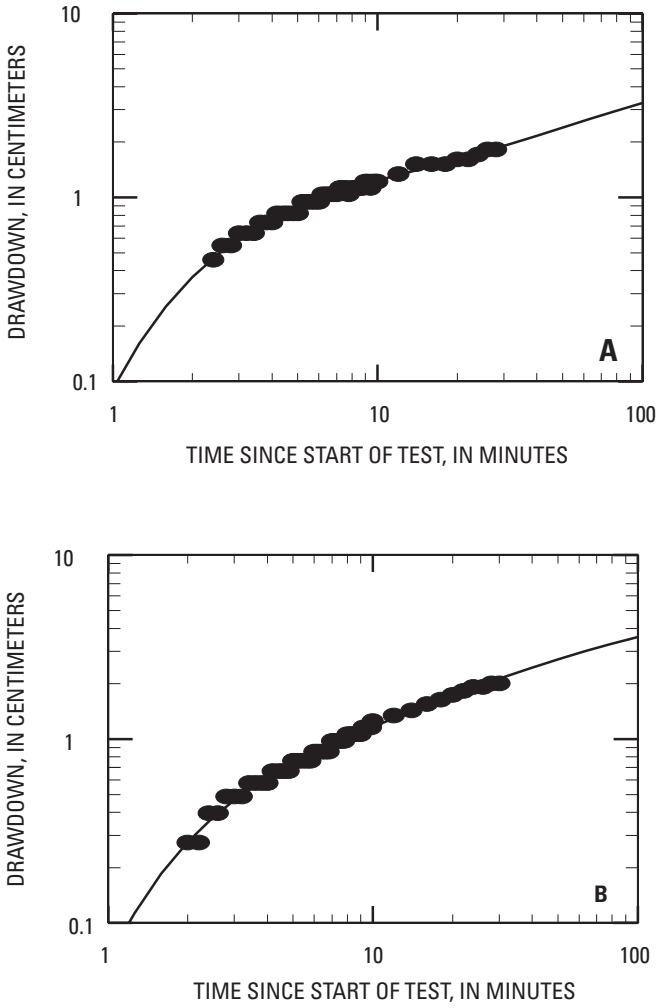


Figure 12. Time/drawdown plot for aquifer test using wells (A) HM1A and (B) HM1B, Hog Marsh, northwestern Indiana, October 1998.

The analyses were done for data collected immediately before and for several days after storms on July 7, 1998, and August 3 and 4, 1998. Precipitation at Hog Marsh during storm 1 (9:30 to 11:45 on July 7, 1998) totaled 8.13 cm, with 7.39 cm of that total falling between 9:45 and 10:30 on that day. Precipitation at Hog Marsh during storm 2 (23:30 on August 3, 1998, to 14:15 on August 4, 1998) totaled 6.25 cm in that period, with 3.81 cm of that total falling between 22:15 on August 3 and 10:30 on August 4.

The flood-wave-response analyses computed a streambed hydraulic conductivity of 0.18 m/d for the Kankakee River and Brown Ditch at all the sites for the two storms. A comparison of the simulated to measured hydrographs of ground-water levels supports the validity of this result; both hydrographs nearly are superposed for all wells across the entire extent of the hydrographs (fig. 13). The surficial aquifer near sites HMUG-20 and HMUG-150 adjacent to Brown Ditch, however, was simulated as confined for storm 1 and unconfined for storm 2. The water table during storm 1 was sufficiently close to ground surface for the surficial aquifer to demonstrate a confined response to the water-level fluctuations. When the water table is close to ground surface, the capillary fringe can occupy the entire unsaturated zone and the limited unconfined storage capacity prevents incorporation of additional recharge; the confined storage coefficient better describes the near-surface water-table condition (DeSimone and Barlow, 1999).

Ground-water levels in the observation wells near the streams reflect the rise and fall of stream stage. Part of the rise in the ground-water hydrograph, however, also may result from recharge of precipitation near the observation well. Recharge from storm 1 was sufficiently large to increase the background water-table altitude near HM4A. When no recharge was simulated, the receding limb of the simulated hydrograph fell below the receding limb of the measured curve. A 0.4 m rise in water level was measured at LITTLE_SHALLOW, a water-table observation well distant from the effect of any surface-water features. Applying 25 percent of that rise to simulations at HM4 caused the simulated hydrograph to match the measured hydrograph. DeSimone and Barlow (1999) have shown that an adjustment to the recharge may be necessary to minimize the difference between measured and modeled recession. Recharge was not added in the simulations of water levels at HMUG-150 and HMUG-20, possibly because recharge was not as great at those sites as at HM4. The recharge occurring from storm 1 was the result of a July thunderstorm that may have generated areally variable rainfall rates.

Numerical Simulations of Ground-Water Flow at the Managed Wetland

Ground-water flow was simulated numerically for near steady-state conditions at Hog Marsh in October 1998. The hydrologic environment during this period consisted of limited precipitation and flow in the Kankakee River and flooding in the center of Hog Marsh to facilitate waterfowl migration. Managed flooding is done during approximately a 4-month period from summer through fall. The hydrographs of river stage and ground-water levels for Hog Marsh shown in figure 14 show small changes during October. The 0.3-m fluctuation in river stage during October is similar to the range in fluctuations in the ground-water levels. The rise in ground-water levels caused by flooding of the Hog Marsh units appears to have ended by the beginning of October because ground-water levels were in recession during that period.

Modeling Approach

A cross-sectional model of ground-water flow through Hog Marsh was completed because flow perpendicular to the regional flow direction was considered small due to the proximity between the managed wetlands and the regional discharge area at the Kankakee River. Simulating flow along an instrumented transect was considered an appropriate representation of the total aquifer system underlying Hog Marsh. The cross-sectional profile for the model was constructed to be approximately perpendicular to the Kankakee River and Brown Ditch and oriented along a single, two-dimensional ground-water-flow path through the center of Hog Marsh. The flow path was identified using water-table-altitude contours calculated by a regional steady-state ground-water-flow simulation (fig. 6) (Bergeron, 1981, p. 40, fig 21). Regional ground-water-flow directions in other alluvial or outwash aquifers in Indiana generally are also toward and often perpendicular to major streams such as the St. Joseph River and parts of the White River (Bayless and Arihood, 1996; Arihood and Cohen, 1998; Gillies, 1976), lending support to this interpretation. A report by Loeltz and Leake (1983) determined that if the ground-water gradient parallel to a river is much smaller than the gradient perpendicular to the river, then the contribution from the parallel gradient can be ignored. Using downstream gradients from the ground-water-model simulation by Bergeron (1981) and perpendicular gradients at Hog Marsh, the gradient parallel to the Kankakee River was calculated to be $1/26^{th}$ of the gradient toward the river. Therefore, the downstream flow gradient and the associated downstream flow were considered insignificant compared to the gradient and flow toward the river as represented in the cross-sectional model.

The model was oriented through the center of Hog Marsh where water was released from the distribution channel into Hog Marsh units. Because the water levels in the units were managed to be greater than the bordering Brown Ditch and Kankakee River, the Hog Marsh area was considered to be the center of a water-table mound. Results by Thompson (2002) for a managed riverine wetland area in South Dakota indicatedthat ground-water levels were mounded beneath the center of a wetland unit and that ground-water flow was directed perpendicular to an adjacent creek that received ground-water discharge.

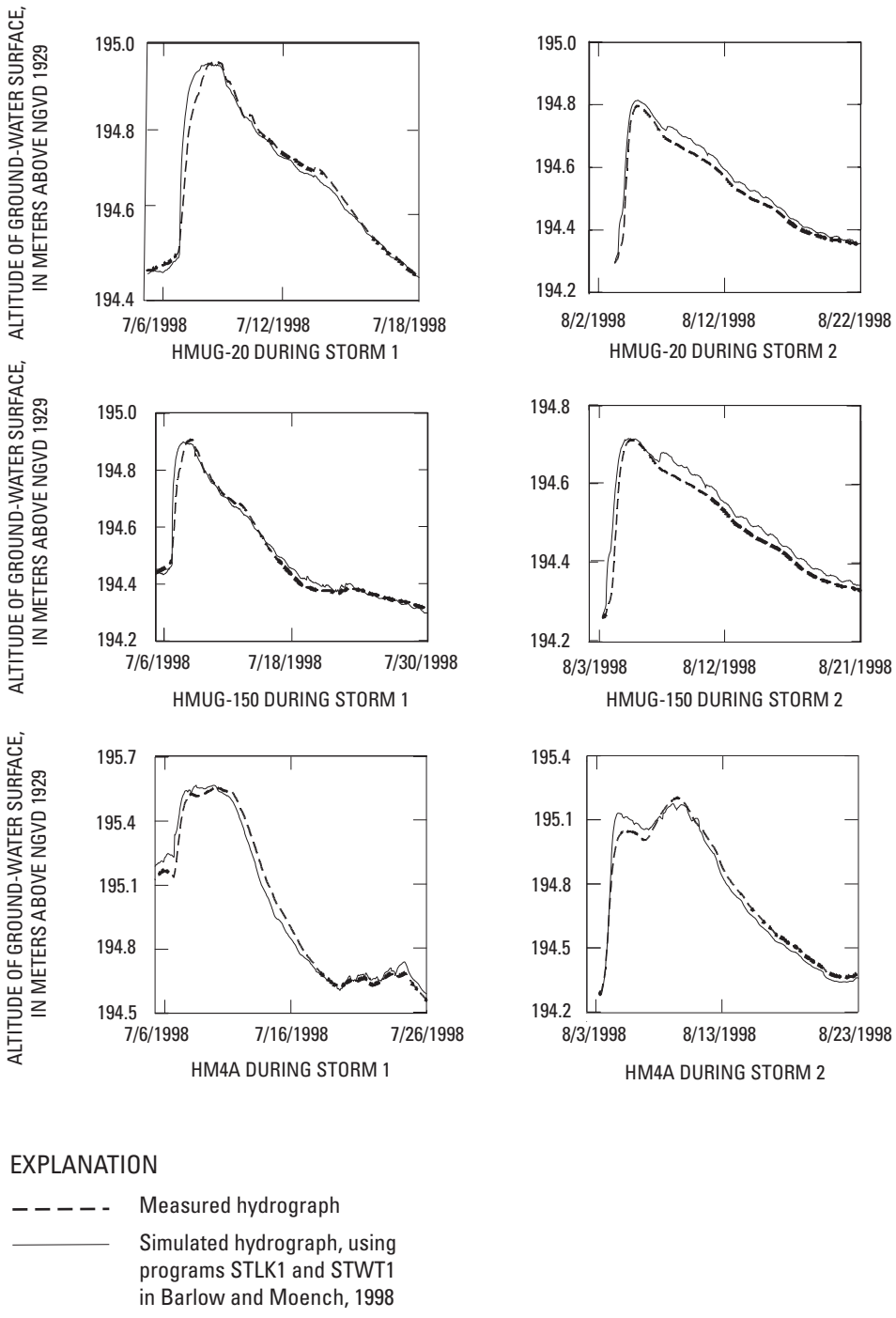


Figure 13. Simulated and measured hydrographs in near-stream observation wells during two storms at Hog Marsh, northwestern Indiana, July—August 1998.

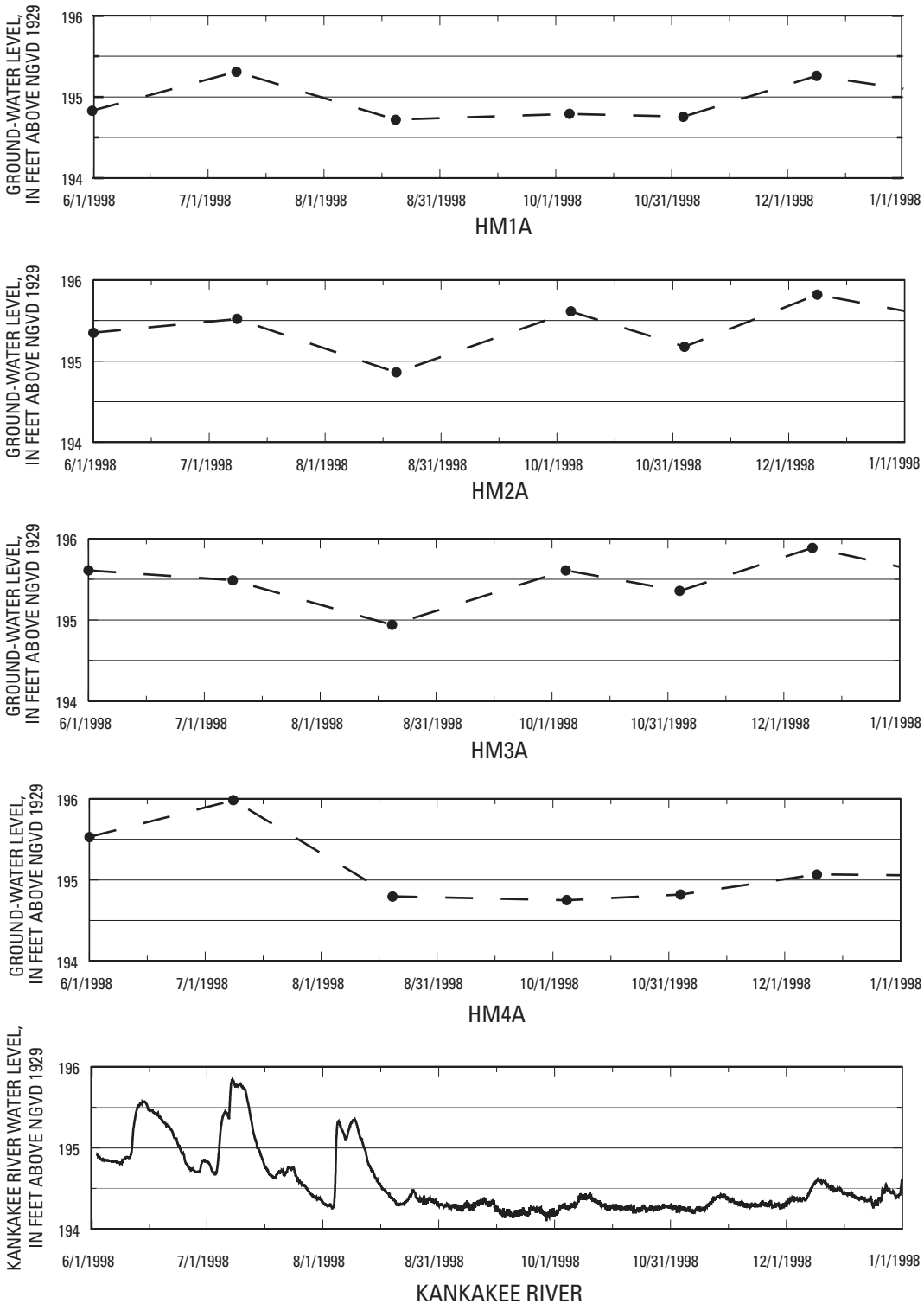


Figure 14. Ground- and surface-water levels at Hog Marsh, northwestern Indiana.

These characteristics support the assumption that the flow-path cross section at Hog Marsh was oriented through the center of the flooding, and the flow path was approximately perpendicular to the river.

Model Grid and Boundary Conditions

The model was based on a uniform, rectangular, block-centered grid that extended along a transect between Brown Ditch and the Kankakee River (fig. 15). The grid represents a cross section that extends approximately 1,100 m horizontally and 19 m vertically (fig. 15). The grid includes 50 rows and 76 columns, and a constant cell dimension of 0.376 m by 14.52 m. The cell size was chosen to adequately represent variations in the surface-water features, surface topography, geologic variability, and water-table altitude.

Four boundary conditions were used to simulate the hydrology at the edges of the model grid. A no-flow boundary was used on the southern vertical boundary because previous studies indicated that all ground water in the region discharges to the Kankakee River (Arihood, 1994; Bergeron, 1981). Head-dependent flux boundaries were used to simulate flow across the confining unit between the surficial and bedrock aquifers and across the northern vertical boundary of the model near Brown Ditch (fig. 15). A head-dependent flux boundary simulates flow across a boundary at a rate proportional to the hydraulic gradient across the boundary and the hydraulic conductance specified for the boundary. The gradient across the northern vertical boundary was estimated from water levels reported in Bergeron (1981). The conductance [(hydraulic conductivity x area) / flow distance] was based on assuming the horizontal hydraulic conductivity of the surficial aquifer was 24.4 m/d, similar to that estimated from the aquifer tests. The gradient and conductance terms for the lower boundary were calculated using water levels and vertical hydraulic conductivity values of the confining unit reported in Arihood and Basch (1994).

A head-dependent flux boundary, shown as stream nodes in figure 15, was used to simulate water levels in the Kankakee River, Brown Ditch, units B and C, and the distribution channel. Units B and C and the distribution channel were simulated with stream nodes only when they contained water; otherwise, they were represented by a free-surface boundary. Water levels for the distribution channel and other water bodies were obtained from the Lake County Parks Department (Marc Robertson, written commun., 1997). A free-surface boundary was used at the top of the grid to represent the water table. Recharge was applied to the top of the model grid wherever the surface was not flooded, thus making the top of the model in those areas also a specified-flux boundary. The specified flux, or recharge rate, was based on rates used in other model studies within the Kankakee River outwash (Arihood and Basch, 1994; Duwelius and others, 2002). Evapotranspiration was not simulated explicitly because net recharge (total recharge less evapotranspiration) was applied at land surface.

Model Calibration

Steady-state calibration of the ground-water model was accomplished by adjusting model-parameter values until simulated ground-water levels approximated field-measured values. Wells at Hog Marsh aligned along the well transect (figs. 2 and 6) provided measured data for comparison with simulations. Eleven water-level measurements and one estimate of pumpage to the Hog Marsh units were used for the model calibration.

The fluxes from units B and C into the cross-sectional model were calculated from pumpage records maintained by the Lake County Parks Department (Robert Studebaker, Lake County Parks Department, written commun., 1998). In October 1998, the Lake County Parks Department reported pumping 1,500,000 m^3 or 0.6 m^3/s of water into the Hog Marsh units. This water was assumed to seep into the surficial aquifer. Most of the pumpage in October was directed to units other than units B and C, which are part of the cross-sectional model, because the desired level of flooding in units B and C was achieved during the previous month. Therefore, a flux rate calculated from the reported pumpage rate would be higher than the actual flux rate reaching units B and C. The flux rate computed from the pumpage records was considered as an upper limit to which a model-simulated flux rate could be compared.

The initial calibration resulted in simulated water levels lower by about 0.5 m than the measured ground-water levels at sites HM2 and HM4. Simulated water levels at HM4 were close to measured water levels when the hydraulic conductivity of the Kankakee River streambed was decreased from 0.18 to 0.021 m/d; this value represented a decrease of about 88 percent from the hydraulic value predicted with the flood-wave-response analysis. The steady-state conditions used as a target for model calibration represented low-streamflow conditions. Studies have shown that during low-streamflow conditions, fine-grained sediments settle out of suspension and reduce the hydraulic conductivity of the streambed (Osterkamp and Harrold, 1982). The flood-wave-response analysis was done during storms when fine-grained sediments in the streambed may have been suspended; therefore, the hydraulic conductivity of the streambed may have been higher than during low-flow conditions.

The second major calibration adjustment to model parameters was to adjust the water levels in unit C and the distribution channel. These adjustments were confirmed to be reasonable after consulting with Grand Kankakee County Park personnel about conditions during the simulation period (Marc Robertson, Lake County Parks Department, oral commun., 1999). A minor calibration adjustment was made to the streambed hydraulic conductivity of Brown Ditch; streambed hydraulic conductivity was increased by about 50 percent from the original value of 0.18 m/d to 0.305 cm/d. The original value was based on a flood-wave-response analysis at a streambed site 700 m downstream from the modeled section; therefore, the adjustment may be reasonable.

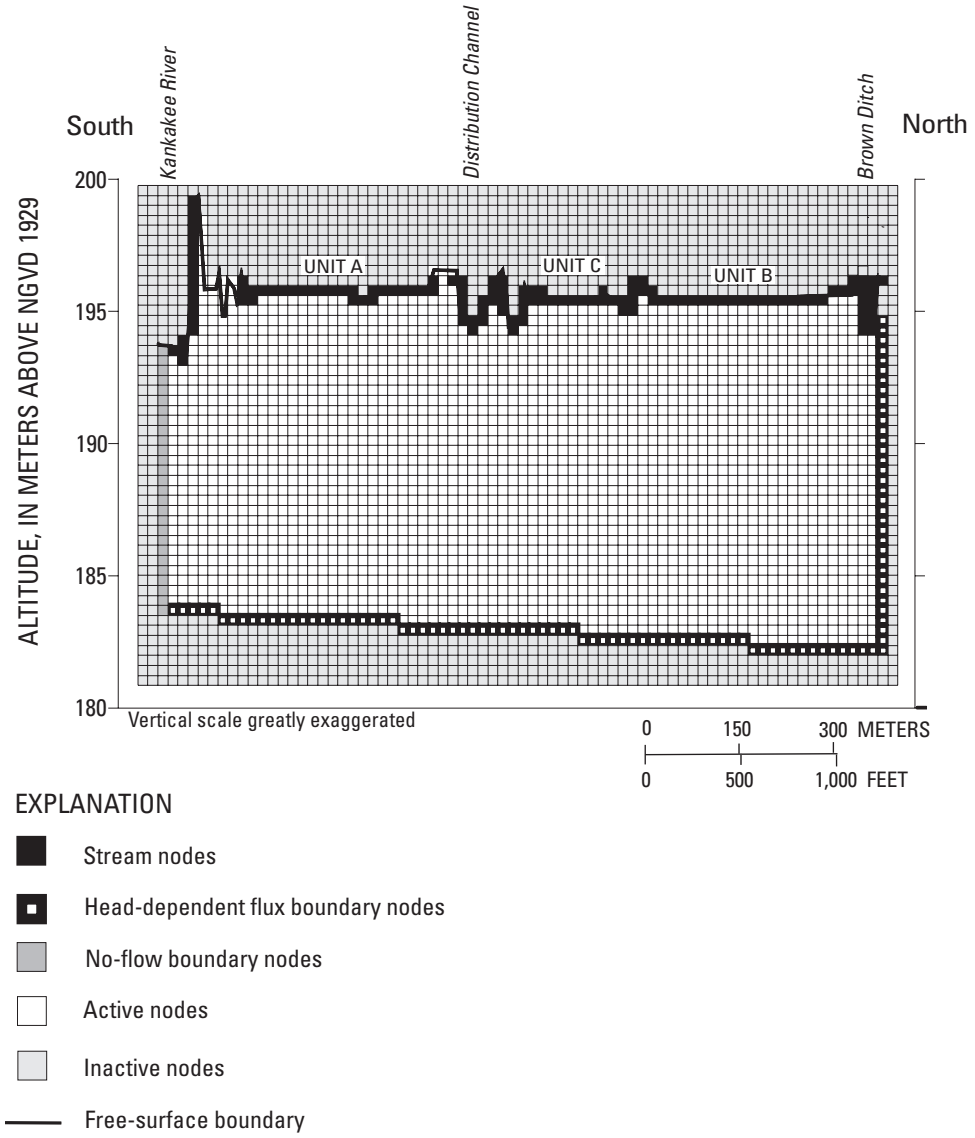


Figure 15. Model grid, boundary conditions, and stream nodes used in the simulation of ground-water flow at Hog Marsh, northwestern Indiana. Location of modeled cross section (section A-A') shown on figure 2.

The parameter values that produced the smallest discrepancies between simulated and measured ground-water levels are shown in table 6. A comparison of simulated and measured water levels is shown in figure 16.

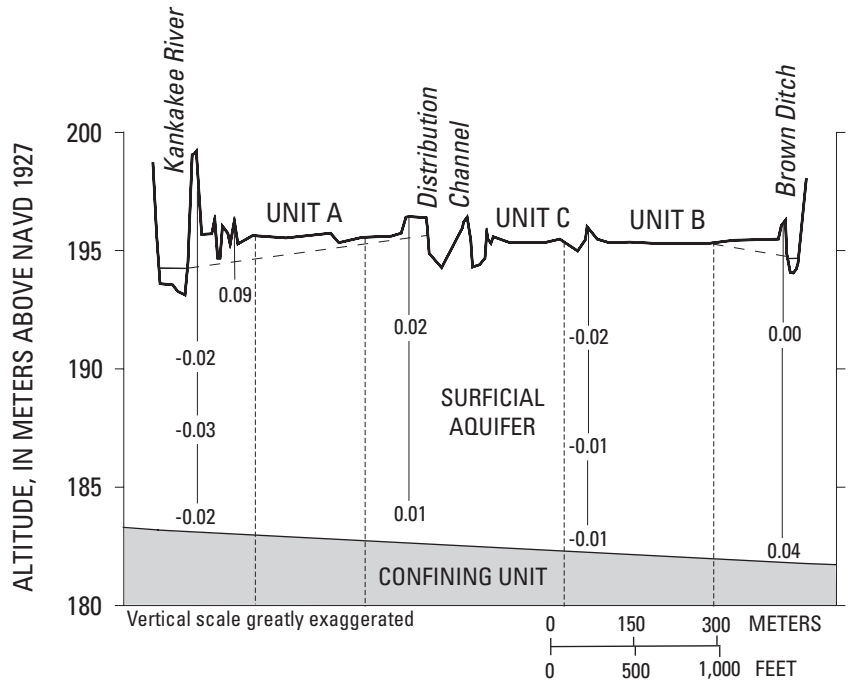
Model Sensitivity Analysis

The purpose of a sensitivity analysis is to determine the extent that model parameters affect simulated water levels. Those parameters determined to affect substantially the simulated water levels require accurate values for the model results to be considered reliable.

Table 6. Initial and calibrated model parameter values for the steady-state simulation of ground-water flow at Hog Marsh, northwestern Indiana, October 1998.

[m/d, meter per day; cm/yr, centimeter per year]

Parameter	Initial value	Calibrated value
Horizontal hydraulic conductivity	24.4 m/d	24.4 m/d
Vertical hydraulic conductivity	2.44 m/d	2.44 m/d
Recharge rate	25 cm/yr	25 cm/yr
Vertical hydraulic conductivity of the Kankakee River	.18 m/d	.021 m/d
Vertical hydraulic conductivity of Brown Ditch	.18 m/d	.305 m/d
Vertical hydraulic conductivity of flooded unit bottoms	.18 m/d	.18 m/d



EXPLANATION

- Approximate water-table surface
- Wetland unit boundaries
- Observation well
- 0.01 — Location of well screen and ground-water-level difference between simulated and measured values, in meters

Figure 16. Difference between simulated and measured ground-water levels, October 1998, in meters, for the calibrated steady-state ground-water-flow simulation at Hog Marsh, northwestern Indiana.

The parameters examined were the horizontal hydraulic conductivity of the surficial aquifer and the vertical hydraulic conductivity of the streambeds and flooded units of Hog Marsh. These parameters were chosen because, according to the model-simulated water budget, they controlled the amount of water that flows through the aquifer system; therefore, these parameters were the most likely to affect the simulated water levels.

Horizontal hydraulic conductivity of the surficial aquifer and vertical hydraulic conductivity of the streambeds (Kankakee River and Brown Ditch) and bed sediments of the Hog Marsh units were examined for model sensitivity. The steady-state ground-water-flow model was used for the sensitivity analysis by multiplying the calibrated-model parameters by factors ranging from 0.2 to 2.4, in 0.2 increments. Values of all other model parameters were held constant during the analysis. Model sensitivity was quantified by computing the mean absolute error and bias of the resulting simulated water levels. Bias is the sum of all positive and negative head residuals. The analysis indicated that the most-sensitive model parameter throughout the range of changes in parameter values was the vertical hydraulic conductivity of the streambeds and bed sediments of the Hog Marsh units (fig. 17). The streambed hydraulic conductivity is important because of its substantial effect on ground-water/surface-water interactions and water levels near the river. Horizontal hydraulic conductivity had less affect on ground-water levels near the river but had a strong affect on simulation results near the center of the marsh; it also should be considered a sensitive parameter.

Steady-State Simulation

The steady-state simulation results indicated that flow paths originating from flooded areas near the center of Hog Marsh, such as unit B and the distribution channel, are sources of recharge to the surficial aquifer during the 4-month managed-flooding period (fig. 18). Flow paths originating from unit B and the distribution channel indicate a strong downward vertical-flow component beneath the Hog Marsh units (fig. 18) and the infiltration of surface water into the aquifer. During the simulated period of managed flooding, recharge from the distribution channel reached a depth of 6 m and recharge from unit B reached a depth of approximately 9 m. The simulation also identified unit C as a discharge area (fig. 18). Unit C becomes a discharge area for ground water because its water level is lower than that in unit B and the distribution channel. The 4-month-flow lines originating from the sides, top, and bottom of the model are short, indicating little movement of water around the boundary of the model during the 4-month period. The time required for ground water to flow through the entire thickness of the surficial aquifer greatly exceeds the 4-month period of managed flooding. Flow lines representing travel times greater than 4 months are not shown because the associated flow patterns never develop during the 4-month period.

The flow paths indicate that surface-water flow from the Hog Marsh units enters limited areas of the surficial aquifer and that water from unit C does not enter the aquifer. Water-quality data, however, indicate that similar surface-water-quality characteristics are found throughout the upper part of the surficial aquifer. Ratios of major element concentrations from shallow wells beneath the Hog Marsh units were described previously as similar to those of water from the Kankakee River and Brown Ditch, the source of water used to flood Hog Marsh (Sidle and others, 2000a).

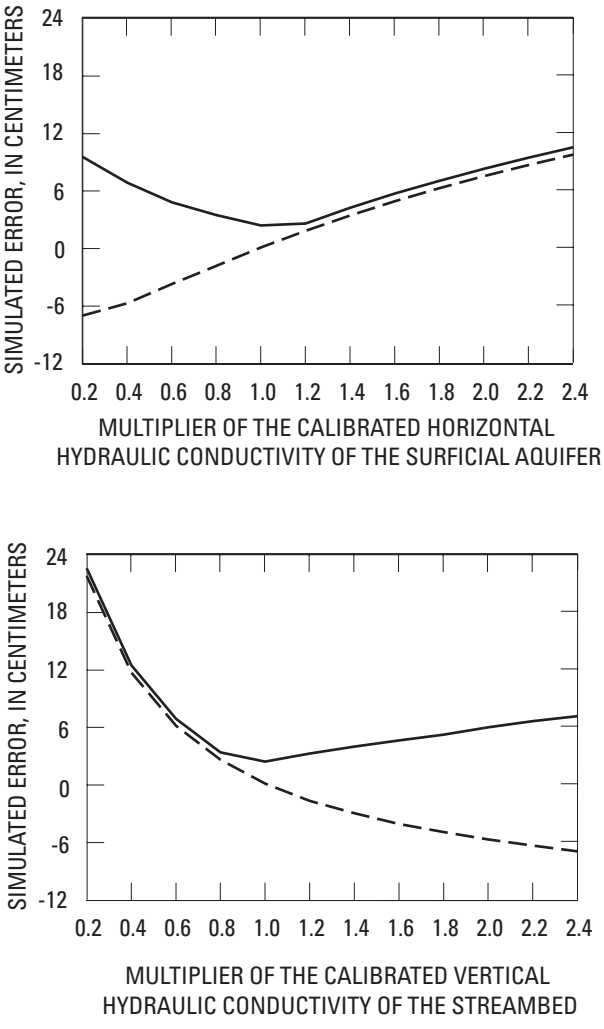


Figure 17. Relation between simulated errors and changes in the value of model parameters for the sensitivity analysis of the steady-state simulation of ground-water flow at Hog Marsh, northwestern Indiana.

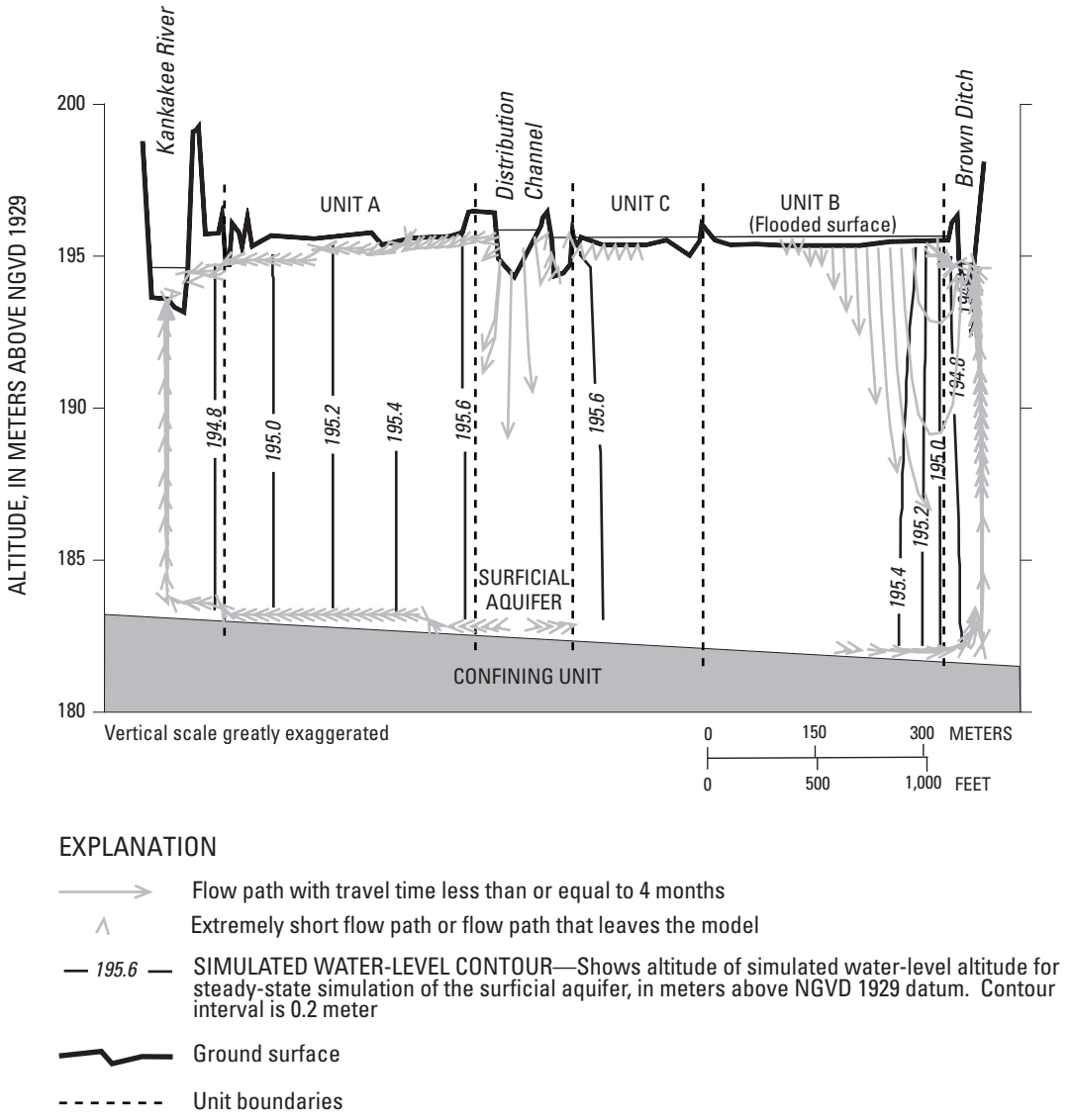


Figure 18. Model-simulated ground-water-flow paths and water-level contours under steady-state conditions of October 1998, at Hog Marsh, northwestern Indiana. Flow lines along the left side, bottom, and right side of the cross section appear continuous but actually are short and overlapping.

Sidle and others (2000b) also identified two patterns of similar oxygen and hydrogen stable-isotope ratios between surface water and ground water from the upper half of the surficial aquifer: (1) in surface water from unit C and ground water at adjacent wells HM2A and HM2B, and (2) in surface water from the Kankakee River and ground water at adjacent wells HM3A, HM4A, and HM4B. These results indicate that the water-quality characteristics of the ground water are influenced by multiple flow patterns at different times of the year, such as the winter/spring and the summer/fall flow patterns.

The model simulations indicated that Brown Ditch captured all of the ground-water flow in the surficial aquifer north of Hog Marsh. Measured ground-water levels and simulated flowlines showed that ground water flowing beneath the northern part of Hog Marsh discharged to Brown Ditch throughout the year and indicated that north-to-south flow beneath the ditch likely was small or nonexistent. Nitrate concentrations were greater in ground water from wells upgradient from and near Brown Ditch (averaging 1.32 mg/L as nitrogen in 1997-1999 water samples) than in water from the surficial aquifer beneath Hog Marsh (averaging 0.68 mg/L as nitrogen in 1997-1999 water samples) (Sidle and others, 2000b). The nitrate-data variation also may indicate the capture of ground water by discharge to Brown Ditch from areas north of the modeled section. Previous to tiling and ditching, Hog Marsh probably was a discharge area for ground-water sources farther to the north. This modeling result indicates the effects of ditching on ground-water-flow patterns at the Hog Marsh study site.

The water-budget results from numerical simulations indicated that 88 percent of inflow to the surficial aquifer beneath Hog Marsh was from flooded water in the distribution channel and unit B (table 7). The remaining inflows were from the surficial aquifer north of the cross section, the bedrock aquifer, and a small quantity of precipitation in areas without flooding. Outflows were mostly to Brown Ditch, probably because of its proximity to the flooded water.

Transient Simulation

A transient simulation was done for a period of high streamflow between January and May 1999. This period was selected because ground-water levels indicated the direction of flow was from the Kankakee River to the surficial aquifer underlying Hog Marsh and might provide information about ground-water/surface-water interactions in the study area. The purposes of the transient simulations were to: (1) examine the distance that surface water from the Kankakee River could penetrate the surficial aquifer during a 5-month high-flow period, and (2) test whether the model-parameter values derived from the steady-state calibration also would provide satisfactory simulation results for a period of variable flow conditions.

Transient conditions were simulated by raising water levels in the Kankakee River and Brown Ditch from the values used in the steady-state calibration to their respective average water levels for the 5-month high-flow period. As such, transient conditions were represented by one model stress period with 10 time steps, starting with a time step of 1.3 days and increasing by a factor of 1.5 for subsequent time-step lengths. Streamflow for the Kankakee River varied during the simulation period. This variation indicated that stream stage also fluctuated. Simulating one value for stream stage throughout the 5-month simulation would result in the simulated water levels being lower than ground-water levels measured during peak-flow periods and in the simulated water levels being higher than levels measured during recession periods. The simulation of average stream stage was used to demonstrate the approximate distance that surface water could travel into the surficial aquifer during periods of high streamflow. Recharge was not included in the transient simulations because the Hog Marsh units were flooded either naturally from streamflow rises or artificially by management practices.

A storage-coefficient value of 0.0048 and a specific-yield value of 0.03 were used for the transient simulations of the surficial aquifer at Hog Marsh. These values are average values from the aquifer tests.

Table 7. Water budget determined by steady-state model simulation, Hog Marsh, northwestern Indiana, October 1998.

[cm^3/s, cubic centimeter per second]

Source of inflow to model	Inflow rate (cm^3/s)	Source of outflow from model	Outflow rate (cm^3/s)
Precipitation	0.4	Discharge to Brown Ditch	16.7
Recharge from unit B and distribution channel	20.4	Discharge to Kankakee River	3.5
Inflow from bedrock aquifer and from north end of cross section	2.4	Discharge to unit C	3.0
Total inflow	23.2	Total outflow	23.2

Calibration was achieved for the transient model through changing one parameter value: streambed hydraulic conductivity. Prior to the adjustment, simulated water levels at HM4 were about 1.2 m lower than measured values. The under-prediction of ground-water levels decreased proportionally with distance from HM4. Changes in horizontal hydraulic conductivity of the surficial aquifer also were attempted during calibration of the transient model but did not substantially affect the match between simulated and measured water levels near the river (at well site HM4). The match between simulated and measured values was improved by increasing the hydraulic conductivity of the streambed for the Kankakee River from 0.021 m/d to 2.44 m/d. Increasing the value of hydraulic conductivity of the streambed increased surface-water movement from the river to the surficial aquifer and subsequently raised simulated water levels near the river. Final hydraulic conductivity of the streambed was set equal to the vertical hydraulic conductivity of the surficial aquifer, 2.44 m/d, resulting in simulated water levels at HM4 that closely approximated measured values (fig. 19).

The model simulations and the result of the flood-wave-response analysis also indicate that ground-water/surface-water interactions at natural riverine wetlands and at managed wetlands in riverine areas may be affected by variations in the hydraulic conductivity of adjacent streambeds. During a low-flow period in the Kankakee River, ground-water-flow simulations of the surficial aquifer at Hog Marsh indicated a streambed hydraulic conductivity of 0.021 m/d. A flood-wave-response analysis during a period of moderate streamflow determined the streambed hydraulic conductivity to be 0.18 m/d. A transient model simulation during a period of high streamflow indicated that the streambed hydraulic conductivity was 2.44 m/d. The apparent relation between streamflow and hydraulic conductivity of the streambed may indicate that the quantity of ground-water/surface-water exchange varies seasonally.

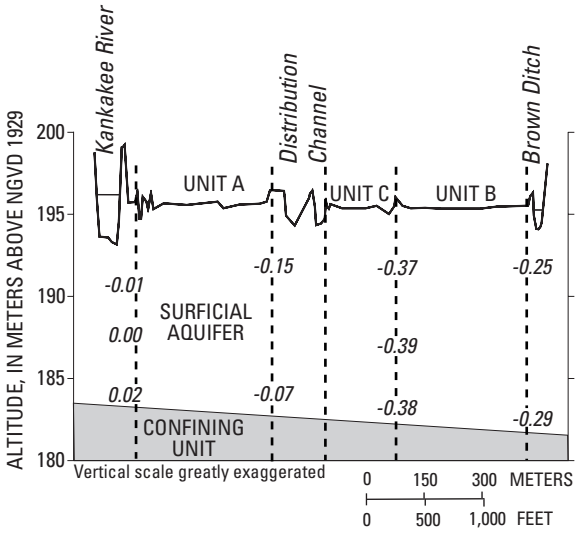
An explanation for differences in the hydraulic conductivity of the Kankakee River streambed could be based on the changing physical structure of streambeds during various flow conditions. The lower value of streambed hydraulic conductivity (0.021 m/d) used for simulating steady-state conditions during a low-flow period in the Kankakee River in October 1998 (20.1 m^3/s mean daily discharge for October 5, 1998; USGS streamflow-gaging station Kankakee River at Shelby, IN) (Stewart and others, 2000) might be appropriate under streamflow conditions that allow settling of fine sediment to the streambed. During higher flow conditions, such as those associated with the flood-wave response analyses, stream turbulence scours the streambed and re-suspends fine sediment; the result is exposure of more hydraulically conductive sand in the streambed. The mean daily discharges at Kankakee River at Shelby, IN, during data collection for the flood-wave response analyses peaked at 84.7 m^3/s on July 8, 1998, after storm 1 and at 62.9 m^3/s on August 23, 1998, after storm 2 (Stewart and others, 1999). The scour process may explain why the flood-wave-response analysis resulted in a higher streambed hydraulic conductivity for the Kankakee River (0.18 m/d) than eventually was used for steady-state model simulation. Likewise, the streambed hydraulic conductivity obtained from the transient simulation (244 cm/d) was higher than that obtained from the flood-wave-response analysis. The monthly maximum values of mean daily discharges at Kankakee River at Shelby, Ind., from January through May 1999 ranged from about 73 m^3/s on March 21, 1999, to about 146 m^3/s on April 29, 1999 (Stewart and others, 2000). Data from this period represented much higher Kankakee River streamflow than during the other analyses and corresponded to the highest streambed hydraulic conductivity. To confirm the described trend in streambed hydraulic conductivity with flow, additional field data and analysis would be required. Streambed particle-size samples would need to be collected during different flow rates with corresponding measurements of stream – aquifer flow direction. Also, a single method would need to be used to measure streambed hydraulic conductivity for all flows. If changes in streambed hydraulic conductivity occur, then such changes may affect the extent of ground-water/surface-water interactions in riverine wetlands, such as those at Hog Marsh and at LaSalle.

Simulated flow paths indicated that surface water from the Kankakee River penetrated only about 2 to 3 m into the surficial aquifer beneath Hog Marsh during the 5-month high-flow period. Surface water from Brown Ditch similarly entered parts of the adjacent surficial aquifer; however, the distance of penetration was small and the flow reversal was shorter (days) than the distance of penetration and flow reversal observed along the Kankakee River. For example, a storm during the first simulated time step caused a rapid increase in the stage of Brown Ditch; that flow reversal lasted less than the 1.3 days and the depth of penetration was less than the row dimension of a single model cell (0.376 m).

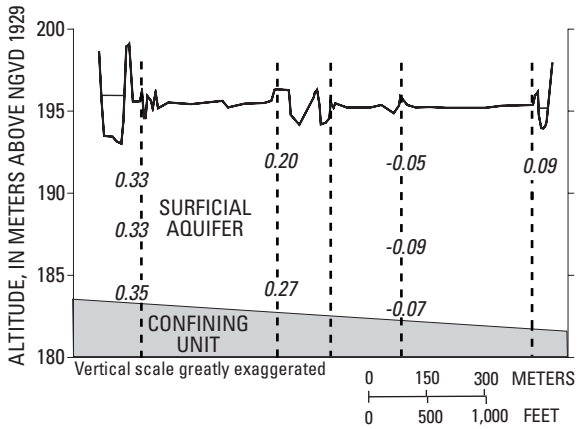
Ground-water levels from the transient simulation were near the measured levels in January, higher than measured levels in February, and lower than measured levels in April. The discrepancies result from simulated stream stages near the measured stages in January, above measured stages in February, and below measured stages in April. The simulated ground-water-level contours for the fifth time step (17.5 days of simulation) and tenth time step (150 days of simulation) are shown in figure 20. Ground-water flow was from south to north during all time steps of the transient simulations.

Limitations of the Model

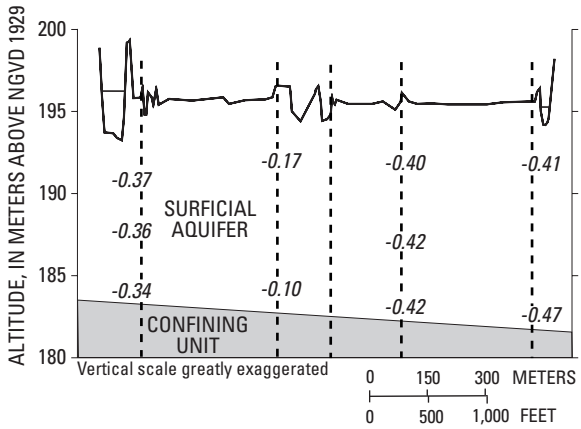
Reliability of model results presented in this report are evaluated on the basis of the frequency and density of field-measured data available for calibration and on the capability of the model to represent major factors that affect ground-water flow. In this section, data frequency and density are discussed so that the limitations in interpreting the simulation results can be evaluated.



A. Differences for January 21, 1999



B. Differences for February 18, 1999



C. Differences for April 1, 1999

EXPLANATION

- - - - - - - Unit boundaries

0.35 Location of well screens and water-level differences between simulated and measured values, in meters

Figure 19. Differences between simulated and measured ground-water levels at Hog Marsh, northwestern Indiana, in meters, for three points in time during the transient simulation, (A) January 21, 1999, (B) February 18, 1999, and (C) April 1, 1999. (Ground-water levels generally were at or above land surface.)

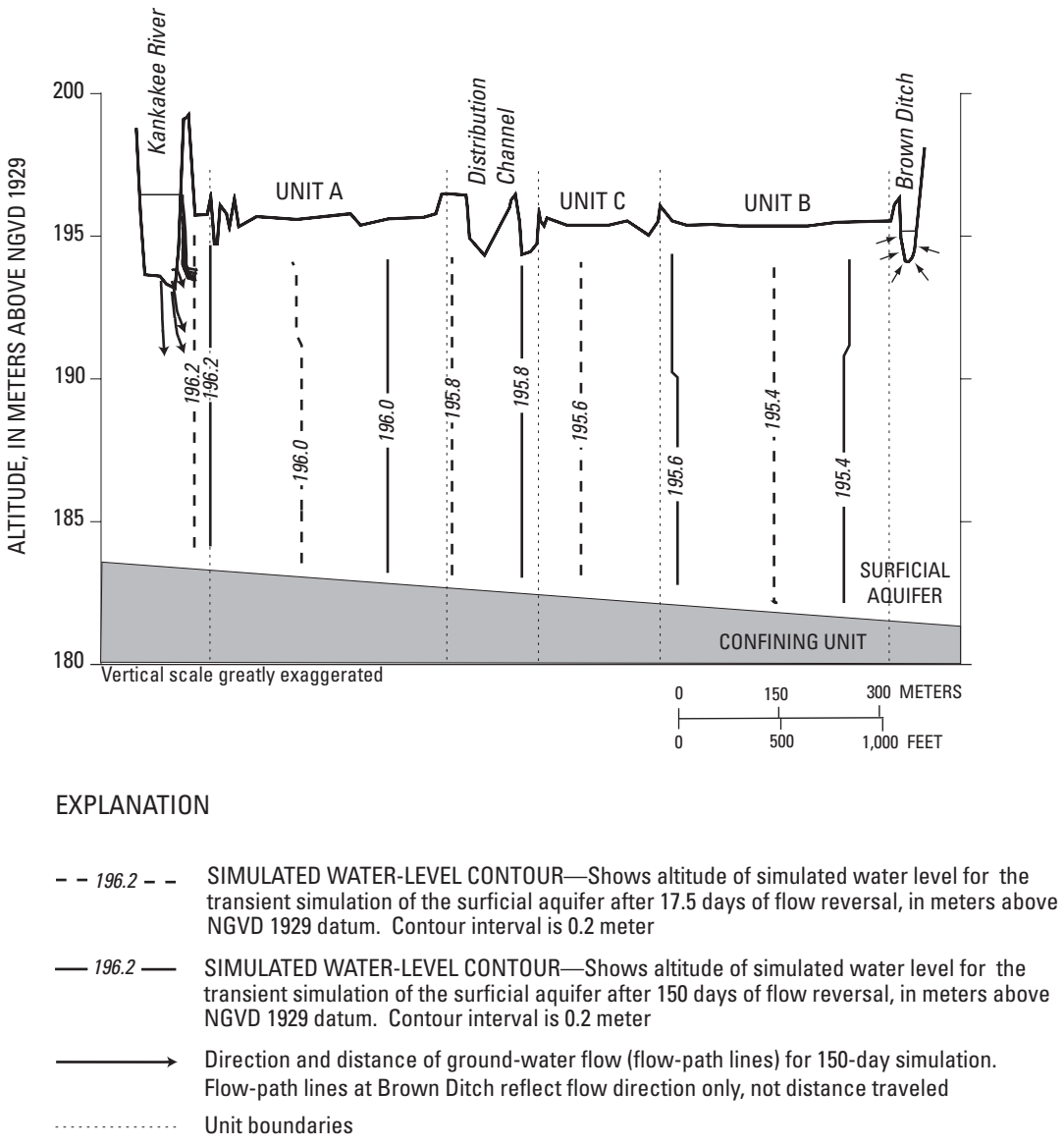


Figure 20. Simulated ground-water-level contours after 17.5 and 150 days of flow reversal from the Kankakee River to the surficial aquifer and flow-path development after 150 days of flow reversal at Hog Marsh, northwestern Indiana. (Ground-water levels generally were at or above land surface.)

Two conditions supported the results of the steady-state model simulations: (1) availability of calibration data, and (2) the successful use of common values for parameters of the surficial aquifer among different analysis techniques. The data availability for the steady-state calibration was greater in this modeling study than in other model calibrations done in Indiana because water-level and aquifer-test data were collected uniformly across the modeled cross section, water levels were measured monthly in every well, and aquifer tests were done in each well used for data collection. The aquifer tests resulted in a consistent and limited range of hydraulic conductivity values for all wells. Average values for parameters of the surficial aquifer, determined from the aquifer tests, then successfully were used in the flood-wave-response analysis and model calibration. The similarity of parameter values in the analytical (aquifer test and flood-wave-response analyses) and modeling exercises provides some confidence that the values and models are reasonably accurate.

One potential problem with any cross-sectional model is that any flow at angles to the model can increase the potential for improper selection of model-calibration parameters. Anderson and Woessner (1992) identified that the vertical anisotropy ratio of hydraulic conductivity may be defined inaccurately when ground-water-flow directions are at angles to a cross-section model. A vertical anisotropy ratio of 10 was used for the calibration of the Hog Marsh simulation. This ratio is similar to the value of 5 obtained by Duwelius and others (2002) in a simulation of ground-water flow in homogeneous glacial sediments in northern Indiana. This value also is reasonable because of the small differences in hydraulic head observed with depth through the surficial aquifer (table 3, at back of report).

The regional ground-water-flow direction in the surficial aquifer (from Bergeron,1981) and results of other analogous studies of ground-water flow near rivers (Thompson, 2002; Loeltz and Leake, 1983) indicate that flow paths that are perpendicular to an alluvial stream receiving ground-water discharge effectively can represent the principal pattern of ground-water flow and the water budget along those paths. Results of one of those studies (Thompson, 2002) indicated that ground-water flow from the center of flooding at a managed wetland toward an adjacent river could be described as perpendicular to that stream. The well transect at Hog Marsh parallels the regional direction of ground-water flow, was oriented through the center of the flooded area, and was as perpendicular to the stream as logistics permitted. These results indicate that although small quantities of ground-water flow in directions oblique to the Hog Marsh well transect are possible during periods of managed flooding, they probably are insubstantial relative to the total hydrologic budget.

The ground-water-flux rates used to simulate the lower and northern model boundary conditions (fig. 9) may be considered a limitation in calibration data. The driving forces for ground-water movement through the modeled cross section primarily were the stream stage at both ends of the modeled section, the boundary fluxes, and the flood-management practices. Stream stages were well known because they were recorded continuously. Recharge flux from the flooded units to the surficial aquifer was estimated from water-management records. Ground-water fluxes across the lower and northern model boundaries were estimated based on information from other reports, measured water levels, and computed conductivity values; fluxes were not derived during model simulations. Although estimates contained uncertainty, boundary fluxes from recharge, the bedrock, and from the north sides of the model were small components of the water budget. Thus, inaccuracies in estimated flux rates probably did not have a large effect on water levels and overall ground-water-flow patterns in Hog Marsh.

A second steady-state calibration based on a period when there was no managed flooding at Hog Marsh would improve confidence in the model results. Simulating evapotranspiration also would provide information about the total recharge to the aquifer along the cross section instead of the net recharge that was used for the steady-state simulation.

The transient calibration was not done to match water-level values for specific measurement dates but rather to match average values during a 5-month period (fig.11). The limitation in this approach was that the simulated values for storage properties of the surficial aquifer could not be validated. The simulated storage properties used as model input, however, were derived from the aquifer tests. As a result, conclusions from the 5-month transient simulation should be considered as only qualitative. An improved transient simulation would include multiple stress periods with simulated stream stage to represent more closely the actual stream stage.

Summary and Conclusions

Wetland functions include flood-water storage, shoreline protection, wildlife habitat, ground-water recharge, and water-quality improvement. Replacement wetland programs designed to compensate for destruction of natural wetlands by new wetland construction can be inequitable when the inherent wetland functions are not reproduced. This study, done by the U.S. Geological Survey in cooperation with the U.S. Environmental Protection Agency, presents the hydrologic characteristics for a managed wetland (controlled water levels, channels, and levees) at Hog Marsh and a natural riverine wetland at LaSalle State Fish and Wildlife Area in the Indiana part of the Kankakee River Basin of northwestern Indiana and northeastern Illinois. Although the wetland at Hog Marsh is managed to maintain waterfowl habitat rather than to recreate a natural riverine wetland, it still provides a suitable managed wetland for purposes of comparison to the LaSalle wetland.

As part of this study, ground-water levels were measured in a network of 22 wells, 20 aquifer tests were performed to estimate hydraulic characteristics, and continuous stage measurements were made at two sites in Hog Marsh and at the USGS streamflow-gaging station in Shelby, Ind, located

between the two wetland areas. Flood-wave-response analyses were completed to compute the hydraulic conductivity of bed sediments in streams and ditches. Numerical simulations were completed to examine two-dimensional ground-water flow through the instrumented transect of wells at Hog Marsh and evaluate the effect of flood-management practices and natural hydrologic processes on the underlying aquifer system. Simulating flow through the transect of wells was considered an appropriate representation of the total aquifer system underlying Hog Marsh.

Ground-water levels in the unconfined surficial aquifer beneath the two wetlands were analyzed by assessing water-level fluctuations. The interquartile range in ground-water levels away from the river at Hog Marsh fluctuated less (from 0.4 to 0.7 m) than all ground-water levels in the same aquifer beneath LaSalle (from 0.9 to 1.0 m). The difference in the range of water-level fluctuation probably is attributable to the managed flooding of Hog Marsh units, which tends to maintain similar water levels in that wetland.

Ground-water-flow directions along a vertical section through the unconfined surficial aquifer at Hog Marsh were more variable than those at LaSalle. During winter and spring, when flow in the Kankakee River is high, flow is from the Kankakee River into the adjacent surficial aquifer and towards Brown Ditch. Water levels in Brown Ditch remain lower than those in the Kankakee River during this period. During summer and fall, when flow in the Kankakee River is moderate to low, a flow divide develops near the center of Hog Marsh. During this period, ground-water flow south of the flow divide is to the Kankakee River; north of the divide, it is toward Brown Ditch. The slight ground-water mounding near the center of Hog Marsh is accentuated by water-management practices that intentionally flood that area. Ground-water flow in the surficial aquifer at LaSalle was not impeded by ditches or managed flooding, and a simple flow-through system from areas south of the Kankakee River to the river was observed. Therefore, the source of ground water beneath LaSalle is different from that for Hog Marsh.

Hydraulic tests at the wetlands consisted of aquifer tests and flood-wave-response analysis. Horizontal hydraulic conductivity values for the surficial aquifer underlying Hog Marsh ranged from 18 to 37 m/d. The hydraulic conductivity of the aquifer underlying LaSalle was estimated at 7.9 m/d from one aquifer test. Analysis of the flood-wave response to two storms and at two locations determined streambed hydraulic conductivity to be 0.18 m/d.

A ground-water-flow model for Hog Marsh was constructed using a uniform grid that extends along a transect between Brown Ditch and the Kankakee River. Four boundary conditions were used to simulate the hydrology at the edges of the model. The model was initially calibrated to steady-state and then to transient conditions. Adjustment of streambed hydraulic conductivity addressed much of the under-prediction of ground-water levels near the Kankakee River by the steady-state and transient simulations. Simulated water levels at well HM4 were close to measured water levels for the final steady-state simulation when the hydraulic conductivity of the Kankakee River streambed was decreased from 0.18 to 0.021 m/d. During the low-streamflow conditions used as the target for the steady-state simulation, it is suspected that settling of fine-grained sediments onto the streambed caused decreases in streambed hydraulic conductivity.

Steady-state-flow simulation results indicated that flow paths originating from flooded areas near the center of Hog Marsh, such as unit B and the distribution channel, are sources of aquifer recharge during the managed-flooding period. Brown Ditch captured all of the ground water from north of Hog Marsh. The simulated water budget along the well transect indicated that 88 percent of inflow to the surficial aquifer beneath Hog Marsh was from flooded water in the distribution channel and unit B. These results indicate that complex ground-water-flow patterns and water-quality characteristics resulting from mixed water sources may develop in these and possibly other managed wetlands with managed-flooding programs where water levels vary in the wetland units. Results of transient simulations indicated that surface water from the Kankakee River penetrated only about 2 to 3 m into the surficial aquifer beneath Hog Marsh during the 5-month high-flow period. These model results indicate that artificial controls on ground-water flow alter the natural pass-through ground-water flow system observed at LaSalle.

Model simulations also indicate that ground-water/surface-water interactions at natural riverine wetlands and at managed wetlands in natural riverine areas may be affected by variations in the hydraulic conductivity of adjacent streambeds. Three values for hydraulic conductivity of the streambed were determined during the study. During a low-flow period in the Kankakee River, ground-water-flow simulations of the surficial aquifer at Hog Marsh indicated a low value of 0.021 m/d for streambed hydraulic conductivity. A flood-wave-response analysis done for conditions of intermediate flow determined the value to be 0.18 m/d, and a transient calibration for a high-flow period resulted in a value of 2.44 m/d. The increase in calculated values for hydraulic conductivity of the streambed at the Kankakee River corresponded to an increase in stream discharge. The apparent relation between streamflow and hydraulic conductivity of the streambed may indicate that the quantity of ground-water/surface-water exchange varies seasonally. For hydrologic studies that include an analysis of ground-water/surface-water interactions, streambed hydraulic conductivity may need to be measured periodically with more than one technique.

The results of this study indicate that a managed wetland may not reproduce the hydrology of a natural riverine wetland. The ditches near the managed wetland at the Hog Marsh appear to change ground-water-flow directions, and managed flooding may hinder the development of natural periodicity and fluctuation in ground-water flow. Fixed water levels, such as those created by flooding of the managed wetland units at the Hog Marsh study site, may cause complex ground-water flow patterns with unintended mixing of water from different sources.

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References Cited

Anderson, M. P., and Woessner, W. W., 1992, Applied groundwater modeling, simulation of flow and advective transport: Academic Press, San Diego, 381 p.

Arihood, L.D., 1994, Hydrogeology and paths of flow in the carbonate bedrock aquifer, northwestern Indiana: Water Resources Bulletin v. 30, no. 2, p. 205–218.

Arihood, L.D., and Basch, M.E., 1994, Geohydrology and simulated ground-water flow in an irrigated area of northwestern Indiana: U.S. Geological Survey Water-Resources Investigations Report 92-4046, 38 p.

Arihood, L.D., and Cohen, D.A., 1998, Geohydrology and simulated ground-water flow in northwestern Elkhart County, Indiana: U.S. Geological Survey Water-Resources Investigations Report 97-4204, 47 p.

Barlow, P.M., and Moench, A.F., 1998, Analytical solutions and computer programs for hydraulic interaction of stream-aquifer systems: U.S. Geological Survey Open-File Report 98-415A, 85 p.

Bayless, E.R., and Arihood, L.D., 1996, Hydrogeology and simulated ground-water flow through the unconsolidated aquifers of northeastern St. Joseph County, Indiana: U.S. Geological Survey Water-Resources Investigations Report 95-4225, 47 p.

Bergeron, M.P., 1981, Effect of irrigation pumping on the ground-water system in Newton and Jasper Counties, Indiana: U.S. Geological Survey Water-Resources Investigations 81-38, 73 p.

Carter, Virginia, 1996, Technical aspects of wetlands *in* National water summary on wetland resources: U.S. Geological Survey Water-Supply Paper 2425, 431 p.

DeSimone, L.A., and Barlow, P.M., 1999, Use of computer programs STLK1 and STWT1 for analysis of stream-aquifer hydraulic interaction: U.S. Geological Survey Water-Resources Investigations Report 98-4212, 61 p.

Duwelius, R.F., Yeskis, D.J., Wilson, J.T., and Robinson, B.A., 2002, Geohydrology, water quality, and simulation of ground-water flow in the vicinity of a former waste-oil refinery near Westville, Indiana, 1997–2000: U.S. Geological Survey Water-Resources Investigations Report 01-4221, 161 p.

Erwin, K.L., 1989, Wetland evaluation for restoration and creation, *in* Wetland creation and restoration—The status of the science, v 2: U.S. Environmental Protection Agency EPA 600/3-89/038b, p. 15–16.

Gillies, D.C., 1976, Availability of ground water near Carmel, Hamilton County, Indiana: U.S. Geological Survey Water-Resources Investigations 76-46, 27 p.

Gray, H.H., 1989, Quaternary geologic map of Indiana: Indiana Geological Survey Miscellaneous Map 49.

Harbaugh, A.W., and McDonald, M.G., 1996, User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference groundwater flow model: U.S. Geological Survey Open-File Report 96-485, 56 p.

HydroSOLVE, Inc., 1998, AQTESOLV for Windows User's Guide: Reston, Va., HydroSOLV, 128p.

Loeltz, O.J., and Leake, S.A., 1983, A method for estimating ground-water return flow to the Lower Colorado River in the Yuma area, Arizona and California: U.S. Geological Survey Water-Resources Investigations Report 83-4220, 86 p.

Meyer, A.H. 1935, The Kankakee '"Marsh" of northern Indiana and Illinois. Papers of the Michigan Academy of Science, Arts, and Letters v. 21: 359-396.

Mitsch, W.J., and Gosselink, J.G., 2000. Wetlands: Van Nostrand Reinhold Co., N.Y., 920 p.

Moench, A.F., 1997, Flow to a well of finite diameter in a homogenous, anisotropic water table aquifer: Water Resources Research, v. 33, p. 1,397–1,407.

Orzol, L.L., 1997, User's guide for MODTOOLS—Computer programs for translating data of MODFLOW and MODPATH into geographic information system files: U.S. Geological Survey Open-File Report 97-240, 86 p.

Osterkamp, W.R., and Harrold, P.E., 1982, Dynamics of alluvial channels—A process model, Proceedings: International Symposium on Rainfall-runoff Modeling, *in* Singh, V.P (ed.), Modeling components of hydrologic cycle: Water Resources Publications, Littleton, Colo., 590 p.

Pollock, D.W., 1994, User's guide for MODPATH/MODPATH-PLOT, Version 3—A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 94-464, 249 p.

Schneider, A.F., 1966, Physiography, *in* Lindsey, A.A. (ed.), Natural features of Indiana: Indiana Academy of Science, p. 40–46.

Sidle, W.C., Arihood, L.D., and Bayless, E.R., 2000a, Isotope hydrology dynamics of riverine wetlands in the Kankakee Watershed, Indiana: Journal of the American Water Resources Association, v. 36, p. 771–790.

Sidle, W.C., Roose, D.L., and Yzerman, V.T., 2000b, Isotope evaluation of nitrate attenuation in restored and native riparian zones in the Kankakee Watershed, Indiana: Wetlands, v. 20, p. 333-345.

Stewart, J.A., Keeton, C.R., Hammil, L.E., Nguyen, H.T., and Majors, D.K., 1999, Water resources data, Indiana, water year 1998: U.S. Geological Survey Water-Data Report IN-98-1, 452 p.

Stewart, J.A., Keeton, C.R., Hammil, L.E., Nguyen, H.T. and Majors, D.K., 2000, Water resources data, Indiana, water year 1999, U.S. Geological Survey Water-Data Report IN-99-1, 386 p.

Thompson, R.F., 2002, Evaluation of recharge to the Skunk Creek Aquifer from a constructed wetland near Lyons, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 02-4133, 27 p.

U.S. Environmental Protection Agency, 1995, Federal guidance for the establishment, use and operation of mitigation banks *in* Federal Register: November 28, 1995, v. 60, no. 228, p. 58,605 – 58,614, accessed July 25, 2006 at http://www.epa.gov/owow/wetlands/guidance/mitbankn.html.

Tables 1, 3, and 4

Table 1. Selected characteristics for observation wells at Hog Marsh and LaSalle, northwestern Indiana.

[USGS, U.S. Geological Survey; mm/dd/yyyy, month/day/year; °, degrees; ’, minutes; ”, seconds; --, not measured or determined; well installation method: B, hollow-stem auger; R, reverse mud rotary; A: air rotary; well casing and well-screen materials: P, polyvinylchloride; S, stainless steel; Z, open hole; geologic unit: 112OTWS, glacial outwash; 340DVNN, Devonian carbonates; 300PLZC, Paleozoic limestone or dolomite, undifferentiated; 350SLRN, Silurian limestone or dolomite; aquifer type: C, confined; U, unconfined; M, confined, multiple aquifers.]

Local well identifier	USGS station identifier	Latitude[1]	Longitude[1]	Date drilled (mm/dd/yyyy)	Well installation method	Depth of well below land surface (meters)	Well-casing diameter (millimeters)	Well-casing material
			Hog Marsh wells					
HM1A	411410087152202	41°14’10”	087°15’22”	10/07/1997	B	4.57	50.8	P
HM1B	411410087152201	41°14’10”	087°15’22”	10/07/1997	B	13.72	50.8	P
HM2A	411401087150501	41°14’01”	087°15’05”	10/08/1997	B	4.57	50.8	P
HM2B	411401087150502	41°14’01”	087°15’05”	10/08/1997	B	9.14	50.8	P
HM2C	411401087150503	41°14’01”	087°15’05”	10/09/1997	B	13.11	50.8	P
HM3A	411352087150101	41°13’52”	087°15’01”	10/10/1997	B	4.57	50.8	P
HM3B	411352087150102	41°13’52”	087°15’01”	10/10/1997	B	12.50	50.8	P
HM4A	411341087145801	41°13’41”	087°14’58”	10/14/1997	B	8.53	50.8	P
HM4B	411341087145802	41°13’41”	087°14’58”	10/15/1997	B	11.58	50.8	P
HM4C	411341087145803	41°13’41”	087°14’58”	10/15/1997	B	15.24	50.8	P
HM150NK	411343087145801	41°13’43”	087°14’58”	08/19/1998	B	4.48	50.8	P
HMUG20	411358087153401	41°13’58”	087°15’34”	12/17/1997	B	7.32	50.8	P
HMUG150	411359087153401	41°13’59”	087°15’34”	12/16/1997	B	7.32	50.8	P
LITTLE_SHALLOW	411506087143701	41°15’06”	087°14’37”	05/21/1998	B	4.57	50.8	P
LITTLE_EAST	411506087143702	41°15’06”	087°14’37”	10/01/1988	R	76.20	254	P
LITTLE_WEST	411506087144201	41°15’06”	087°14’42”	10/10/1988	A	25.91	254	P
RASA2	411312087163501	41°13’12”	087°16’35”	06/29/1990	A	201.17	152.4	P
			LaSalle wells					
L1A	410953087271701	41°09’53”	087°27’17”	03/04/1998	B	1.74	50.8	S
L1B	410953087271702	41°09’53”	087°27’17”	08/09/1998	B	6.10	50.8	P
L2A	410959087271501	41°09’59”	087°27’15”	03/03/1998	B	4.57	50.8	P
L2B	410959087271502	41°09’59”	087°27’15”	03/03/1998	B	6.10	50.8	P
L2-BEDROCK	411000087271001	41°10’00”	087°27’10”	02/08/1956	--	39.01	101.6	S
L3A	411012087273001	41°10’12”	087°27’30”	03/03/1998	B	3.96	50.8	P
L3B	411012087273002	41°10’12”	087°27’30”	12/19/1997	B	7.32	50.8	P

Table 1. Selected characteristics for observation wells at Hog Marsh and LaSalle, northwestern Indiana.—*Continued*

[USGS, U.S. Geological Survey; mm/dd/yyyy, month/day/year; °, degrees; ', minutes; ", seconds; --, not measured or determined; well installation method: B, hollow-stem auger; R, reverse mud rotary; A: air rotary; well casing and well-screen materials: P, polyvinylchloride; S, stainless steel; Z, open hole; geologic unit: 112OTWS, glacial outwash; 340DVNN, Devonian carbonates; 300PLZC, Paleozoic limestone or dolomite, undifferentiated; 350SLRN, Silurian limestone or dolomite; aquifer type: C, confined; U, unconfined; M, confined, multiple aquifers.]

Local well identifier	Top of well screen depth (meters)	Bottom of well screen depth (meters)	Well-screen material	Geologic unit	Aquifer type	Land-surface altitude[1]	Begin date for measuring point use (mm/dd/yyyy)	Measuring point altitude
				Hog Marsh wells—*Continued*				
HM1A	3.05	4.57	P	112OTWS	U	196.44	10/07/1997 05/19/1998	196.44 196.35
HM1B	12.19	13.72	P	112OTWS	U	196.44	10/08/1997 05/19/1998	196.44 196.41
HM2A	3.05	4.57	P	112OTWS	U	196.24	10/08/1997	196.24
HM2B	7.62	9.14	P	112OTWS	U	196.19	10/08/1997	196.19
HM2C	11.58	13.11	P	112OTWS	U	196.38	10/09/1997	196.38
HM3A	3.05	4.57	P	112OTWS	U	196.65	10/10/1997	196.65
HM3B	10.97	12.50	P	112OTWS	U	196.73	10/10/1997	196.73
HM4A	7.01	8.53	P	112OTWS	U	199.46	10/14/1997 05/19/1998	199.43 199.40
HM4B	10.06	11.58	P	112OTWS	U	199.46	10/15/1997	199.41
HM4C	13.72	15.24	P	112OTWS	U	199.46	10/15/1997	199.39
HM150NK	2.96	4.48	P	112OTWS	U	196.54	08/19/1988	196.43
HMUG20	5.79	7.32	P	112OTWS	U	197.02	12/17/1997 05/19/1998	196.95 197.92
HMUG150	5.79	7.32	P	112OTWS	U	196.44	12/16/1997 05/19/1998	196.39 197.39
LITTLE_SHALLOW	3.05	4.57	P	112OTWS	U	195.87	05/21/1998	195.76
LITTLE_EAST	29.26	76.20	Z	340DVNN	C	198.73	10/01/1988	198.73
LITTLE_WEST	24.99	25.91	Z	340DVNN	C	195.99	10/10/1988	195.99
RASA2	16.46	201.17	Z	300PLZC	M	196.4	--	--

Table 1. Selected characteristics for observation wells at Hog Marsh and LaSalle, northwestern Indiana.—*Continued*

[USGS, U.S. Geological Survey; mm/dd/yyyy, month/day/year; °, degrees; ', minutes; ", seconds; --, not measured or determined; well installation method: B, hollow-stem auger; R, reverse mud rotary; A: air rotary; well casing and well-screen materials: P, polyvinylchloride; S, stainless steel; Z, open hole; geologic unit: 112OTWS, glacial outwash; 340DVNN, Devonian carbonates; 300PLZC, Paleozoic limestone or dolomite, undifferentiated; 350SLRN, Silurian limestone or dolomite; aquifer type: C, confined; U, unconfined; M, confined, multiple aquifers.]

Local well identifier	Top of well screen depth (meters)	Bottom of well screen depth (meters)	Well-screen material	Geologic unit	Aquifer type	Land-surface altitude[1]	Begin date for measuring point use (mm/dd/yyyy)	Measuring point altitude
				LaSalle wells—*Continued*				
L1A	0.98	1.74	S	112OTWS	U	193.02	03/04/1998	193.73
L1B	4.57	6.10	P	112OTWS	U	192.96	08/09/1998	193.69
L2A	3.05	4.57	P	112OTWS	U	194.07	03/03/1998	193.98
L2B	4.57	6.10	P	112OTWS	U	194.16	03/03/1998	194.10
L2-BEDROCK	21.49	39.01	Z	350SLRN	C	195.03	02/08/1956	195.03
L3A	2.44	3.96	P	112OTWS	U	193.69	03/03/1998	194.64
L3B	5.79	7.32	P	112OTWS	U	193.69	12/19/1997	194.66

[1]Altitudes are reported in meters above vertical datum. Vertical datum is referenced to National Geodetic Vertical Datum of 1929. Horizontal datum is referenced to North American Datum of 1927.

Table 3. Ground-water and surface-water levels measured at Hog Marsh and LaSalle, northwestern Indiana, 1997–1999.

[mm/dd/yyyy, month/day/year; HM, Hog Marsh; L, LaSalle; --, not measured; ground-water and surface-water levels reported as altitudes in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Local well identifier									
	HM1A	HM1B	HM2A	HM2B	HM2C	HM3A	HM3B	HM4A	HM4B	HM4C
10/16/1997	194.48	194.19	195.19	195.16	195.20	195.26	195.21	194.50	194.50	194.53
11/03/1997	194.75	194.76	195.40	195.45	195.45	195.48	195.43	194.80	194.76	194.79
12/08/1997	194.83	194.83	195.42	--	195.41	195.60	195.54	195.03	195.03	195.03
01/21/1998	195.20	195.24	195.46	195.47	195.47	195.52	195.45	195.77	195.77	195.77
02/18/1998	194.88	--	195.23	195.24	195.24	195.26	195.21	195.46	195.46	195.46
04/01/1998	195.40	195.46	195.59	195.59	195.61	195.65	195.59	196.16	196.15	196.15
05/06/1998	194.93	194.96	195.23	195.23	195.24	195.30	195.24	195.60	195.61	195.60
06/01/1998	194.50	194.55	194.93	194.93	194.90	195.17	195.11	195.08	195.09	195.09
07/09/1998	194.98	195.00	195.09	195.07	195.09	195.05	195.07	195.53	195.55	195.57
08/20/1998	194.39	194.42	194.44	194.41	194.43	194.50	194.51	194.36	194.36	--
10/05/1998	194.46	194.49	195.19	195.15	195.17	195.16	195.18	194.30	194.31	194.33
11/04/1998	194.42	194.46	194.76	194.72	194.74	194.92	194.94	194.37	194.38	194.40
12/09/1998	194.93	194.95	195.40	195.36	195.38	195.45	195.47	194.62	--	--
12/10/1998	--	--	--	--	--	--	--	--	194.64	194.65
02/23/1999	194.75	194.77	195.16	--	195.15	195.12	195.14	195.04	195.05	195.07
03/24/1999	195.02	195.05	195.49	195.46	195.48	195.58	195.61	195.25	195.26	195.28
05/03/1999	195.50	195.48	195.54	195.51	195.53	195.57	195.59	196.17	196.18	196.20
06/01/1999	194.57	194.60	194.98	194.95	194.97	194.96	194.98	194.83	194.84	194.86
07/15/1999	194.35	194.38	194.47	194.43	194.45	194.59	194.60	194.34	194.35	194.37
08/19/1999	194.29	194.32	194.35	194.31	194.33	194.42	194.45	193.99	194.01	194.02

Table 3. Ground-water and surface-water levels measured at Hog Marsh and LaSalle, northwestern Indiana, 1997–1999.—*Continued*

[mm/dd/yyyy, month/day/year; HM, Hog Marsh; L, LaSalle; --, not measured; ground-water and surface-water levels reported as altitudes in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Local well identifier					Local surface-water site identifier		
	HM150NK	HMUG20	HMUG150	LITTLE_ SHALLOW	RASA2	HMBD (Brown Ditch)	HMGKR (Kankakee River)	HM-UNITD
11/03/1997	--	--	--	--	194.1	--	--	--
01/21/1998	--	195.20	195.08	--	194.7	--	--	--
02/18/1998	--	194.90	194.82	--	194.6	--	--	--
04/01/1998	--	195.42	195.29	--	--	--	--	--
05/06/1998	--	194.96	194.88	--	--	--	--	--
07/09/1998	--	195.00	194.76	--	193.3	--	195.28	--
08/20/1998	--	194.44	194.23	--	192.9	194.83	193.83	--
10/05/1998	194.49	--	--	194.54	--	194.72	193.80	--
11/04/1998	194.74	--	--	194.51	194.9	194.38	193.77	--
12/09/1998	--	194.91	194.64	--	--	194.80	194.11	195.49
12/10/1998	194.87	194.72	194.51	194.55	195.0	--	--	--
01/22/1999	--	--	--	194.68	194.8	--	194.72	--
02/23/1999	195.06	194.82	194.58	194.64	195.2	194.70	194.65	195.24
03/24/1999	195.41	--	--	194.62	195.2	194.83	194.85	195.53
05/03/1999	195.62	195.53	195.18	194.82	--	195.63	196.31	--
06/01/1999	194.89	194.63	194.43	194.68	195.1	194.50	194.43	195.06
07/15/1999	194.49	194.41	194.20	194.65	194.5	194.31	193.89	194.75
08/19/1999	--	194.26	194.04	194.54	194.4	194.26	193.60	--

Table 3. Ground-water and surface-water levels measured at Hog Marsh and LaSalle, northwestern Indiana, 1997–1999.—*Continued*

[mm/dd/yyyy, month/day/year; HM, Hog Marsh; L, LaSalle; --, not measured; ground-water and surface-water levels reported as altitudes in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Local well site identifier						
	L1A	L1B	L2A	L2B	L2-BEDROCK	L3A	L3B
04/01/1998	--	--	193.25	193.25	--	--	--
05/06/1998	--	--	192.97	192.97	--	192.71	192.72
06/01/1998	--	--	192.41	192.40	--	192.15	192.16
07/09/1998	192.42	--	192.48	192.48	190.77	192.63	192.65
08/19/1998	191.81	192.18	192.10	192.10	--	191.74	191.74
10/05/1998	191.79	191.86	191.69	191.70	--	191.56	191.56
11/05/1998	191.81	191.88	191.65	191.64	189.98	191.53	191.53
12/09/1998	191.95	192.02	191.74	191.73	190.23	191.81	191.81
01/21/1999	192.08	192.21	191.86	192.04	190.37	192.20	192.21
02/24/1999	192.74	192.87	192.65	192.65	191.02	190.43	190.38
03/24/1999	192.72	192.85	192.66	192.65	--	192.41	192.41
05/03/1999	193.04	193.17	193.14	193.14	--	--	--
06/01/1999	192.51	192.64	192.44	192.44	--	192.08	192.08
07/15/1999	192.00	192.13	192.07	192.07	--	191.66	191.65
08/19/1999	191.80	191.93	191.73	191.72	187.40	191.21	191.21

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/05/1998	0:00	194.93	194.50	194.45	194.48	195.13
07/05/1998	1:00	194.95	194.50	194.45	194.48	195.15
07/05/1998	2:00	194.97	194.50	194.45	194.48	195.17
07/05/1998	3:00	194.99	194.50	194.45	194.48	195.19
07/05/1998	4:00	195.00	194.50	194.45	194.48	195.22
07/05/1998	5:00	195.02	194.50	194.45	194.48	195.24
07/05/1998	6:00	195.03	194.50	194.45	194.48	195.25
07/05/1998	7:00	195.05	194.50	194.45	194.49	195.27
07/05/1998	8:00	195.06	194.50	194.45	194.49	195.29
07/05/1998	9:00	195.07	194.49	194.45	194.49	195.30
07/05/1998	10:00	195.08	194.49	194.45	194.49	195.31
07/05/1998	11:00	195.10	194.49	194.44	194.49	195.33
07/05/1998	12:00	195.10	194.49	194.44	194.49	195.34
07/05/1998	13:00	195.11	194.49	194.44	194.49	195.35
07/05/1998	14:00	195.12	194.49	194.44	194.49	195.36
07/05/1998	15:00	195.13	194.49	194.44	194.49	195.37
07/05/1998	16:00	195.14	194.49	194.44	194.49	195.38
07/05/1998	17:00	195.15	194.49	194.44	194.49	195.38
07/05/1998	18:00	195.16	194.49	194.44	194.49	195.39
07/05/1998	19:00	195.17	194.49	194.44	194.49	195.40
07/05/1998	20:00	195.18	194.49	194.44	194.49	195.40
07/05/1998	21:00	195.18	194.49	194.44	194.49	195.41
07/05/1998	22:00	195.19	194.49	194.44	194.49	195.41
07/05/1998	23:00	195.19	194.50	194.45	194.49	195.42
07/06/1998	0:00	195.20	194.49	194.44	194.49	195.42
07/06/1998	1:00	195.20	194.50	194.45	194.49	195.43
07/06/1998	2:00	195.20	194.50	194.45	194.49	195.43
07/06/1998	3:00	195.21	194.50	194.45	194.49	195.44
07/06/1998	4:00	195.21	194.50	194.45	194.49	195.44
07/06/1998	5:00	195.21	194.50	194.45	194.49	195.44
07/06/1998	6:00	195.21	194.50	194.45	194.50	195.45
07/06/1998	7:00	195.21	194.50	194.45	194.50	195.45

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/06/1998	8:00	195.21	194.50	194.45	194.50	195.45
07/06/1998	9:00	195.22	194.50	194.45	194.50	195.45
07/06/1998	10:00	195.22	194.50	194.45	194.50	195.46
07/06/1998	11:00	195.22	194.50	194.45	194.50	195.46
07/06/1998	12:00	195.22	194.50	194.45	194.50	195.45
07/06/1998	13:00	195.22	194.50	194.45	194.51	195.46
07/06/1998	14:00	195.22	194.50	194.45	194.51	195.45
07/06/1998	15:00	195.22	194.50	194.45	194.51	195.45
07/06/1998	16:00	195.22	194.50	194.44	194.51	195.45
07/06/1998	17:00	195.23	194.50	194.44	194.51	195.45
07/06/1998	18:00	195.24	194.50	194.45	194.51	195.44
07/06/1998	19:00	195.24	194.50	194.45	194.51	195.44
07/06/1998	20:00	195.25	194.50	194.45	194.51	195.44
07/06/1998	21:00	195.25	194.50	194.45	194.51	195.44
07/06/1998	22:00	195.25	194.51	194.45	194.52	195.43
07/06/1998	23:00	195.26	194.51	194.45	194.52	195.43
07/07/1998	0:00	195.26	194.51	194.45	194.52	195.43
07/07/1998	1:00	195.25	194.51	194.46	194.52	195.42
07/07/1998	2:00	195.25	194.52	194.46	194.52	195.41
07/07/1998	3:00	195.25	194.52	194.46	194.53	195.41
07/07/1998	4:00	195.25	194.52	194.47	194.53	195.40
07/07/1998	5:00	195.25	194.52	194.47	194.54	195.40
07/07/1998	6:00	195.25	194.53	194.47	194.54	195.39
07/07/1998	7:00	195.25	194.53	194.47	194.54	195.38
07/07/1998	8:00	195.24	194.53	194.47	194.54	195.38
07/07/1998	9:00	195.24	194.53	194.47	194.55	195.37
07/07/1998	10:00	195.24	194.54	194.48	194.57	195.38
07/07/1998	11:00	195.34	194.69	194.65	194.65	195.43
07/07/1998	12:00	195.34	194.75	194.72	194.67	195.46
07/07/1998	13:00	195.35	194.79	194.75	194.71	195.50
07/07/1998	14:00	195.36	194.82	194.78	194.74	195.53
07/07/1998	15:00	195.37	194.84	194.80	194.77	195.57
07/07/1998	16:00	195.39	194.86	194.82	194.82	195.60

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/07/1998	17:00	195.41	194.88	194.83	194.86	195.64
07/07/1998	18:00	195.43	194.90	194.85	194.90	195.67
07/07/1998	19:00	195.44	194.92	194.86	194.93	195.70
07/07/1998	20:00	195.46	194.92	194.87	194.94	195.73
07/07/1998	21:00	195.48	194.93	194.87	194.95	195.75
07/07/1998	22:00	195.49	194.94	194.88	194.96	195.78
07/07/1998	23:00	195.51	194.95	194.88	194.96	195.80
07/08/1998	0:00	195.52	194.95	194.89	194.97	195.81
07/08/1998	1:00	195.53	194.96	194.89	194.98	195.82
07/08/1998	2:00	195.53	194.96	194.90	194.98	195.83
07/08/1998	3:00	195.54	194.96	194.90	194.99	195.84
07/08/1998	4:00	195.54	194.97	194.90	194.99	195.84
07/08/1998	5:00	195.55	194.97	194.90	194.99	195.85
07/08/1998	6:00	195.55	194.97	194.90	195.00	195.85
07/08/1998	7:00	195.55	194.97	194.90	195.00	195.84
07/08/1998	8:00	195.55	194.97	194.91	195.01	195.84
07/08/1998	9:00	195.55	194.98	194.91	195.02	195.84
07/08/1998	10:00	195.55	194.98	194.91	195.03	195.85
07/08/1998	11:00	195.55	194.98	194.91	195.04	195.85
07/08/1998	12:00	195.55	194.98	194.91	195.04	195.84
07/08/1998	13:00	195.55	194.98	194.91	195.05	195.84
07/08/1998	14:00	195.55	194.98	194.91	195.05	195.83
07/08/1998	15:00	195.55	194.98	194.91	195.06	195.83
07/08/1998	16:00	195.54	194.99	194.91	195.06	195.82
07/08/1998	17:00	195.54	194.98	194.90	195.06	195.82
07/08/1998	18:00	195.55	194.98	194.90	195.06	195.81
07/08/1998	19:00	195.56	194.98	194.90	195.05	195.80
07/08/1998	20:00	195.56	194.98	194.90	195.05	195.80
07/08/1998	21:00	195.57	194.98	194.90	195.05	195.79
07/08/1998	22:00	195.57	194.98	194.90	195.05	195.78
07/08/1998	23:00	195.57	194.98	194.90	195.04	195.78
07/09/1998	0:00	195.57	194.98	194.90	195.04	195.77
07/09/1998	1:00	195.58	194.98	194.90	195.04	195.77

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/09/1998	2:00	195.57	194.98	194.90	195.04	195.77
07/09/1998	3:00	195.57	194.98	194.90	195.04	195.77
07/09/1998	4:00	195.56	194.98	194.90	195.04	195.77
07/09/1998	5:00	195.56	194.98	194.90	195.04	195.77
07/09/1998	6:00	195.56	194.98	194.90	195.03	195.77
07/09/1998	7:00	195.56	194.97	194.90	195.03	195.77
07/09/1998	8:00	195.56	194.97	194.89	195.01	195.77
07/09/1998	9:00	195.56	194.96	194.89	195.00	195.77
07/09/1998	10:00	195.56	194.95	194.88	194.98	195.78
07/09/1998	11:00	195.56	194.94	194.86	194.97	195.78
07/09/1998	12:00	195.56	194.93	194.87	194.97	195.78
07/09/1998	13:00	195.56	194.93	194.86	194.97	195.78
07/09/1998	14:00	195.56	194.93	194.86	194.97	195.78
07/09/1998	15:00	195.56	194.93	194.86	194.97	195.78
07/09/1998	16:00	195.56	194.92	194.86	194.96	195.78
07/09/1998	17:00	195.56	194.92	194.85	194.95	195.77
07/09/1998	18:00	195.56	194.91	194.85	194.95	195.78
07/09/1998	19:00	195.56	194.91	194.85	194.94	195.78
07/09/1998	20:00	195.57	194.91	194.84	194.93	195.78
07/09/1998	21:00	195.57	194.90	194.84	194.92	195.78
07/09/1998	22:00	195.57	194.90	194.84	194.91	195.78
07/09/1998	23:00	195.57	194.89	194.83	194.91	195.78
07/10/1998	0:00	195.57	194.89	194.83	194.90	195.78
07/10/1998	1:00	195.57	194.88	194.83	194.89	195.78
07/10/1998	2:00	195.57	194.88	194.82	194.88	195.79
07/10/1998	3:00	195.57	194.88	194.82	194.88	195.79
07/10/1998	4:00	195.57	194.87	194.82	194.87	195.79
07/10/1998	5:00	195.57	194.87	194.81	194.86	195.79
07/10/1998	6:00	195.58	194.86	194.81	194.86	195.79
07/10/1998	7:00	195.58	194.86	194.81	194.85	195.80
07/10/1998	8:00	195.58	194.86	194.81	194.86	195.80
07/10/1998	9:00	195.58	194.86	194.81	194.87	195.80
07/10/1998	10:00	195.57	194.86	194.80	194.87	195.80

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/10/1998	11:00	195.57	194.86	194.80	194.88	195.80
07/10/1998	12:00	195.57	194.85	194.80	194.88	195.80
07/10/1998	13:00	195.57	194.85	194.79	194.88	195.80
07/10/1998	14:00	195.56	194.85	194.79	194.88	195.79
07/10/1998	15:00	195.56	194.84	194.79	194.87	195.78
07/10/1998	16:00	195.55	194.84	194.78	194.86	195.78
07/10/1998	17:00	195.55	194.84	194.78	194.85	195.77
07/10/1998	18:00	195.55	194.83	194.78	194.84	195.77
07/10/1998	19:00	195.55	194.83	194.77	194.84	195.77
07/10/1998	20:00	195.55	194.82	194.77	194.83	195.77
07/10/1998	21:00	195.54	194.82	194.77	194.83	195.77
07/10/1998	22:00	195.54	194.82	194.77	194.82	195.76
07/10/1998	23:00	195.54	194.82	194.76	194.82	195.76
07/11/1998	0:00	195.54	194.82	194.77	194.82	195.76
07/11/1998	1:00	195.54	194.82	194.76	194.82	195.76
07/11/1998	2:00	195.54	194.81	194.76	194.81	195.76
07/11/1998	3:00	195.53	194.81	194.76	194.81	195.75
07/11/1998	4:00	195.53	194.81	194.76	194.81	195.75
07/11/1998	5:00	195.53	194.81	194.76	194.81	195.75
07/11/1998	6:00	195.53	194.81	194.76	194.81	195.75
07/11/1998	7:00	195.53	194.81	194.76	194.81	195.74
07/11/1998	8:00	195.53	194.80	194.75	194.81	195.75
07/11/1998	9:00	195.53	194.80	194.75	194.80	195.75
07/11/1998	10:00	195.53	194.80	194.75	194.80	195.75
07/11/1998	11:00	195.52	194.80	194.74	194.80	195.75
07/11/1998	12:00	195.52	194.79	194.74	194.80	195.75
07/11/1998	13:00	195.52	194.79	194.74	194.79	195.75
07/11/1998	14:00	195.51	194.78	194.74	194.79	195.74
07/11/1998	15:00	195.51	194.78	194.73	194.79	195.73
07/11/1998	16:00	195.50	194.78	194.73	194.78	195.73
07/11/1998	17:00	195.50	194.78	194.73	194.78	195.72
07/11/1998	18:00	195.50	194.77	194.72	194.78	195.72
07/11/1998	19:00	195.49	194.77	194.72	194.78	195.71

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/11/1998	20:00	195.49	194.77	194.72	194.77	195.70
07/11/1998	21:00	195.48	194.77	194.72	194.77	195.69
07/11/1998	22:00	195.48	194.77	194.72	194.77	195.68
07/11/1998	23:00	195.47	194.77	194.72	194.77	195.67
07/12/1998	0:00	195.46	194.77	194.72	194.77	195.66
07/12/1998	1:00	195.46	194.76	194.72	194.77	195.65
07/12/1998	2:00	195.45	194.76	194.72	194.76	195.64
07/12/1998	3:00	195.44	194.76	194.72	194.76	195.63
07/12/1998	4:00	195.44	194.76	194.71	194.76	195.62
07/12/1998	5:00	195.43	194.76	194.71	194.76	195.61
07/12/1998	6:00	195.42	194.76	194.71	194.76	195.60
07/12/1998	7:00	195.41	194.76	194.71	194.76	195.59
07/12/1998	8:00	195.41	194.76	194.71	194.76	195.58
07/12/1998	9:00	195.40	194.76	194.71	194.76	195.57
07/12/1998	10:00	195.39	194.75	194.71	194.76	195.57
07/12/1998	11:00	195.39	194.75	194.70	194.75	195.56
07/12/1998	12:00	195.38	194.75	194.70	194.75	195.55
07/12/1998	13:00	195.37	194.74	194.70	194.75	195.54
07/12/1998	14:00	195.36	194.74	194.69	194.75	195.53
07/12/1998	15:00	195.35	194.74	194.69	194.75	195.52
07/12/1998	16:00	195.34	194.74	194.69	194.75	195.51
07/12/1998	17:00	195.33	194.73	194.69	194.74	195.50
07/12/1998	18:00	195.33	194.73	194.69	194.74	195.48
07/12/1998	19:00	195.32	194.73	194.68	194.74	195.47
07/12/1998	20:00	195.31	194.73	194.68	194.74	195.46
07/12/1998	21:00	195.31	194.73	194.68	194.74	195.45
07/12/1998	22:00	195.30	194.73	194.68	194.74	195.44
07/12/1998	23:00	195.29	194.73	194.68	194.74	195.43
07/13/1998	0:00	195.28	194.73	194.68	194.73	195.42
07/13/1998	1:00	195.27	194.73	194.68	194.73	195.41
07/13/1998	2:00	195.27	194.73	194.68	194.73	195.40
07/13/1998	3:00	195.26	194.73	194.68	194.73	195.38
07/13/1998	4:00	195.25	194.73	194.68	194.73	195.38

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/13/1998	5:00	195.24	194.73	194.68	194.73	195.37
07/13/1998	6:00	195.24	194.72	194.68	194.73	195.36
07/13/1998	7:00	195.23	194.72	194.68	194.73	195.34
07/13/1998	8:00	195.22	194.72	194.67	194.73	195.33
07/13/1998	9:00	195.21	194.72	194.68	194.74	195.33
07/13/1998	10:00	195.20	194.72	194.67	194.74	195.32
07/13/1998	11:00	195.19	194.72	194.67	194.74	195.30
07/13/1998	12:00	195.18	194.72	194.67	194.74	195.30
07/13/1998	13:00	195.17	194.71	194.67	194.73	195.28
07/13/1998	14:00	195.16	194.71	194.66	194.73	195.27
07/13/1998	15:00	195.15	194.71	194.66	194.73	195.26
07/13/1998	16:00	195.14	194.71	194.66	194.72	195.25
07/13/1998	17:00	195.13	194.71	194.66	194.72	195.23
07/13/1998	18:00	195.12	194.70	194.66	194.72	195.22
07/13/1998	19:00	195.12	194.70	194.65	194.71	195.21
07/13/1998	20:00	195.11	194.70	194.65	194.71	195.20
07/13/1998	21:00	195.11	194.70	194.65	194.71	195.20
07/13/1998	22:00	195.10	194.70	194.65	194.70	195.19
07/13/1998	23:00	195.10	194.70	194.65	194.70	195.18
07/14/1998	0:00	195.09	194.70	194.65	194.70	195.17
07/14/1998	1:00	195.08	194.69	194.65	194.69	195.16
07/14/1998	2:00	195.08	194.69	194.65	194.69	195.16
07/14/1998	3:00	195.07	194.69	194.65	194.69	195.15
07/14/1998	4:00	195.07	194.69	194.64	194.68	195.14
07/14/1998	5:00	195.06	194.68	194.64	194.68	195.13
07/14/1998	6:00	195.06	194.68	194.64	194.68	195.13
07/14/1998	7:00	195.05	194.68	194.64	194.67	195.12
07/14/1998	8:00	195.05	194.68	194.64	194.67	195.12
07/14/1998	9:00	195.04	194.68	194.63	194.67	195.11
07/14/1998	10:00	195.04	194.67	194.63	194.66	195.11
07/14/1998	11:00	195.03	194.67	194.63	194.66	195.10
07/14/1998	12:00	195.02	194.66	194.62	194.66	195.10
07/14/1998	13:00	195.01	194.66	194.62	194.65	195.09

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/14/1998	14:00	195.01	194.66	194.62	194.65	195.08
07/14/1998	15:00	195.00	194.65	194.61	194.65	195.08
07/14/1998	16:00	194.99	194.65	194.61	194.64	195.07
07/14/1998	17:00	194.98	194.65	194.61	194.64	195.05
07/14/1998	18:00	194.97	194.64	194.60	194.64	195.04
07/14/1998	19:00	194.97	194.64	194.60	194.63	195.03
07/14/1998	20:00	194.96	194.64	194.60	194.63	195.02
07/14/1998	21:00	194.96	194.64	194.60	194.63	195.02
07/14/1998	22:00	194.95	194.64	194.60	194.62	195.01
07/14/1998	23:00	194.95	194.63	194.60	194.62	195.01
07/15/1998	0:00	194.95	194.63	194.60	194.62	195.01
07/15/1998	1:00	194.95	194.63	194.60	194.61	195.01
07/15/1998	2:00	194.95	194.63	194.59	194.61	195.01
07/15/1998	3:00	194.95	194.63	194.59	194.61	195.01
07/15/1998	4:00	194.94	194.63	194.59	194.60	195.00
07/15/1998	5:00	194.94	194.62	194.59	194.60	195.00
07/15/1998	6:00	194.94	194.62	194.59	194.60	195.00
07/15/1998	7:00	194.93	194.62	194.58	194.59	194.99
07/15/1998	8:00	194.93	194.61	194.58	194.59	194.98
07/15/1998	9:00	194.93	194.61	194.58	194.59	194.98
07/15/1998	10:00	194.92	194.61	194.58	194.58	194.98
07/15/1998	11:00	194.91	194.61	194.58	194.58	194.97
07/15/1998	12:00	194.91	194.61	194.58	194.58	194.97
07/15/1998	13:00	194.90	194.60	194.57	194.57	194.96
07/15/1998	14:00	194.90	194.60	194.57	194.57	194.96
07/15/1998	15:00	194.89	194.59	194.56	194.57	194.95
07/15/1998	16:00	194.89	194.59	194.56	194.57	194.94
07/15/1998	17:00	194.88	194.59	194.56	194.56	194.93
07/15/1998	18:00	194.88	194.59	194.56	194.56	194.93
07/15/1998	19:00	194.88	194.58	194.55	194.56	194.92
07/15/1998	20:00	194.87	194.58	194.55	194.55	194.92
07/15/1998	21:00	194.87	194.58	194.55	194.55	194.91
07/15/1998	22:00	194.87	194.58	194.55	194.55	194.91

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/15/1998	23:00	194.86	194.58	194.55	194.55	194.90
07/16/1998	0:00	194.86	194.58	194.55	194.54	194.90
07/16/1998	1:00	194.86	194.58	194.55	194.54	194.89
07/16/1998	2:00	194.85	194.57	194.55	194.54	194.89
07/16/1998	3:00	194.85	194.57	194.55	194.54	194.88
07/16/1998	4:00	194.84	194.57	194.54	194.53	194.88
07/16/1998	5:00	194.84	194.57	194.54	194.53	194.87
07/16/1998	6:00	194.84	194.57	194.54	194.53	194.87
07/16/1998	7:00	194.83	194.56	194.54	194.53	194.86
07/16/1998	8:00	194.83	194.56	194.54	194.53	194.86
07/16/1998	9:00	194.82	194.56	194.54	194.52	194.85
07/16/1998	10:00	194.82	194.56	194.53	194.52	194.85
07/16/1998	11:00	194.81	194.55	194.53	194.52	194.84
07/16/1998	12:00	194.80	194.55	194.52	194.52	194.83
07/16/1998	13:00	194.80	194.55	194.52	194.51	194.83
07/16/1998	14:00	194.80	194.54	194.52	194.51	194.82
07/16/1998	15:00	194.79	194.54	194.51	194.51	194.81
07/16/1998	16:00	194.79	194.54	194.51	194.51	194.81
07/16/1998	17:00	194.78	194.54	194.51	194.51	194.80
07/16/1998	18:00	194.78	194.53	194.51	194.51	194.80
07/16/1998	19:00	194.78	194.53	194.51	194.51	194.79
07/16/1998	20:00	194.78	194.53	194.51	194.50	194.79
07/16/1998	21:00	194.78	194.53	194.51	194.50	194.78
07/16/1998	22:00	194.78	194.53	194.51	194.50	194.78
07/16/1998	23:00	194.77	194.53	194.50	194.50	194.78
07/17/1998	0:00	194.77	194.53	194.50	194.50	194.77
07/17/1998	1:00	194.77	194.53	194.50	194.50	194.77
07/17/1998	2:00	194.77	194.53	194.50	194.49	194.77
07/17/1998	3:00	194.76	194.53	194.50	194.49	194.76
07/17/1998	4:00	194.76	194.53	194.50	194.49	194.76
07/17/1998	5:00	194.76	194.52	194.50	194.49	194.76
07/17/1998	6:00	194.76	194.52	194.50	194.48	194.75
07/17/1998	7:00	194.76	194.52	194.50	194.48	194.75

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/17/1998	8:00	194.75	194.52	194.50	194.48	194.75
07/17/1998	9:00	194.75	194.52	194.49	194.48	194.75
07/17/1998	10:00	194.75	194.51	194.49	194.48	194.75
07/17/1998	11:00	194.74	194.51	194.49	194.47	194.74
07/17/1998	12:00	194.74	194.51	194.49	194.47	194.74
07/17/1998	13:00	194.74	194.50	194.48	194.47	194.74
07/17/1998	14:00	194.73	194.50	194.48	194.47	194.74
07/17/1998	15:00	194.73	194.50	194.48	194.47	194.73
07/17/1998	16:00	194.72	194.50	194.47	194.47	194.73
07/17/1998	17:00	194.72	194.49	194.47	194.46	194.72
07/17/1998	18:00	194.72	194.49	194.47	194.46	194.72
07/17/1998	19:00	194.72	194.49	194.47	194.46	194.71
07/17/1998	20:00	194.71	194.49	194.47	194.46	194.70
07/17/1998	21:00	194.70	194.49	194.47	194.46	194.69
07/17/1998	22:00	194.70	194.49	194.47	194.45	194.69
07/17/1998	23:00	194.70	194.49	194.47	194.45	194.69
07/18/1998	0:00	194.70	194.49	194.47	194.45	194.69
07/18/1998	1:00	194.70	194.48	194.47	194.45	194.69
07/18/1998	2:00	194.70	194.48	194.46	194.45	194.69
07/18/1998	3:00	194.69	194.48	194.46	194.44	194.69
07/18/1998	4:00	194.69	194.48	194.46	194.44	194.69
07/18/1998	5:00	194.69	194.48	194.46	194.44	194.68
07/18/1998	6:00	194.69	194.48	194.46	194.44	194.68
07/18/1998	7:00	194.69	194.48	194.46	194.44	194.68
07/18/1998	8:00	194.69	194.48	194.46	194.44	194.68
07/18/1998	9:00	194.69	194.47	194.45	194.43	194.68
07/18/1998	10:00	194.68	194.47	194.45	194.43	194.68
07/18/1998	11:00	194.68	194.47	194.45	194.43	194.68
07/18/1998	12:00	194.68	194.47	194.45	194.43	194.67
07/18/1998	13:00	194.67	194.46	194.44	194.43	194.67
07/18/1998	14:00	194.67	194.46	194.44	194.42	194.67
07/18/1998	15:00	194.67	194.46	194.44	194.42	194.66
07/18/1998	16:00	194.66	194.45	194.44	194.42	194.66

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/18/1998	17:00	194.66	194.45	194.43	194.42	194.66
07/18/1998	18:00	194.66	194.45	194.43	194.42	194.66
07/18/1998	19:00	194.66	194.45	194.43	194.42	194.66
07/18/1998	20:00	194.66	194.45	194.43	194.41	194.66
07/18/1998	21:00	194.66	194.45	194.43	194.41	194.66
07/18/1998	22:00	194.66	194.45	194.43	194.41	194.66
07/18/1998	23:00	194.66	194.45	194.43	194.41	194.65
07/19/1998	0:00	194.66	194.45	194.43	194.41	194.65
07/19/1998	1:00	194.65	194.45	194.43	194.41	194.64
07/19/1998	2:00	194.65	194.45	194.43	194.41	194.64
07/19/1998	3:00	194.65	194.45	194.43	194.41	194.64
07/19/1998	4:00	194.65	194.45	194.43	194.41	194.64
07/19/1998	5:00	194.65	194.44	194.43	194.41	194.64
07/19/1998	6:00	194.65	194.44	194.43	194.40	194.64
07/19/1998	7:00	194.65	194.44	194.43	194.41	194.64
07/19/1998	8:00	194.64	194.45	194.44	194.41	194.64
07/19/1998	9:00	194.64	194.45	194.44	194.41	194.65
07/19/1998	10:00	194.63	194.45	194.44	194.41	194.65
07/19/1998	11:00	194.62	194.45	194.43	194.41	194.65
07/19/1998	12:00	194.62	194.45	194.43	194.41	194.65
07/19/1998	13:00	194.62	194.44	194.43	194.41	194.65
07/19/1998	14:00	194.62	194.44	194.42	194.41	194.65
07/19/1998	15:00	194.62	194.44	194.42	194.41	194.65
07/19/1998	16:00	194.62	194.44	194.42	194.41	194.65
07/19/1998	17:00	194.62	194.44	194.42	194.41	194.65
07/19/1998	18:00	194.62	194.44	194.42	194.41	194.65
07/19/1998	19:00	194.63	194.44	194.42	194.41	194.66
07/19/1998	20:00	194.63	194.44	194.42	194.41	194.66
07/19/1998	21:00	194.64	194.44	194.42	194.41	194.67
07/19/1998	22:00	194.64	194.43	194.42	194.41	194.67
07/19/1998	23:00	194.65	194.43	194.42	194.40	194.68
07/20/1998	0:00	194.65	194.43	194.42	194.40	194.69
07/20/1998	1:00	194.66	194.43	194.42	194.40	194.69

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/20/1998	2:00	194.66	194.44	194.42	194.40	194.70
07/20/1998	3:00	194.66	194.43	194.41	194.40	194.70
07/20/1998	4:00	194.67	194.43	194.41	194.40	194.70
07/20/1998	5:00	194.67	194.43	194.41	194.40	194.70
07/20/1998	6:00	194.68	194.43	194.41	194.40	194.70
07/20/1998	7:00	194.68	194.43	194.41	194.40	194.71
07/20/1998	8:00	194.68	194.43	194.41	194.40	194.71
07/20/1998	9:00	194.68	194.43	194.41	194.40	194.71
07/20/1998	10:00	194.67	194.43	194.41	194.40	194.71
07/20/1998	11:00	194.66	194.43	194.41	194.40	194.71
07/20/1998	12:00	194.66	194.43	194.40	194.40	194.70
07/20/1998	13:00	194.66	194.42	194.40	194.40	194.70
07/20/1998	14:00	194.66	194.42	194.40	194.40	194.70
07/20/1998	15:00	194.66	194.42	194.40	194.40	194.70
07/20/1998	16:00	194.66	194.42	194.40	194.41	194.70
07/20/1998	17:00	194.67	194.43	194.40	194.41	194.70
07/20/1998	18:00	194.66	194.43	194.41	194.41	194.70
07/20/1998	19:00	194.66	194.43	194.40	194.41	194.71
07/20/1998	20:00	194.67	194.42	194.40	194.41	194.71
07/20/1998	21:00	194.68	194.42	194.40	194.41	194.71
07/20/1998	22:00	194.69	194.42	194.40	194.41	194.71
07/20/1998	23:00	194.69	194.43	194.40	194.41	194.72
07/21/1998	0:00	194.69	194.43	194.41	194.41	194.72
07/21/1998	1:00	194.68	194.43	194.41	194.41	194.72
07/21/1998	2:00	194.69	194.43	194.41	194.41	194.72
07/21/1998	3:00	194.69	194.43	194.41	194.41	194.72
07/21/1998	4:00	194.69	194.43	194.41	194.41	194.73
07/21/1998	5:00	194.69	194.43	194.41	194.41	194.73
07/21/1998	6:00	194.69	194.43	194.40	194.41	194.73
07/21/1998	7:00	194.69	194.43	194.40	194.41	194.73
07/21/1998	8:00	194.69	194.42	194.40	194.41	194.74
07/21/1998	9:00	194.69	194.42	194.40	194.41	194.73
07/21/1998	10:00	194.68	194.42	194.40	194.40	194.73

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/21/1998	11:00	194.67	194.42	194.40	194.40	194.73
07/21/1998	12:00	194.70	194.42	194.39	194.40	194.73
07/21/1998	13:00	194.70	194.42	194.39	194.40	194.72
07/21/1998	14:00	194.69	194.41	194.39	194.40	194.72
07/21/1998	15:00	194.69	194.41	194.39	194.40	194.71
07/21/1998	16:00	194.68	194.41	194.39	194.40	194.71
07/21/1998	17:00	194.68	194.41	194.39	194.40	194.70
07/21/1998	18:00	194.67	194.41	194.39	194.40	194.69
07/21/1998	19:00	194.67	194.41	194.39	194.40	194.68
07/21/1998	20:00	194.67	194.41	194.39	194.40	194.68
07/21/1998	21:00	194.67	194.41	194.39	194.40	194.67
07/21/1998	22:00	194.66	194.41	194.38	194.40	194.67
07/21/1998	23:00	194.67	194.41	194.38	194.40	194.68
07/22/1998	0:00	194.67	194.41	194.39	194.40	194.68
07/22/1998	1:00	194.67	194.41	194.39	194.40	194.68
07/22/1998	2:00	194.67	194.41	194.39	194.40	194.68
07/22/1998	3:00	194.67	194.41	194.38	194.40	194.69
07/22/1998	4:00	194.67	194.41	194.39	194.40	194.69
07/22/1998	5:00	194.67	194.41	194.39	194.40	194.69
07/22/1998	6:00	194.67	194.42	194.39	194.41	194.70
07/22/1998	7:00	194.68	194.43	194.40	194.41	194.70
07/22/1998	8:00	194.68	194.43	194.40	194.41	194.70
07/22/1998	9:00	194.68	194.43	194.41	194.41	194.71
07/22/1998	10:00	194.67	194.43	194.41	194.41	194.71
07/22/1998	11:00	194.66	194.43	194.40	194.41	194.71
07/22/1998	12:00	194.67	194.43	194.40	194.41	194.71
07/22/1998	13:00	194.66	194.43	194.40	194.41	194.72
07/22/1998	14:00	194.66	194.42	194.40	194.41	194.72
07/22/1998	15:00	194.66	194.43	194.40	194.41	194.71
07/22/1998	16:00	194.66	194.43	194.40	194.41	194.71
07/22/1998	17:00	194.67	194.43	194.40	194.42	194.72
07/22/1998	18:00	194.67	194.44	194.41	194.42	194.74
07/22/1998	19:00	194.68	194.44	194.41	194.42	194.74

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/22/1998	20:00	194.69	194.43	194.41	194.42	194.75
07/22/1998	21:00	194.69	194.44	194.41	194.42	194.76
07/22/1998	22:00	194.70	194.44	194.41	194.42	194.76
07/22/1998	23:00	194.70	194.44	194.41	194.42	194.76
07/23/1998	0:00	194.70	194.44	194.41	194.42	194.76
07/23/1998	1:00	194.70	194.44	194.41	194.42	194.77
07/23/1998	2:00	194.70	194.44	194.41	194.42	194.77
07/23/1998	3:00	194.71	194.44	194.41	194.42	194.77
07/23/1998	4:00	194.71	194.44	194.41	194.42	194.77
07/23/1998	5:00	194.71	194.44	194.41	194.42	194.78
07/23/1998	6:00	194.72	194.44	194.41	194.42	194.78
07/23/1998	7:00	194.72	194.43	194.41	194.42	194.78
07/23/1998	8:00	194.72	194.43	194.41	194.42	194.78
07/23/1998	9:00	194.72	194.43	194.41	194.42	194.78
07/23/1998	10:00	194.71	194.43	194.40	194.42	194.77
07/23/1998	11:00	194.71	194.43	194.40	194.42	194.77
07/23/1998	12:00	194.71	194.42	194.40	194.42	194.77
07/23/1998	13:00	194.71	194.42	194.39	194.42	194.77
07/23/1998	14:00	194.70	194.42	194.39	194.42	194.76
07/23/1998	15:00	194.70	194.42	194.39	194.42	194.75
07/23/1998	16:00	194.68	194.42	194.39	194.42	194.75
07/23/1998	17:00	194.69	194.42	194.39	194.42	194.75
07/23/1998	18:00	194.70	194.42	194.39	194.42	194.75
07/23/1998	19:00	194.71	194.42	194.39	194.42	194.75
07/23/1998	20:00	194.71	194.41	194.39	194.42	194.75
07/23/1998	21:00	194.72	194.41	194.38	194.42	194.75
07/23/1998	22:00	194.73	194.42	194.39	194.42	194.75
07/23/1998	23:00	194.73	194.42	194.39	194.42	194.75
07/24/1998	0:00	194.73	194.42	194.39	194.42	194.75
07/24/1998	1:00	194.73	194.42	194.39	194.42	194.76
07/24/1998	2:00	194.74	194.42	194.39	194.41	194.76
07/24/1998	3:00	194.74	194.42	194.39	194.41	194.76
07/24/1998	4:00	194.74	194.42	194.39	194.41	194.77

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/24/1998	5:00	194.74	194.42	194.39	194.41	194.77
07/24/1998	6:00	194.75	194.42	194.39	194.41	194.77
07/24/1998	7:00	194.75	194.42	194.39	194.41	194.77
07/24/1998	8:00	194.75	194.42	194.39	194.41	194.78
07/24/1998	9:00	194.75	194.41	194.39	194.41	194.78
07/24/1998	10:00	194.75	194.41	194.38	194.41	194.77
07/24/1998	11:00	194.74	194.41	194.38	194.41	194.77
07/24/1998	12:00	194.73	194.41	194.38	194.41	194.76
07/24/1998	13:00	194.73	194.41	194.38	194.41	194.75
07/24/1998	14:00	194.72	194.40	194.38	194.41	194.75
07/24/1998	15:00	194.71	194.40	194.38	194.40	194.74
07/24/1998	16:00	194.71	194.40	194.38	194.40	194.73
07/24/1998	17:00	194.70	194.40	194.37	194.40	194.72
07/24/1998	18:00	194.69	194.40	194.37	194.40	194.71
07/24/1998	19:00	194.69	194.40	194.37	194.40	194.70
07/24/1998	20:00	194.68	194.40	194.37	194.40	194.69
07/24/1998	21:00	194.68	194.40	194.37	194.40	194.69
07/24/1998	22:00	194.67	194.40	194.37	194.40	194.68
07/24/1998	23:00	194.67	194.40	194.37	194.40	194.68
07/25/1998	0:00	194.67	194.40	194.37	194.40	194.68
07/25/1998	1:00	194.67	194.40	194.37	194.40	194.67
07/25/1998	2:00	194.66	194.40	194.37	194.40	194.67
07/25/1998	3:00	194.66	194.40	194.37	194.40	194.66
07/25/1998	4:00	194.66	194.40	194.37	194.40	194.66
07/25/1998	5:00	194.66	194.40	194.37	194.40	194.66
07/25/1998	6:00	194.65	194.40	194.37	194.40	194.65
07/25/1998	7:00	194.65	194.40	194.37	194.40	194.65
07/25/1998	8:00	194.65	194.40	194.37	194.40	194.65
07/25/1998	9:00	194.65	194.40	194.37	194.40	194.64
07/25/1998	10:00	194.64	194.40	194.37	194.40	194.64
07/25/1998	11:00	194.64	194.40	194.37	194.40	194.63
07/25/1998	12:00	194.63	194.39	194.37	194.39	194.62
07/25/1998	13:00	194.63	194.39	194.37	194.39	194.62

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/25/1998	14:00	194.63	194.39	194.36	194.39	194.62
07/25/1998	15:00	194.62	194.39	194.36	194.39	194.61
07/25/1998	16:00	194.62	194.39	194.36	194.39	194.61
07/25/1998	17:00	194.61	194.39	194.36	194.39	194.61
07/25/1998	18:00	194.61	194.39	194.36	194.39	194.60
07/25/1998	19:00	194.61	194.39	194.36	194.39	194.60
07/25/1998	20:00	194.61	194.39	194.36	194.39	194.60
07/25/1998	21:00	194.60	194.39	194.36	194.39	194.59
07/25/1998	22:00	194.60	194.39	194.36	194.39	194.59
07/25/1998	23:00	194.60	194.39	194.36	194.39	194.59
07/26/1998	0:00	194.60	194.39	194.36	194.39	194.59
07/26/1998	1:00	194.60	194.39	194.36	194.39	194.59
07/26/1998	2:00	194.60	194.39	194.36	194.39	194.59
07/26/1998	3:00	194.60	194.39	194.36	194.38	194.59
07/26/1998	4:00	194.60	194.39	194.36	194.39	194.59
07/26/1998	5:00	194.60	194.39	194.36	194.38	194.58
07/26/1998	6:00	194.60	194.39	194.36	194.38	194.58
07/26/1998	7:00	194.60	194.39	194.36	194.38	194.58
07/26/1998	8:00	194.59	194.39	194.36	194.38	194.58
07/26/1998	9:00	194.59	194.39	194.36	194.38	194.58
07/26/1998	10:00	194.59	194.39	194.36	194.38	194.58
07/26/1998	11:00	194.59	194.38	194.36	194.38	194.58
07/26/1998	12:00	194.58	194.38	194.35	194.38	194.57
07/26/1998	13:00	194.58	194.38	194.35	194.38	194.57
07/26/1998	14:00	194.58	194.38	194.35	194.38	194.56
07/26/1998	15:00	194.57	194.38	194.35	194.38	194.56
07/26/1998	16:00	194.57	194.38	194.35	194.38	194.56
07/26/1998	17:00	194.57	194.38	194.35	194.38	194.56
07/26/1998	18:00	194.57	194.38	194.35	194.38	194.56
07/26/1998	19:00	194.57	194.38	194.35	194.38	194.55
07/26/1998	20:00	194.57	194.38	194.35	194.38	194.55
07/26/1998	21:00	194.56	194.38	194.35	194.38	194.55
07/26/1998	22:00	194.56	194.38	194.35	194.38	194.55

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/26/1998	23:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	0:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	1:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	2:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	3:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	4:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	5:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	6:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	7:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	8:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	9:00	194.56	194.38	194.35	194.38	194.55
07/27/1998	10:00	194.56	194.38	194.35	194.38	194.54
07/27/1998	11:00	194.55	194.38	194.35	194.38	194.54
07/27/1998	12:00	194.55	194.37	194.34	194.38	194.54
07/27/1998	13:00	194.55	194.37	194.34	194.37	194.53
07/27/1998	14:00	194.55	194.37	194.34	194.37	194.53
07/27/1998	15:00	194.55	194.37	194.34	194.37	194.53
07/27/1998	16:00	194.54	194.37	194.34	194.37	194.53
07/27/1998	17:00	194.54	194.37	194.34	194.37	194.53
07/27/1998	18:00	194.54	194.37	194.34	194.37	194.52
07/27/1998	19:00	194.54	194.37	194.34	194.37	194.52
07/27/1998	20:00	194.53	194.37	194.34	194.37	194.52
07/27/1998	21:00	194.53	194.37	194.34	194.37	194.51
07/27/1998	22:00	194.53	194.37	194.34	194.37	194.51
07/27/1998	23:00	194.53	194.37	194.34	194.37	194.51
07/28/1998	0:00	194.53	194.37	194.34	194.37	194.51
07/28/1998	1:00	194.53	194.37	194.34	194.37	194.50
07/28/1998	2:00	194.52	194.37	194.34	194.37	194.50
07/28/1998	3:00	194.52	194.37	194.34	194.37	194.49
07/28/1998	4:00	194.52	194.37	194.34	194.37	194.49
07/28/1998	5:00	194.52	194.37	194.34	194.37	194.49
07/28/1998	6:00	194.52	194.37	194.34	194.37	194.49
07/28/1998	7:00	194.51	194.37	194.34	194.37	194.49

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/28/1998	8:00	194.51	194.37	194.34	194.37	194.48
07/28/1998	9:00	194.51	194.37	194.34	194.37	194.48
07/28/1998	10:00	194.51	194.36	194.34	194.37	194.48
07/28/1998	11:00	194.51	194.36	194.33	194.37	194.48
07/28/1998	12:00	194.50	194.36	194.33	194.37	194.47
07/28/1998	13:00	194.50	194.36	194.33	194.36	194.47
07/28/1998	14:00	194.50	194.36	194.33	194.36	194.47
07/28/1998	15:00	194.49	194.36	194.33	194.36	194.46
07/28/1998	16:00	194.49	194.36	194.33	194.36	194.46
07/28/1998	17:00	194.49	194.35	194.33	194.36	194.46
07/28/1998	18:00	194.49	194.35	194.33	194.36	194.46
07/28/1998	19:00	194.48	194.35	194.32	194.36	194.46
07/28/1998	20:00	194.48	194.35	194.32	194.36	194.46
07/28/1998	21:00	194.48	194.35	194.32	194.36	194.45
07/28/1998	22:00	194.48	194.35	194.33	194.36	194.45
07/28/1998	23:00	194.48	194.35	194.33	194.36	194.44
07/29/1998	0:00	194.47	194.35	194.33	194.36	194.44
07/29/1998	1:00	194.47	194.36	194.33	194.36	194.44
07/29/1998	2:00	194.47	194.36	194.33	194.35	194.44
07/29/1998	3:00	194.47	194.35	194.33	194.35	194.44
07/29/1998	4:00	194.47	194.35	194.33	194.35	194.44
07/29/1998	5:00	194.47	194.35	194.33	194.35	194.43
07/29/1998	6:00	194.47	194.35	194.33	194.35	194.43
07/29/1998	7:00	194.46	194.35	194.33	194.35	194.43
07/29/1998	8:00	194.46	194.35	194.32	194.35	194.43
07/29/1998	9:00	194.46	194.35	194.32	194.35	194.43
07/29/1998	10:00	194.46	194.35	194.32	194.35	194.43
07/29/1998	11:00	194.46	194.34	194.32	194.35	194.42
07/29/1998	12:00	194.45	194.34	194.32	194.35	194.42
07/29/1998	13:00	194.45	194.34	194.32	194.35	194.42
07/29/1998	14:00	194.45	194.34	194.31	194.35	194.41
07/29/1998	15:00	194.45	194.34	194.31	194.35	194.41
07/29/1998	16:00	194.44	194.34	194.31	194.35	194.41

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/29/1998	17:00	194.44	194.34	194.31	194.34	194.41
07/29/1998	18:00	194.44	194.34	194.31	194.34	194.41
07/29/1998	19:00	194.44	194.34	194.31	194.34	194.41
07/29/1998	20:00	194.44	194.34	194.31	194.34	194.41
07/29/1998	21:00	194.44	194.34	194.31	194.34	194.41
07/29/1998	22:00	194.43	194.34	194.31	194.34	194.40
07/29/1998	23:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	0:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	1:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	2:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	3:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	4:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	5:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	6:00	194.43	194.34	194.31	194.34	194.40
07/30/1998	7:00	194.43	194.34	194.31	194.34	194.41
07/30/1998	8:00	194.43	194.34	194.31	194.34	194.41
07/30/1998	9:00	194.43	194.34	194.31	194.34	194.41
07/30/1998	10:00	194.42	194.33	194.31	194.34	194.40
07/30/1998	11:00	194.42	194.33	194.31	194.34	194.40
07/30/1998	12:00	194.42	194.33	194.30	194.34	194.39
07/30/1998	13:00	194.42	194.33	194.30	194.34	194.39
07/30/1998	14:00	194.41	194.33	194.30	194.34	194.39
07/30/1998	15:00	194.41	194.33	194.30	194.33	194.39
07/30/1998	16:00	194.41	194.32	194.30	194.33	194.39
07/30/1998	17:00	194.41	194.32	194.30	194.33	194.39
07/30/1998	18:00	194.41	194.32	194.29	194.33	194.39
07/30/1998	19:00	194.41	194.32	194.29	194.33	194.39
07/30/1998	20:00	194.40	194.32	194.29	194.33	194.39
07/30/1998	21:00	194.40	194.32	194.30	194.33	194.38
07/30/1998	22:00	194.40	194.32	194.30	194.33	194.38
07/30/1998	23:00	194.40	194.32	194.30	194.33	194.38
07/31/1998	0:00	194.40	194.33	194.30	194.33	194.38
07/31/1998	1:00	194.40	194.33	194.30	194.33	194.38

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
07/31/1998	2:00	194.40	194.33	194.30	194.33	194.39
07/31/1998	3:00	194.40	194.33	194.30	194.33	194.39
07/31/1998	4:00	194.40	194.33	194.30	194.33	194.39
07/31/1998	5:00	194.40	194.33	194.30	194.33	194.39
07/31/1998	6:00	194.40	194.33	194.30	194.33	194.39
07/31/1998	7:00	194.40	194.32	194.30	194.33	194.39
07/31/1998	8:00	194.40	194.32	194.30	194.33	194.39
07/31/1998	9:00	194.40	194.32	194.29	194.33	194.39
07/31/1998	10:00	194.40	194.32	194.29	194.33	194.39
07/31/1998	11:00	194.39	194.32	194.29	194.33	194.38
07/31/1998	12:00	194.39	194.32	194.29	194.33	194.38
07/31/1998	13:00	194.39	194.32	194.29	194.33	194.38
07/31/1998	14:00	194.39	194.31	194.29	194.33	194.38
07/31/1998	15:00	194.39	194.31	194.28	194.33	194.37
07/31/1998	16:00	194.39	194.31	194.28	194.33	194.37
07/31/1998	17:00	194.38	194.31	194.28	194.33	194.37
07/31/1998	18:00	194.38	194.31	194.28	194.33	194.37
07/31/1998	19:00	194.38	194.31	194.28	194.33	194.37
07/31/1998	20:00	194.38	194.31	194.28	194.33	194.36
07/31/1998	21:00	194.38	194.31	194.28	194.33	194.36
07/31/1998	22:00	194.38	194.31	194.28	194.33	194.36
07/31/1998	23:00	194.37	194.32	194.28	194.33	194.35
08/01/1998	0:00	194.37	194.32	194.29	194.33	194.35
08/01/1998	1:00	194.37	194.32	194.29	194.33	194.35
08/01/1998	2:00	194.37	194.32	194.29	194.33	194.34
08/01/1998	3:00	194.36	194.32	194.29	194.33	194.34
08/01/1998	4:00	194.36	194.32	194.29	194.33	194.34
08/01/1998	5:00	194.36	194.32	194.29	194.33	194.34
08/01/1998	6:00	194.36	194.32	194.29	194.33	194.33
08/01/1998	7:00	194.36	194.32	194.29	194.33	194.33
08/01/1998	8:00	194.35	194.32	194.29	194.33	194.33
08/01/1998	9:00	194.35	194.32	194.29	194.33	194.33
08/01/1998	10:00	194.35	194.31	194.28	194.33	194.33

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/01/1998	11:00	194.35	194.31	194.28	194.33	194.33
08/01/1998	12:00	194.35	194.31	194.28	194.33	194.33
08/01/1998	13:00	194.35	194.31	194.28	194.33	194.32
08/01/1998	14:00	194.34	194.31	194.28	194.33	194.32
08/01/1998	15:00	194.34	194.31	194.28	194.33	194.32
08/01/1998	16:00	194.34	194.31	194.28	194.33	194.32
08/01/1998	17:00	194.34	194.31	194.28	194.33	194.31
08/01/1998	18:00	194.34	194.31	194.28	194.33	194.31
08/01/1998	19:00	194.33	194.31	194.28	194.33	194.31
08/01/1998	20:00	194.33	194.31	194.28	194.33	194.31
08/01/1998	21:00	194.33	194.31	194.28	194.33	194.31
08/01/1998	22:00	194.33	194.31	194.28	194.33	194.31
08/01/1998	23:00	194.33	194.31	194.28	194.33	194.31
08/02/1998	0:00	194.33	194.31	194.28	194.33	194.31
08/02/1998	1:00	194.33	194.31	194.28	194.33	194.31
08/02/1998	2:00	194.33	194.31	194.28	194.33	194.31
08/02/1998	3:00	194.33	194.31	194.28	194.33	194.30
08/02/1998	4:00	194.32	194.32	194.28	194.33	194.31
08/02/1998	5:00	194.32	194.32	194.28	194.33	194.30
08/02/1998	6:00	194.32	194.32	194.28	194.33	194.30
08/02/1998	7:00	194.32	194.32	194.28	194.33	194.30
08/02/1998	8:00	194.32	194.32	194.28	194.33	194.30
08/02/1998	9:00	194.32	194.32	194.28	194.33	194.30
08/02/1998	10:00	194.32	194.31	194.28	194.33	194.30
08/02/1998	11:00	194.32	194.31	194.28	194.33	194.30
08/02/1998	12:00	194.32	194.31	194.27	194.33	194.30
08/02/1998	13:00	194.32	194.31	194.27	194.33	194.30
08/02/1998	14:00	194.31	194.30	194.27	194.33	194.29
08/02/1998	15:00	194.31	194.30	194.27	194.33	194.30
08/02/1998	16:00	194.31	194.30	194.27	194.33	194.29
08/02/1998	17:00	194.31	194.30	194.27	194.33	194.29
08/02/1998	18:00	194.31	194.30	194.27	194.33	194.29
08/02/1998	19:00	194.31	194.30	194.27	194.33	194.29

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/02/1998	20:00	194.31	194.31	194.27	194.33	194.30
08/02/1998	21:00	194.31	194.31	194.27	194.33	194.30
08/02/1998	22:00	194.31	194.31	194.27	194.33	194.31
08/02/1998	23:00	194.32	194.31	194.27	194.33	194.31
08/03/1998	0:00	194.32	194.31	194.27	194.33	194.32
08/03/1998	1:00	194.32	194.31	194.27	194.33	194.32
08/03/1998	2:00	194.32	194.31	194.28	194.33	194.32
08/03/1998	3:00	194.32	194.31	194.28	194.33	194.32
08/03/1998	4:00	194.32	194.31	194.28	194.33	194.32
08/03/1998	5:00	194.32	194.31	194.28	194.33	194.32
08/03/1998	6:00	194.32	194.31	194.28	194.33	194.31
08/03/1998	7:00	194.32	194.31	194.28	194.33	194.31
08/03/1998	8:00	194.31	194.31	194.28	194.33	194.31
08/03/1998	9:00	194.31	194.31	194.28	194.33	194.30
08/03/1998	10:00	194.31	194.31	194.28	194.33	194.29
08/03/1998	11:00	194.30	194.31	194.27	194.33	194.28
08/03/1998	12:00	194.30	194.31	194.27	194.33	194.28
08/03/1998	13:00	194.30	194.31	194.27	194.33	194.28
08/03/1998	14:00	194.30	194.31	194.27	194.33	194.27
08/03/1998	15:00	194.29	194.31	194.27	194.33	194.27
08/03/1998	16:00	194.29	194.30	194.27	194.33	194.27
08/03/1998	17:00	194.29	194.30	194.27	194.33	194.27
08/03/1998	18:00	194.29	194.30	194.27	194.33	194.27
08/03/1998	19:00	194.29	194.30	194.27	194.33	194.27
08/03/1998	20:00	194.29	194.30	194.27	194.33	194.28
08/03/1998	21:00	194.29	194.30	194.27	194.33	194.28
08/03/1998	22:00	194.29	194.31	194.27	194.33	194.28
08/03/1998	23:00	194.28	194.32	194.28	194.35	194.28
08/04/1998	0:00	194.28	194.32	194.28	194.35	194.28
08/04/1998	1:00	194.28	194.33	194.29	194.36	194.29
08/04/1998	2:00	194.28	194.33	194.29	194.36	194.30
08/04/1998	3:00	194.30	194.34	194.30	194.37	194.32
08/04/1998	4:00	194.31	194.39	194.36	194.40	194.36

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/04/1998	5:00	194.32	194.41	194.39	194.42	194.38
08/04/1998	6:00	194.34	194.43	194.41	194.42	194.41
08/04/1998	7:00	194.36	194.44	194.42	194.43	194.44
08/04/1998	8:00	194.38	194.45	194.43	194.44	194.48
08/04/1998	9:00	194.41	194.45	194.43	194.44	194.54
08/04/1998	10:00	194.44	194.46	194.44	194.45	194.59
08/04/1998	11:00	194.48	194.47	194.45	194.47	194.66
08/04/1998	12:00	194.51	194.49	194.47	194.51	194.72
08/04/1998	13:00	194.54	194.52	194.49	194.56	194.78
08/04/1998	14:00	194.60	194.54	194.51	194.63	194.90
08/04/1998	15:00	194.65	194.58	194.53	194.70	194.98
08/04/1998	16:00	194.71	194.61	194.56	194.77	195.04
08/04/1998	17:00	194.78	194.64	194.57	194.84	195.10
08/04/1998	18:00	194.84	194.67	194.60	194.89	195.15
08/04/1998	19:00	194.89	194.69	194.61	194.93	195.19
08/04/1998	20:00	194.94	194.72	194.63	194.97	195.23
08/04/1998	21:00	194.99	194.73	194.64	195.00	195.26
08/04/1998	22:00	195.02	194.75	194.66	195.02	195.28
08/04/1998	23:00	195.05	194.77	194.67	195.03	195.30
08/05/1998	0:00	195.07	194.78	194.68	195.04	195.31
08/05/1998	1:00	195.09	194.79	194.68	195.04	195.32
08/05/1998	2:00	195.10	194.79	194.69	195.04	195.33
08/05/1998	3:00	195.11	194.80	194.70	195.04	195.34
08/05/1998	4:00	195.12	194.81	194.70	195.03	195.34
08/05/1998	5:00	195.13	194.81	194.71	195.03	195.34
08/05/1998	6:00	195.13	194.81	194.71	195.03	195.34
08/05/1998	7:00	195.13	194.82	194.71	195.02	195.34
08/05/1998	8:00	195.13	194.82	194.72	195.02	195.34
08/05/1998	9:00	195.13	194.82	194.72	195.01	195.33
08/05/1998	10:00	195.13	194.82	194.72	195.01	195.33
08/05/1998	11:00	195.13	194.82	194.72	195.01	195.32
08/05/1998	12:00	195.13	194.82	194.72	195.00	195.32
08/05/1998	13:00	195.13	194.82	194.72	195.00	195.31

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/05/1998	14:00	195.12	194.82	194.72	194.99	195.31
08/05/1998	15:00	195.12	194.82	194.72	194.98	195.30
08/05/1998	16:00	195.11	194.82	194.72	194.98	195.30
08/05/1998	17:00	195.11	194.82	194.72	194.97	195.30
08/05/1998	18:00	195.11	194.82	194.72	194.96	195.29
08/05/1998	19:00	195.11	194.82	194.72	194.96	195.28
08/05/1998	20:00	195.12	194.82	194.72	194.95	195.28
08/05/1998	21:00	195.12	194.82	194.72	194.95	195.27
08/05/1998	22:00	195.12	194.81	194.72	194.94	195.26
08/05/1998	23:00	195.12	194.81	194.72	194.93	195.26
08/06/1998	0:00	195.11	194.81	194.72	194.93	195.25
08/06/1998	1:00	195.11	194.81	194.72	194.92	195.25
08/06/1998	2:00	195.11	194.81	194.72	194.92	195.24
08/06/1998	3:00	195.11	194.81	194.72	194.91	195.24
08/06/1998	4:00	195.11	194.81	194.72	194.91	195.24
08/06/1998	5:00	195.10	194.81	194.72	194.90	195.23
08/06/1998	6:00	195.10	194.80	194.72	194.90	195.23
08/06/1998	7:00	195.10	194.80	194.72	194.90	195.22
08/06/1998	8:00	195.10	194.80	194.72	194.89	195.22
08/06/1998	9:00	195.10	194.80	194.71	194.89	195.22
08/06/1998	10:00	195.09	194.79	194.71	194.88	195.22
08/06/1998	11:00	195.09	194.79	194.71	194.88	195.21
08/06/1998	12:00	195.08	194.79	194.71	194.87	195.21
08/06/1998	13:00	195.08	194.78	194.70	194.87	195.20
08/06/1998	14:00	195.09	194.78	194.70	194.86	195.20
08/06/1998	15:00	195.09	194.78	194.70	194.86	195.19
08/06/1998	16:00	195.09	194.78	194.70	194.85	195.19
08/06/1998	17:00	195.09	194.77	194.70	194.85	195.18
08/06/1998	18:00	195.08	194.77	194.69	194.84	195.18
08/06/1998	19:00	195.08	194.77	194.69	194.84	195.17
08/06/1998	20:00	195.08	194.77	194.69	194.83	195.16
08/06/1998	21:00	195.08	194.76	194.69	194.83	195.15
08/06/1998	22:00	195.07	194.76	194.69	194.83	195.15

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/06/1998	23:00	195.07	194.76	194.69	194.82	195.14
08/07/1998	0:00	195.07	194.76	194.69	194.82	195.13
08/07/1998	1:00	195.06	194.75	194.68	194.81	195.13
08/07/1998	2:00	195.06	194.75	194.68	194.81	195.13
08/07/1998	3:00	195.06	194.75	194.68	194.80	195.12
08/07/1998	4:00	195.06	194.75	194.68	194.80	195.12
08/07/1998	5:00	195.06	194.75	194.68	194.80	195.12
08/07/1998	6:00	195.06	194.74	194.68	194.79	195.12
08/07/1998	7:00	195.06	194.74	194.67	194.79	195.12
08/07/1998	8:00	195.06	194.74	194.67	194.78	195.12
08/07/1998	9:00	195.06	194.73	194.67	194.78	195.13
08/07/1998	10:00	195.06	194.73	194.67	194.78	195.14
08/07/1998	11:00	195.06	194.73	194.67	194.78	195.14
08/07/1998	12:00	195.06	194.73	194.67	194.77	195.14
08/07/1998	13:00	195.06	194.73	194.67	194.77	195.15
08/07/1998	14:00	195.06	194.73	194.67	194.77	195.16
08/07/1998	15:00	195.06	194.73	194.66	194.77	195.17
08/07/1998	16:00	195.06	194.73	194.67	194.76	195.18
08/07/1998	17:00	195.07	194.73	194.67	194.77	195.19
08/07/1998	18:00	195.07	194.74	194.68	194.77	195.19
08/07/1998	19:00	195.07	194.74	194.69	194.76	195.20
08/07/1998	20:00	195.08	194.74	194.69	194.76	195.21
08/07/1998	21:00	195.08	194.74	194.69	194.76	195.22
08/07/1998	22:00	195.08	194.74	194.69	194.76	195.22
08/07/1998	23:00	195.09	194.74	194.69	194.76	195.23
08/08/1998	0:00	195.09	194.74	194.69	194.76	195.23
08/08/1998	1:00	195.10	194.74	194.69	194.76	195.24
08/08/1998	2:00	195.10	194.74	194.69	194.76	195.25
08/08/1998	3:00	195.10	194.74	194.69	194.75	195.26
08/08/1998	4:00	195.10	194.73	194.68	194.75	195.26
08/08/1998	5:00	195.11	194.73	194.68	194.75	195.27
08/08/1998	6:00	195.11	194.73	194.68	194.75	195.27
08/08/1998	7:00	195.11	194.73	194.68	194.75	195.28

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/08/1998	8:00	195.12	194.73	194.68	194.75	195.28
08/08/1998	9:00	195.12	194.73	194.68	194.75	195.29
08/08/1998	10:00	195.12	194.73	194.68	194.75	195.30
08/08/1998	11:00	195.11	194.73	194.68	194.74	195.30
08/08/1998	12:00	195.11	194.72	194.67	194.74	195.31
08/08/1998	13:00	195.11	194.72	194.67	194.74	195.31
08/08/1998	14:00	195.11	194.72	194.67	194.74	195.31
08/08/1998	15:00	195.13	194.72	194.67	194.74	195.32
08/08/1998	16:00	195.13	194.72	194.66	194.74	195.32
08/08/1998	17:00	195.13	194.71	194.66	194.74	195.32
08/08/1998	18:00	195.14	194.71	194.66	194.73	195.33
08/08/1998	19:00	195.14	194.71	194.66	194.73	195.33
08/08/1998	20:00	195.15	194.71	194.66	194.73	195.34
08/08/1998	21:00	195.15	194.71	194.66	194.73	195.33
08/08/1998	22:00	195.16	194.71	194.65	194.73	195.34
08/08/1998	23:00	195.16	194.71	194.66	194.73	195.34
08/09/1998	0:00	195.16	194.71	194.65	194.72	195.34
08/09/1998	1:00	195.16	194.71	194.65	194.72	195.34
08/09/1998	2:00	195.16	194.71	194.66	194.72	195.35
08/09/1998	3:00	195.17	194.71	194.66	194.72	195.35
08/09/1998	4:00	195.17	194.71	194.65	194.72	195.35
08/09/1998	5:00	195.17	194.70	194.65	194.72	195.36
08/09/1998	6:00	195.18	194.70	194.65	194.72	195.36
08/09/1998	7:00	195.18	194.70	194.65	194.72	195.36
08/09/1998	8:00	195.18	194.70	194.65	194.72	195.36
08/09/1998	9:00	195.18	194.70	194.65	194.71	195.36
08/09/1998	10:00	195.17	194.70	194.65	194.71	195.36
08/09/1998	11:00	195.17	194.70	194.65	194.71	195.36
08/09/1998	12:00	195.16	194.70	194.65	194.71	195.36
08/09/1998	13:00	195.16	194.70	194.65	194.71	195.36
08/09/1998	14:00	195.15	194.69	194.65	194.71	195.36
08/09/1998	15:00	195.15	194.69	194.64	194.71	195.36
08/09/1998	16:00	195.15	194.69	194.64	194.71	195.36

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/09/1998	17:00	195.16	194.69	194.64	194.70	195.35
08/09/1998	18:00	195.16	194.68	194.63	194.70	195.35
08/09/1998	19:00	195.16	194.68	194.63	194.70	195.34
08/09/1998	20:00	195.17	194.68	194.63	194.70	195.34
08/09/1998	21:00	195.17	194.68	194.63	194.70	195.33
08/09/1998	22:00	195.17	194.68	194.63	194.70	195.33
08/09/1998	23:00	195.17	194.68	194.63	194.69	195.32
08/10/1998	0:00	195.17	194.68	194.63	194.69	195.31
08/10/1998	1:00	195.17	194.68	194.63	194.69	195.31
08/10/1998	2:00	195.17	194.68	194.63	194.69	195.30
08/10/1998	3:00	195.17	194.68	194.63	194.69	195.29
08/10/1998	4:00	195.17	194.68	194.63	194.69	195.29
08/10/1998	5:00	195.17	194.68	194.63	194.68	195.28
08/10/1998	6:00	195.17	194.67	194.63	194.68	195.27
08/10/1998	7:00	195.16	194.67	194.63	194.68	195.27
08/10/1998	8:00	195.16	194.67	194.63	194.68	195.26
08/10/1998	9:00	195.16	194.67	194.62	194.68	195.25
08/10/1998	10:00	195.15	194.67	194.62	194.68	195.24
08/10/1998	11:00	195.14	194.67	194.62	194.68	195.24
08/10/1998	12:00	195.13	194.66	194.62	194.68	195.23
08/10/1998	13:00	195.12	194.66	194.62	194.67	195.22
08/10/1998	14:00	195.12	194.66	194.61	194.67	195.21
08/10/1998	15:00	195.11	194.66	194.61	194.67	195.20
08/10/1998	16:00	195.10	194.65	194.61	194.67	195.19
08/10/1998	17:00	195.10	194.65	194.60	194.67	195.19
08/10/1998	18:00	195.10	194.65	194.60	194.67	195.18
08/10/1998	19:00	195.10	194.65	194.61	194.67	195.17
08/10/1998	20:00	195.10	194.65	194.60	194.66	195.16
08/10/1998	21:00	195.10	194.65	194.60	194.66	195.16
08/10/1998	22:00	195.10	194.65	194.60	194.66	195.15
08/10/1998	23:00	195.11	194.65	194.60	194.66	195.14
08/11/1998	0:00	195.11	194.65	194.60	194.66	195.14
08/11/1998	1:00	195.11	194.65	194.60	194.65	195.13

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/11/1998	2:00	195.11	194.65	194.60	194.65	195.13
08/11/1998	3:00	195.11	194.65	194.60	194.65	195.13
08/11/1998	4:00	195.11	194.64	194.60	194.65	195.13
08/11/1998	5:00	195.10	194.64	194.60	194.65	195.12
08/11/1998	6:00	195.10	194.64	194.60	194.64	195.12
08/11/1998	7:00	195.06	194.64	194.60	194.64	195.12
08/11/1998	8:00	195.05	194.64	194.59	194.64	195.12
08/11/1998	9:00	195.05	194.64	194.59	194.64	195.12
08/11/1998	10:00	195.05	194.63	194.59	194.64	195.11
08/11/1998	11:00	195.04	194.63	194.59	194.64	195.11
08/11/1998	12:00	195.03	194.63	194.58	194.63	195.10
08/11/1998	13:00	195.02	194.62	194.58	194.63	195.09
08/11/1998	14:00	195.02	194.62	194.58	194.63	195.08
08/11/1998	15:00	195.01	194.62	194.57	194.63	195.07
08/11/1998	16:00	195.00	194.62	194.57	194.62	195.07
08/11/1998	17:00	195.00	194.61	194.57	194.62	195.06
08/11/1998	18:00	195.00	194.61	194.57	194.62	195.06
08/11/1998	19:00	194.99	194.61	194.57	194.62	195.05
08/11/1998	20:00	194.99	194.61	194.57	194.61	195.04
08/11/1998	21:00	194.98	194.61	194.56	194.61	195.04
08/11/1998	22:00	194.98	194.60	194.56	194.61	195.03
08/11/1998	23:00	194.98	194.60	194.56	194.60	195.02
08/12/1998	0:00	194.97	194.60	194.56	194.60	195.02
08/12/1998	1:00	194.97	194.60	194.56	194.60	195.02
08/12/1998	2:00	194.96	194.60	194.56	194.60	195.01
08/12/1998	3:00	194.96	194.60	194.56	194.59	195.01
08/12/1998	4:00	194.96	194.59	194.56	194.59	195.00
08/12/1998	5:00	194.95	194.59	194.56	194.59	195.00
08/12/1998	6:00	194.95	194.59	194.55	194.59	194.99
08/12/1998	7:00	194.95	194.59	194.55	194.58	194.99
08/12/1998	8:00	194.95	194.59	194.55	194.58	194.98
08/12/1998	9:00	194.94	194.58	194.55	194.58	194.98
08/12/1998	10:00	194.94	194.58	194.54	194.58	194.97

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/12/1998	11:00	194.93	194.58	194.54	194.57	194.97
08/12/1998	12:00	194.92	194.58	194.54	194.57	194.96
08/12/1998	13:00	194.92	194.57	194.54	194.57	194.95
08/12/1998	14:00	194.91	194.57	194.53	194.57	194.94
08/12/1998	15:00	194.90	194.57	194.53	194.56	194.92
08/12/1998	16:00	194.89	194.56	194.53	194.56	194.91
08/12/1998	17:00	194.88	194.56	194.53	194.56	194.90
08/12/1998	18:00	194.87	194.56	194.52	194.56	194.89
08/12/1998	19:00	194.86	194.56	194.52	194.56	194.88
08/12/1998	20:00	194.86	194.56	194.53	194.56	194.87
08/12/1998	21:00	194.85	194.56	194.52	194.56	194.86
08/12/1998	22:00	194.84	194.56	194.52	194.56	194.86
08/12/1998	23:00	194.84	194.56	194.53	194.56	194.85
08/13/1998	0:00	194.83	194.56	194.52	194.56	194.84
08/13/1998	1:00	194.83	194.56	194.53	194.56	194.83
08/13/1998	2:00	194.82	194.56	194.53	194.56	194.83
08/13/1998	3:00	194.82	194.56	194.53	194.56	194.82
08/13/1998	4:00	194.81	194.56	194.52	194.55	194.82
08/13/1998	5:00	194.81	194.56	194.52	194.55	194.81
08/13/1998	6:00	194.81	194.56	194.52	194.55	194.81
08/13/1998	7:00	194.80	194.56	194.52	194.55	194.80
08/13/1998	8:00	194.80	194.56	194.52	194.55	194.80
08/13/1998	9:00	194.79	194.56	194.52	194.55	194.79
08/13/1998	10:00	194.79	194.55	194.52	194.55	194.79
08/13/1998	11:00	194.79	194.55	194.52	194.54	194.79
08/13/1998	12:00	194.78	194.55	194.52	194.54	194.79
08/13/1998	13:00	194.78	194.55	194.51	194.54	194.78
08/13/1998	14:00	194.77	194.54	194.51	194.54	194.78
08/13/1998	15:00	194.77	194.54	194.51	194.54	194.77
08/13/1998	16:00	194.77	194.54	194.51	194.54	194.77
08/13/1998	17:00	194.76	194.54	194.50	194.53	194.77
08/13/1998	18:00	194.76	194.54	194.50	194.53	194.76
08/13/1998	19:00	194.76	194.53	194.50	194.53	194.76

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/13/1998	20:00	194.75	194.53	194.50	194.53	194.75
08/13/1998	21:00	194.75	194.53	194.50	194.53	194.75
08/13/1998	22:00	194.75	194.53	194.50	194.53	194.75
08/13/1998	23:00	194.75	194.53	194.50	194.53	194.74
08/14/1998	0:00	194.74	194.53	194.50	194.53	194.74
08/14/1998	1:00	194.74	194.53	194.50	194.53	194.74
08/14/1998	2:00	194.74	194.53	194.50	194.53	194.73
08/14/1998	3:00	194.74	194.53	194.50	194.53	194.73
08/14/1998	4:00	194.74	194.53	194.50	194.53	194.73
08/14/1998	5:00	194.73	194.53	194.50	194.52	194.73
08/14/1998	6:00	194.73	194.53	194.50	194.52	194.72
08/14/1998	7:00	194.73	194.53	194.50	194.52	194.72
08/14/1998	8:00	194.73	194.53	194.50	194.52	194.72
08/14/1998	9:00	194.72	194.53	194.50	194.52	194.72
08/14/1998	10:00	194.72	194.53	194.50	194.52	194.72
08/14/1998	11:00	194.72	194.53	194.49	194.52	194.71
08/14/1998	12:00	194.71	194.53	194.49	194.52	194.70
08/14/1998	13:00	194.70	194.52	194.49	194.52	194.70
08/14/1998	14:00	194.70	194.52	194.49	194.52	194.69
08/14/1998	15:00	194.69	194.52	194.49	194.52	194.69
08/14/1998	16:00	194.69	194.52	194.48	194.52	194.68
08/14/1998	17:00	194.68	194.52	194.48	194.52	194.68
08/14/1998	18:00	194.68	194.51	194.48	194.51	194.67
08/14/1998	19:00	194.68	194.51	194.48	194.51	194.67
08/14/1998	20:00	194.67	194.51	194.48	194.51	194.66
08/14/1998	21:00	194.67	194.51	194.48	194.51	194.66
08/14/1998	22:00	194.67	194.51	194.48	194.51	194.65
08/14/1998	23:00	194.66	194.51	194.48	194.51	194.65
08/15/1998	0:00	194.66	194.51	194.48	194.51	194.65
08/15/1998	1:00	194.66	194.51	194.48	194.51	194.64
08/15/1998	2:00	194.66	194.51	194.48	194.51	194.64
08/15/1998	3:00	194.65	194.51	194.48	194.51	194.64
08/15/1998	4:00	194.65	194.51	194.48	194.50	194.63

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/15/1998	5:00	194.65	194.51	194.48	194.50	194.63
08/15/1998	6:00	194.65	194.51	194.48	194.50	194.63
08/15/1998	7:00	194.65	194.51	194.48	194.50	194.63
08/15/1998	8:00	194.64	194.50	194.47	194.50	194.63
08/15/1998	9:00	194.64	194.50	194.47	194.50	194.63
08/15/1998	10:00	194.64	194.50	194.47	194.50	194.62
08/15/1998	11:00	194.64	194.50	194.47	194.50	194.63
08/15/1998	12:00	194.63	194.50	194.47	194.50	194.62
08/15/1998	13:00	194.63	194.50	194.46	194.50	194.61
08/15/1998	14:00	194.62	194.49	194.46	194.49	194.60
08/15/1998	15:00	194.62	194.49	194.46	194.49	194.60
08/15/1998	16:00	194.61	194.49	194.46	194.49	194.59
08/15/1998	17:00	194.61	194.49	194.45	194.49	194.59
08/15/1998	18:00	194.61	194.49	194.45	194.49	194.59
08/15/1998	19:00	194.61	194.48	194.45	194.49	194.59
08/15/1998	20:00	194.60	194.48	194.45	194.48	194.58
08/15/1998	21:00	194.60	194.48	194.45	194.48	194.58
08/15/1998	22:00	194.60	194.48	194.45	194.48	194.58
08/15/1998	23:00	194.60	194.48	194.45	194.48	194.58
08/16/1998	0:00	194.59	194.48	194.45	194.48	194.57
08/16/1998	1:00	194.59	194.48	194.45	194.47	194.57
08/16/1998	2:00	194.59	194.48	194.45	194.47	194.57
08/16/1998	3:00	194.59	194.48	194.45	194.47	194.56
08/16/1998	4:00	194.59	194.48	194.45	194.47	194.56
08/16/1998	5:00	194.58	194.48	194.45	194.47	194.56
08/16/1998	6:00	194.58	194.47	194.44	194.46	194.56
08/16/1998	7:00	194.58	194.47	194.44	194.46	194.55
08/16/1998	8:00	194.58	194.47	194.44	194.46	194.55
08/16/1998	9:00	194.58	194.47	194.44	194.46	194.55
08/16/1998	10:00	194.57	194.47	194.44	194.46	194.55
08/16/1998	11:00	194.57	194.46	194.44	194.45	194.54
08/16/1998	12:00	194.57	194.46	194.43	194.45	194.54
08/16/1998	13:00	194.56	194.46	194.43	194.45	194.54

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/16/1998	14:00	194.56	194.46	194.43	194.45	194.53
08/16/1998	15:00	194.55	194.45	194.43	194.45	194.53
08/16/1998	16:00	194.55	194.45	194.42	194.44	194.53
08/16/1998	17:00	194.55	194.45	194.42	194.44	194.52
08/16/1998	18:00	194.54	194.45	194.42	194.44	194.51
08/16/1998	19:00	194.54	194.45	194.42	194.44	194.51
08/16/1998	20:00	194.54	194.45	194.42	194.44	194.51
08/16/1998	21:00	194.54	194.44	194.42	194.44	194.51
08/16/1998	22:00	194.53	194.44	194.42	194.43	194.50
08/16/1998	23:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	0:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	1:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	2:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	3:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	4:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	5:00	194.53	194.44	194.42	194.43	194.50
08/17/1998	6:00	194.52	194.44	194.42	194.43	194.50
08/17/1998	7:00	194.52	194.44	194.41	194.42	194.50
08/17/1998	8:00	194.52	194.44	194.41	194.42	194.50
08/17/1998	9:00	194.52	194.44	194.41	194.42	194.50
08/17/1998	10:00	194.52	194.43	194.41	194.42	194.50
08/17/1998	11:00	194.52	194.43	194.41	194.42	194.50
08/17/1998	12:00	194.52	194.43	194.40	194.42	194.49
08/17/1998	13:00	194.51	194.43	194.40	194.42	194.49
08/17/1998	14:00	194.51	194.43	194.40	194.42	194.49
08/17/1998	15:00	194.51	194.42	194.40	194.42	194.48
08/17/1998	16:00	194.51	194.42	194.40	194.42	194.48
08/17/1998	17:00	194.50	194.42	194.39	194.42	194.48
08/17/1998	18:00	194.50	194.42	194.39	194.41	194.48
08/17/1998	19:00	194.50	194.42	194.39	194.41	194.47
08/17/1998	20:00	194.50	194.42	194.39	194.41	194.47
08/17/1998	21:00	194.50	194.42	194.39	194.41	194.47
08/17/1998	22:00	194.49	194.42	194.39	194.41	194.46

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/17/1998	23:00	194.49	194.42	194.39	194.41	194.46
08/18/1998	0:00	194.49	194.42	194.39	194.41	194.46
08/18/1998	1:00	194.49	194.42	194.39	194.41	194.46
08/18/1998	2:00	194.49	194.42	194.39	194.41	194.46
08/18/1998	3:00	194.49	194.42	194.39	194.41	194.46
08/18/1998	4:00	194.49	194.42	194.39	194.41	194.46
08/18/1998	5:00	194.48	194.41	194.39	194.41	194.46
08/18/1998	6:00	194.48	194.41	194.39	194.41	194.46
08/18/1998	7:00	194.48	194.41	194.39	194.41	194.46
08/18/1998	8:00	194.48	194.41	194.39	194.41	194.46
08/18/1998	9:00	194.48	194.41	194.39	194.41	194.46
08/18/1998	10:00	194.48	194.41	194.39	194.41	194.45
08/18/1998	11:00	194.48	194.41	194.38	194.41	194.45
08/18/1998	12:00	194.48	194.41	194.38	194.41	194.45
08/18/1998	13:00	194.47	194.41	194.38	194.41	194.45
08/18/1998	14:00	194.47	194.41	194.38	194.40	194.44
08/18/1998	15:00	194.47	194.40	194.38	194.40	194.44
08/18/1998	16:00	194.47	194.40	194.38	194.40	194.44
08/18/1998	17:00	194.46	194.40	194.38	194.40	194.43
08/18/1998	18:00	194.46	194.40	194.38	194.40	194.43
08/18/1998	19:00	194.46	194.40	194.38	194.40	194.42
08/18/1998	20:00	194.45	194.40	194.37	194.40	194.42
08/18/1998	21:00	194.45	194.40	194.37	194.40	194.41
08/18/1998	22:00	194.45	194.40	194.37	194.40	194.41
08/18/1998	23:00	194.45	194.40	194.38	194.40	194.40
08/19/1998	0:00	194.44	194.40	194.38	194.40	194.40
08/19/1998	1:00	194.44	194.40	194.38	194.40	194.40
08/19/1998	2:00	194.44	194.40	194.38	194.40	194.40
08/19/1998	3:00	194.44	194.40	194.37	194.40	194.40
08/19/1998	4:00	194.43	194.40	194.38	194.40	194.40
08/19/1998	5:00	194.43	194.40	194.37	194.40	194.39
08/19/1998	6:00	194.43	194.40	194.37	194.40	194.39
08/19/1998	7:00	194.43	194.40	194.37	194.40	194.39

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/19/1998	8:00	194.43	194.40	194.37	194.40	194.39
08/19/1998	9:00	194.43	194.40	194.37	194.40	194.39
08/19/1998	10:00	194.42	194.39	194.37	194.40	194.39
08/19/1998	11:00	194.42	194.39	194.37	194.40	194.39
08/19/1998	12:00	194.42	194.39	194.37	194.39	194.38
08/19/1998	13:00	194.42	194.39	194.36	194.39	194.38
08/19/1998	14:00	194.42	194.39	194.36	194.39	194.38
08/19/1998	15:00	194.41	194.39	194.36	194.39	194.38
08/19/1998	16:00	194.41	194.39	194.36	194.39	194.38
08/19/1998	17:00	194.41	194.39	194.36	194.39	194.38
08/19/1998	18:00	194.41	194.39	194.36	194.39	194.37
08/19/1998	19:00	194.41	194.38	194.36	194.39	194.37
08/19/1998	20:00	194.41	194.38	194.36	194.39	194.37
08/19/1998	21:00	194.41	194.39	194.36	194.39	194.37
08/19/1998	22:00	194.41	194.39	194.36	194.39	194.37
08/19/1998	23:00	194.41	194.39	194.36	194.39	194.37
08/20/1998	0:00	194.40	194.39	194.36	194.39	194.36
08/20/1998	1:00	194.40	194.39	194.36	194.39	194.36
08/20/1998	2:00	194.40	194.39	194.36	194.39	194.36
08/20/1998	3:00	194.40	194.39	194.36	194.39	194.36
08/20/1998	4:00	194.40	194.39	194.36	194.39	194.36
08/20/1998	5:00	194.40	194.39	194.36	194.39	194.36
08/20/1998	6:00	194.40	194.39	194.36	194.39	194.35
08/20/1998	7:00	194.39	194.39	194.36	194.39	194.35
08/20/1998	8:00	194.39	194.39	194.36	194.39	194.35
08/20/1998	9:00	194.39	194.39	194.36	194.39	194.34
08/20/1998	10:00	194.39	194.38	194.36	194.39	194.34
08/20/1998	11:00	194.38	194.38	194.35	194.39	194.33
08/20/1998	12:00	194.37	194.38	194.35	194.39	194.33
08/20/1998	13:00	194.37	194.38	194.35	194.39	194.32
08/20/1998	14:00	194.37	194.38	194.35	194.39	194.32
08/20/1998	15:00	194.36	194.38	194.35	194.39	194.30
08/20/1998	16:00	194.36	194.38	194.35	194.39	194.32

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/20/1998	17:00	194.36	194.37	194.35	194.39	194.32
08/20/1998	18:00	194.36	194.38	194.35	194.39	194.32
08/20/1998	19:00	194.36	194.38	194.35	194.39	194.32
08/20/1998	20:00	194.36	194.38	194.35	194.39	194.32
08/20/1998	21:00	194.36	194.38	194.35	194.39	194.32
08/20/1998	22:00	194.35	194.38	194.35	194.39	194.32
08/20/1998	23:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	0:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	1:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	2:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	3:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	4:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	5:00	194.35	194.38	194.35	194.38	194.31
08/21/1998	6:00	194.35	194.38	194.35	194.38	194.31
08/21/1998	7:00	194.35	194.38	194.35	194.38	194.31
08/21/1998	8:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	9:00	194.35	194.38	194.35	194.39	194.31
08/21/1998	10:00	194.35	194.37	194.35	194.39	194.31
08/21/1998	11:00	194.35	194.37	194.35	194.38	194.31
08/21/1998	12:00	194.34	194.37	194.34	194.38	194.31
08/21/1998	13:00	194.34	194.37	194.34	194.38	194.31
08/21/1998	14:00	194.34	194.37	194.34	194.38	194.31
08/21/1998	15:00	194.34	194.37	194.34	194.38	194.31
08/21/1998	16:00	194.34	194.37	194.34	194.38	194.31
08/21/1998	17:00	194.34	194.36	194.34	194.38	194.32
08/21/1998	18:00	194.34	194.36	194.34	194.38	194.31
08/21/1998	19:00	194.34	194.36	194.34	194.38	194.31
08/21/1998	20:00	194.34	194.36	194.34	194.38	194.31
08/21/1998	21:00	194.34	194.36	194.34	194.38	194.32
08/21/1998	22:00	194.34	194.37	194.34	194.38	194.32
08/21/1998	23:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	0:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	1:00	194.34	194.37	194.34	194.38	194.32

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/22/1998	2:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	3:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	4:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	5:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	6:00	194.34	194.37	194.34	194.38	194.32
08/22/1998	7:00	194.35	194.37	194.34	194.38	194.32
08/22/1998	8:00	194.35	194.37	194.34	194.38	194.32
08/22/1998	9:00	194.35	194.37	194.34	194.37	194.32
08/22/1998	10:00	194.35	194.36	194.34	194.37	194.32
08/22/1998	11:00	194.35	194.36	194.34	194.37	194.32
08/22/1998	12:00	194.35	194.36	194.34	194.37	194.33
08/22/1998	13:00	194.35	194.36	194.33	194.37	194.33
08/22/1998	14:00	194.35	194.36	194.33	194.37	194.33
08/22/1998	15:00	194.35	194.36	194.34	194.38	194.33
08/22/1998	16:00	194.35	194.36	194.34	194.38	194.34
08/22/1998	17:00	194.36	194.36	194.33	194.38	194.34
08/22/1998	18:00	194.36	194.36	194.33	194.38	194.35
08/22/1998	19:00	194.36	194.36	194.33	194.37	194.35
08/22/1998	20:00	194.36	194.36	194.33	194.37	194.35
08/22/1998	21:00	194.36	194.36	194.33	194.37	194.35
08/22/1998	22:00	194.36	194.36	194.33	194.37	194.35
08/22/1998	23:00	194.36	194.36	194.34	194.37	194.34
08/23/1998	0:00	194.36	194.36	194.34	194.37	194.34
08/23/1998	1:00	194.36	194.36	194.34	194.37	194.34
08/23/1998	2:00	194.36	194.36	194.34	194.37	194.34
08/23/1998	3:00	194.36	194.36	194.34	194.37	194.34
08/23/1998	4:00	194.36	194.36	194.34	194.37	194.35
08/23/1998	5:00	194.36	194.37	194.34	194.37	194.35
08/23/1998	6:00	194.36	194.37	194.34	194.37	194.35
08/23/1998	7:00	194.37	194.36	194.34	194.37	194.35
08/23/1998	8:00	194.37	194.36	194.34	194.37	194.36
08/23/1998	9:00	194.37	194.36	194.33	194.37	194.36
08/23/1998	10:00	194.37	194.36	194.33	194.37	194.37

Table 4. Hourly data for ground-water and surface-water levels measured at Hog Marsh, northwestern Indiana, July 5, 1998, to August 23, 1998.—*Continued*

[mm/dd/yyyy, month/day/year format; hh:mm, hours and minutes; HM, Hog Marsh; ground-water and surface-water levels reported as altitude in meters above National Geodetic Vertical Datum of 1929]

Date measured (mm/dd/yyyy)	Time measured (hh:mm)	Local well identifier			Local surface-water site identifier	
		HM4A	HMUG-20	HMUG-150	HMBD (Brown Ditch)	HMGKR (Kankakee River)
08/23/1998	11:00	194.37	194.36	194.33	194.37	194.37
08/23/1998	12:00	194.37	194.36	194.33	194.37	194.37
08/23/1998	13:00	194.38	194.36	194.33	194.37	194.37
08/23/1998	14:00	194.38	194.35	194.33	194.37	194.37
08/23/1998	15:00	194.38	194.35	194.33	194.37	194.38
08/23/1998	16:00	194.38	194.35	194.32	194.37	194.38
08/23/1998	17:00	194.38	194.35	194.32	194.37	194.38
08/23/1998	18:00	194.38	194.35	194.32	194.37	194.39
08/23/1998	19:00	194.39	194.35	194.32	194.37	194.39
08/23/1998	20:00	194.39	194.35	194.32	194.37	194.40
08/23/1998	21:00	194.39	194.35	194.32	194.37	194.40
08/23/1998	22:00	194.40	194.35	194.32	194.37	194.40
08/23/1998	23:00	194.40	194.35	194.32	194.37	194.41

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