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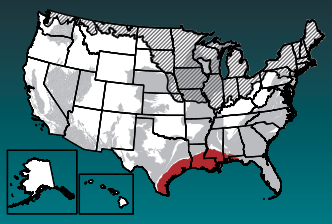
National Water Quality Program
National Water-Quality Assessment Project

# Groundwater Quality in the Coastal Lowlands Aquifer System, South-Central United States



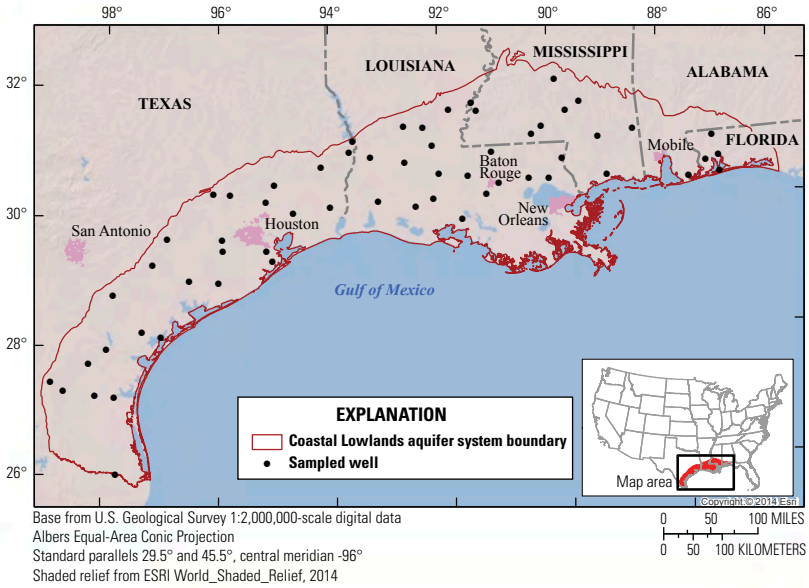
**Groundwater provides nearly 50 percent of the Nation's drinking water. To help protect this vital resource, the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Project assesses groundwater quality in aquifers that are important sources of drinking water (Burow and Belitz, 2014). The Coastal Lowlands aquifer system constitutes one of the important aquifers being evaluated.**

## Background

The Coastal Lowlands aquifer system underlies an area of 99,000 square miles along the Gulf Coast, where about 15 million people live in Texas, Louisiana, Mississippi, Alabama, and Florida. The aquifer system ranks fourth in the Nation as a source of groundwater for public supply and fifth as a source of private domestic supply, with about 1 billion gallons per day pumped for these uses in 2000 (Maupin and Arnold, 2010). Land use overlying the Coastal Lowlands aquifer system is mostly agricultural (24 percent) and undeveloped (67 percent), with a relatively small amount (9 percent) of urban land. The cities of Houston, New Orleans, Baton Rouge, and Mobile overlie this aquifer system.

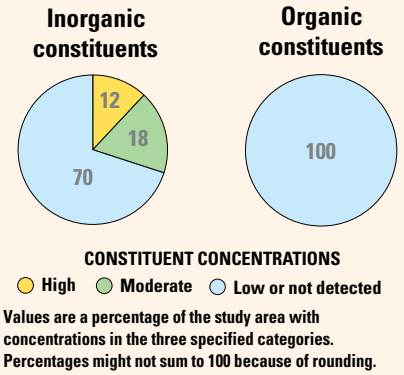
Unconsolidated to partially consolidated sand, silt, and clay of Oligocene to Holocene age make up the Coastal Lowlands aquifer system. The sediments thicken and dip coastward, from a few tens of feet thick at the northern edge of the aquifer to as much as 14,000 feet thick near the coast of southern Louisiana (Ryder, 1996; Renken, 1998). Recharge to the aquifer system is primarily precipitation infiltrating topographically high areas and along the aquifer system's landward margin. Groundwater flow is toward the coast and laterally toward the Mississippi River—discharging to streams, wetlands, and the Gulf of Mexico (Renken, 1998). Previous studies divided the Coastal Lowlands aquifer system into five permeable zones (Weiss, 1992); however, the lack of regionally continuous confining units make it difficult to distinguish between individual aquifers (Renken, 1998). For the purpose of the Coastal Lowlands network design, the aquifer system was considered as one unit.

Groundwater quality in the Coastal Lowlands aquifer system was evaluated by sampling 60 public-supply wells that were spatially distributed across the aquifer system. For this discussion, the study area is defined as the depth zone used for public supply in the Coastal Lowlands aquifer system. Water-quality data, collected from a set of spatially distributed wells (27 in Texas, 19 in Louisiana, 9 in Mississippi, 1 in Alabama, and 4 in Florida), were used to estimate the percentage of the study area where concentrations are high, moderate, and low with respect to constituent benchmarks. The accuracy of the estimates depends on the distribution and number of wells, not on the size of the area (Belitz and others, 2010). The wells ranged from about 115 to 2,540 feet deep (averaging about 660 feet deep) and were open to the aquifer across long depth intervals (averaging about 100 feet). Samples were analyzed for a great number of water-quality constituents derived from natural and human sources.




Base from U.S. Geological Survey 1:2,000,000-scale digital data
Albers Equal-Area Conic Projection
Standard parallels 29.5° and 45.5°, central meridian -96°
Shaded relief from ESRI World_Shaded_Relief, 2014

## Overview of Water Quality




**Values are a percentage of the study area with concentrations in the three specified categories. Percentages might not sum to 100 because of rounding.**

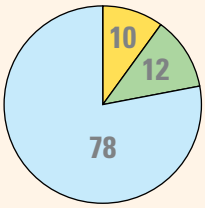
Principal Aquifer Studies are designed to evaluate groundwater used for public supply prior to any treatment. Groundwater quality is assessed by comparing concentrations to benchmarks established for drinking-water quality. Benchmarks and definitions of high, moderate, and low relative concentrations are discussed in the inset box on page 3.

Many inorganic constituents are naturally present in groundwater. The concentrations of inorganic constituents can be affected by natural processes as well as by human activities. One or more inorganic constituents with human-health benchmarks were detected at high concentrations in about 12 percent of the study area and at moderate concentrations in about 18 percent.

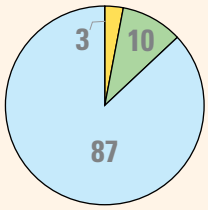
Organic constituents derived from human activities are found in household, business, industrial, and agricultural products. They can enter the environment through normal usage, spills, or improper disposal. Organic constituents were not detected at high or moderate concentrations in the study area.

# Results: Groundwater Quality at the Depth Zone Used for Public Supply in the Coastal Lowlands Aquifers

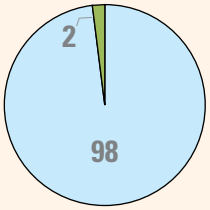
## INORGANIC CONSTITUENTS



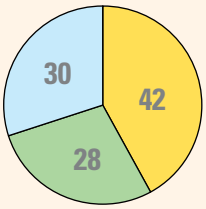

**Trace elements and major and minor ions**




**Radioactive constituents**




**Nutrients**




**All non-health benchmarks**

### Inorganic Constituents with Human-Health Benchmarks

Trace elements and major and minor ions are naturally present in the minerals of rocks, soils, and sediments and in the water that comes into contact with those materials. Samples were analyzed for 34 trace elements, of which 19 have human-health benchmarks. Constituents from this group were detected at high concentrations in about 10 percent of the study area (the depth zone used for public supply) and at moderate concentrations in about 12 percent. Arsenic and manganese were the only trace elements detected at high concentrations.

Radioactivity is the release of energy or energetic particles during the spontaneous decay of unstable atoms. Humans are continuously exposed to small amounts of natural radioactivity. Most of the radioactivity in groundwater comes from the decay of isotopes of uranium and thorium that are naturally present in minerals in aquifer materials. Samples were analyzed for eight radioactive constituents, of which four have human-health benchmarks. Radioactive constituents were present at high levels in about 3 percent of the study area and at moderate levels in about 10 percent of the study area. Gross alpha activity and radon-222 were the only radioactive constituents detected at high concentrations.

Nutrients are naturally present at low concentrations in groundwater; high and moderate concentrations (relative to human-health benchmarks) generally result from human activities. Samples were analyzed for five nutrients, of which two (nitrate and nitrite) have human-health benchmarks. Common sources of nutrients, aside from soils, include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. Nutrients were not present at high concentrations in the study area. Nitrate was the only nutrient detected at moderate concentrations, which was measured in about 2 percent of the study area.

### Inorganic Constituents and Field Measurements with Non-Health Benchmarks

*(Not included in water-quality overview charts shown on the front page)*

Some constituents affect the aesthetic properties of water, such as taste, color, and odor, or can create nuisance problems, such as staining and scaling. The benchmarks used for these constituents are non-regulatory secondary maximum contaminant level (SMCL) benchmarks established for public drinking water. Some constituents, such as manganese, have human-health benchmarks and SMCLs. Samples were analyzed for 11 constituents that have SMCLs. One or more of these were present at high concentrations or values relative to the SMCL in about 42 percent of the study area and at moderate concentrations in about 28 percent.

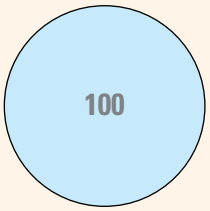
Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater based primarily on the concentrations of ions, and all water naturally contains TDS as a result of the weathering and dissolution of minerals in rocks and sediments. Concentrations of TDS can be high because of natural factors or as a result of human activities, such as applications to the land surface of road salt, fertilizers, or other chemicals in urban or agricultural areas. Most of the study area had high (27 percent) or moderate (30 percent) concentrations of TDS. Chloride and sulfate were present at high concentrations in about 10 and 3 percent of the study area, respectively, and at moderate concentrations in 15 and 3 percent, respectively. Fluoride was present at high concentrations relative to the SMCL in about 2 percent of the study area and at moderate concentrations in 10 percent.

Anoxic conditions in groundwater (low amounts of dissolved oxygen) can result in the release of iron and manganese in minerals to the groundwater. Manganese was present at high concentrations relative to the SMCL in about 20 percent of the study area. Iron was present at high concentrations relative to the SMCL in about 13 percent of the study area and at moderate concentrations in 5 percent.

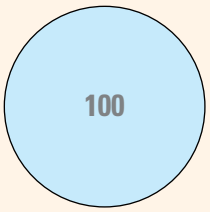
In some areas, the pH of the groundwater was not in the SMCL range of 6.5 to 8.5. The pH did not meet the standard in 27 percent of the study area, typically because it was less than 6.5, which is acidic and potentially corrosive.

# Results: Groundwater Quality at the Depth Zone Used for Public Supply in the Coastal Lowlands Aquifers

## ORGANIC CONSTITUENTS




**VOCs**




**Pesticides**

### Volatile Organic Compounds with Human-Health Benchmarks

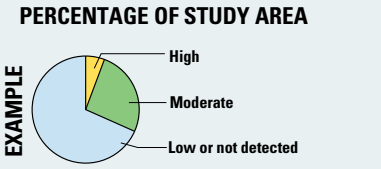
Volatile organic compounds (VOCs) are present in many household, commercial, industrial, and agricultural products and are characterized by their tendency to volatilize (evaporate). Samples were analyzed for 90 VOCs, of which 38 have human-health benchmarks. No VOCs were detected at high or moderate concentrations in the study area.

### Pesticides with Human-Health Benchmarks

Pesticides, including herbicides, insecticides, and fumigants, are applied to crops, gardens and lawns, around buildings, and along roads to help control unwanted vegetation (weeds), insects, fungi, and other pests. Samples were analyzed for 227 pesticide compounds (pesticides and their breakdown products), of which 119 have human-health benchmarks. Pesticide compounds were not detected at high or moderate concentrations in the study area.

## BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

The USGS NAWQA Project uses benchmarks established for drinking water to provide context for evaluating the quality of untreated groundwater. The quality of water received by consumers can be different, because after withdrawal, groundwater may be treated prior to delivery. Federal regulatory benchmarks for protecting human health are used for this evaluation of water quality when available. Otherwise, non-regulatory human-health benchmarks and non-regulatory aesthetic benchmarks are used. Not all constituents analyzed have benchmarks and, thus, are not considered in this context. Out of 55 inorganic constituents and properties and 317 organic constituents, 24 and 157, respectively, have human-health benchmarks.




Values are a percentage of the study area with concentrations in the three specified categories. Percentages might not sum to 100 because of rounding.

Concentrations are considered high if they are greater than a human-health benchmark (Toccalino and others, 2014) or SMCL. For inorganic constituents, concentrations are moderate if they are greater than one-half of a benchmark. For organic constituents, concentrations are moderate if they are greater than one-tenth of a benchmark; this lower threshold is used because organic constituents are generally less prevalent and have smaller concentrations relative to benchmarks than inorganic constituents (Toccalino and others, 2004).

### Benchmarks Type and Value for Selected Constituents

This table presents benchmarks for those constituents detected at high concentrations in the Coastal Lowlands aquifer system. Benchmark types are regulatory U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs), non-regulatory health-based screening levels (HBSLs), and non-regulatory EPA secondary maximum contaminant levels (SMCLs).

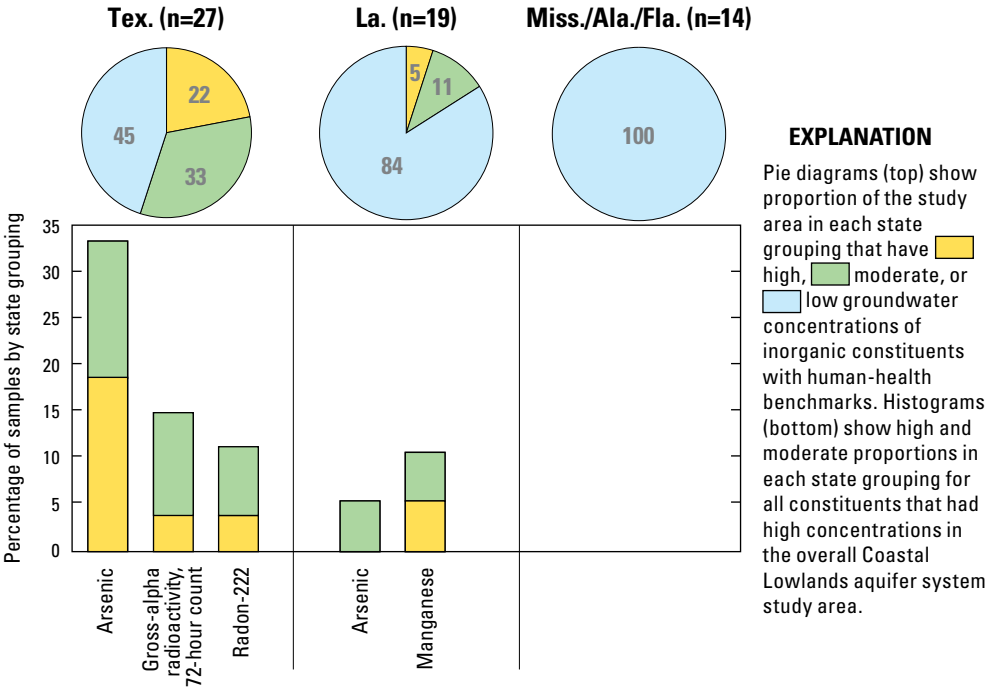
[Abbreviations: ppb, parts per billion or micrograms per liter (µg/L); ppm, parts per million or milligrams per liter (mg/L); pCi/L, picocuries per liter].

| Constituent | Benchmark | | Constituent | Benchmark | |
|---|---|---|---|---|---|
| | Type | Value | | Type | Value |
| Arsenic | MCL | 10 ppb | Sulfate | SMCL | 250 ppm |
| Manganese | HBSL | 300 ppb | Manganese | SMCL | 50 ppb |
| Radon-222 | HBSL | 4,000 pCi/L | Iron | SMCL | 300 ppb |
| Gross alpha activity | MCL | 15 pCi/L | Total dissolved solids (TDS) | SMCL | 500 ppm |
| | | | Chloride | SMCL | 250 ppm |
| | | | pH | SMCL | 6.5–8.5 |

# Spatial Distribution of Constituents in Concentrations Above Human-Health Benchmarks

Inorganic constituents with human-health benchmarks were present at high or moderate concentrations in 30 percent of the Coastal Lowlands aquifer system study area. The distribution of elevated concentrations, however, varied with 55 percent in Texas (Tex.; 27 wells), 16 percent in Louisiana (La.;19 wells), and zero percent (14 wells) in Mississippi (Miss.), Alabama (Ala.) and Florida (Fla.).

Individual constituents present at high or moderate concentrations were also not the same and varied by state. Gross alpha activity (4 percent), radon-222 (4 percent), and arsenic (19 percent) only exceeded human-health benchmarks in Texas, whereas manganese (5 percent) only exceeded human-health based benchmarks in Louisiana.




By Jeannie R.B. Barlow and Kenneth Belitz


SELECTED REFERENCES

Arnold, T.L., DeSimone, L.A., Bexfield, L.M., Lindsey, B.D., Barlow, J.R., Kulongoski, J.T., Musgrove, M., Kingsbury, J.A., and Belitz, K., 2016, Groundwater quality data from the National Water-Quality Assessment Program, May 2012 through December 2013: U.S. Geological Survey Data Series 997, 56 p., http://dx.doi.org/10.3133/ds997.

Belitz, Kenneth, Jurgens, Bryant, Landon, M.K., Fram, M.S., and Johnson, T., 2010, Estimation of aquifer scale proportion using equal area grids: Assessment of regional scale groundwater quality: Water Resources Research., v. 46, 14 p., http://dx.doi.org/10.1029/2010WR009321.

Burow, K.R., and Belitz, Kenneth, 2014, Groundwater studies—Principal aquifer surveys: U.S. Geological Survey Fact Sheet 2014–3024, 2 p., http://dx.doi.org/10.3133/fs20143024.

DeSimone, L.A., McMahon, P.B., and Rosen, M.R., 2014, The quality of our Nation's waters—Water quality in Principal Aquifers of the United States, 1991–2010: U.S. Geological Survey Circular 1360, 151 p., http://dx.doi.org/10.3133/cir1360.

Maupin, M.A., and Arnold, T.L., 2010, Estimates for self-supplied domestic withdrawals and population served for selected principal aquifers, calendar year 2005: U.S. Geological Survey Open-File Report 2010–1223, 10 p.

Renken, R.A., 1998, Ground water atlas of the United States—segment 5, Arkansas, Louisiana, Mississippi: U.S. Geological Survey Hydrologic Atlas 730–F, http://pubs.usgs.gov/ha/ha730/ch_f/index.html.

Ryder, P.D., 1996, Ground water atlas of the United States—segment 4, Oklahoma, Texas: U.S. Geological Survey Hydrologic Atlas 730–E, http://pubs.usgs.gov/ha/ha730/ch_e/index.html.

Toccalino, P.L., Norman, J.E., Phillips, R.H., Kauffman, L.J., Stackelberg, P.E., Nowell, L.H., Krietzman, S.J., and Post, G.B., 2004, Application of health-based screening levels to ground-water quality data in a state-scale pilot effort: U.S. Geological Survey Scientific Investigations Report 2004–5174, 64 p., http://pubs.usgs.gov/sir/2004/5174/.

Toccalino, P.L., Norman, J.E., and Schoephoester, K.M., 2014, Health-based screening levels for evaluating water-quality data, http://water.usgs.gov/nawqa/HBSL, doi:10.5066/F71C1TWP.

Weiss, J.S., 1992, Geohydrologic units of the Coastal Lowlands aquifer system, south-central United States: U.S. Geological Survey Professional Paper 1416–C, 32 p.


## Principal Aquifer Studies

The USGS NAWQA Project has been assessing the quality of groundwater since 1991. The NAWQA studies include Land Use Studies (LUS), Major Aquifer Studies (MAS), and Principal Aquifer Studies (PAS). These three study types are based on sampling networks of wells distributed across an area of interest. The LUS networks typically consist of observation wells that are relatively shallow; MAS networks typically consist of domestic-supply wells that are intermediate in depth; and PAS networks typically consist of public-supply wells that are relatively deep. A national synthesis of shallow- and intermediate-depth groundwater quality was reported by DeSimone and others (2014). This fact sheet provides a summary of PAS data for 60 public-supply wells sampled in 2013 in the Coastal Lowlands aquifer system (data available in Arnold and others, 2016).

The PAS assessments like this one allow for the comparison of constituent concentrations in untreated groundwater with benchmarks established for the protection of human health and for aesthetic qualities of drinking water and also provide a basis for comparison of groundwater quality among the principal aquifers.

The data collected by NAWQA include chemical analyses generally not available as part of regulatory compliance monitoring, including measurements at concentrations much lower than the levels used as human-health benchmarks and measurements of constituents that can be used to trace the sources and movement of groundwater.

## *For more information*

Technical reports and hydrologic data collected for the NAWQA Project may be obtained from: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