Geology of Fontainebleau State Park

State Parks and Land Series No.1
Spring 2011

Louisiana Geological Survey
3079 Energy, Coast & Environment Building
Baton Rouge, Louisiana 70803
Tel: 225 578 5320
Fax: 225 578 3662
www.lgs.lsu.edu

State of Louisiana
Bobby J. Jindal, Governor

Louisiana State University, Baton Rouge
Michael Martin, Chancellor

Louisiana Geological Survey
Chacko J. John, Director and State Geologist

The purpose of this series is to make a variety of geological information for state-owned lands accessible to the public.

Front cover: Fontainebleau State Park from the air. Photo by Robert Paulsell.

This public information document is part of a series published periodically by the Louisiana Geological Survey, whose offices are located at Louisiana State University, Room 3079 Energy, Coast & Environment Building, Baton Rouge, LA 70803-4101. The publisher does not guarantee the accuracy or correctness of any information. Contact the LGS business office at (225) 578-5320 for extra copies or for more information, or visit the web site at http://www.lgs.lsu.edu.

State Parks and Land Series No. 1

Fontainebleau State Park

by:
Richard P. McCulloh

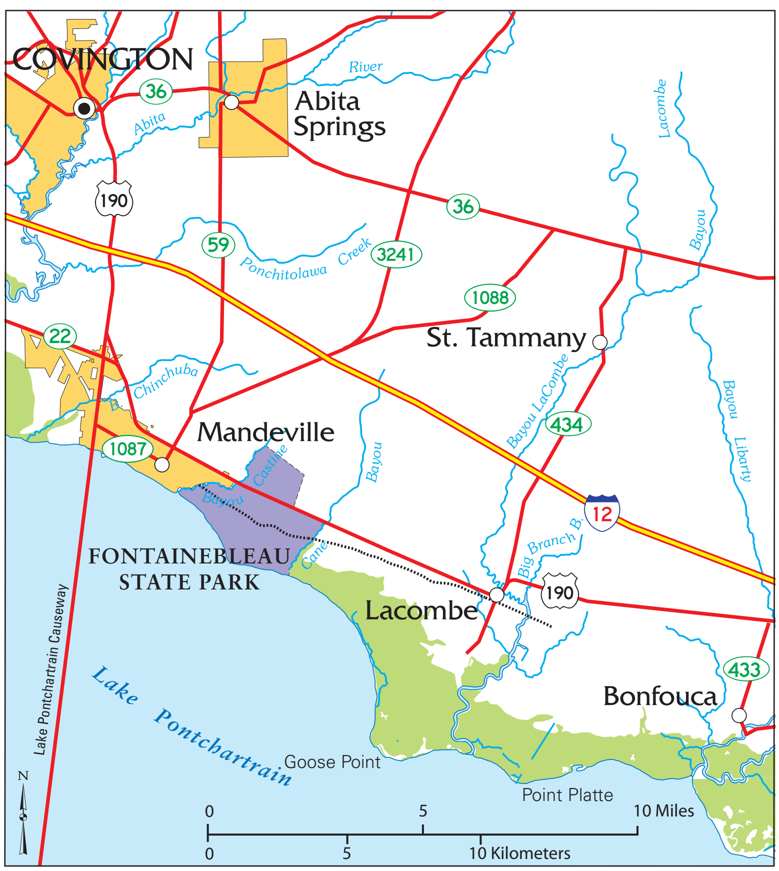
Baton Rouge
2011

Table of Contents

Patrick O'Neill

Location and Facilities

Fontainebleau State Park comprises 2,809 acres (1,137 hectares) on the north shore of Lake Pontchartrain, between Bayou Castine to the northwest and Cane Bayou to the southeast. Built by the Civilian Conservation Corps (CCC), it was established in 1938 as Tchefuncte State Park and renamed in the early 1940s. The park is approximately 4 mi (6.4 km) east-southeast of the City of Mandeville via U.S. Highway 190. Virtually all of the park grounds are south of the highway, but approximately 80 acres (32.4 hectares) are north of it. The grounds are adjoined on the northeast by property belonging to the Southeast Louisiana State Hospital and on the southeast by the Big Branch Marsh National Wildlife Refuge (administered by both the U.S. Fish and Wildlife Service and the Louisiana Department of Wildlife and Fisheries).



Location of Fontainebleau State Park (purple tint), along the north shore of Lake Pontchartrain. Map adapted from the Louisiana Department of Transportation and Development Official Map of Louisiana 2000.

The park grounds contain the ruins of an early nineteenth-century sugar mill, built ca.1829, the sole remnant of the area's early days as a sugar plantation.

Fountainebleau offers meeting areas, Fontainebleau State Park lodge located north of U.S. Highway 190, vacation cabins (newly constructed following hurricane Katrina's devastation and opened in April 2008), and a group teepees campsite. The Tammany Trace hiking/biking trail has entry points in the park. (Three top right photos provided by Fontainebleau State Park. Other photos by Patrick O'Neill)

The park offers a variety of options for camping, from "primitive" to "premium" and group campsites, as well as cabins, a lodge, and meeting rooms. It features a beach, canoe/sailboat launch, fishing, picnic pavilions, playground, nature and hiking trails (including part of the Tammany Trace, which was converted from an abandoned railroad grade that traverses the northern part of the park), and a visitor center. The park grounds also contain the ruins of an early nineteenth-century sugar mill, the sole remnant of the area's early days as a sugar plantation developed by Bernard de Marigny de Mandeville, who also founded the nearby town. Complete information about the park's facilities, services, and activities, which include nature and history programs, is available from the Louisiana Department of Culture, Recreation and Tourism at http://www.crt.state.la.us/parks/ifontaine.aspx.

Natural Regions

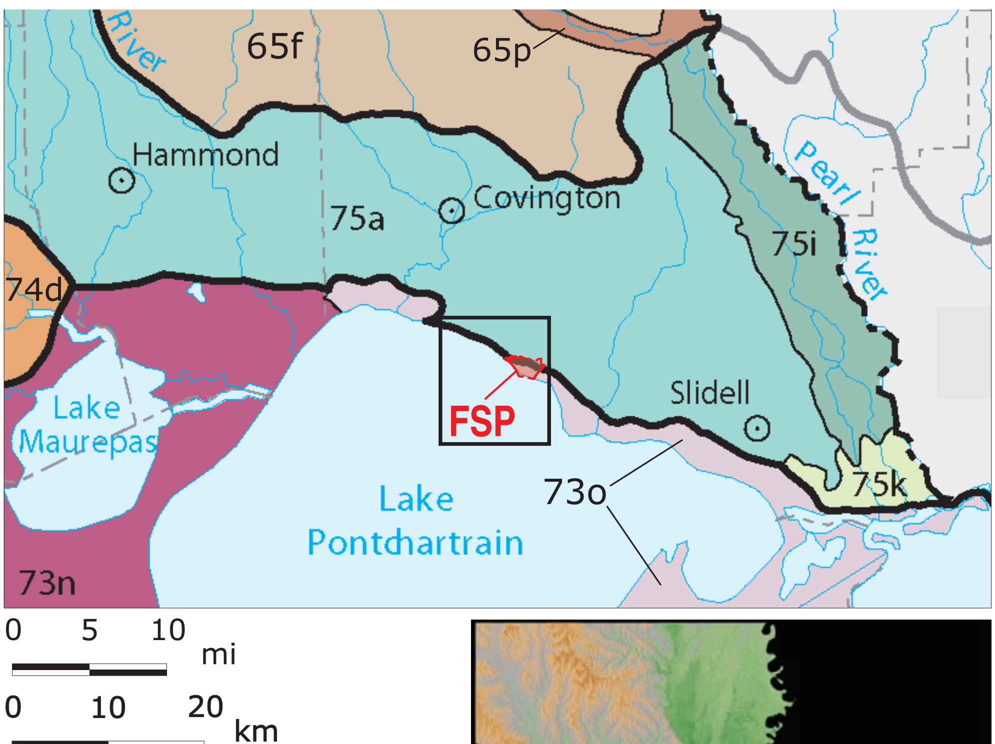
The area encompassing Fontainebleau State Park spans a natural boundary between forested, *terraced*[1] uplands to the north-northeast and wetland-dominated lowlands to the south-southwest. One way of thinking of the natural regions of Fontainebleau State Park and vicinity uses the concept of *ecoregions*, which are areas of similarity in the mosaic of biotic, abiotic, aquatic, and terrestrial ecosystem components that have been interpreted and mapped for the surrounding area. Ecoregions typically correspond to suites of components of an ecosystem, rather than to specific single components or attributes. In the Fontainebleau State Park area, however, the meaningful suites of ecosystem components correlate with the mapped surface-geologic units (see "Surface Geology," below), which thus are associated directly with the ecoregions.

The uplands in the park are within the Gulf Coast Flatwoods level IV ecoregion and represent the southern edge of a natural region encompassing Slidell to the east, Covington to the north, and Mandeville, Ponchatoula, Hammond, and Amite to the west and northwest. The Gulf Coast Flatwoods is a subregion of the Southern Coastal Plain level III ecoregion, which

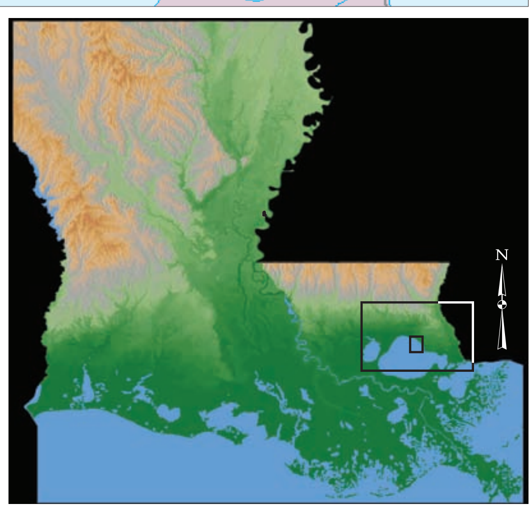
1 Technical terms defined in the Glossary are italicized when used for the first time in the narrative.

fringes the southern Atlantic and northern Gulf coasts of the United States from South Carolina through eastern Louisiana. Historically, the Southern Coastal Plain consisted mostly of longleaf pine flatwoods and savannas, but it also supported communities of slash pine, pond pine, pond cypress, beech, sweetgum, southern magnolia, white oak, and laurel oak. Today, the regional cover comprises mainly slash and loblolly pine, in many places mixed with hardwoods, bottomland hardwood forest in some low-lying areas, pasture, and urban land. The Gulf Coast Flatwoods ecoregion is developed on terraced *Quaternary alluvial* and *deltaic sand* and *clay,* with poorly to moderately well drained, silty and fine sandy loam surface soils. In its natural (pre-settlement) state, longleaf pine was dominant and a high natural fire frequency maintained the open pine flatwoods and savannas. Presently, much of the landscape is covered in mixed forest or pine plantations, with some pasture or crops on better drained land. The rare remnant savannas support diverse plant species, including grasses, sedges, rushes, and numerous wildflowers.

The lowlands to the south-southwest fringe the north shore of Lake Pontchartrain and extend along it farther to the east-southeast; they lie within the Deltaic Coastal Marshes and Barrier Islands level IV ecoregion of the Mississippi Alluvial Plain level III ecoregion, which spans an area from southern Illinois to the Gulf of Mexico. Many of the soils of the Mississippi Alluvial Plain ecoregion are fine grained and poorly drained relative to adjacent upland soils. Originally, bottomland deciduous forest covered the region; today artificial levees permit most of the region to be kept in cropland that supports sugarcane, soybeans, and pasture in southern Louisiana. Despite the widespread loss of forest and wetland habitat, it is still a major bird migration corridor. The Deltaic Coastal Marshes and Barrier Islands subregion, at the southern margin of the Mississippi Alluvial Plain,



Landscape types and natural regions of Fontainebleau State Park and vicinity. Map shows ecoregions adapted from Daigle et al. (2006); solid outline is the area of the Mandeville 7.5-minute quadrangle, wherein Fontainebleau State Park (FSP) is located. Differently colored areas separated by finer lines on map A are level IV ecoregions; bolder lines separate level III ecoregions. Level IV ecoregions: 65f (Southern Pine Plains and Hills), 65p (Southeastern Floodplains and Low Terraces), 73n (Inland Swamps), 73o (Deltaic Coastal Marshes and Barrier Islands), 74d (Baton Rouge Terrace), 75a (Gulf Coast Flatwoods), 75i (Floodplains and Low Terraces), 75k (Gulf Barrier Islands and Coastal Marshes).



Louisiana physiography adapted from Chalk Butte Inc. (1995; used with permission); solid outlines are the area of map A and the Mandeville quadrangle.

differs from much of that ecoregion in that it is dominated by brackish and saline marshes that support saltmarsh cordgrass, marshhay cordgrass, black needlerush, and coastal saltgrass, with black mangrove in a few areas and some live oak along old natural levees. Sediments comprise silt, clay, and peat having a high water content. Mucky surface soils are developed on extensive organic deposits in permanently flooded settings near and below sea level. Drainage of such soils as part of development results in pronounced subsidence at the surface owing to shrinkage of the near-surface material. The coastal marshes serve to buffer adjacent inland areas against the more severe effects of storm surges. Because waterways draining the coastal plain increasingly have been shortened, straightened, dredged, and enclosed by levees in the last few centuries, the supply of new sediment required to maintain coastal wetlands in a natural state has been cut off and the marshes are deteriorating and converting to open water at unprecedented rates. These effects recently were accelerated, at least for the short term, by hurricanes Katrina and Rita in late August and September of 2005.

The adjacent Big Branch Marsh National Wildlife Refuge, along the north shore of Lake Pontchartrain directly to the east and southeast, is cooperatively managed by the U.S. Fish and Wildlife Service and the Louisiana Department of Wildlife and Fisheries. It consists (as of April 2007) of 18,600 acres (7,527 hectares) of coastal marsh and pine-forested wetlands within the 24,000-acre (9,712-hectare) acquisition boundary, the purpose of which is

to protect some of the only Lake Pontchartrain shoreline that exists in its natural state and to provide habitat for a diversity of wildlife species, with special emphases on migratory birds and endangered species. The refuge supports over 5,000 wintering waterfowl, including mallards, gadwall and Northern Pintails. The endangered red cockaded woodpecker and American bald eagle nest in the refuge's pine forests.

(U.S. Fish and Wildlife Service, no date given, http://www.fws.gov/refuges/profiles/index.cfm?id=43558).

Several osprey nests also are present (U.S. Fish and Wildlife Service, no date given, http://www.fws.gov/southeast/pubs/facts/bgbcon.pdf). In addition to preserving wildlife habitat, the refuge offers a variety of recreational activities for the public, including hunting and fishing, formal environmental education programs for different age groups, and weekend interpretive tours that feature biking, bird-watching, canoeing, and hiking. The headquarters and visitor center are in the nearby town of Lacombe, which is centered on the intersection of State Highway 434 and U.S. Highway 190, adjacent to the western part of the refuge.

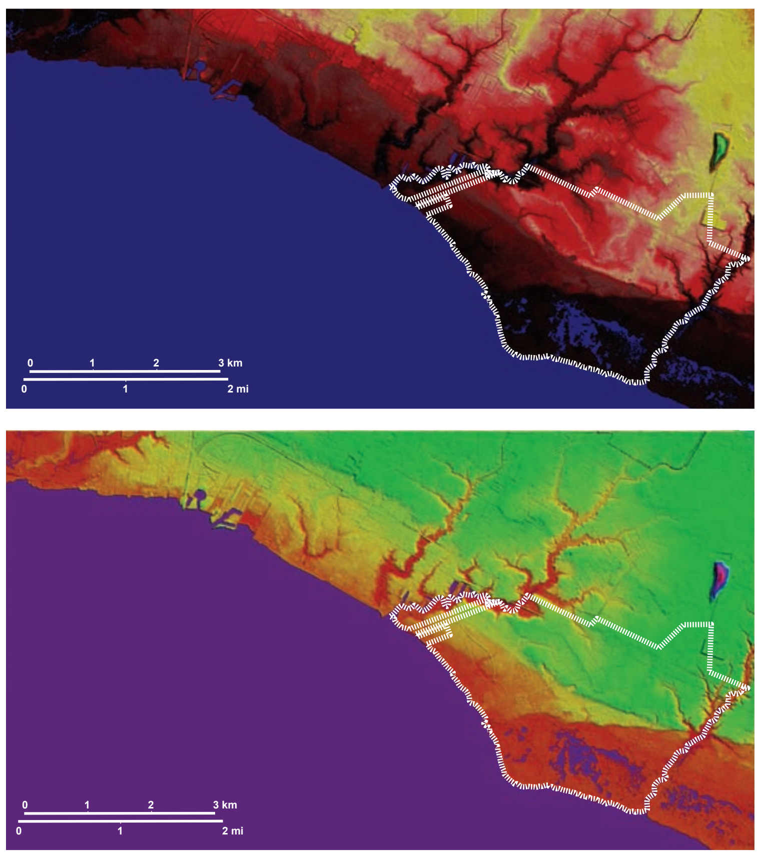
Marybeth Pinsonneault

Geology

Surface Geology

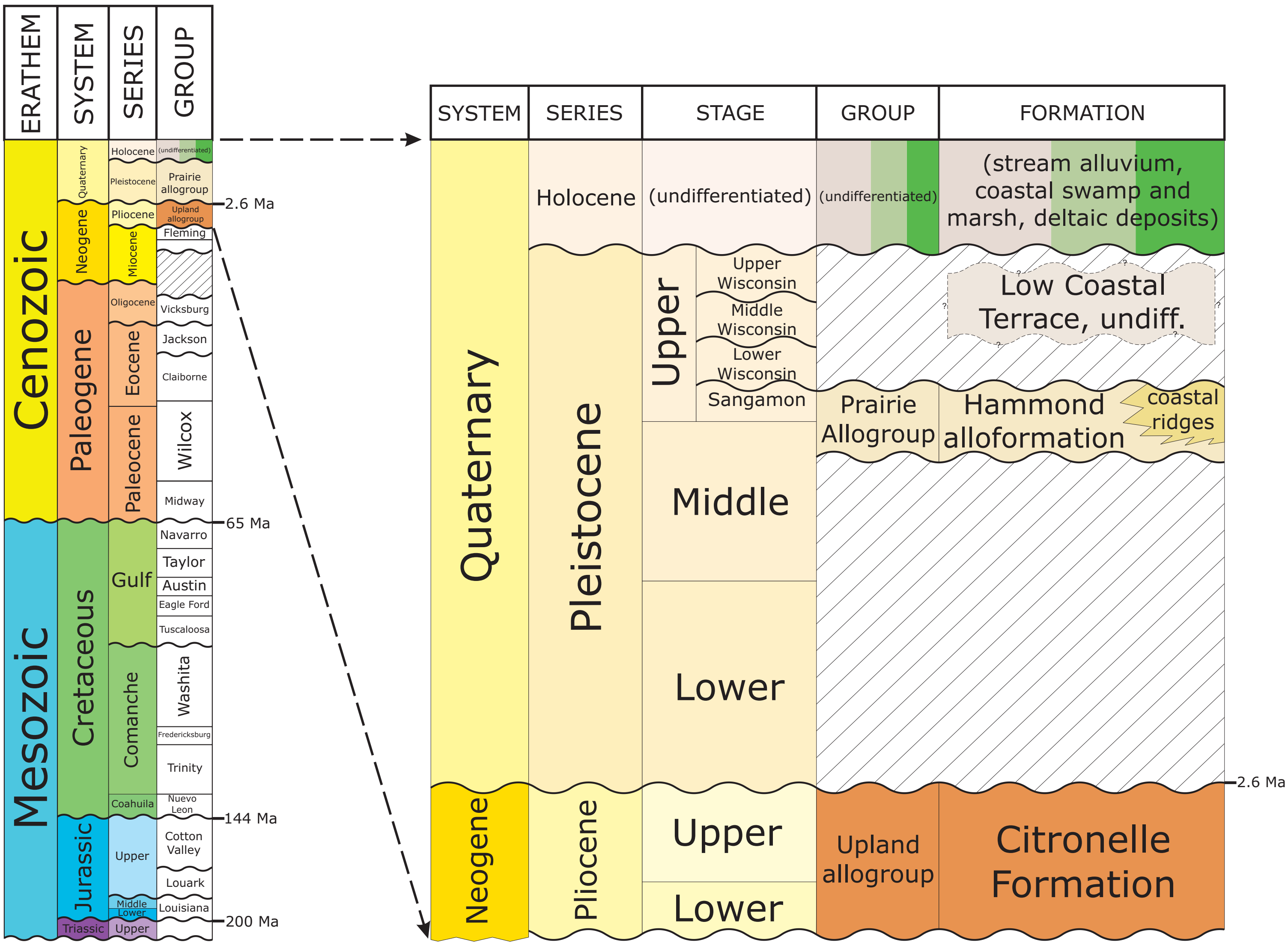
The area encompassing Fontainebleau State Park and the adjacent Southeast Louisiana State Hospital grounds is underlain by sediment of late Quaternary age, deposited during the late Pleistocene and Holocene epochs. The strata of late Pleistocene age occur as one geologic unit, the Hammond alloformation, classified as a subunit of the Prairie Allogroup. On the 1984 Geologic Map of Louisiana this unit was designated as Prairie Terraces, a name that refers to the comparatively low, flat, gently sloping, and little-dissected (among Pleistocene units) geomorphic expression of the upper surface of the unit. The Hammond surface is underlain by clay, silt, sand, and gravel of a relict alluvial and deltaic coastal plain. This plain was raised above younger deposits in response to downwarping of the crustal floor of the Gulf of Mexico by the deposition of the voluminous younger deltaic sediment to the southeast. Regionally, the Hammond sediment sequence is predominantly clayey at the surface but the texture may become finer from the subsurface to the surface. Sandier sediment tends to occur in separate relict meander belts, deltas, and beach ridges, none of which is definitely known to be present within the area of the park. Holocene deposits comprise undifferentiated alluvium deposited by streams and brackish-water coastal marsh deposits formed on the Mississippi River delta plain (delta plain, saline marsh of the 1984 map). The alluvium consists of clay, silt, sand, and gravel deposited on the valley floors of Bayou Castine and Cane Bayou, which are incised into the Hammond surface. The coastal marsh deposits consist chiefly of mud and organic matter.

The southern edge of the surface exposure of the Pleistocene Hammond alloformation is the main Pleistocene-Holocene boundary in the area. This boundary is parallel to the coast. It forms an escarpment because the surface Pleistocene strata have been incised along their gulfward edge as a result of their upraising as outlined above. The Holocene sediments deposited in the incision are undergoing subsidence in tandem with the uplift of the Pleistocene strata to the north, and so have not filled the incision to the same height as the now elevated Pleistocene surface. This escarpment between Pleistocene uplands and Holocene lowlands is essentially parallel to the northern shore of Lake Pontchartrain and in the western part of the park coincides with it.That is, the terraced surface exposed at the top of the Hammond alloformation extends all the way to the lakeshore with no intervening Holocene sediments. This proximity to the lake and the Hammond's higher elevation relative to adjoining Holocene coastal marsh deposits probably were the main attributes that made the area occupied by the city of Mandeville, directly west of the park, attractive to its founders.



Physiography of the northern Mandeville, Louisiana, 7.5-minute quadrangle, as indicated by two color-shaded views of a mosaic of LIDAR digital elevation models (DEMs) (from http://atlas.lsu.edu/lidar, viewed with Global Mapper DEM viewer). Dashed white outline is the area of Fontainebleau State Park. Elevation of the natural landscape (i.e., excluding landfill in northeastern part of quadrangle) according to this LIDAR mosaic ranges from -2 ft (-0.6 m) to +27 ft (+8.2 m).

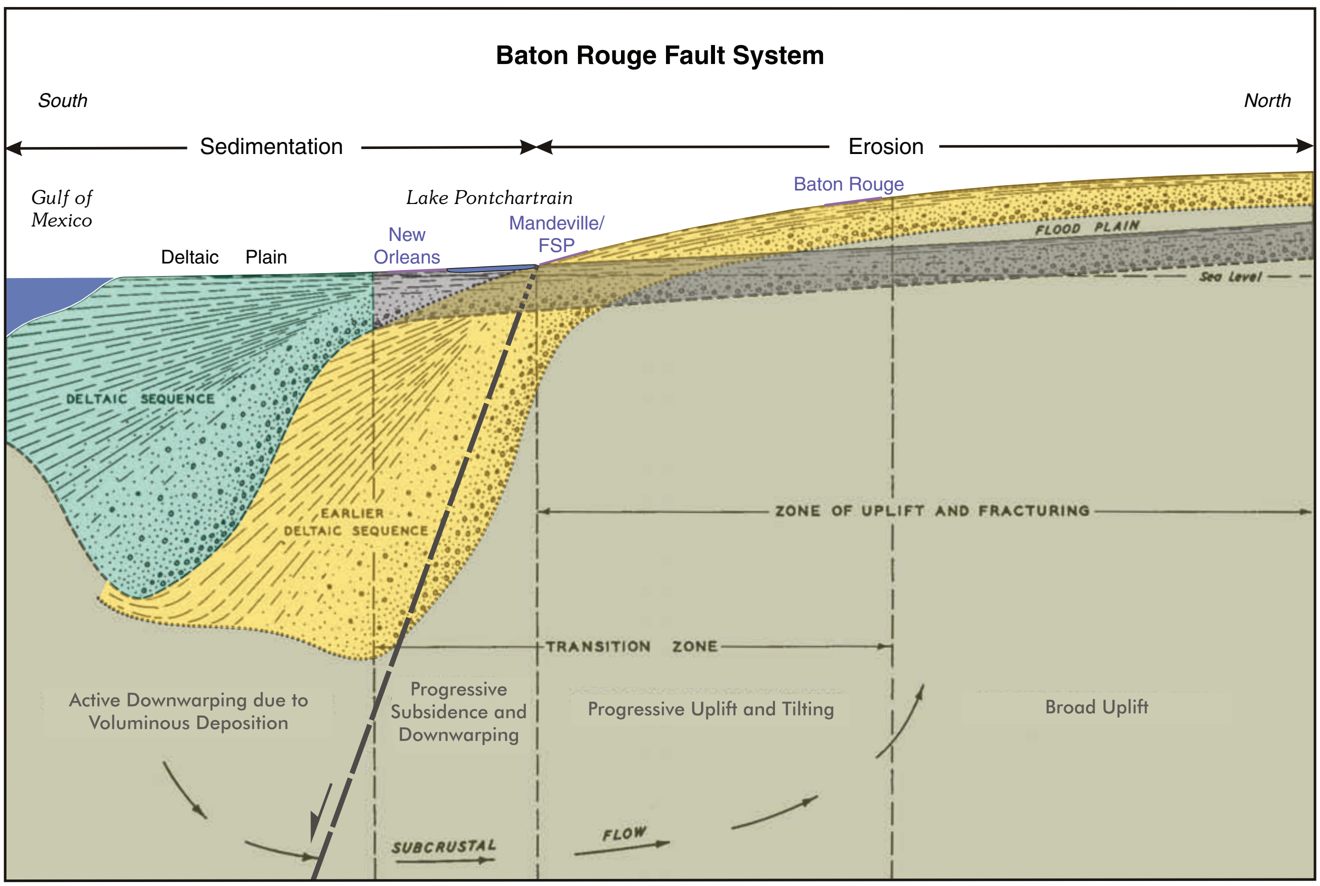
The area is transected by a regional geologic structure, an extension of the Denham Springs–Scotlandville fault zone of the Baton Rouge fault system. The fault zone consists of shorter individual fault segments arranged en echelon and is the surface expression of a zone of underlying



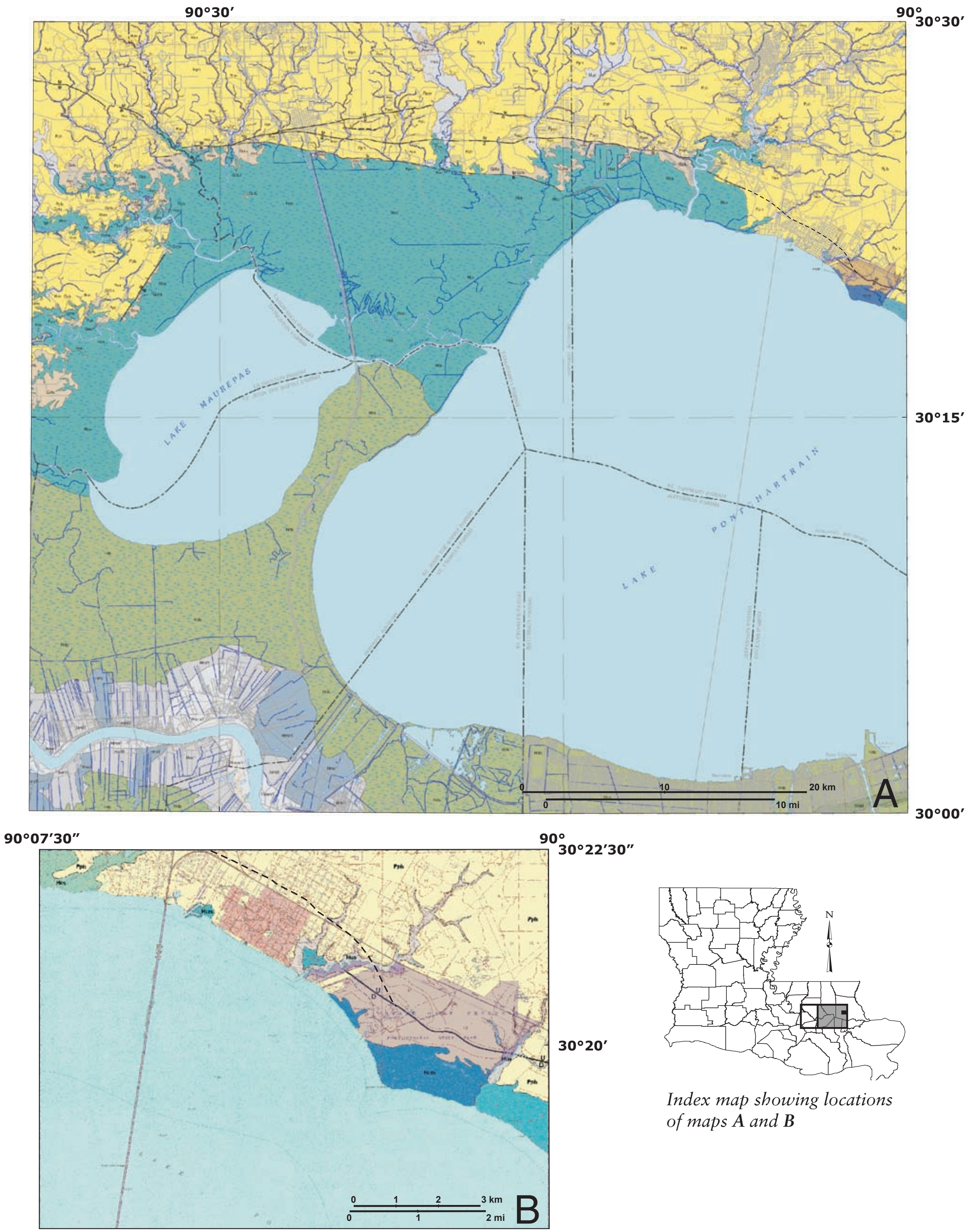
Geologic column showing stratigraphic *units underlying the area including Fontainebleau State Park (redrawn and adapted from Johnston et al., 2000). Surface exposures comprise sediments of the Pleistocene Hammond alloformation and deposits of Holocene age (stream alluvium, coastal swamp, and coastal marsh). The rank (group, formation) of stratigraphic units in this figure and in the text is capitalized for formally defined units and lower-cased for informally defined units. Wavy lines represent surfaces called* unconformities, *which are gaps in the geologic record indicative of nondeposition and/or erosion in the geologic past. Allogroups and alloformations are units of group and formation rank defined and recognized entirely by their having unconformities as boundaries. Colors used for* Erathem, System, Series, *and* Stage *are adapted from those specified for these intervals by the Commission for the Geological Map of the World; colors used for groups and formations shown in the Pliocene-Quaternary interval detailed accord with those used for these units on maps of surface geology prepared by LGS (in the Holocene interval, gray corresponds to Hua, light green to Hcs, and darker green to Hcm). The Paleogene and Neogene systems together correspond to the Tertiary System of previous time scales.* Ma=Mega-annum *(millions of years); diagonal ruling corresponds to intervals of missing record.*

growth faults in the deep subsurface. Faults of the Baton Rouge system are active, but they show some distinctive characteristics that indicate geologically recent reactivation after a long period of dormancy. The renewed movement along older (early Cenozoic) growth-fault trends is related to the downwarping associated with voluminous deltaic sedimentation in the Gulf of Mexico.

Neither the regional nor the detailed depiction of surface geology incorporated a review of LIDAR (LIght Detection And Ranging) imagery when they were compiled. The regional map originally was compiled in 1997 before LIDAR altimetry data and digital elevation models (DEMs) became available, and the detailed map was prepared in 2002 when these data were still quite new. The advent of LIDAR-based images has since revealed a number of linear escarpments in this region and in other parts of southern Louisiana that were too subtle to detect with previously available elevation data.



Schematic section (adapted from Fisk, 1944) showing the geologic setting of the area including Fontainebleau State Park (FSP). In this simplified drawing the yellow sequence corresponds to the Pleistocene Hammond alloformation, and the green and gray sequences correspond to the younger Holocene deposits, the green representing Mississippi River deltaic deposits and the gray representing deposits of the distal alluvial plain of the Mississippi River. The Baton Rouge fault system is generalized as a single zone, with the arrow placed on the downthrown block.

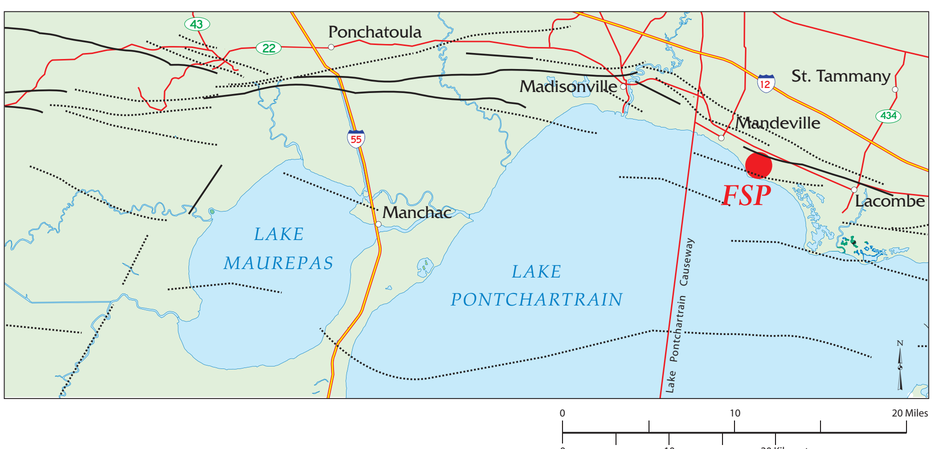


*Index map showing locations of maps **A** and **B***

Surface geology of Fontainebleau State Park. Map A is adapted from McCulloh et al. (2003); map B is from McCulloh and Heinrich (2002). Solid outline on index map is Ponchatoula 30 x 60 minute quadrangle; shaded area within it is map A; solid black area within shaded area is map B. Geologic units are differently colored areas separated by finer lines; heavier lines are faults.

The detailed map of surface geology shows a single fault trace (shown on the map as a solid line) interpreted as displacing the Hammond surface, corresponding to an escarpment interrupting this surface within the park. This fault was mapped previously from differences in elevation shown by a 5-ft (1.5-m) contour interval on the 7.5-minute topographic quadrangle sheet. The LIDAR imagery available for this area since 1999 reveals much finer elevation differences, as small as 0.1 ft (0.03 m) after correcting for the presence of vegetation.

The dashed heavy line on the detailed and regional maps marks an escarpment, discernible on LIDAR images of the area, that could be a continuation of the fault trace that transects the park. This escarpment extends to the northwest and appears continuous with another previously interpreted fault trace aligned with the southern edge of a band of coastal ridges (unit Ppec) shown on the regional map of surface geology. On the map these ridges are shown to be enclosed by a fault bounding their southern edge and by a nearly parallel fault segment near their northwestern edge. In an interpretation based on present information it is conceivable that the edges of the band of coastal ridges could be defined entirely by fault traces, that the edges could be defined largely but only partly by fault traces, or that the edges could be primarily depositional even though the ridges occur in an area traversed by faults. To the west of the ridges, however, some faults of the Baton Rouge system coincide with the Pleistocene-Holocene escarpment at the southern edge of the Hammond alloformation surface exposure, indicating structural control of the position of this boundary in these areas. It is clear that the region of Fontainebleau State Park has significant potential for complex interaction between structure and deposition, and that the specific association between them will be a focus in future geologic mapping.



Surface fault traces interpreted from LIDAR imagery in the region of Fontainebleau State Park (FSP). Known traces are shown by solid lines; suspected traces are shown by fine-dashed lines. Adapted from a systematic LIDAR-based remapping of surface faults in southeastern Louisiana by Van Biersel (2006, fig. 1; used with permission), on a base map consisting of mosaicked 7.5-minute topographic quadrangle sheets.

Geologic Units of Fontainebleau State Park and Vicinity

Hua Holocene undifferentiated alluvium*—Undifferentiated stream deposits of varying textures, filling valleys incised into older deposits.*

Hcs Holocene coastal swamp and marsh*—Gray to black clays of high organic content and thick peat beds, underlying fresh-water marsh and swamp.*

Hcm Holocene coastal marsh*—Gray to black clays, in places containing thin peat beds, underlying brackish and salt-water marsh.*

Hds Deltaic plain deposits of the St. Bernard delta lobe, Mississippi River

Hdsl Natural levee complex of the St. Bernard delta lobe, Mississippi River

Hmm1 Mississippi River meander belt 1*—Point-bar deposits of Mississippi river meander belt 1, buried by a thin layer of overbank sediments.*

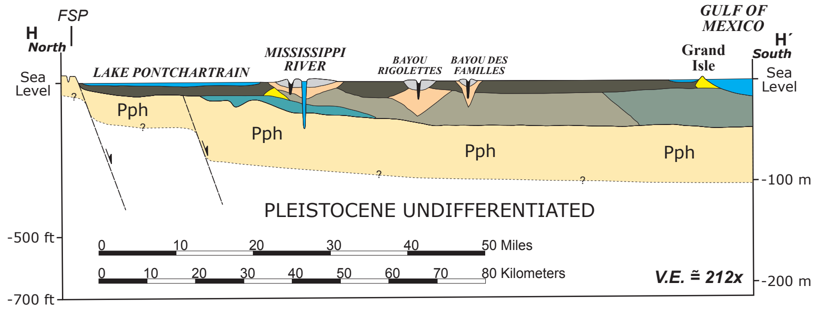
Hml1 Natural levee complex of Mississippi River meander belt 1*—Deposits of the natural levees flanking Mississippi River meander belt 1.*

Hmc1 Crevasse complex of Mississippi River meander belt 1*—Crevasse channel and splay deposits of Mississippi River meander belt 1.*

Qctu Undifferentiated low coastal terrace*—Sediment underlying a coastal terrace beneath the level of the Hammond surface in the area north of Lake Pontchartrain, consisting of gray-brown silt and very fine sand showing weak consolidation and soil development.*

Ppec Relict Pleistocene coastal ridges*—Ridges parallel to the coast that have been delineated for parts of the surface of the Hammond alloformation.*

Pph Hammond alloformation*—Deposits of late Pleistocene coastal plain streams in the Florida Parishes of southeastern Louisiana.*



Key

- Pph — Pleistocene Hammond alloformation, Prairie Allogroup
- Natural levee
- Abandoned channel fill
- Distributary channel complex—delta front, distributary mouth bar, crevasse, point bar, abandoned course, backswamp
- Interdistributary deposits—bay fill, lacustrine, marsh, swamp
- Prodelta
- Beach
- Nearshore Gulf—marine facies undifferentiated
- Deltaic plain undifferentiated
- Fault, arrow on downthrown block

Index map showing cross-section location

Shallow-subsurface geology along a line of section passing approximately 6 mi (10 km) to the west of Fontainebleau State Park (FSP, position projected onto the line of section). V.E. = vertical exaggeration. Modified from Autin (1990; cross section H–H' accompanying Autin et al., 1991; used with permission). Since this section was constructed, additional suspected surface faults have been identified in the area traversed by the cross section to the south of Lake Pontchartrain (Gagliano et al., 2003).

Subsurface Geology

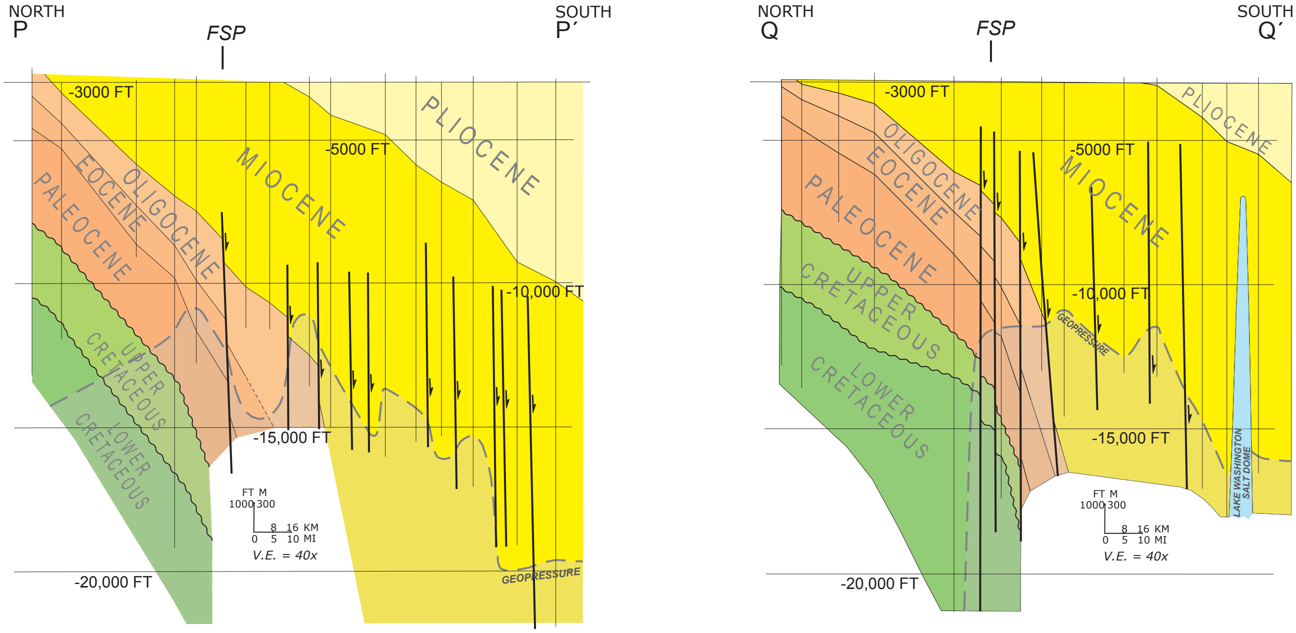
The base of the upper Pleistocene (Quaternary) Hammond alloformation is approximately several hundred feet deep beneath the park grounds. Its exact thickness, and the consequent depth to the top of the underlying Pliocene (upper Neogene) Citronelle Formation, is uncertain because of ambiguity introduced by a decades-old classification controversy. The Citronelle and its equivalents originally were classified as Pliocene, and still are in adjacent states, but were viewed as Pleistocene in Louisiana through much of the 20th century. More recently, work in the past decade that focused on the Citronelle in Louisiana has confirmed that it is Pliocene. Correlating this and other post-Miocene/pre-Holocene surface geologic units with the shallow-subsurface aquifer units recognized by hydrologists, however, is still a problem to be solved.

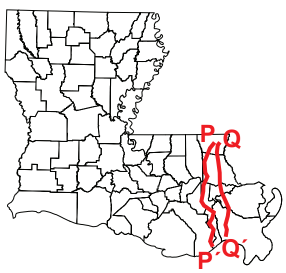
In the deep subsurface beneath the area encompassing Fontainebleau State Park, the Cenozoic-Mesozoic contact (base of Paleogene and top of Cretaceous strata) is deeper than 13,000 ft (approximately 4,000 m): it is at 13,300 ft (approximately 4,050 m) below sea level in section Q–Q', and nearly 17,500 ft (approximately 5,330 m) below sea level in section P–P'.

Mineral Resources

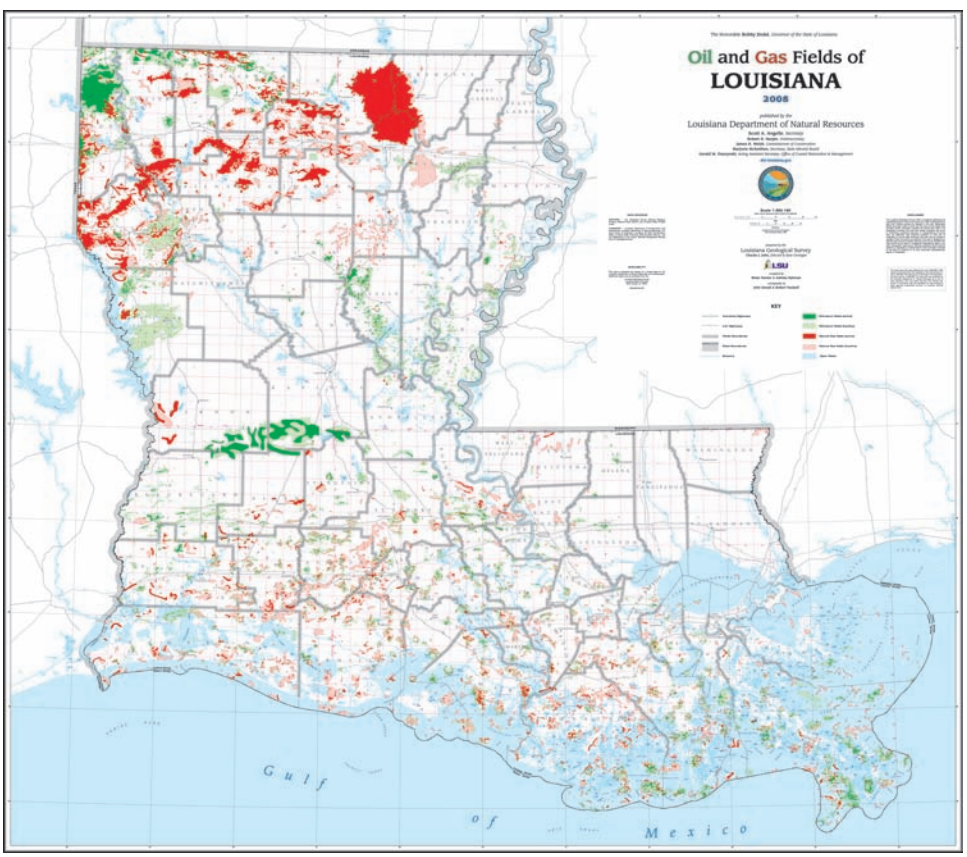
Fuels

Hydrocarbons are not produced from beneath park lands; the nearest production has been from the Big Point gas field (discovered in 1946 but now depleted) in Lake Pontchartrain 7 mi (11.3 km) to the southeast. As of 2008, no oil or gas had been produced from onshore St. Tammany Parish apart from the Mulatto Bayou field, discovered in 1964, near the southeastern tip of the parish. The deep Tuscaloosa gas trend extends beneath the southern part of the parish but has been tested fairly extensively, and no wells have proved to be commercially productive. The Austin Chalk trend, developed in the 1990s, extended into Louisiana from Texas, but thus far its easternmost extent still lies 28 mi (45 km) west of St. Tammany Parish.





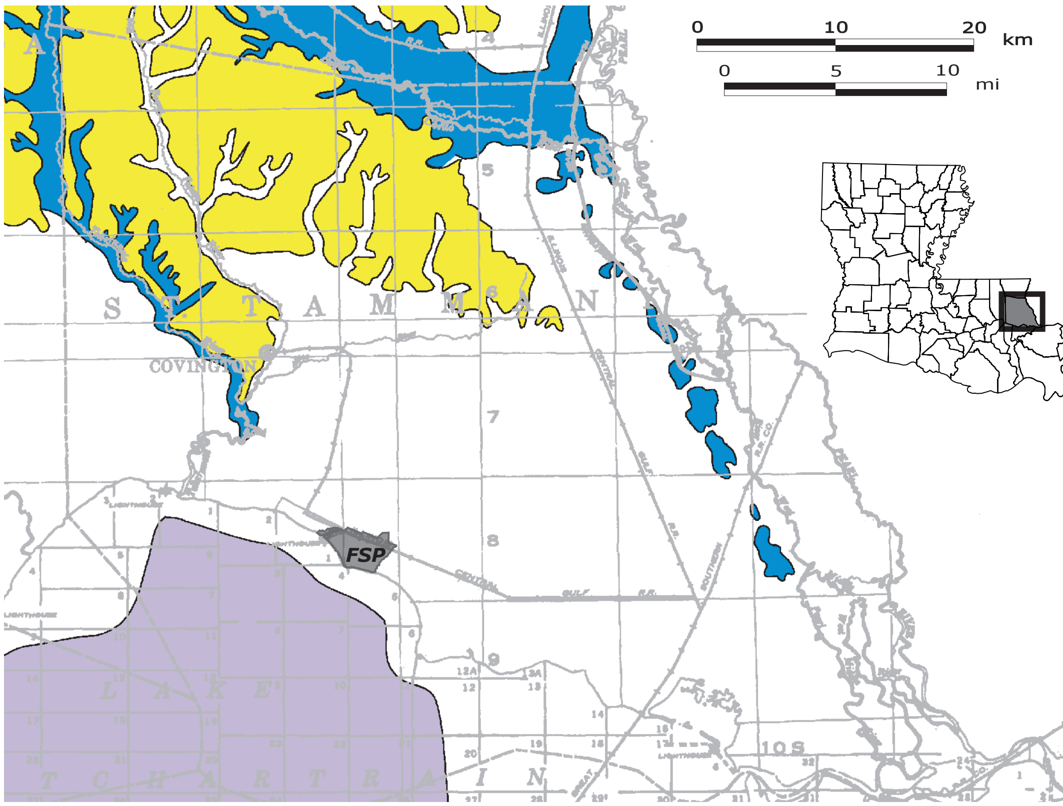
Regional cross sections showing the deep-subsurface geology underlying the area including Fontainebleau State Park (FSP), based on information from wells drilled for oil and gas (redrawn and adapted from Bebout and Gutiérrez, 1983, their sections P–P' and Q–Q').Upper boundary of each section lies in the subsurface at an elevation of 3,000 ft below sea level. Only major unconformities (wavy lines) and fault zones (heavy lines, generalized for zones with much greater displacement than the individual faults show at the surface) are shown. "Geopressure" refers to pressure of fluid that typically underlies a regionally extensive seal and exceeds that pressure that would derive solely from the weight of the fluid in pores; vertical lines represent wells; V.E. = vertical exaggeration.



Distribution of hydrocarbon production in Louisiana, showing relative scarcity of oil and gas fields in onshore St. Tammany (gray tint) and adjacent parishes (redrawn and adapted from Louisiana Geological Survey, 1981, and Harder and Rahman, 2008). No hydrocarbons have been produced from beneath Fontainebleau State Park (FSP) or its vicinity.

Nonfuels

St. Tammany Parish yields extensive sand and gravel, predominantly from strata of the Hammond alloformation, but the potential for commercially significant gravel deposits is principally north of Covington. There appears to be no potential for salt or sulfur within about 25 mi (40 km) of the park. No previous tradition of salt or sulfur production exists in the area because no salt domes are known to underlie the parish, and essentially no potential exists at present for recovery of sulfur as a byproduct from oil in St. Tammany Parish because of the general scarcity of hydrocarbon production.



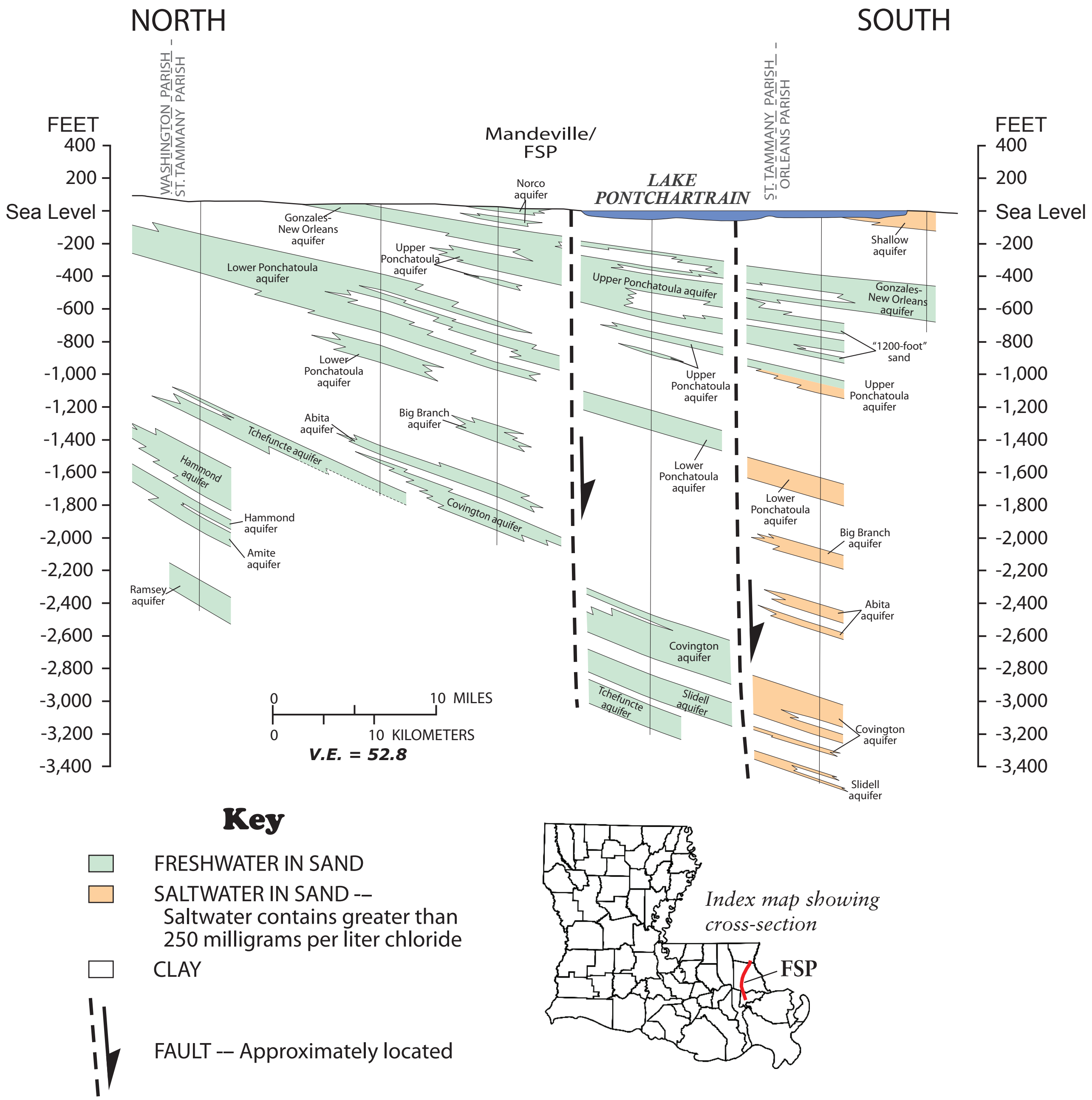
Distribution of nonfuel mineral resources in the area including Fontainebleau State Park (FSP), adapted from Heinrich and McCulloh (1999). Yellow and blue represent areas having potential for sand and gravel resources, showing areas with gravel in clayey or iron oxide matrix (yellow) or in sandy matrix (blue).Lavender represents area of former production of shells of the brackish-water clam genus Rangia *in Lake Pontchartrain, which was discontinued in 1990.*

	Mississippi River Valley	New Orleans Area	Baton Rouge Area	Western Florida Parishes	Eastern Florida Parishes	State of Mississippi	Geologic Age
	Mississippi River Alluvial	Shallow Sand	Shallow Sand	Shallow Sand	Shallow Sand	Post-Graham Ferry	Holocene
		Gramercy					Pleistocene
		Norco					
		Gonzales-New Orleans					
Chicot Equivalent		1,200-foot Sand	400-foot Sand	Upland Terrace	Upper Ponchatoula	Citronelle	Pliocene
			600-foot Sand	Upper Ponchatoula		Upper Graham Ferry	
Evangeline Equivalent			800-foot Sand	Lower Ponchatoula	Lower Ponchatoula	Lower Graham Ferry	
	1,000-foot Sand		1,000-foot Sand				
	1,200-foot Sand		1,200-foot Sand		Big Branch		
	1,500-foot Sand		1,500-foot Sand	Kentwood	Abita	Upper Pascagoula	Miocene
	1,700-foot Sand		1,700-foot Sand		Covington	Lower Pascagoula	
				Slidell	Slidell		
Jasper Equivalent	2,000-foot Sand		2,000-foot Sand	Hammond	Tchefuncte/ Hammond	Upper Hattiesburg	
	2,400-foot Sand		2,400-foot Sand	Amite	Amite		
	2,800-foot Sand		2,800-foot Sand	Ramsay	Ramsay	Lower Hattiesburg	
Catahoula Equivalent	Catahoula		Catahoula	Franklinton	Franklinton	Upper Catahoula	
						Lower Catahoula	Oligocene

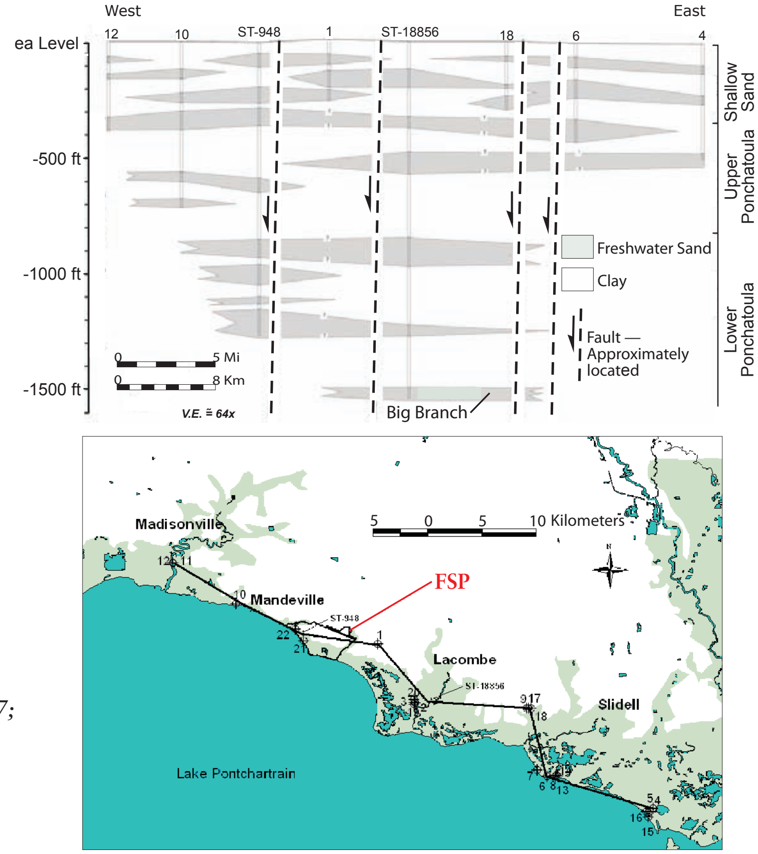
Hydrostratigraphic column for southeastern Louisiana (Van Biersel, 2008), including the Eastern Florida Parishes (yellow tint), in which Fontainebleau State Park is located.

Ground Water

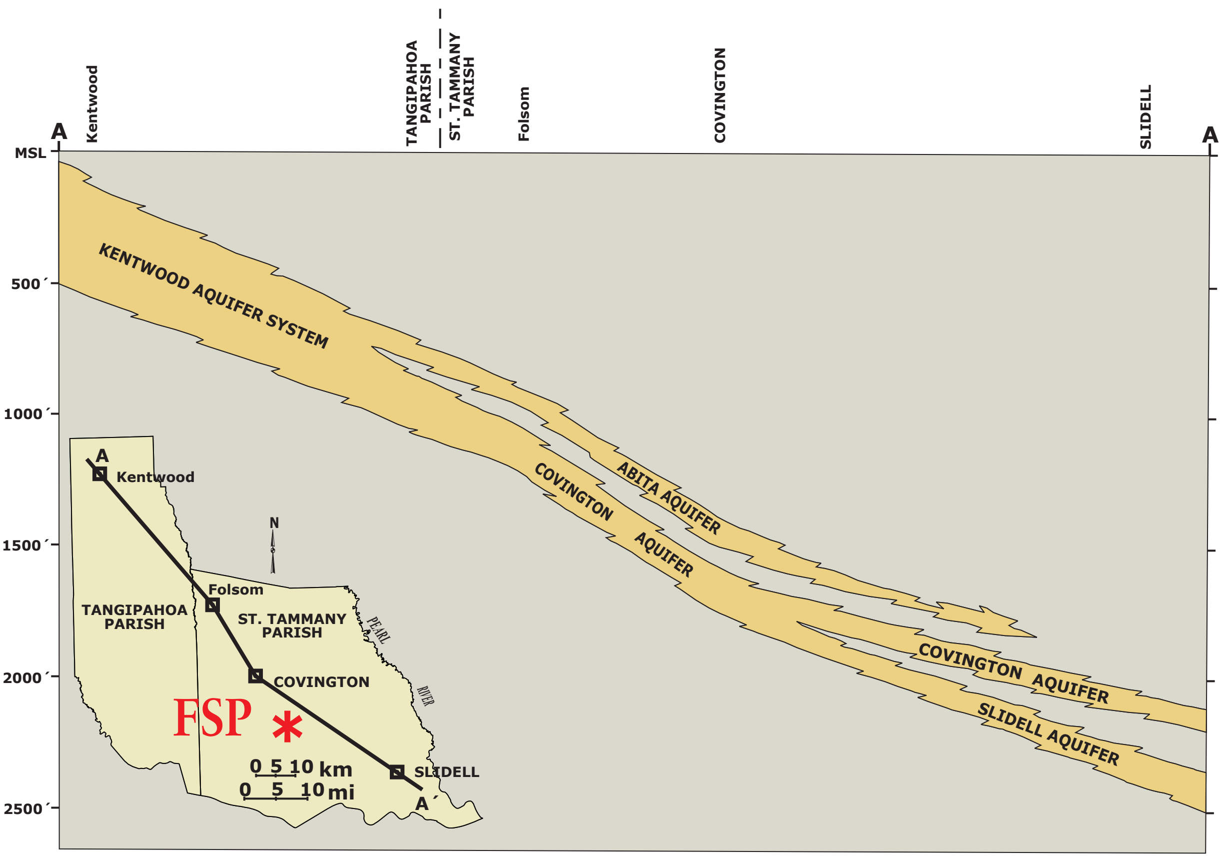
Ground water is abundant in the area and is available in quantity and quality suitable for public and rural domestic supply. Many important aquifers underlie the area. They include, from deepest to shallowest, Amite, Hammond, and Tchefuncte aquifers (Jasper aquifer system); Slidell, Covington, Abita, Big Branch, and Lower Ponchatoula aquifers (Evangeline aquifer system); and Upper Ponchatoula and Shallow Sand aquifers (Chicot aquifer system). These all are grouped into a larger complex of aquifers termed the Southern Hills Aquifer System. The aquifers tapped in the Fontainebleau State Park area are the Lower Ponchatoula, Big Branch, and Abita. The Shallow Sand aquifer directly beneath the park is recharged from the surface by rainwater infiltration and by local streams and rivers. The deeper aquifers are recharged in southern Mississippi where they crop out at the surface. The Abita aquifer is thin or missing beneath the southeastern part of the park.



Regional hydrostratigraphic section showing distribution of important aquifers underlying Fontainebleau State Park (FSP) and vicinity (redrawn and adapted from Griffith, 2003). Vertical lines represent wells; V.E. = vertical exaggeration.



Hydrostratigraphic section showing distribution of aquifers in the shallow section beneath Fontainebleau State Park (FSP) and vicinity (adapted from Van Biersel et al., 2007; used with permission). Map shows the line of section and numbered wells corresponding to those in the section. V.E. = vertical exaggeration.



Schematic regional hydrostratigraphic section showing relationships between aquifers within the Kentwood aquifer system (redrawn and adapted from Nyman and Fayard, 1978). Inset index map shows the line of section A–A' and the location of Fontainebleau State Park (FSP). MSL = mean sea level.

Archeological Sites

The park is home to several archaeological sites, the principal one of which is known as the Tchefuncte site. This site is located near the park's eastern boundary within 0.5 mi (0.8 km) of the north shore of Lake Pontchartrain, and is the type site for the culture whose name it bears.

The Tchefuncte culture, which succeeded the Poverty Point culture, is one of the best documented prehistoric cultures in the lower Mississippi valley and the Gulf Coast of the United States. People of this culture lived between 1,000 B.C.E. and 200 C.E. in coastal areas and in lowlands near streams, and they were the first to make large amounts of pottery in Louisiana. Most Tchefuncte sites have been found in coastal Louisiana, but ceramics of the culture have been found from eastern Texas to eastern Florida and northward to southern Arkansas. The sites typically contain large shell middens (refuse heaps), and their artifacts include large quantities of pottery fragments.

The Tchefuncte site in Fontainebleau State Park is distinguished by two shell middens. Owing primarily to commercial dredging for construction material in the late 1930s and subsequent excavation by CCC construction crews into the early 1940s for roadwork in the park, both middens have been reduced significantly in size, one to the point of complete removal. Originally, the oval middens, composed mainly of shells of the brackish-water clam *Rangia cuneata*, measured 5 ft (1.5 m) thick and 100+ ft (30+ m) across. By the mid 1940s, excavations of the middens had yielded nearly 50,000 ceramic fragments. Radiocarbon dating of materials from the site indicate it was occupied primarily between approximately 900 B.C.E. and 1 C.E.

Acknowledgments

This publication is amplified from a document originally produced in response to a query in 1992 from Karl Morgan, then Public Lands Manager with the Division of Administration, State Land Office, requesting a synopsis of the geology of Fontainebleau State Park and Southeast Louisiana State Hospital. The author thanks Chacko J. John, State Geologist and Director of the Louisiana Geological Survey (LGS), for supporting the inauguration of this series and the preparation of this publication. Assistance from Fontainebleau State Park personnel Terri L. Jenkins (Administrative Coordinator) and Frank Jones (Manager) was essential to the description of facilities and services available at the park. I am grateful to several persons with the Louisiana Department of Culture, Recreation, and Tourism (CRT) for helpful consultation on a range of topics: Sharon Broussard, Public Information Officer for the Office of State Parks with CRT, regarding the park's history and holdings; Patricia L. Duncan, National Register Program, Louisiana Division of Historic Preservation, regarding attribution of documents posted on the Division's Web site; and John Lavin, who provided a current map of the park boundaries and surrounding area as used for the illustrations. I also benefited from consultation with the following: Brian Harder (LGS) regarding an updated rendering of areas of hydrocarbon production in Louisiana; Malcolm Shuman of Surveys Unlimited Research Associates, Inc. (SURA), regarding the Tchefuncte archaeological site; and Lorene E. Smith of the LSU Museum of Natural Science, regarding the complete route of the Tammany Trace hiking and biking trail. Patrick O'Neill (LGS) provided the photographs from among those he took during an excursion to the park, and Fontainebleau State Park provided the photographs of its lodge.

Glenn Griffith (Dynamac Corporation / U.S. Environmental Protection Agency), Riley Milner (LGS), and Thomas Van Biersel (LGS) reviewed draft versions of the manuscript, and their comments led to substantial improvements. Paul V. Heinrich (LGS) reviewed the section on archeological sites. Thomas Van Biersel (LGS) and Erin L. Walden (LGS student employee) selected the terms for inclusion in the glossary, and Marybeth Pinsonneault (LSU Center for Energy Studies) consulted with the author regarding formatting the first-use of glossary terms in the narrative.

Diane Lane edited the final manuscript for public release, and Lisa Pond (LGS) developed and prepared the graphic layout and design of the final document.

Glossary

alloformation—A stratigraphic unit of formation rank defined and recognized entirely by its having unconformities as boundaries.

allogroup—A stratigraphic unit of group rank defined and recognized entirely by its having unconformities as boundaries.

alluvial—Relating to, or consisting of, alluvium.

alluvium—Unconsolidated sediment consisting of a mix of clay, silt, sand, and/or gravel, deposited in or by streams.

brackish—Said of water that is intermediate between fresh water and sea water in its saltiness, or salinity.

Cenozoic—The youngest era of the geologic time scale; also the strata and rocks formed during this era, corresponding to the uppermost erathem of the geologic rock record.

clay—Fine-grained sediment produced by weathering and disintegration of preexisting rocks, of particle size less than 1/16 (0.0625) mm; it typically is characterized by distinct minerals (clay minerals) relative to those predominating in most coarser sediment.

deltaic—Relating to, or deposited by or on, a delta or deltas.

dissected—A reference to the eroded character of landscapes incised (cut), gullied, and sculpted to varying degrees by downcutting streams.

ecoregion—An area of similarity in ecosystems and environmental resources among the mosaic of biotic, abiotic, aquatic, and terrestrial ecosystem components that have been interpreted and mapped for a larger encompassing area. Ecoregions are organized into a hierarchical scheme with subdivisions designated by Roman numerals. Level I divides North America into 15 ecoregions, and level II divides it into 52 regions; level III further subdivides level II ecoregions, and level IV further subdivides level III ecoregions.

ecosystem—A community of organisms and their interactions, considered collectively as integrated and interacting with their physical environment and functioning with it as a unit.

***en echelon*—**A reference to a pattern characterized in map or plan view by discontinuous and discrete, but parallel and overlapping, linear segments arrayed in a zone or trend that shows a consistent overall orientation.

erathem—The strata and rocks formed during a particular era of geologic time; composed of subunits termed systems. (The hierarchy erathem/system/series/stage corresponds directly with the geologic-time hierarchy era/period/epoch/age.)

fault—A relatively thin boundary, constituting an essentially planar zone or surface in three dimensions, along which rocks have ruptured to produce two blocks that move relative to one another.

fault system—A group of fault zones and/or an array of faults viewed as related and referred to collectively.

gravel—Sediment originally produced by fragmentation and disintegration of preexisting rocks, of particle size greater than 2 mm, divided by size into classes termed granules, pebbles, cobbles, and boulders.

growth fault—A fault that is or was active during the deposition of some of the strata it displaces, as a result of which the thickness of such strata on the downthrown side expands or "grows," in some cases very dramatically.

Holocene—The upper series of the Quaternary System, overlying the Pleistocene Series; also the epoch of time during which this series was deposited. The Holocene is the most recent epoch of Earth's geologic history, which began after the last glaciation, between 10,000 and 12,000 years ago.

LIDAR—Acronym for LIght Detection And Ranging, a reference to laser altimetry (terrain-altitude measurement via laser) and to imagery produced from digital elevation data generated in this manner once it is processed and prepared to model the ground surface.

loam—A permeable soil of a texture and consistency easily crumbled by hand, composed of a mixture of clay, silt, and sand with some organic matter content.

Neogene—The middle system of the Cenozoic Erathem, overlying the Paleogene System; also the period of time during which this system was deposited.

peat—A sedimentary deposit rich in organic matter and composed of unconsolidated, water-saturated plant remains; the initial stage in the development of coal.

Paleogene—The lower system of the Cenozoic Erathem; also the period of time during which this system was deposited.

Pleistocene—The lower series of the Quaternary System, underlying the Holocene Series; also the epoch of time during which this series was deposited, marked by intervals of continental glaciation and known informally as the ice age.

Quaternary—The upper system of the Cenozoic Erathem, overlying the Neogene System; also the period of time during which this system was deposited.

saline—In reference to coastal marsh, saltiness (salinity) of water comparable to that of sea water.

sand—Sediment originally produced by fragmentation and disintegration of preexisting rocks, of particle size between 1/16 (0.0625) and 2 mm.

sandy loam—Loam containing approximately 50 percent or more sand.

series—The strata and rocks formed during a particular epoch of geologic time; composed of subunits termed stages.

silt—Sediment originally produced by fragmentation and disintegration of preexisting rocks, of particle size between 1/256 (0.0039) and 1/16 (0.0625) mm.

stage—The strata and rocks formed during a particular age of geologic time.

storm surge—A temporary rise in level of the ocean adjacent to a coastline, produced by increased wind velocity and decreased atmospheric pressure accompanying a storm, such that sea water overrides normally dry land.

stratigraphic unit—A unit of stratified (layered), predominantly sedimentary rock grouped according to its distribution, thickness, composition, texture, internal features, fossils, and other distinctive attributes.

system—The strata and rocks formed during a particular period of geologic time; composed of subunits termed series.

terrace—A surface having in profile the overall form of a step, consisting of a relatively flat part marked by steeper escarpments below it on one side and above it on another side.

terraced—Having the form of one or more terraces.

Tertiary—The lower system of the Cenozoic Erathem, underlying the Quaternary System; also the period of time during which this system was deposited. This name was discontinued in the time scale ratified by the International Union of Geological Sciences in 2009, which uses the names Paleogene and Neogene systems for lower and upper portions of the same interval.

trend—An array of oil and/or gas fields, or faults, that is linear in map view, or the compass orientation of such an array.

type site—The location taken as an internationally accepted standard of reference for a distinct type of tool, assemblage, or culture.

unconformity—A surface corresponding to a gap in the geologic record indicative of nondeposition and/or erosion in the geologic past.

Information Sources

[n.d., no date given]

Location and Facilities

Louisiana Department of Culture, Recreation and Tourism, n.d., Louisiana state parks—A guide to Louisiana's state parks, state historic sites and preservation areas: Baton Rouge, Louisiana Department of Culture, Recreation and Tourism, Office of State Parks, folded 1-sheet brochure.

Louisiana Department of Culture, Recreation and Tourism, 2007a, Louisiana state parks—Greater New Orleans: Baton Rouge, Louisiana Department of Culture, Recreation and Tourism, Office of State Parks, folded 1-sheet brochure.

Louisiana Department of Culture, Recreation and Tourism, 2007b, Fontainebleau State Park: Louisiana Department of Culture, Recreation and Tourism, Office of State Parks, http://www.crt.state.la.us/parks/ifontaine.aspx Accessed (monthDecember, day16, year2009).

Louisiana Department of Transportation and Development, 2001, 2001 official highway map of Louisiana: Baton Rouge, Louisiana Department of Transportation and Development, approximate scale 1:760,320, 1 folded sheet.

The Tammany Trace, 2008, Find the Trace, *in* A visitor's guide to the Tammany Trace: The Tammany Trace, <http://www.tammanytrace.org/find.shtml#map> Accessed January 22, 2008.

U.S. Fish and Wildlife Service, n.d., Big Branch Marsh National Wildlife Refuge: U.S. Fish and Wildlife Service, <http://www.fws.gov/refuges/profiles/recEdMore.cfm?ID=43558> Accessed November 26, 2007.

U.S. Fish and Wildlife Service, n.d., Big Branch Marsh National Wildlife Refuge: U.S. Fish and Wildlife Service, 2 p., <http://www.fws.gov/southeast/pubs/facts/bgbcon.pdf> Accessed November 26, 2007.

U.S. Geological Survey, 1998, Mandeville, LA: 7.5-minute topographic quadrangle map, scale 1:24,000.

Natural Regions

Barras, J. A., 2007, Satellite images and aerial photographs of the effects of hurricanes Katrina and Rita on coastal Louisiana: U.S. Geological Survey Data Series 281 (Version 1.0, posted July 2007), <http://pubs.usgs.gov/ds/2007/281> Accessed December 16, 2009(month, day, year).

Chalk Butte Inc., 1995, Eleven large digital maps: Boulder, Wyoming, Chalk Butte, Inc., digital images.

Daigle, J. J., G. E. Griffith, J. M. Omernik, P. L. Faulkner, R. P. McCulloh, L. R. Handley, L. M. Smith, and S. S. Chapman, 2006, Ecoregions of Louisiana: U.S. Environmental Protection agency; color poster with map, descriptive text, summary tables, and photographs; map scale 1:1,000,000, <http://www.epa.gov/wed/pages/ecoregions/la_eco.htm> Accessed December 16, 2009(month, day, year).

Goins, C. R., and J. M. Caldwell, 1995, Historical atlas of Louisiana: Norman, Oklahoma, University of Oklahoma Press, maps and accompanying text.

Keys, J., Jr., C. Carpenter, S. Hooks, F. Koenig, W. H. McNab, W. Russell, and M. L. Smith, 1995, Ecological units of the eastern United States—First approximation: Atlanta, Georgia, U.S. Department of Agriculture, Forest Service; GIS coverage in ARCINFO format, selected imagery, and map unit tables, on 1 compact disc.

Lester, G. D., S. G. Sorensen, P. L. Faulkner, C. S. Reid, and I. E. Maxit, 2005, Louisiana Comprehensive Wildlife Conservation Strategy: Baton Rouge, Louisiana Department of Wildlife and Fisheries, 455 p., <http://www.wlf.louisiana.gov/experience/wildlifeactionplan/wildlifeplandetails/> Accessed December 16, 2009(month, day, year).

National Wildlife Federation, n.d., Big Branch National Wildlife Refuge: National Wildlife Federation, <http://online.nwf.org/site/PageServer?pagename=Louisiana_Big_Branch> Accessed November 26, 2007.

The Nature Conservancy, 2007, East Gulf Coastal Plain: The Nature Conservancy, <http://www.nature.org/wherewework/northamerica/states/louisiana/preserves/art6869.html> Accessed December 16, 2009(month, day, year).

U.S. Fish and Wildlife Service, n.d., Big Branch Marsh National Wildlife Refuge: U.S. Fish and Wildlife Service, <http://www.fws.gov/refuges/profiles/index.cfm?id=43558> Accessed November 26, 2007.

U.S. Fish and Wildlife Service, n.d., Big Branch Marsh National Wildlife Refuge: U.S. Fish and Wildlife Service, 2 p., <http://www.fws.gov/southeast/pubs/facts/bgbcon.pdf> Accessed November 26, 2007.

U.S. Fish and Wildlife Service, n.d., Big Branch Marsh National Wildlife Refuge: U.S. Fish and Wildlife Service, map and 1-p. text, <http://www.fws.gov/southeast/pubs/bigtear.pdf> (color) and <http://library.fws.gov/Refuges/bigbranchmarsh_map.pdf> (monochrome). Both versions accssed November 26, 2007.

Geology

Surface Geology

Autin, W. J., 1990 [1991], Plate 7, Lower Mississippi Valley cross sections [cross section H–H'], approximate horizontal scale 1:524,928, approximate vertical scale 1:2,470, *in* R. B. Morrison, ed., Quaternary nonglacial geology—Conterminous U.S.; v. K-2 *of* The Geology of North America: Boulder, Colorado, Geological Society of America, plate 7, scale _____ (accompanies Autin et al., 1991).

Autin, W. J., S. F. Burns, B. J. Miller, R. T. Saucier, and J. I. Snead, 1991, Quaternary geology of the lower Mississippi Valley, *in* R. B. Morrison, ed., Quaternary nonglacial geology—Conterminous U.S.; v. K-2 *of* The Geology of North America: Boulder, Colorado, Geological Society of America, chapter 18, p. 547–582.

Chabreck, R. H., and G. Linscombe, 1978, Vegetative type map of the Louisiana coastal marshes: New Orleans, Louisiana Department of Wildlife and Fisheries, scale 1:380,160 (1inch = 6 miles).

Cullinan, T. A., 1969, Contributions to the geology of Washington and St. Tammany parishes, Louisiana: U.S. Army Corps of Engineers, New Orleans district, 287 p. plus plates.

Durham, C. O., Jr. (compiler), 1982 [Baton Rouge and Denham Springs–Scotlandville fault zones, Florida parishes, Louisiana]: Baton Rouge, Louisiana Geological Survey, unpublished map, scale 1:250,000.

Fisk, H. N., 1944, Geological investigation of the alluvial valley of the lower Mississippi River: Vicksburg, Mississippi, War Department, U.S. Army Corps of Engineers, 78 p. plus plates.

Gagliano, S. M., E. B. Kemp, K. M. Wicker, and K. S. Wiltenmuth, 2003, Active geological faults and land change in southeastern Louisiana: Final report prepared for U.S. Army Corps of Engineers, New Orleans District under contract no. DACW 29–00–C–0034 and presented to the CWPPRA Task Force, New Orleans, by Coastal Environments, Inc., Baton Rouge (CEI–2003–001), 178 p.

Gibbard, P. L., M. J. Head, M. J. C. Walker, and the Subcommission on Quaternary Stratigraphy, 2009, Formal ratification of the Quaternary System/Period and the Pleistocene Series/Epoch with a base at 2.58 Ma: Journal of Quaternary Science, v. 24, Digital Object Identifier: 10.1002/jqs.1338.

Kolb, C. R., F. L. Smith, and R. C. Silva, 1975, Pleistocene sediments of the New Orleans–Lake Pontchartrain area: Vicksburg, Mississippi, U.S. Army Corps of Engineers Technical Report S–75–6, 7 p. plus 49 plates.

Louisiana Geological Survey, 2008, Generalized geology of Louisiana: Baton Rouge, Louisiana Geological Survey, page-size map with narrative text on back.

McCarty, P., and S. Penland, 2002, Geologic setting of the Big Branch shoreline, *in* S. Penland, A. Beall, and J. Kindinger, eds., Environmental atlas of the Lake Pontchartrain Basin: Lake Pontchartrain Basin Foundation, New Orleans, LA, Basin geology—Geology: U.S. Geological Survey Open-File Report 02-206, <http://pubs.usgs.gov/of/2002/of02-206/geology/geologic-setting.html> Accessed November 28, 2007.

McCulloh, R. P., and P. V. Heinrich (compilers), 2002, Mandeville, LA, 7.5-minute geologic quadrangle: Baton Rouge, Louisiana Geological Survey Open-File Map 2002-04, scale 1:24,000.

McCulloh, R. P., P. Heinrich, and J. Snead (compilers), 1997, Ponchatoula, Louisiana 30 × 60 minute geologic quadrangle (preliminary): Prepared in cooperation with U.S. Geological Survey, STATEMAP program, under cooperative agreement no. 1434–HQ–96–AG–01490, 1 map plus explanation and notes, scale 1:100,000.

McCulloh, R. P., P. V. Heinrich, and J. Snead (compilers), 2003, Ponchatoula 30 × 60 minute geologic quadrangle: Baton Rouge, Louisiana Geological Survey (any series name and number here), scale 1:100,000.

Penland, S., A. Beall, and J. Kindinger (eds.), 2002, Environmental Atlas of the Lake Pontchartrain Basin: U.S. Geological Survey Open-File Report 02-206, <http://pubs.usgs.gov/of/2002/of02-206/> and <http://pubs.usgs.gov/of/2002/of02-206/index.html> Both accessed November 28, 2007 (also available on CD-ROM).

Saucier, R. T., 1994, Geomorphology and Quaternary geologic history of the lower Mississippi Valley: Vicksburg, Mississippi, U.S. Army Corps of Engineers Waterways Experiment Station (two volumes).

Saucier, R. T., and J. I. Snead (compilers), 1989, Quaternary geology of the lower Mississippi Valley, *in* R. B. Morrison, ed., Quaternary nonglacial geology—Conterminous U.S.; v. K-2 of The Geology *of* North America: Boulder, Colorado, Geological Society of America, plate 6, scale 1:1,100,000.

Snead, J. I., and R. P. McCulloh (compilers), 1984, Geologic map of Louisiana: Baton Rouge, Louisiana Geological Survey, scale 1:500,000,1 sheet.

Van Biersel, T. P., 2006, The extent of geologic control on the storm surge flooding by Hurricane Katrina along the north shore of Lake Pontchartrain, southeastern Louisiana: (place of publication?), Gulf Coast Association of Geological Societies Transactions, v. 56, p. 847–857.

Subsurface Geology

Bebout, D. G., and D. R. Gutiérrez, 1983, Regional cross sections, Louisiana Gulf Coast (eastern part): Baton Rouge, Louisiana Geological Survey Folio Series No. 6, 10 p.

Gulf Coast Association of Geological Societies and American Association of Petroleum Geologists, 1972, Tectonic map of the Gulf Coast region U.S.A.: Gulf Coast Association of Geological Societies and American Association of Petroleum Geologists(put publisher here, even if it is both of the organizations listed as authors or one of them), scale 1:1,000,000, __1 sheet.

Hanor, J. S., 1982, Reactivation of fault movement, Tepetate fault zone, south central Louisiana: Gulf Coast Association of Geological Societies Transactions, v. 32, p. 237–245.

Heinrich, P. V., and R. P. McCulloh, 2000, Pliocene surface stratigraphy in the Fort Polk region—Implications for Louisiana surface geology: (where published?) Baton Rouge, Basin Research Institute Bulletin, v. 9, p. 51–74.

Johnston, J. E., III, P. V. Heinrich, J. K. Lovelace, R. P. McCulloh, and R. K. Zimmerman, 2000, Stratigraphic charts of Louisiana: Baton Rouge, Louisiana Geological Survey, Folio Series No. 8, 6 p.

Mineral Resources

Fuels

Geomap Company (compiler), 2007, State of Louisiana: Plano, Texas, Geomap Company, approximate scale 1:360,000 (1 inch = 30,000 ft), 1 sheet.

Harder, B., and A. Rahman (compilers), 2008, Oil and gas fields of Louisiana: Baton Rouge, Louisiana Geological Survey, scale 1:380,160 (1 inch = 6 miles), 1 sheet.

Louisiana Geological Survey (compiler), 1981, Oil and gas map of Louisiana: Baton Rouge, Louisiana Geological Survey, scale 1:380,160 (1 inch = 6 miles), 1 sheet.

Marsalis, B., C. John, B. Harder, R. Bourgeois, and R. Milner, 2000, Louisiana petroleum industry facts: Baton Rouge, Louisiana Geological Survey Public Information Series, no. 2, 7 p.

Nonfuels

Heinrich, P. V., and R. P. McCulloh, 1999, Mineral resources map of Louisiana: Baton Rouge, Louisiana Geological Survey, scale 1:500,000, 1 sheet.

U.S. Geological Survey, 2003, The mineral industry of Louisiana, in U.S. Geological Survey minerals yearbook—2002; Mineral Industry Surveys: Louisiana—2002 annual estimate: Reston, Virginia, U.S. Geological Survey, p. 20.0–20.3.

Ground Water

Boniol, D. P. (compiler), 1988, Recharge potential of Louisiana aquifers: Baton Rouge, Louisiana Geological Survey, map prepared for Louisiana Department of Environmental Quality (funded by U.S. Environmental Protection Agency), scale 1:750,000.

Cardwell, G. T., H. C. McWreath, III, and J. E. Rogers, 1985, Louisiana ground-water resources, *in* U.S. Geological Survey, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, p. 229–236.

Griffith, J. M., 2003, Hydrogeologic framework of southeastern Louisiana: Baton Rouge, Louisiana Department of Transportation and Development, Office of Public Works and Intermodal Public Works and Water Resources Division, Water Resources Technical Report No. 72, 21 p. plus plates.

Nyman, D. J., and L. D. Fayard, 1978, Ground-water resources of Tangipahoa and St. Tammany parishes, southeastern Louisiana: Baton Rouge, Louisiana Department of Transportation and Development, Office of Public Works, Water Resources Technical Report No. 15, 76 p. plus plates.

Tomaszewski, D. J., J. K. Lovelace, and P. A. Ensminger, 2002, Water withdrawals and trends in ground-water levels and stream discharge in Louisiana: Baton Rouge, Louisiana Department of Transportation and Development, Public Works and Water Resources Division, Water Resources Section, Water Resources Technical Report No. 68, prepared in cooperation with U.S. Geological Survey, 30 p.

Van Biersel, T., 2008, Generalized hydrostratigraphy of southeastern Louisiana: Baton Rouge, Louisiana Geological Survey, unpublished chart.

Van Biersel, T., D. Carlson, and L. R. Milner, 2007, Impact of hurricane storm surges on the groundwater resources: Environmental Geology, v. 53, no. 4, p. 813–826.

Cultural Resources

Archaeological Sites

Hays, C. T., 2000 [National Register nomination for the Tchefuncte Site]: Louisiana Department of Culture, Recreation and Tourism, Louisiana Division of Historic Preservation, text (PDF format) plus graphics (JPEG format), <http://www.crt.state.la.us/hp/nhl/search_results.asp?search_type=historicname&value=Tchefuncte+Site&pageno=1> Accessed November 19, 2008.

Neuman, R. W., and N. H. Hawkins, 1993, Tchefuncte, *in* R. W. Neuman and N. H. Hawkins, Louisiana prehistory: Louisiana Department of Culture, Recreation and Tourism, <http://www.crt.state.la.us/archaeology/laprehis/ppt.htm> Accessed November 19, 2008.

Louisiana Geological Survey

Chacko J. John,
Director & State Geologist

Design: Lisa Pond

Louisiana Geological Survey
3079 Energy, Coast &
Environment Building
Baton Rouge, Louisiana
70803
Tel: 225 578 5320
Fax: 225 578 3662