Bacteriological Water Quality in the Lake Pontchartrain Basin, Louisiana, Following Hurricanes Katrina and Rita, September 2005

By Donald M. Stoeckel, Rebecca N. Bushon, Dennis K. Demcheck, Stanley C. Skrobialowski, Christopher M. Kephart, Erin E. Bertke, Brian E. Mailot, Scott V. Mize, and Robert B. Fendick, Jr.

Data Series 143

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

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
P. Patrick Leahy, Acting Director

U.S. Geological Survey, Reston, Virginia 2005

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

.

Contents

Figures

Tables

Conversion Factors and Abbreviations

Multiply	By	To obtain
meter (m)	3.281	foot (ft)
mile (mi)	1.609	kilometer (km)
liter (L)	0.2642	gallon (gal)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32

Bacteria concentrations are reported as colony-forming units per 100 milliliters (CFU/100 mL) or most probable number per 100 milliliters (MPN/100 mL).

Bacteriological Water Quality in the Lake Pontchartrain Basin, Louisiana, Following Hurricanes Katrina and Rita, September 2005

By Donald M. Stoeckel, Rebecca N. Bushon, Dennis K. Demcheck, Stanley C. Skrobialowski, Christopher M. Kephart, Erin E. Bertke, Brian E. Mailot, Scott V. Mize, and Robert B. Fendick, Jr.

Abstract

The U.S. Geological Survey (USGS), in collaboration with the Louisiana Department of Environmental Quality, monitored bacteriological quality of water at 22 sites in and around Lake Pontchartrain, La., for three consecutive weeks beginning September 13, 2005, following hurricanes Katrina and Rita and the associated flooding. Samples were collected and analyzed by USGS personnel from the USGS Louisiana Water Science Center and the USGS Ohio Water Microbiology Laboratory. Fecal-indicator bacteria (*Escherichia coli*, enterococci, and fecal coliform) concentrations ranged from the detection limit to 36,000 colony-forming units per 100 milliliters. Data are presented in tabular form and as plots of data in the context of available historical data and water-quality standards and criteria for each site sampled. Quality-control data were reviewed to ensure that methods performed as expected in a mobile laboratory setting.

Introduction

Hurricane Katrina made landfall in coastal Alabama, Mississippi, and Louisiana on August 29, 2005; Hurricane Rita made landfall at the Texas-Louisiana border on September 23–24, 2005. The local population and the American public were concerned about water quality—especially in New Orleans, La.—at the time these samples were collected because of widespread damage caused by the wind, storm surge, and levee failures associated with Hurricane Katrina, followed by Hurricane Rita. Lake Pontchartrain is a major recreational area for the region and an important fishery, so contamination from the storm surge—along with runoff and water pumped from flooded areas of New Orleans—were considered a potential threat to this waterbody.

The U.S. Geological Survey (USGS), in collaboration with the Louisiana Department of Environmental Quality (DEQ), collected water-quality samples and measured physical and chemical characteristics at 22 sites in and around Lake Pontchartrain, La., to determine the level of fecal contamination. Water samples were collected and onsite physical and chemical measurements were made for three consecutive weeks beginning September 13, 2005, at various tributary streams and canals, Lake Pontchartrain, and two outflows. Samples were analyzed for fecal-indicator bacteria. Sample collection and analysis was done by personnel from the USGS Louisiana Water Science Center and the USGS Ohio Water Science Center, with support from the Ohio Water Microbiology Laboratory (OWML).

In consultation with other agencies, the USGS analyzed for three fecal indicator bacteria (*Escherichia coli*, enterococci, and fecal coliforms) in water samples to facilitate comparison with established bacteriological water-quality criteria and standards. Current (2005) U.S. Environmental Protection Agency (USEPA) recreational criteria for evaluating the bacteriogical quality of water bodies specify use of enterococci (freshwater and marine water) or *E. coli* (freshwater) (U.S. Environmental Protection Agency, 2004.) In addition, comparisons to historical data and sampling efforts by other agencies were facilitated by adding various test methods and indicators to the analyses used. For example, USEPA, in analyses prior to this effort (U.S. Environmental Protection Agency, 2005), measured *E. coli* concentrations in New Orleans floodwater by use of the Colilert method in Quanti-Tray/2000 format (Idexx, Westbrook, Maine). Evaluation of floodwater effects on receiving waters will be facilitated by the USGS monitoring for *E. coli* by use of the same method. The Louisiana DEQ (2005) and the Lake Pontchartrain Basin Foundation (2005) monitor fecal coliform concentrations; thus, comparison with current (2005) and historical data was facilitated by the USGS monitoring for fecal coliform concentrations.

Description of Study Area

Lake Pontchartrain is in southeastern Louisiana (fig. 1). The lake is actually a shallow estuarine embayment that measures approximately 25 mi from north to south and 40 mi from east to west (Demcheck, 1995). New Orleans is on the south shore of the lake, and the east and north shores are mostly residential areas (fig. 2). Much of the west shore remains marshy and sparsely populated. The Lake Pontchartrain Causeway connects Mandeville, La., on the north shore with Metairie, La., on the south shore. Water-quality data-collection sites in the Lake Pontchartrain study area have been previously characterized by Demcheck (1995, 1996).

Figure 1. Index map showing general location of the study area in and around Lake Pontchartrain, Louisiana.

Figure 2. Location of data-collection sites in the Lake Pontchartrain, La., area. [pdf file, 2.0 MB]

Methods of Study

Samples for bacteriological water quality were collected weekly at 22 sites for 3 weeks and analyzed at a mobile laboratory, as described in the following sections.

Site Selection and Description

Nineteen of the 22 sites sampled in and around Lake Pontchartrain are part of the Louisiana DEQ ambient monitoring network. Three additional sites were added by the USGS to help evaluate whether fecal contamination detected in Lake Pontchartrain was released into the

Mississippi Sound (The Rigolets, Chef Pass) and what concentration of fecal-indicator bacteria was present in a major plume discharged into Lake Pontchartrain (3117P) (fig. 2). The 22 sites represent inputs, the lake, and outputs (table 1, at back of report). Inputs from the New Orleans side (south shore) were represented by three inland sites on canals and a repeatedly sampled visible plume near site 3117 (fig. 2). Other inputs were represented by one sample site on Pass Manchac (site 0036, the connecting channel from Lake Maurepas to Lake Pontchartrain) and tributaries represented by six sites on north and east shore rivers and bayous. The ambient water quality of Lake Pontchartrain was represented by three sites on a north-south transect across the Lake Pontchartrain Causeway and by six sites on a west-east transect, about 0.5 mi off the south shore of Lake Pontchartrain, from the Bonnet-Carré Spillway to Little Woods. Outflow from Lake Pontchartrain to Lake Borgne (the connecting channel from Lake Pontchartrain to the Gulf of Mexico by way of Mississippi Sound) was represented by two sites, on Chef Menteur Pass and The Rigolets (fig. 2).

Sample Collection

Water samples were collected according to sampling procedures from Louisiana DEQ (2004). Sterile 1-L or 3-L bottles and caps were used to collect water samples in a weighted sampler at a depth of 1 m below water surface.

Onsite Physical and Chemical Measurements

Water temperature, specific conductance, pH, and dissolved oxygen were measured onsite with portable multiparameter meters according to standard field protocols (Wilde, chapter sections variously dated). Where onsite measurements were not collected, specific conductance was measured on sample residuals to allow site classification as freshwater or marine water based on salinity, calculated from specific conductance. In some instances, conductivity of sample residuals was adjusted to specific conductance at 25°C by use of a standard algorithm for temperature compensation (Hydrolab Corporation, 1991). Salinities were computed from specific conductance values by use of equations developed by Schemel (2001).

Bacteriological Analyses

Samples were kept on ice and analyzed for bacteria within 6 hours of sample collection. Standard operating procedures for the OWML were used to process samples (Francy and others, 2005). Matrix effects were anticipated in waters of unusual or variable composition—particularly metals or other antimicrobial agents in New Orleans pumpage water—so independent analyses by membrane filtration and most-probable-number (MPN) methods were done when possible. Membrane filtration analyses result in a colony count from a defined volume of water, generally reported as colony-forming units (CFU) per 100 mL of water. Most-probable-number analyses result in a statistical estimate of the original concentration of cells in a water volume based on positive reactions (plus-minus response) in multiple subaliquots. Results of MPN tests generally are reported as MPN per 100 mL with a 95-percent confidence interval.

Samples were analyzed for *E. coli* concentration by membrane filtration and cultivation on modified mTEC agar (U.S. Environmental Protection Agency, 2000), and by MPN using Colilert defined-substrate medium in Quanti-Tray/2000 wells (Idexx). Enterococci concentrations were measured by membrane filtration and cultivation on mEI agar (U.S. Environmental Protection Agency, 2000) and by MPN using Enterolert defined-substrate medium in Quanti-Tray/2000 wells

(Idexx). Fecal coliform concentrations were measured by membrane filtration and cultivation on mFC agar (American Public Health Association and others, 1998).

Confidence intervals were applied to concentration estimates by the MPN methods according to a tabulation of 95-percent confidence intervals provided by the manufacturer (accessed October 18, 2005, at *www.idexx.com/water/refs/qt2k95.pdf)*. Confidence intervals were applied to concentrations measured by membrane filtration by the following steps. (1) The percent error about the mean was calculated for 12 duplicate analyses that had counts in the ideal range by use of log-transformed concentrations. (2) The upper 95-percent confidence interval of the percent errors was added to and subtracted from each sample result to provide a confidence interval about log-transformed concentration measurements. (3) The results were converted back to regular units by taking the antilog and were reported as the confidence interval about the measured concentration (Rosner, 1990).

Quality-Control and Quality-Assurance Practices

Quality-assurance practices as described in Francy and others (2005) and Myers (2004) were followed at the frequency recommended or greater. All sample-collection and processing information was recorded on USGS microbiology field forms. A media batch preparation form was completed daily to document the lot numbers and expiration dates of media and supplies used. Performance of autoclaves was checked with biological indicators at the beginning of sampling and also was checked throughout the sampling period with heat-indicating autoclave tape, which was used with every run to ensure that supplies were properly sterilized. Incubator temperatures were monitored with a digital thermometer that was checked against a National Institute of Standards and Technology (NIST) thermometer before use. At a minimum, incubators were checked at the beginning, middle, and end of every day, and temperatures were recorded in a logbook. Each time the incubators were opened during the day, maintenance of temperature was checked and recorded on the field sheets.

Quality-control samples were collected to measure analytical variability and to assess possible bias by contamination. In general, one water sample was analyzed each day in duplicate on each type of medium to test analytical variability. Field blanks were collected and analyzed at a frequency of 12 percent to ensure that there was no contamination from the equipment, supplies, and the environment. A field blank is a blank solution that is processed through all stages of sample collection, preservation, and handling under field conditions. Filter and procedure blanks were analyzed during sample processing to ensure that filtration equipment and buffer solutions were not contaminated. One filter blank was analyzed on each filtration apparatus before the sample was filtered. A procedure blank was processed through the filtration apparatus after the sample was filtered for approximately one-third of the samples.

Each lot of media was tested with pure cultures to ensure the media were performing according to specifications. Positive- and negative-control cultures were processed on each type of media during week 1 and for new lot numbers of media during weeks 2 and 3. Deionized dilution-water blanks were processed by Colilert and Enterolert twice during week 1 and once during weeks 2 and 3 to assess sterility of the deionized water, the reagents, and multiple-well sample containers used in the MPN methods.

Water-Quality Characteristics

Table 2 (at back of report) lists water temperature, specific conductance, pH, dissolved oxygen, and salinity for each sample, where measured or calculated. A salinity of greater than 0.5 parts per thousand during the first two weeks of sampling was the basis for classifying sites (freshwater or marine water) (table 1, at back of report) (Mitsch and Gosselink, 1993.) Classification of sites as freshwater or marine water was integral in determination of the appropriate water-quality criterion to apply (U.S. Environmental Protection Agency, 2004) for comparison to data presented in the plots associated with figure 2.

Bacteriological data for membrane filtration and MPN analyses are presented in table 3 (at back of report). Membrane filtration concentrations were computed according to guidance from Myers (2004). The MPN test results are a statistical estimate of the actual concentration of fecal-indicator bacteria in a water sample, and membrane filtration test results are the actual count of colony-forming units under the conditions of the analysis.

Figure 2 is a map with site locations indicated. Embedded in the map at each site is a series of plots describing bacteriological water quality at that site. In addition to data collected as part of this study, USEPA recreational criteria for the protection of public health (table 4, at back of report) (U.S. Environmental Protection Agency, 2004) are indicated where relevant. The Louisiana DEQ fecal coliform standard for recreational water quality (400 CFU/100 mL) (State of Louisiana, 2001) also is indicated. Previously collected fecal coliform concentration data are included in the plots for comparison.

Extensive quality-control data were collected in support of this study (table 5, at back of report). Nine water samples were analyzed in duplicate on each type of media, with a 4.2 percent average error of the mean. Among the plates that had greater than 5 colonies, the maximum percent error of the mean was 11 percent. Among the nine field blanks that were collected and analyzed, one had a detection of fecal coliforms. A probable explanation for this detection was the use of water from an environmental sample rather than the actual field blank. Corrective action was taken, and the number of field blanks collected and analyzed in the following week was increased. All filter blanks, procedure blanks, pure culture cultivation tests, and deionized-water blanks produced acceptable results in the mobile laboratory setting.

Acknowledgments

The authors acknowledge and thank Dugan Sabins, Clinton Twilley, Robert Hannah, and Wilbert Jordan of the Louisiana Department of Environmental Quality for their support and for providing historical data from the sampled sites.

References Cited

American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1998, Standard methods for analysis of water and wastewater (20th ed.): Washington, D.C., American Public Health Association [variously paginated].

Demcheck, D.K., 1995, The Lake Pontchartrain Watershed—A unique resource of the Louisiana Coast: U.S. Geological Survey Fact Sheet FS–118–95, 2 p.

Demcheck, D.K., 1996, Analysis of selected water-quality data for surface water in St. Tammany Parish, Louisiana, April–August 1995: U.S. Geological Survey Open-File Report 96–345, 59 p.

Francy, D.S., Bushon, R.N., Brady, A.M.G., Kephart, C.M., and Stoeckel, D.M., 2005, Quality-assurance and quality-control manual for the Ohio Water Microbiology Laboratory, accessed October 19, 2005, at *http://oh.water.usgs.gov/micro/qcmanual/manual.html*

Hydrolab Corporation, 1991, Multiparameter water quality data transmitter operating manual: Austin, Tex., Technical notes, part 5.4.1, specific conductance temperature standardization, p. 47.

Lake Pontchartrain Basin Foundation, 2005, Weekly water quality reports: Baton Rouge, La., accessed October 21, 2005, at *http://www.saveourlake.org/water_quality.asp*

Louisiana Department of Environmental Quality, 2004, Standard operating procedure (SOP) for water sample collection, preservation, documentation, and shipping: Water Sampling Procedures, SOP_1134_R04, 25 p.

Louisiana Department of Environmental Quality, 2005, Selected ambient water quality sites: Baton Rouge, La., accessed October 21, 2005, at *http://www.deq.louisiana.gov/surveillance/wqdata/wqsites.htm*

Mitsch, W.J., and Gosselink, J.G., 1993, Wetlands (2d ed.): New York, Van Nostrand Reinhold, p. 636.

Myers, D.N., 2004, Biological indicators (3d ed.): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.1, accessed October 20, 2005, at *http://pubs.water.usgs.gov/twri9A7/*

Rosner, B., 1990, Fundamentals of biostatistics: Belmont, Calif., Wadsworth Publishing Company, p. 163.

Schemel, L.E., 2001, Simplified conversions between specific conductance and salinity units for use with data from monitoring stations, accessed July 27, 2004, at *http://www.iep.ca.gov/report/newsletter/2001winter/IEPNewsletterWinter2001.pdf*

State of Louisiana, 2001, Beach Monitoring Program—Indicator organisms: Louisiana Department of Health and Hospitals Office of Public Health, accessed October 19, 2005, at *www.oph.dhh.state.la.us/sanitarianservices/beachmonitor/pageaff8.html?page=607*

U.S. Environmental Protection Agency, 2000, Improved enumeration methods for the recreational water quality indicators—Enterococci and *Escherichia coli*: Washington, D.C., Office of Science and Technology, EPA/821/R-97/004, 49 p.

U.S. Environmental Protection Agency, 2004, Water quality standards for coastal and Great Lakes recreation waters: Washington, D.C., Federal Register, v. 69, no. 220, November 16, 2004, p. 67217–67243.

U.S. Environmental Protection Agency, 2005, Hurricane response—Katrina and Rita: Washington, D.C., accessed October 21, 2005, at *http://www.epa.gov/katrina/testresults/water/index.htmlV*

Wilde, F.D., ed., chapter sections variously dated, Field measurements: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, accessed October 21, 2005, at *http://water.usgs.gov/owq/FieldManual/Chapter6/Ch6_contents.html*

Table 1. Site descriptions.
[Waterbody classifcations are valid only in the sampling period; W-E or N-S indicates that site was along a directional lake transect]

Site number	Site name	Site type	Waterbody classification	Latitude	Longitude
0036	Pass Manchac at Manchac, La.	Inflow	Marine	30.2814	-90.4003
0306	Inner Harbor Navigation Canal at New Orleans, La.	Canal	Marine	30.0151	-90.0293
1049	Duncan Canal at I-10 mile marker 221, La.	Canal	Marine	30.0067	-90.2797
1050	Suburban Canal near pumping station number 2, La.	Canal	Marine	30.0197	-90.1803
3117P	Pumpage plume, Lake Pontchartrain, La., near 17th Street Canal	Canal (plume)	Marine	Variable	Variable
0033	Tangipahoa River west of Robert, La.	Tributary	Fresh	30.5064	-90.3617
0106	Tchefuncte River at Madisonville, La.	Tributary	Marine	30.4044	-90.1544
0300	Bayou Lacombe west of Slidell, La.	Tributary	Fresh	30.3136	-89.9353
0301	Bayou Bonfouca at Slidell, La.	Tributary	Marine	30.2711	-89.7936
0302	Cane Bayou east of Mandeville, La.	Tributary	Fresh	30.3372	-90.0025
1077	Bayou Liberty at Highway 433 bridge, La.	Tributary	Marine	30.2678	-89.8444
La Branche	Lake Pontchartrain, La., near Bayou La Branche north of Norco	Lake, W-E	Marine	30.0606	-90.3667
3115	Lake Pontchartrain, La., near Duncan Canal	Lake, W-E	Marine	30.0567	-90.2797
3116	Lake Pontchartrain, La., near Suburban Canal	Lake, W-E	Marine	30.0300	-90.1802
3117	Lake Pontchartrain, La., near 17th Street Canal	Lake, W-E	Marine	30.0364	-90.1196
3118	Lake Pontchartrain, La., near Inner Harbor Navigation Canal	Lake, W-E	Marine	30.0588	-90.0422
3119	Lake Pontchartrain, La., near Little Woods	Lake, W-E	Marine	30.0817	-89.9497
0137	Lake Pontchartrain, La., Causeway at Crossover 7	Lake, N-S	Marine	30.0772	-90.1428
0138	Lake Pontchartrain, La., Causeway at Crossover 4	Lake, N-S	Marine	30.1833	-90.1167
0139	Lake Pontchartrain, La., Causeway at Crossover 1	Lake, N-S	Marine	30.3078	-90.1036
Chef Pass	Chef Menteur Pass at Highway 90, La.	Outflow	Marine	30.0675	-89.8045
Rigolets	The Rigolets at Highway 90 southeast of Slidell, La.	Outflow	Marine	30.1717	-89.7332

Table 2. Onsite physical and chemical water-quality measurements at a 1-m depth at 22 sites in and around Lake Pontchartrain, La.
[°C, degrees Celsius; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; ppt, parts per thousand; --, not measured; <, less than]

Date	Time	Temperature (°C)	Specific conductance (μS/cm)	pH	Dissolved oxygen (mg/L)	Salinity (ppt, calculated)
0036 Pass Manchac at Manchac, La.						
9/13/05	9:00	--	3,480	--	--	1.82
9/16/05	8:00	--	3,670	--	--	1.93
9/20/05	8:30	30.3	4,540	6.80	6.3	2.42
9/27/05	11:30	28.0	5,820	6.75	6.1	3.15
0306 Inner Harbor Navigation Canal at New Orleans, La.						
9/15/05	14:55	--	16,600	--	--	9.73
9/29/05	16:00	29.4	16,700	7.45	6.8	9.79
1049 Duncan Canal at I-10 mile marker number 221, La.						
9/15/05	9:10	--	5,150	--	--	2.76
9/21/05	9:10	30.6	4,830	6.45	6.0	2.58
9/28/05	11:45	29.1	8,020	6.75	2.8	4.44
1050 Suburban Canal near pumping station number 2, La.						
9/14/05	13:45	--	2,420	--	--	1.24
9/21/05	12:15	30.3	14,800	7.70	3.9	8.59
9/28/05	13:15	30.6	2,300	8.00	7.9	1.18
3117P Pumpage Plume, Lake Pontchartrain, La., near 17th Street Canal						
9/15/05	12:55	--	11,300	--	--	6.42
9/21/05	14:40	--	--	--	--	--
9/29/05	11:00	28.9	12,900	7.05	6.8	7.40
0033 Tangipahoa River west of Robert, La.						
9/13/05	8:30	--	67	--	--	0.04
9/16/05	8:55	--	63	--	--	0.04
9/20/05	14:50	30.5	54	7.05	7.1	0.03
9/27/05	12:46	28.8	72	6.70	7.0	0.04
0106 Tchefuncte River at Madisonville, La.						
9/13/05	9:30	--	825	--	--	0.40
9/16/05	10:10	28.4	1,160	--	0.8	0.57
9/20/05	10:30	29.9	1,080	6.25	0.9	0.53
9/27/05	10:00	28.6	4,560	6.25	1.2	2.43
0300 Bayou Lacombe west of Slidell, La.						
9/13/05	14:15	--	--	--	--	--
9/20/05	11:30	27.4	42	5.35	1.4	0.03
9/27/05	10:35	27.2	990	5.80	0.5	0.49
0301 Bayou Bonfouca at Slidell, La.						
9/13/05	12:45	--	2,000	--	--	1.02
9/20/05	10:10	29.3	1,050	6.55	0.8	0.52
9/27/05	9:30	28.9	3,900	6.45	0.5	2.06

Date	Time	Temperature (°C)	Specific conductance (µS/cm)	pH	Dissolved oxygen (mg/L)	Salinity (ppt, calculated)
0302 Cane Bayou east of Mandeville, La.						
9/13/05	11:15	--	1,460	--	--	0.73
9/16/05	11:30	26.0	318	6.20	0.6	0.15
9/20/05	13:00	26.6	396	5.85	0.6	0.19
9/27/05	11:00	27.4	6,950	6.05	1.2	3.81
1077 Bayou Liberty at Highway 433 bridge, La.						
9/13/05	13:30	--	--	--	--	--
9/20/05	10:30	28.4	2,250	6.30	<0.5	1.15
9/27/05	9:55	28.5	10,400	6.40	1.0	5.87
Lake Pontchartrain, La., near Bayou La Branche north of Norco						
9/15/05	11:10	--	6,140	--	--	3.33
9/21/05	10:10	30.2	4,410	6.25	7.0	2.34
9/28/05	11:00	28.6	11,500	6.85	7.4	6.54
3115 Lake Pontchartrain, La., near Duncan Canal						
9/15/05	10:40	--	10,500	--	--	5.93
9/21/05	10:55	30.2	4,880	6.55	6.5	2.61
9/28/05	10:30	28.8	11,000	6.65	6.6	6.23
3116 Lake Pontchartrain, La., near Suburban Canal						
9/14/05	12:40	--	12,100	--	--	6.91
9/21/05	13:40	31.3	5,800	6.80	9.3	3.14
9/28/05	13:10	29.9	13,000	7.65	8.0	7.46
3117 Lake Pontchartrain, La., near 17th Street Canal						
9/15/05	12:50	--	13,600	--	--	7.84
9/21/05	14:25	31.2	6,760	6.75	8.8	3.70
9/29/05	11:15	29.1	14,600	8.25	9.1	8.46
3118 Lake Pontchartrain, La., near Inner Harbor Navigation Canal						
9/15/05	14:35	--	13,200	--	--	7.59
9/29/05	15:20	29.3	13,700	8.35	10.1	7.90
3119 Lake Pontchartrain, La., near Little Woods						
9/15/05	14:05	--	13,100	--	--	7.53
9/29/05	15:00	29.8	12,400	8.40	9.8	7.09
0137 Lake Pontchartrain, La., Causeway at Crossover 7						
9/14/05	11:05	--	12,800	--	--	7.34
9/21/05	10:20	29.9	12,800	7.40	6.7	7.34
9/28/05	12:00	28.3	13,400	8.40	7.3	7.71
0138 Lake Pontchartrain, La., Causeway at Crossover 4						
9/14/05	10:45	--	12,800	--	--	7.34
9/21/05	9:45	29.2	11,600	7.75	7.5	6.60
9/28/05	11:00	28.3	13,100	8.10	8.2	7.53
0139 Lake Pontchartrain, La., Causeway at Crossover 1						
9/14/05	9:30	--	9,710	--	--	5.45
9/21/05	9:00	28.8	7,460	7.45	7.6	4.11
9/28/05	10:30	27.8	9,760	7.95	9.1	5.48

Date	Time	Temperature (°C)	Specific conductance (μS/cm)	pH	Dissolved oxygen (mg/L)	Salinity (ppt, calculated)
Chef Menteur Pass at Highway 90, La.						
9/16/05	13:20	28.9	13,800	7.20	6.5	7.96
9/22/05	9:55	25.6	14,700	7.55	6.5	8.53
9/29/05	17:00	29.7	15,400	7.65	7.7	8.97
The Rigolets at Highway 90 southeast of Slidell, La.						
9/16/05	13:20	29.4	10,500	6.95	6.1	5.93
9/22/05	9:10	29.4	10,600	7.40	6.7	5.99
9/29/05	19:00	29.2	15,000	7.70	7.6	8.71

Table 3. Bacteriological data from the Lake Pontchartrain area, Louisiana.
[CFU, colony-forming units; MPN, most probable number; mL, milliliter; K, results based on colony count outside the ideal range; --, not measured. Data are presented as concentration followed by confidence interval in parentheses]

Date	Time	*E. coli* modified mTEC (CFU/100 mL)	*E. coli* Colilert (MPN/100 mL)	*Enterococci* mEI (CFU/100 mL)	*Enterococci* Enterolert (MPN/100 mL)	Fecal coliforms mFC (CFU/100 mL)
0036 Pass Manchac at Manchac, La.						
9/13/05	9:00	1 (K)	10 (1-55)	<1 --	-- --	-- --
9/16/05	8:00	-- --	10 (1-55)	-- --	10 (0-37)	1 (K)
9/20/05	8:30	-- --	<10 (0-37)	11 (K)	<10 (0-37)	7 (K)
9/27/05	11:30	-- --	6 (2-13)	68 (K)	79 (56-110)	220 (190-250)
0306 Inner Harbor Navigation Canal at New Orleans, La.						
9/15/05	14:55	180 (160-210)	270 (170-400)	120 (110-140)	890 (670-1,200)	480 (420-550)
9/15/05	14:56	150 (130-170)	360 (240-520)	160 (140-180)	330 (210-480)	300 (260-340)
9/29/05	16:00	-- --	420 (280-600)	100 (88-110)	31 (7-89)	7 (K)
1049 Duncan Canal at I-10 mile marker number 221, La.						
9/15/05	9:10	30 (26-34)	30 (7-74)	130 (110-150)	74 (32-140)	92 (81-110)
9/21/05	9:10	-- --	52 (18-130)	83 (73-94)	63 (25-130)	120 (110-140)
9/28/05	11:45	-- --	130 (74-220)	750 (K)	630 (440-870)	180 (K)
1050 Suburban Canal near pumping station number 2, La.						
9/14/05	13:45	220 (190-250)	450 (300-630)	87 (76-99)	75 (36-150)	520 (460-590)
9/21/05	12:15	-- --	860 (630-1,200)	95 (84-110)	160 (88-260)	1,200 (1,100-1,400)
9/28/05	13:15	-- --	190 (110-300)	420 (370-480)	52 (18-110)	520 (460-590)
3117P Pumpage Plume, Lake Pontchartrain, La., near 17th Street Canal						
9/15/05	12:55	-- --	240 (150-360)	2,100 (1,800-2,400)	200 (130-300)	2,200 (1,900-2,500)
9/21/05	14:40	-- --	<10 (0-37)	5 (K)	10 (1-55)	20 (K)
9/29/05	11:00	220 (193-250)	140 (78-230)	95 (84-110)	20 (3-59)	580 (510-660)
0033 Tangipahoa River west of Robert, La.						
9/13/05	8:30	38 (33-43)	37 (25-54)	100 (88-110)	-- --	-- --
9/16/05	8:55	-- --	34 (22-49)	-- --	41 (28-57)	70 (62-80)
9/20/05	14:50	-- --	13 (7-22)	-- --	150 (114-198)	75 (66-85)
9/27/05	12:46	-- --	61 (43-83)	110 (97-120)	45 (30-63)	580 (K)
9/27/05	12:46	-- --	53 (37-72)	120 (110-140)	28 (18-41)	500 (440-570)

Date	Time	*E. coli* modified mTEC (CFU/100 mL)		*E. coli* Colilert (MPN/100 mL)		*Enterococci* mEI (CFU/100 mL)		*Enterococci* Enterolert (MPN/100 mL)		Fecal coliforms mFC (CFU/100 mL)	
0106 Tchefuncte River at Madisonville, La.											
9/13/05	9:30	150	(130-170)	120	(86-160)	290	(260-330)	--	--	--	--
9/16/05	10:10	--	--	41	(28-57)	--	--	98	(72-130)	200	(180-230)
9/20/05	10:30	47	(41-53)	70	(50-95)	--	--	54	(38-74)	180	(160-200)
9/27/05	10:00	--	--	440	(280-650)	2,300	(K)	2,400	(1,600-4,700)	3,600	(K)
0300 Bayou Lacombe west of Slidell, La.											
9/13/05	14:15	25	(K)	26	(16-38)	16	(K)	--	--	250	(220-280)
9/20/05	11:30	--	--	40	(27-56)	38	(33-43)	16	(9-26)	160	(K)
9/20/05	11:31	--	--	42	(29-58)	21	(K)	26	(17-38)	220	(190-250)
9/27/05	10:35	180	(160-200)	160	(110-230)	950	(840-1,100)	240	(160-340)	270	(240-310)
0301 Bayou Bonfouca at Slidell, La.											
9/13/05	12:45	360	(320-410)	300	(210-420)	88	(77-100)	--	--	750	(660-850)
9/20/05	10:10	--	--	180	(130-260)	450	(400-510)	870	(650-1,200)	240	(210-270)
9/27/05	9:30	--	--	21,000	(15,000-30,000)	36,000	(K)	6,600	(4,700-8,900)	>6,000	--
0302 Cane Bayou east of Mandeville, La.											
9/13/05	11:15	52	(K)	34	(23-50)	54	(K)	--	--	--	--
9/13/05	11:16	56	(K)	81	(29-61)	60	(K)	--	--	--	--
9/16/05	11:30	--	--	86	(58-110)	--	--	340	(220-520)	280	(250-320)
9/20/05	13:00	--	--	24	(15-37)	230	(200-260)	72	(54-94)	100	(88-110)
9/27/05	11:00	--	--	2,400	(1,600-4,700)	9,300	(K)	620	(490-790)	7,500	(K)
1077 Bayou Liberty at Highway 433 bridge, La.											
9/13/05	13:30	730	(640-830)	550	(360-800)	210	(180-240)	--	--	1,400	(1,200-1,600)
9/20/05	10:30	--	--	190	(110-300)	160	(140-180)	41	(12-90)	600	(530-680)
9/27/05	9:55	--	--	280	(200-380)	17,000	(K)	2,600	(1,700-4,000)	7,300	(K)
Lake Pontchartrain, La., near Bayou La Branche north of Norco											
9/15/05	11:10	49	(43-56)	41	(12-91)	87	(76-99)	31	(7-89)	140	(120-160)
9/21/05	10:10	--	--	20	(3-71)	--	--	20	(3-59)	2	(K)
9/28/05	11:00	--	--	63	(29-140)	25	(22-28)	41	(17-95)	7	(K)

Date	Time	*E. coli* modified mTEC (CFU/100 mL)	*E. coli* Colilert (MPN/100 mL)	*Enterococci* mEI (CFU/100 mL)	*Enterococci* Enterolert (MPN/100 mL)	Fecal coliforms mFC (CFU/100 mL)
3115 Lake Pontchartrain, La., near Duncan Canal						
9/15/05	10:40	3 (K)	<10 (0-37)	17 (K)	<10 (0-37)	17 (K)
9/21/05	10:55	-- --	31 (7-89)	8 (K)	<10 (0-37)	5 (K)
9/28/05	10:30	-- --	52 (23-120)	160 (140-180)	98 (47-180)	100 (88-110)
3116 Lake Pontchartrain, La., near Suburban Canal						
9/14/05	12:40	20 (18-23)	20 (3-70)	3 (K)	63 (25-130)	31 (27-35)
9/14/05	12:41	40 (K)	31 (7-89)	5 (K)	<10 (0-37)	42 (K)
9/21/05	13:40	2 (K)	10 (1-55)	1 (K)	10 (1-55)	6 (K)
9/21/05	13:41	1 (K)	10 (0-37)	2 (K)	10 (1-55)	7 (K)
9/28/05	13:10	9 (K)	<10 (0-37)	5 (K)	10 (1-55)	20 (K)
3117 Lake Pontchartrain, La., near 17th Street Canal						
9/15/05	12:50	3 (K)	41 (17-95)	<1 --	63 (29-140)	18 (K)
9/21/05	14:25	-- --	<10 (0-37)	3 (K)	10 (1-55)	6 (K)
9/29/05	11:15	-- --	<10 (0-37)	<1 --	<10 (0-37)	11 (K)
3118 Lake Pontchartrain, La., near Inner Harbor Navigation Canal						
9/15/05	14:35	1 (K)	10 (1-55)	2 (K)	<10 (0-37)	1 (K)
9/29/05	15:20	-- --	<10 (0-37)	<1 --	<10 (0-37)	<1 --
9/29/05	15:20	-- --	10 (1-55)	2 (K)	10 (1-55)	<1 --
3119 Lake Pontchartrain, La., near Little Woods						
9/15/05	14:05	<1 --	<10 (0-37)	<1 --	<10 (0-37)	<1 --
9/29/05	15:00	-- --	20 (3-71)	1 (K)	10 (1-55)	1 (K)
0137 Lake Pontchartrain, La., Causeway at Crossover 7						
9/14/05	11:05	7 (K)	<10 (0-37)	1 (K)	10 (1-55)	5 (K)
9/21/05	10:20	-- --	<10 (0-37)	3 (K)	<10 (0-37)	4 (K)
9/28/05	12:00	-- --	<10 (0-37)	-- --	30 (7-74)	61 (K)
9/28/05	12:00	-- --	<10 (0-37)	-- --	<10 (0-37)	44 (39-50)
0138 Lake Pontchartrain, La., Causeway at Crossover 4						
9/14/05	10:45	<1 --	<10 (0-37)	<1 --	<10 (0-37)	1 (K)
9/21/05	9:45	<1 --	-- --	-- --	<10 (0-37)	3 (K)
9/28/05	11:00	-- --	-- --	140 (120-160)	10 (1-55)	18 (K)

Date	Time	*E. coli* modified mTEC (CFU/100 mL)	*E. coli* Colilert (MPN/100 mL)	*Enterococci* mEI (CFU/100 mL)	*Enterococci* Enterolert (MPN/100 mL)	Fecal coliforms mFC (CFU/100 mL)
0139 Lake Pontchartrain, La., Causeway at Crossover 1						
9/14/05	9:30	<1 --	<10 (0-37)	<1 --	<10 (0-37)	1 (K)
9/21/05	9:00	-- --	-- --	-- --	<10 (0-37)	<1 --
9/28/05	10:30	-- --	-- --	73 (64-83)	<10 (0-37)	16 (K)
Chef Menteur Pass at Highway 90, La.						
9/16/05	13:20	1 (K)	10 (1-55)	2 (K)	<10 (0-37)	2
9/22/05	9:55	-- --	120 (61-200)	20 (K)	41 (17-95)	30 (26-35)
9/29/05	17:00	-- --	1,300 (960-1,700)	490 (430-560)	96 (44-170)	61 (K)
The Rigolets at Highway 90 southeast of Slidell, La.						
9/16/05	13:20	2 (K)	<10 (0-37)	5 (K)	<10 (0-37)	5 (K)
9/16/05	13:21	2 (K)	<10 (0-37)	6 (K)	10 (1-55)	7 (K)
9/22/05	9:10	-- --	10 (0-37)	2 (K)	<10 (0-37)	2 (K)
9/29/05	19:00	-- --	120 (68-210)	720 (630-820)	41 (17-95)	48 (K)

Table 4. U.S. Environmental Protection Agency (2004) criteria for recreational waters.

Fecal indicator bacteria	Single-sample concentration (per 100 milliliters; not to be exceeded in more than 10 percent of samples taken over a 30-day period)		
	Designated beach areas	Moderate full-body contact	Infrequent full-body contact
Freshwater			
Enterococci	61	78	151
Escherichia coli	235	298	575
Marine water			
Enterococci	104	158	501

Table 5. Summary of quality-control analyses for bacteriological water-quality sampling in the Lake Pontchartrain area, Louisiana.
[DI, deionized water; --, not applicable]

Date	Regular samples	Field blanks	Replicates	Filter blanks (Membrane filtration analyses)	Procedure blanks (Membrane filtration analyses)	DI blanks (MPN analyses)	Positive/negative culture controls
Number of samples analyzed							
9/13/2005	7	1	1	7	3	1	--
9/14/2005	5	0	1	6	5	1	--
9/15/2005	8	1	1	10	5	0	mFC, modified mTEC, mEI, Colilert, Enterolert
9/16/2005	6	0	1	7	2	0	--
9/20/2005	7	1*	1	8	1	0	--
9/21/2005	10	1	1	10	0	0	--
9/22/2005	2	0	0	1	0	1	mFC
9/27/2005	7	2	1	7	2	1	mFC, modified mTEC, mEI
9/28/2005	8	2	1	9	2	0	--
9/29/2005	7	1	1	8	2	0	mFC
TOTAL	**67**	**9**	**9**	**73**	**22**	**4**	

* Field blank had detection of fecal coliform bacteria on mFC plate.