Effects of Hurricane Katrina's Storm Surge on the Quality of Shallow Aquifers near the Northern Shoreline of Lake Pontchartrain, Southeastern Louisiana

By Dan J. Tomaszewski and John K. Lovelace

The U.S. Geological Survey (USGS) sampled 13 wells on the northern shoreline of Lake Pontchartrain to determine the effect of Hurricane Katrina-induced storm surge water on the shallow groundwater resources. Surge water entering damaged wells did not contaminate the entire aquifer; however, contamination did occur locally at well sites. Because the storm surge from Katrina lasted only a few hours, surge water entering the aquifer will probably have only a short-term effect.

Introduction

Katrina made landfall in southeastern Louisiana on August 29, 2005 (fig. 1). Maximum estimated sustained winds reached 120–130 mi/hour (193–209 km/hour) at landfall near Buras (Knabb and others, 2005) and created a storm surge along the northern shoreline of Lake Pontchartrain in St. Tammany Parish that approximately ranged from 7 ft (2.1 m) at Madisonville to 16 ft (4.9 m) near The Rigolets (fig. 2) (Federal Emergency Management Agency, 2006). With the exception of the Madisonville area and the Pearl River basin, the inland extent of Katrina's storm surge along the northern shoreline of Lake Pontchartrain was confined to areas south of U.S. Highway 190 (fig. 2).

Approximately 1,400 wells, primarily small-diameter domestic-use wells, were located in the storm-surge inundation area (B.C. Hanson, Louisiana Department of Transportation and Development, written commun., 2006). The storm surge overtopped many of these wells, destroying aboveground well structures and breaking casings, which may have allowed surge water to enter some of the wells.

Most of the wells in the inundation area have screened intervals open to shallow aquifers, including the Gonzales-New Orleans and the upper Ponchatoula aquifers. Because water levels in the shallow aquifers generally are

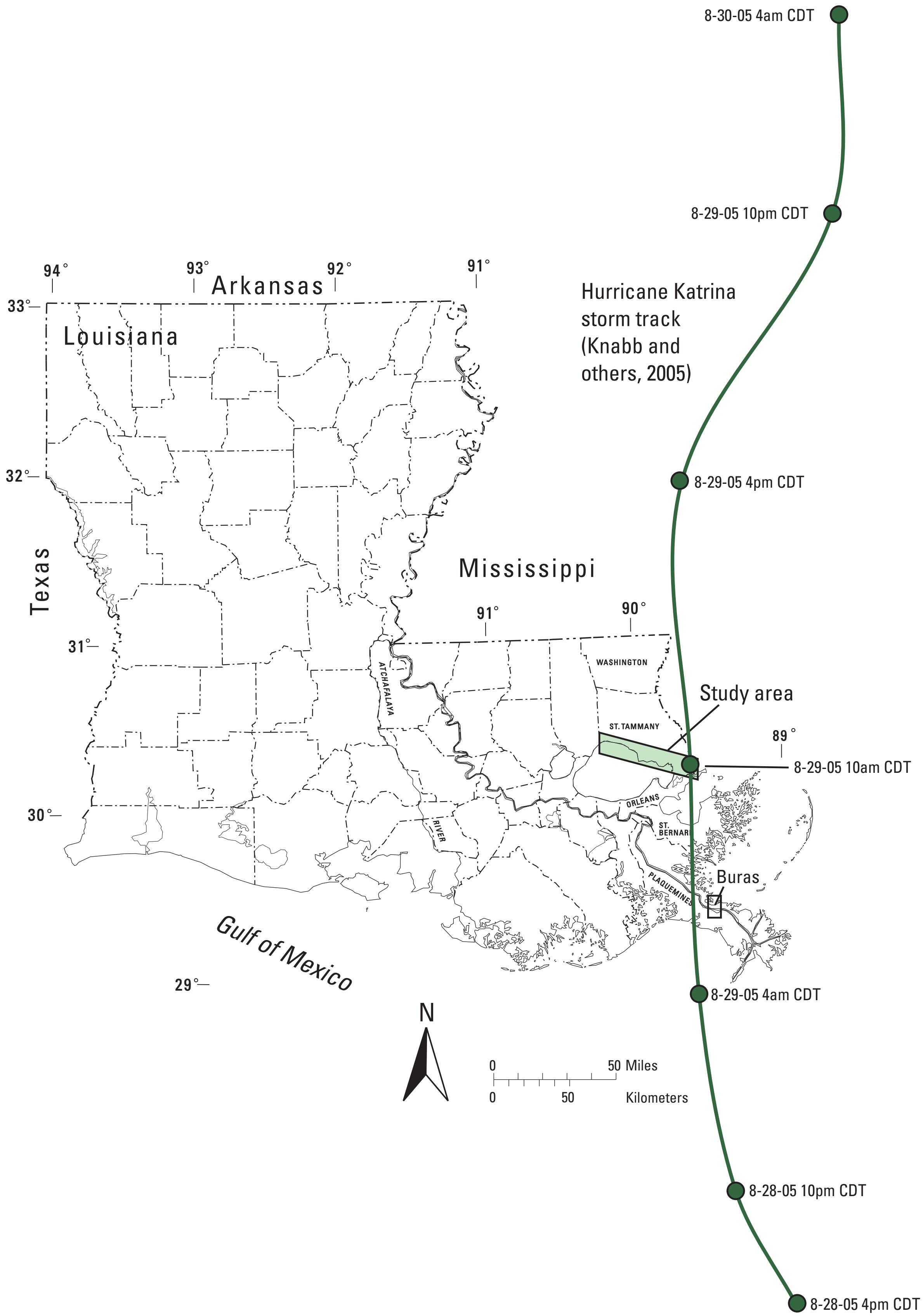

Figure 1. Location of the study area. Note: CDT refers to central daylight time.

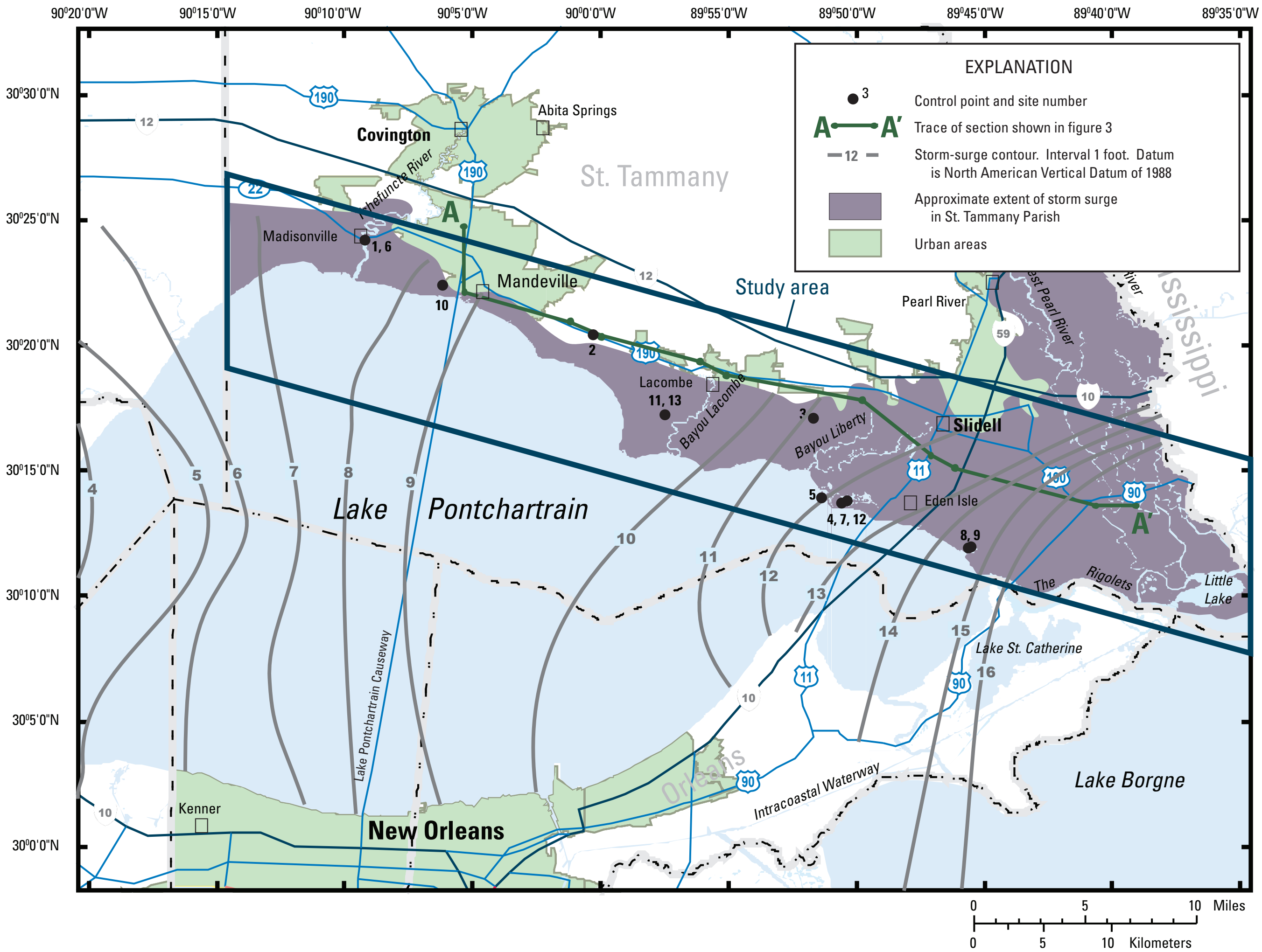

Figure 2. Location of sampled wells and Hurricane Katrina storm-surge elevations in southeastern Louisiana.

below land surface (Nyman and Fayard, 1978), surge water may have entered shallow aquifers through damaged wells. Although wells with screened intervals in deeper aquifers may have been damaged, water levels in the deeper aquifers are generally above land surface (Nyman and Fayard, 1978), and natural flow from the well would prevent surge water from entering the aquifers.

The USGS sampled 13 wells on the northern shoreline of Lake Pontchartrain to determine the effect of Katrina-induced storm surge water on the shallow groundwater resources. Twelve wells were located in the inundated area (fig. 2), and one well (site number 2) was located north of the inundated area. Seven of the sampled wells were registered with the Louisiana Department of Transportation and Development (DOTD). Data for registered wells indicate that wells were completed 250–460 ft (76–140 m) in depth.

Most of the sampled wells had been damaged by the hurricane but had recently been repaired and were in use. Typical damage included shearing of the well casing near land surface and displacement of the water-storage tank. Seven of the wells had centrifugal pumps and 1.5–2-inch (3.8–5.1-cm) casings. Five wells were constructed with submersible pumps and 4-inch (10.2-cm) diameter casing; one well was constructed with a submersible pump and 6-inch (15.2-cm) casing. Two wells with submersible pumps had not been used since the storm and had no power. A portable generator was brought to the sites and used to run the pumps.

Field measurements and water samples generally were collected prior to treatment (such as water softeners) and as close as possible to the well head by using procedures documented in Wilde (chapter sections variously dated). Specific conductance and water temperature were measured at each well by using field meters while the pumps were running. Raw and filtered samples for water-quality analysis were collected and shipped to the USGS National Water Quality Laboratory in Denver, Colo. Further information on analysis of water-quality constituents listed in table 1 is presented in Hem (1985) and Fishman and Friedman (1989).

Samples for bacterial analysis from eight wells were collected in sterilized bottles, which were immediately capped and cooled with ice. The samples were analyzed for bacteria by USGS personnel at a mobile field laboratory within 6 hours of sample collection. Further information on procedures for analysis and presentation of bacteriological results is presented in Stoeckel and others (2005). The wells were sampled for additional constituents by teams from the Louisiana Department of Environmental Quality and the Louisiana Geological Survey.

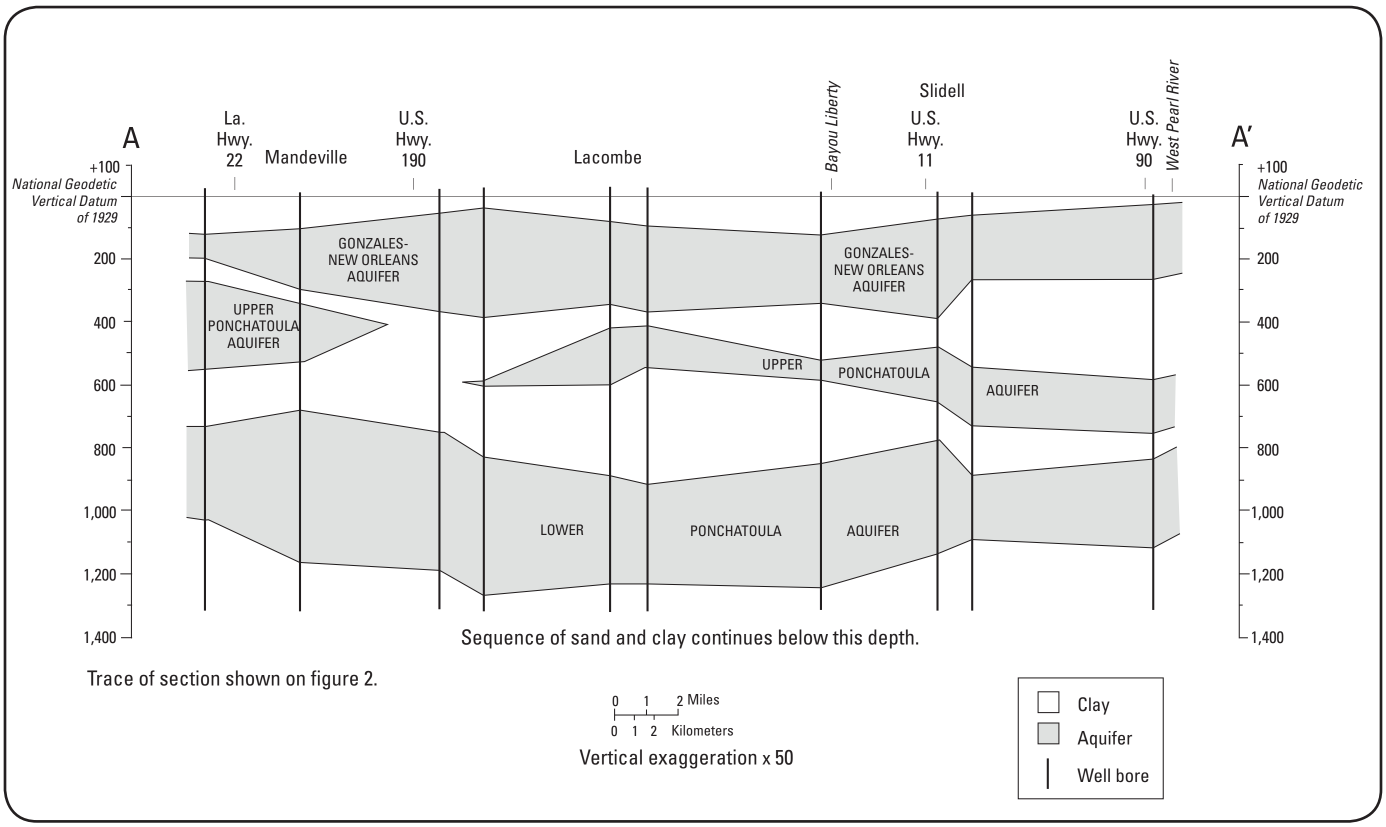

Figure 3. East-west geohydrologic section along Highway 190 from Mandeville to the Pearl River, southeastern Louisiana.

Table 1. General ground-water properties and constituent concentrations in wells sampled post-Katrina, northern shoreline Lake Pontchartrain, St. Tammany Parish, southeastern Louisiana.

[U. PONCH, upper Ponchatoula aquifer; GZNO, Gonzales-New Orleans aquifer; NGVD 29, National Geodetic Vertical Datum of 1929; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; —, not measured; lab, laboratory; <, less than]

Site number	Sample date	Depth of well, in feet, below land surface	Aquifer	Land surface, in feet, above NGVD 29	Lab pH, standard units	Specific conductance, field, µS/cm	Temperature, °C	Hardness, mg/L $CaCO_3$
1	9/29/2005	380	U. PONCH	5	8	207	26.4	12
2	9/20/2005	260	GZNO	17	8	292	21	13
3	9/29/2005	273	GZNO	10	8.3	398	22.5	6
4	10/20/2005	390	U. PONCH	5	8	500	23.5	10
5	9/28/2005	430	U. PONCH	5	8.3	531	24.9	13
6	9/29/2005	400	U. PONCH	12	8.2	247	—	7
7	10/20/2005	460	U. PONCH	0	7.7	1530	23.8	100
8	9/22/2005	500	U. PONCH	0	7.1	20,500	24.1	2,200
9	9/22/2005	—	—	5	8.2	571	—	9
10	9/29/2005	—	—	5	8.2	271	22.2	5
11	9/20/2005	—	—	5	6.8	312	24.3	2
12	9/28/2005	—	—	5	7.9	543	23.6	12
13	9/20/2005	—	—	5	7.8	612	22	36
min		260			6.8	207	21	2
max		500			8.3	20,500	26.4	2,200
median		395			8	500	23.6	12

Site number	Calcium, mg/L	Magnesium, mg/L	Potassium, mg/L	Sodium adsorption ratio	Sodium, mg/L	Sodium, percent	Bromide, mg/L	Chloride, mg/L	Sulfate, mg/L
1	3.29	0.856	1.73	6	43.5	87	0.11	3.25	7.7
2	2.96	1.39	1.61	8	65.2	90	0.24	7.76	<0.2
3	1.67	0.538	1.06	16	95.6	96	0.3	10.1	<0.2
4	2.12	1.08	2.4	16	116	95	—	22.4	—
5	2.14	1.85	2.35	14	119	94	0.28	26.9	0.4
6	2.28	0.424	1.16	9	56.7	93	0.2	3	9.2
7	16.6	14.3	7.3	12	273	84	1.31	309	31.5
8	140	441	148	36	3820	78	25.3	6730	891
9	2.16	0.863	1.79	19	132	96	0.31	28	<0.2
10	1.19	0.462	0.96	13	63.5	96	0.15	5.86	5.8
11	0.59	0.123	0.62	23	76.1	98	0.26	4.8	0.4
12	2.07	1.78	2.75	15	122	94	0.29	34.8	1.8
13	7.86	4.01	4.62	10	131	87	0.3	10.8	<0.2
min	0.59	0.123	0.62	6	43.5	78	0.11	3	0.4
max	140	441	148	36	3820	98	25.3	6730	891
median	2.16	1.08	1.79	14	116	94	0.285	10.8	6.75

Hydrogeology

Aquifers are underground formations consisting of sediments capable of yielding water to wells. In southeastern Louisiana, aquifers are composed of mostly sand with some gravel and are separated from one another and confined by clays (Nyman and Fayard, 1978, pl. 3). The aquifers extend beyond the study area and may contain fresh water as far south as New Orleans, La.

In the study area, the near-surface aquifer is known locally as the Shallow aquifer and includes the Gonzales-New Orleans aquifer (Nyman and Fayard, 1978; Griffith, 2003). For the purposes of this report, the Shallow aquifer is referred to as the Gonzales-New Orleans aquifer. Evaluation of data (on file at the USGS and DOTD) for sampled wells and nearby wells indicates that sand lenses in the Gonzales-New Orleans aquifer range in thickness from less than 20 ft (6 m) to about 140 ft (43 m). The base of the aquifer ranges from 200 to 400 ft (61 to 121 m) below National Geodetic Vertical Datum of 1929 (NGVD 29) in the study area (fig. 3). The aquifer is overlain by a surficial confining clay that ranges in thickness from about 60 to 100 ft (18 to 30 m).

The Gonzales-New Orleans aquifer is underlain by the upper Ponchatoula aquifer (Nyman and Fayard, 1978; Griffith, 2003). Well lithology data indicate that the aquifers are separated by a confining layer at sample sites. The top of the upper Ponchatoula aquifer is about 470 ft (143 m) below NGVD 29 at site 8 and 500 ft (152 m) below NGVD 29 near the east end of geohydrologic section A-A’ (fig. 3). The base of the upper Ponchatoula aquifer is about 600–700 ft (183–213 m) below NGVD 29 (Nyman and Fayard, 1978).

Effects of Katrina’s Storm Surge on the Quality of Shallow Aquifers

Seven sampled wells were screened in the Gonzales-New Orleans or upper Ponchatoula aquifers at depths ranging from 250 to 460 ft (73 to 140 m). Although 5 of the 13 sampled wells do not have confirmed depths, water-temperature data indicate that the wells are probably screened in the Gonzales-New Orleans or upper Ponchatoula aquifers.

Water Quality

Water-quality data are presented in table 1. Field measurements made during sampling include water temperature and specific conductance. Water temperature ranged from 21.0°C to 26.4°C (68°F to 79.5°F). Specific conductance, which is related to the amount of dissolved substances in water, was measured in the field and ranged from 207 to 612 µS/cm (microsiemens per centimeter at 25°C (77°F)) in 11 of the wells. This may represent background conditions or near background conditions. Much of the surge water was probably discharged from the wells by the users or owners prior to sample collection at the 11 sites.

Specific conductance in two wells, 7 and 8, was elevated (1,530 and 20,500 µS/cm) relative to other wells, indicating that surge water was present in the aquifer at these sites. Chloride concentrations in the 2 wells also were elevated (309 and 6,730 mg/L) relative to the other 11 wells, which had chloride concentrations ranging from about 3 to 35 mg/L.

Wells 7 and 8 had been damaged by the hurricane, and surge water could have entered the casing through broken discharge lines, causing the elevated chloride concentrations. Specific conductance decreased at both sites during pumping for samples. The decrease in specific conductance indicates that water quality was changing at the sites. As pumping continued, some of the surge water (higher conductance water) was removed from the well casing and the aquifer surrounding the well screen. Fresh water (lower conductance water), naturally occurring in the aquifer prior to the hurricane, was drawn into the well and the area surrounding the well screen, replacing discharged surge water. Other constituents, including bromide, calcium, magnesium, sodium, and sulfate, were greater in wells 7 and 8 compared to other wells, supporting the conclusion that surge water was present in these wells.

Bacteriological Quality

Bacteriological data for membrane filtration and most probable number (MPN) analyses for eight sampled wells are presented in table 2. Fecal coliform bacteria concentrations ranged from the detection limit (less than 1) to 10 colony-forming units per 100 mL. Bacteria colony counts (enterococci, fecal coliform, and total coliform) were elevated in water from two wells, 5 and 8. Elevated bacteria counts may indicate that the wells were open to surficial contamination from surge water. Both wells had been damaged by the hurricane, and surge water could have entered the casing through broken discharge lines. Although the sanitary seal on well 8 was still in place, small access holes were plugged with debris, indicating that surge water probably entered the casing. Well 5 had been repaired by a driller earlier on the day that it was sampled (J. Lauga, well owner, oral commun., September 2005). Well 7 was not sampled for bacteria.

Conclusions

Surge water entering damaged wells did not contaminate the entire aquifer; however, contamination did occur locally at well sites. Groundwater quality in shallow aquifers in the inundation area has been locally affected by surge water and possibly rain water entering damaged wells. Because the

Table 2. Bacteriological data from wells sampled post-Katrina, northern shoreline of Lake Pontchartrain, southeastern Louisiana.

[U. PONCH, upper Ponchatoula aquifer; GZNO, Gonzales-New Orleans aquifer; NGVD 29, National Geodetic Vertical Datum of 1929; MPN, most probable number; cfu, colony forming unit; —, not measured; <, less than; >, greater than]

Site number	Sample date	Depth of well, in feet, below land surface	Aquifer	Land surface, in feet, above NGVD 29	Enterococci, MPN/ 100 mL	*Escherichia coli*, MPN/ 100 mL	Fecal coliforms, cfu/100 mL	Total coliform, MPN/ 100 mL
1	9/29/2005	380	U. PONCH	5	<1	<1	<1	<1
2	9/20/2005	260	GZNO	17	—	—	—	—
3	9/29/2005	273	GZNO	10	1	0	<1	<1
4	10/20/2005	390	U. PONCH	5	—	—	—	—
5	9/28/2005	430	U. PONCH	5	2	<1	10	77
6	9/29/2005	400	U. PONCH	12	—	—	—	—
7	10/20/2005	460	U. PONCH	0	—	—	—	—
8	9/22/2005	500	U. PONCH	0	7	42	3	>2,400
9	9/22/2005	—	—	5	<1	<1	0	<1
10	9/29/2005	—	—	5	<1	<1	<1	3
11	9/20/2005	—	—	5	—	—	—	—
12	9/28/2005	—	—	5	<1	<1	<1	1
13	9/20/2005	—	—	5	—	0	—	3

storm surge from Katrina lasted only a few hours, surge water entering the aquifer probably will have only a short-term effect. Many of the sampled wells were in use by owners and probably had much of the surge water withdrawn prior to sample collection. The two wells that yielded water with the highest chloride concentrations had not been used since the storm and prior to sampling.

Because damage from Katrina was catastrophic, damaged wells in some areas may remain open to surficial contaminants for an extended period. It is possible that damaged wells that are open at land surface may allow additional contamination from subsequent rainfall or flooding events. Future sampling could determine whether contamination to the shallow aquifer has occurred.

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Contact Information

Dan J. Tomaszewski, Hydrologist (*djtomasz@usgs.gov*); and John K. Lovelace, Hydrologist (*jlovelac@usgs.gov*)

U.S. Department of the Interior

U.S. Geological Survey

Louisiana Water Science Center

3535 South Sherwood Forest Blvd., Suite 120

Baton Rouge, LA 70816