Louisiana Geological Survey

NewsInsightsonline

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The Louisiana Geological Survey (LGS) was first organized in 1869 and was permanently established by Act 131 of the Louisiana State Legislature in 1934. It was legislatively transferred from the Louisiana Department Natural Resources to Louisiana State University (LSU) in 1997 and currently reports through the Executive Director of the LSU Center for Energy Studies to the LSU Vice Chancellor of Research and Economic Development.

Geological investigations ongoing at LGS generally reflect its primary mission of promoting environmentally sound economic development of energy, mineral, water and environmental resources of the state. Reports of investigations are provided to the funding sponsors of the project and after approval, are made available to all interested parties. LGS research publications are provided to those interested through articles in professional journals, LGS publications and presentations at appropriate technical conferences and other venues as and when needed. Currently, LGS has14 full time and 2 part time staff including all categories of personnel. Research projects are conducted primarily under four sections:

- ***Geologic Mapping and Mineral Resources Section*** conducts investigations of the Surface Geology of Louisiana and does surface mapping under the federally funded State Map Program managed by the U.S. Geological Survey and produces maps at 1:100,000 and 1:24,000 scales.
- The ***Basin Research Energy Section*** conducts oil, gas, and coal related research projects.
- The ***Water and Environmental Section*** currently monitors and provides data on streams to add to the state's water data base and also supports the efforts of the USGS and the Department of Natural Resources for management of the state's water resources.
- The LGS ***Cartographic Section*** prepares the final maps and other LGS publications, and does GIS work on research projects. Over the years it has received many major awards for excellence of its products.

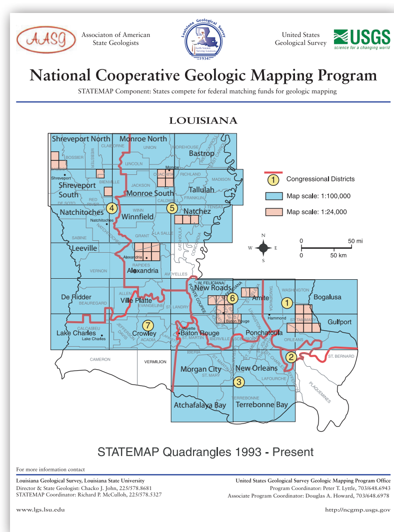
Contracts/Grants

Geologic Mapping

The Louisiana Geological Survey is the only research organization doing geologic mapping in the state of Louisiana. The continuing mapping effort is supported by cooperative agreements with the U.S. Geological Survey (USGS) under the STATEMAP component of the National Cooperative Geologic Mapping Program approved by the U.S. Congress.

The STATEMAP project for fiscal year 2013-2014 involved geologic mapping and compilation of the final two remaining uncovered 30 X 60 minute quadrangles, Bastrop and Tallulah, in the northeastern corner of the state, completing 1:100,000-scale state coverage with a mix of cartographically prepared lithographs and draft GIS compilations. LGS cooperative agreements with the USGS under the STATEMAP program through fiscal year 2013 have resulted in 25 compilations of 30 X 60 minute geologic quadrangles, 15 of which are published LGS lithographs and 10 of which are open-filed GIS compilations. Another five 30 X 60 minute geologic quadrangles were produced in-house entirely by LGS or with partial support from other sources.

Since the late 1990s LGS also has prepared 7.5 minute geologic quadrangles at 1:24,000 scale totaling 46 sheets. Thirty-six were prepared with STATEMAP support, and the other ten were prepared for the U.S. Army Corps of Engineers in the Fort Polk region, west-central Louisiana. The fiscal year 2014-2015 STATEMAP project resumes 1:24,000-scale field mapping with three 7.5 minute quadrangles in the Lake Charles area.



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LGS Mission Statement

The goals of the Geological Survey are to perform geological investigations that benefit the state of Louisiana by:

(1) encouraging the economic development of the natural resources of the state (energy, mineral, water, and environmental);

(2) providing unbiased geologic information on natural and environmental hazards; and

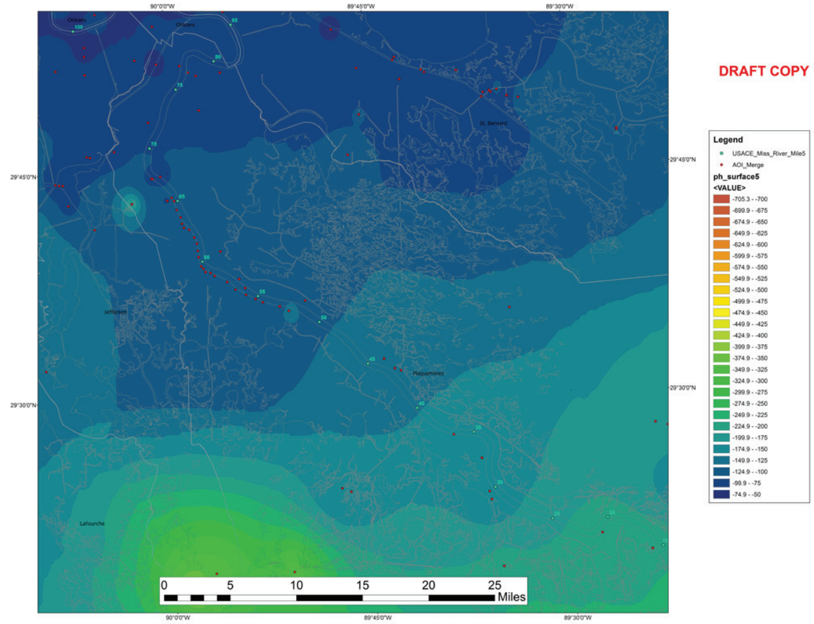
(3) ensuring the effective transfer of geological information.

The Louisiana Geological Survey was created by Act 131 of the Louisiana Legislature in 1934 to investigate the geology and resources of the State. LGS is presently a research unit affiliated with the Louisiana State University and reports through the Executive Director of the Center for Energy Studies to the Vice Chancellor for Research and Graduate Studies.

The Louisiana Geological Survey is housed on the second and third floors of the Energy, Coast & Environement Building.

Research and GIS Development of the Base of the Holocene in the Louisiana Coastal Plain and Adjacent Continental Shelf

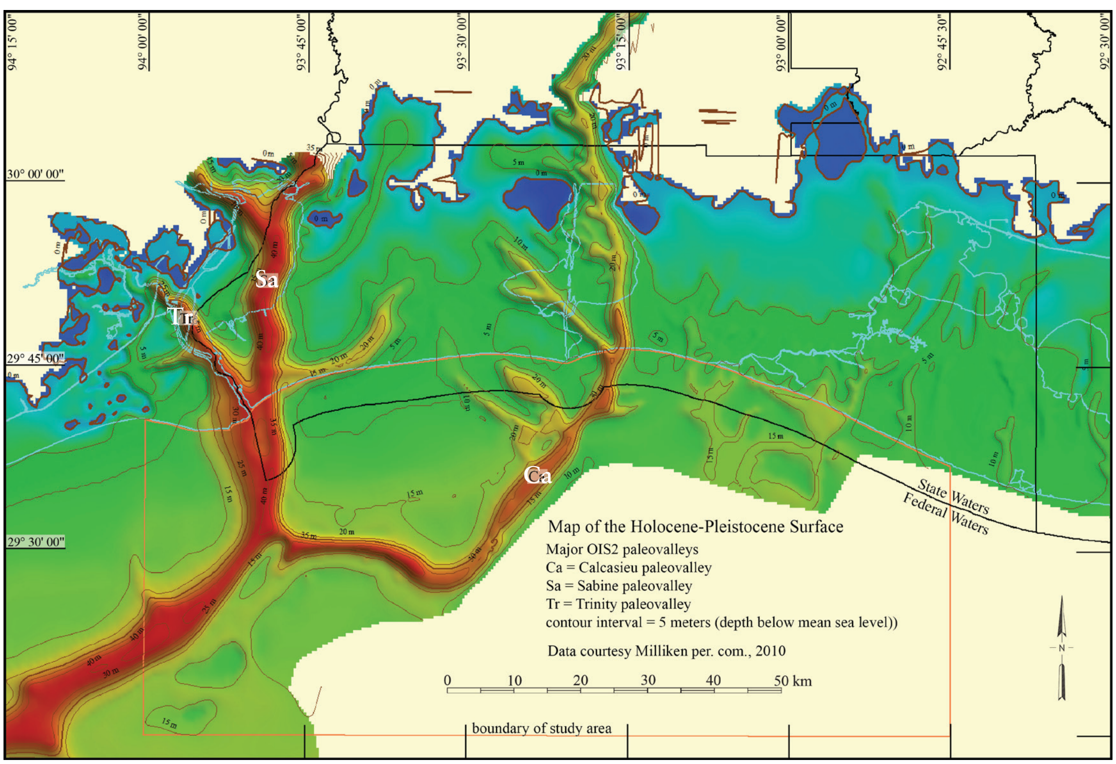
A 2-year (2013-2015) project funded by the Louisiana Coastal Protection and Restoration Authority (CPRA) continues in its second year. For the first year, a detailed structural map of the unconformity that forms the base of Holocene sediments within the Louisiana Coastal Zone and report were prepared for its eastern part, which consists of the Mississippi River Delta plain. Work for the second year is focused on preparing a detailed structural map of this unconformity for the entire Louisiana Coastal Zone. This unconformity, which is known as the "Holocene-Pleistocene surface," is a critical geologic feature because the overlying thickness of typically under-consolidated Holocene sediments is a major factor governing local subsidence rates and depth to solid sediments for the foundation of major structures.



Preliminary structural maps have been generated with data that has been compiled and evaluated. Isolated structural highs and lows associated with individual borings likely reflect inconsistencies in the identification of the Pleistocene-Holocene surface between researchers, structural highs associated with salt domes, or simple typos. As the mapping progresses, these artifacts and structural anomalies will be evaluated and remedied. Eight datasets have been reviewed with five of these being suitable for surface development. These five datasets were modified and merged yielding some 2,935 points for surface development within the study area. Although 3,000 points seem enough to yield a preliminary surface, the spatial distribution and poor spatial detail of some of the data may be insufficient in some areas.

Late Quaternary Stream and Estuarine System Responses to Holocene Sea Level Rise on the OCS Louisiana and Mississippi: Preservation Potential of Prehistoric Cultural Resources and Sand Resources

The LGS is finishing work on "Late Quaternary Stream and Estuarine Systems to Holocene Sea Level Rise on the OCS Louisiana and Mississippi: Preservation Potential of Prehistoric Cultural Resources and Sand Resources" for a cooperative agreement from the Bureau of Ocean Energy Management (BOEM), Bureau of Safety and Environmental Enforcement (BSEE) to investigate possible sand resources and possible archeological sites in the Louisiana state waters in the Outer Continental Shelf. It is examining the responses of Late Quaternary stream and estuarine systems to Holocene sea level rise. It has so far developed a geophysical and geologic database for the study area. This database contains over 118 offshore hazards maps, boring data, and seismic track line locations. This data is currently being used to develop geologic/stratigraphic models and predictive models for paleo-landscape preservation potential for the evaluation of sand resources of paleo-fluvial channel fills within the study area. An understanding of these processes should result in the evaluation and refinement of models used to predict cultural and non-fuel mineral resources within the offshore continental shelf. A fully functional Geographic Information System (GIS) will be developed from all collected geospatial data.



Geologic Review

This project is a continuing program which began in 1982 and provides regulatory technical assistance to the Coastal Management Division of the Louisiana Department of Natural Resources and the U.S. Army Corps of Engineers (USACE) and is renewed every year. The purpose of this program is to review drilling permit applications in Louisiana's coastal zone to avoid and/or minimize environmental damage to the wetlands by proposing alternate concepts like reducing the size of ring levees and slips, reducing lengths of board roads and canals, directional drilling and potential use of alternate access routes. This has been a very successful program and is, as far as we know, the only one of its kind in the country.

Surface Water Gaging Network Improvements

LGS received a three year contract (2012-2015) from the Louisiana Department of Natural Resources (LDNR) titled "Surface Water Gaging Network Improvements". The main objective of this project is to provide additional data to supplement efforts to monitor and manage surface and groundwater resources being conducted by the USGS for DNR. During the first two years of the project, fifty gaging stations were selected for discharge measurements and data so obtained was used to develop new rating curves and profiles or revise them if there was existing data. Four new surface gaging sites were also established where there were none. Further, LGS compiled hydrologic and geologic data for publicly owned reservoirs and lakes from existing records. During the second and third years of the project, the monitoring work will be continued and the data will be kept updated and revised as needed.

Natural Coal Resources Data System (NCRDS)

Louisiana Geological Survey is investigating the occurrence of coal in Louisiana and its potential for exploitation as an economically significant source of natural gas. The current effort, begun in 2010 under contract with the U.S. Geological Survey as part of the National Coal Resource Data System, focuses on the distribution and abundance of coal seams in the Paleocene-Eocene Wilcox group confined to the subsurface in the northern half of the state (north of the 31^{o} parallel). This study has produced stratigraphic correlation cross-sections depicting modern subsurface structure over a comprehensive set of N-S and W-E traverses. Information from these cross sections combined with data from additional well logs yielded a set of structural contour maps for the upper and basal contact surfaces of Wilcox. During 2012 – 2013 selected well logs were analyzed to correlate coal seams to stratigraphic horizons in Wilcox and to produce isopach maps of coal for the entire study area. Narrative text crafted in 2014-2015 will be combined with revised and updated maps and cross-sections for a final report to be submitted at the close of fiscal year 2015.

Inventory and Digital Infrastructure of Historic Louisiana Geologic Maps, Publications, and Other Data

Thousands of published and unpublished geologic maps, cross-sections, sample site maps, petroleum mapping and other geo-data dating back to the 1870's exist in Louisiana Geological Survey (LGS) cartographic storage rooms. The material consists of lithographic prints, working drafts, historic reference maps, and many original manuscripts on linen, vellum, positive and negative film, contact prints, and even some metal plates. Much of this data is from publications long out of print and some are unpublished manuscripts unknown to the research community. An estimated 6,000 map sheets are involved. This material has been kept in climate-controlled rooms, but it has been moved many times over the decades and original inventories have not survived. The current project is to continue an effort begun in 2010 to systematically inventory and catalog the extensive LGS cartographic repository of historic maps, cross-sections, and other geologic and topographic data. All documents in tube rack storage were completed in 2010 and all documents in fireproof vertical cabinets were completed in a 2011 project. This year the map documents that reside in over 40 flat map filing cabinets were processed. The project also selected candidates for digital archiving based on the inventory database. Paper and film documents were converted to high-resolution digital formats, stored on permanent media, and metadata records were prepared for entry into the National Digital Catalog. A relational database was created to index the material. The project will result in vastly improved accessibility of the LGS cartographic archival material for LGS research, the geologic research community, and the general public.

Evaluation of Water Permit Requests

LGS provides the Louisiana Department of Natural Resources with unbiased recommendation of water permit requests. These requests are received by LDNR from other state agencies, parish governments, etc., and are sent to LDNR mainly to evaluate environmental consequences resulting from the action proposed.

Louisiana's Potential for Unconventional Energy Resources

The last major LGS study on unconventional shale energy resources was completed in 1997 and the results were published in the Basin Research Institute (now part of LGS) bulletin in the following paper:

John, C.J., B.L. Jones, J.E. Moncrief, Reed Bourgeois and Brian J. Harder, 1997, An Unproven Unconventional Seven Billion Barrel Oil Reource - the Tuscaloosa Marine Shale: Basin Research Bulletin, Louisiana State University, v.7, August, p.3-23.

The entire article can be viwed at www.lgs.lsu.edu/deploy/uploads/Tuscaloosa%20Marine%20Shale.pdf

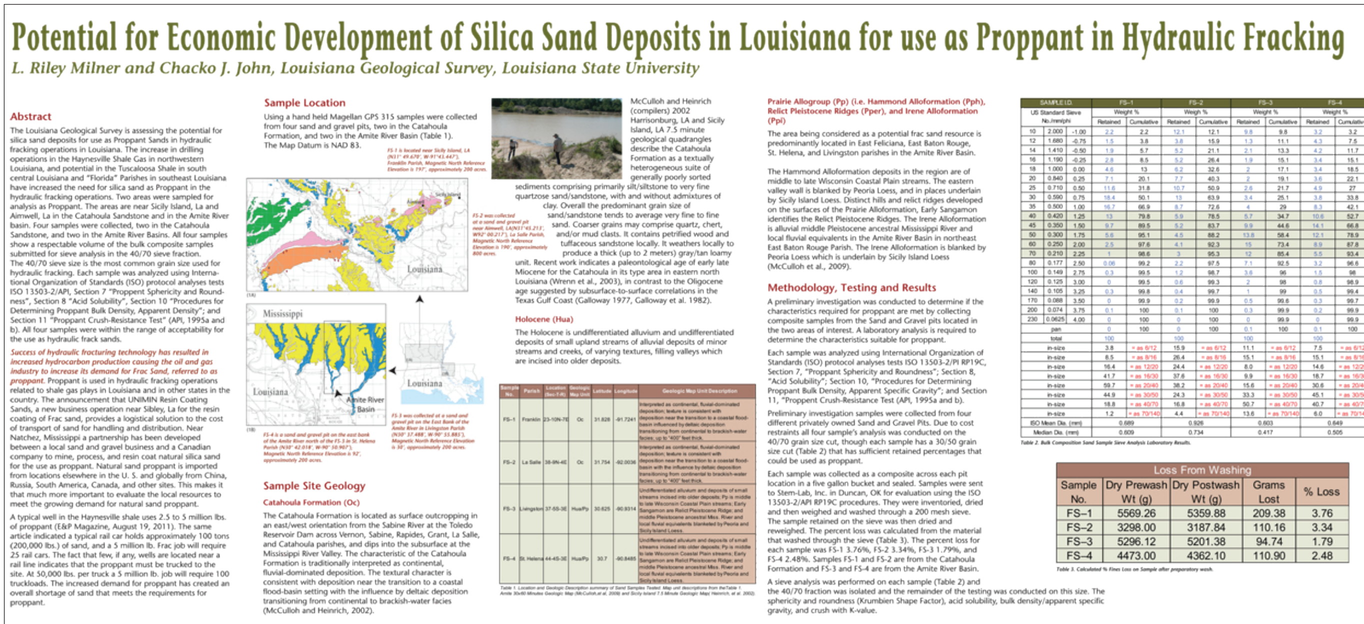
As is now well known, the Tuscaloosa Marine Shale (TMS) has become an active major oil play covering parts of Louisiana and Mississippi with many completed successful oil wells. This LGS paper remains a landmark reference for the continuing commercial development of the TMS.

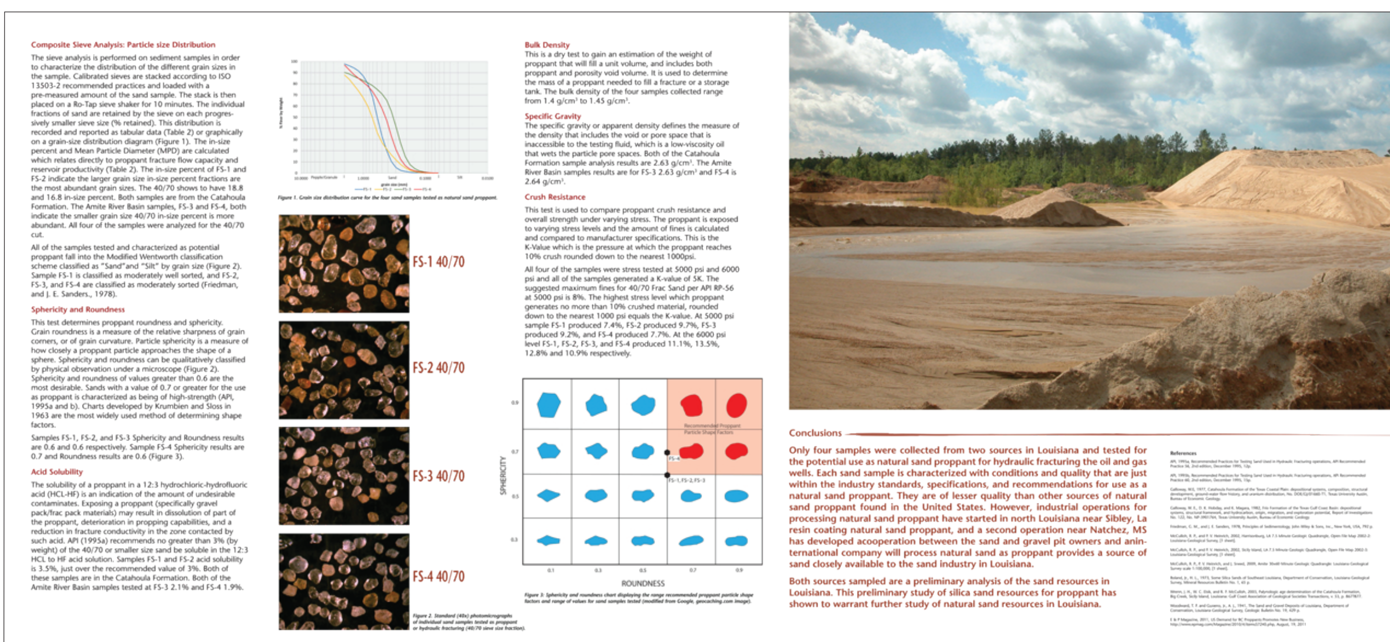
Similarly, the geopressured-geothermal unconventional resources of the Gulf Coast represent a future major energy resource when the technology is developed and the economics of commercial development become profitable and feasible. LGS was a participant in the US Department of Energy, Gulf Coast Study on this topic (1975-1992) and a contributor of temperature and geologic data to the National Geothermal Data System (NGDS) project. These projects have provided critical data and information needed for the commercial development of this unconventional resource over time.

LGS plans to initiate a statewide investigation to evaluate the existence of unconventional potential shale gas/oil plays, including by-passed oil/gas sources and are currently looking for funding sources

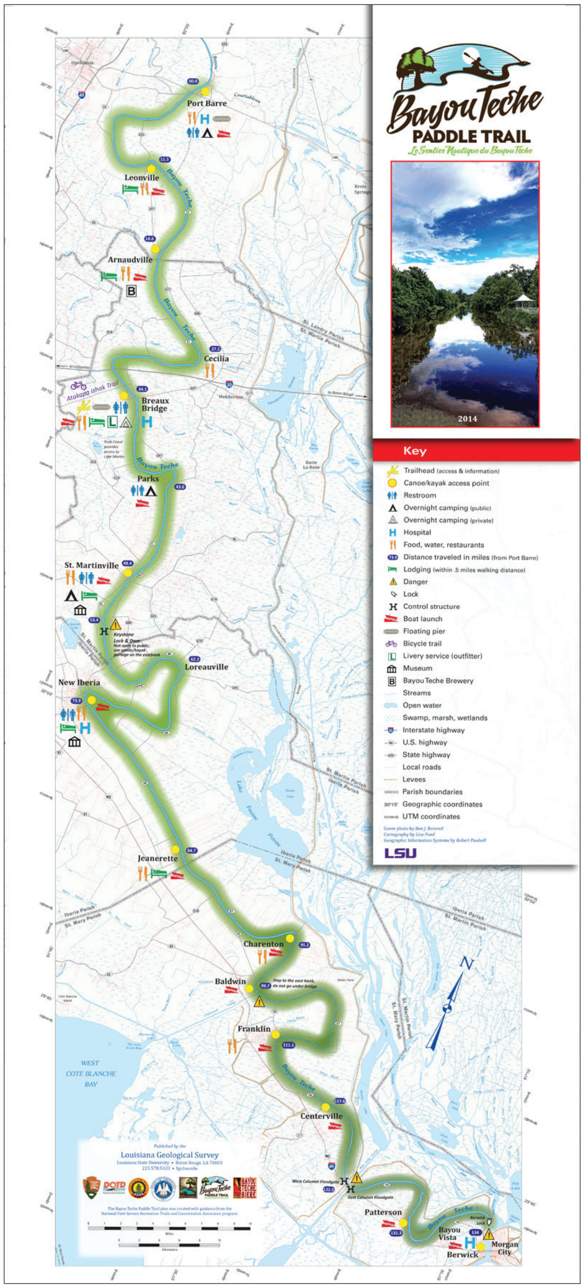
Preliminary Geologic Assessment and Economic Analysis of Louisiana's Sand Resources and its Suitability for use in Hydro-Fracture Operations

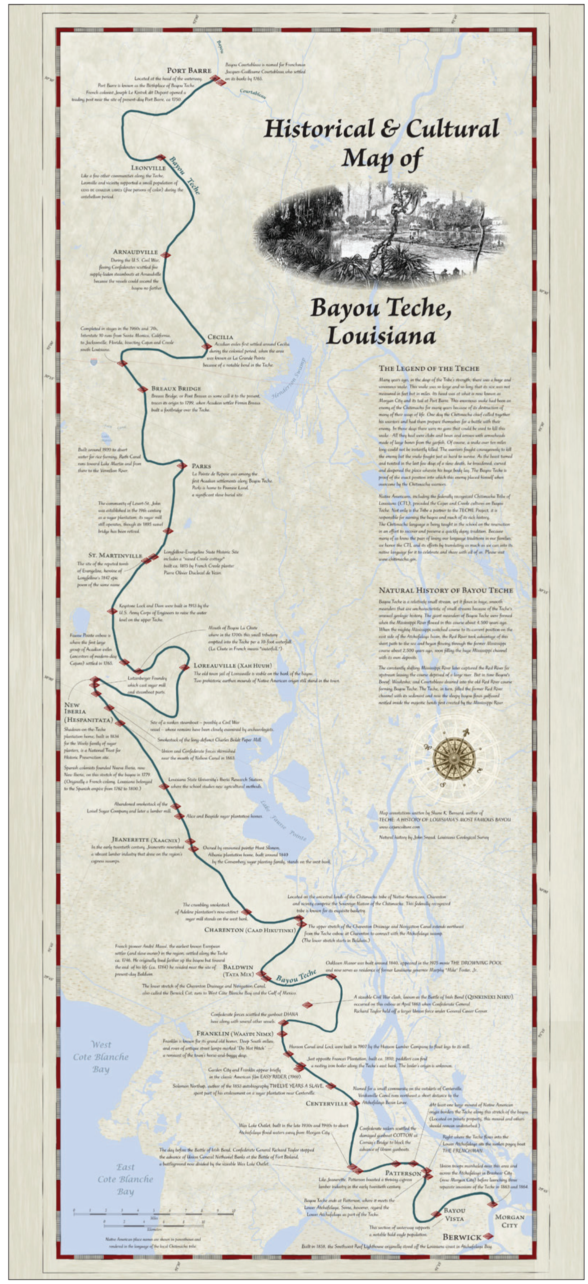
LGS conducted a preliminary study of sand resources in four areas to determine its suitability for use as proppant in hydraulic fracturing and to assess its potential for economic development. Samples were collected in the Catahoula sandstone near Sicily Island and from the Amite River Basin. After laboratory analysis, it appeared that all the samples analyzed were on the borderline of acceptance for use as proppant. Initial findings of this study were also reported in the AAPG Explorer (September 2014) in an article by Louise Durham titled "Getting Down to the Nitty Gritty of Fracturing". LGS intends to expand this initial study into a statewide investigation subject to the availability of funds.





Research poster presented at the GCAGS Conference October 5-7, 2014 in Lafayette,LA. The idea for the study was a curiosity about the possibility of Louisiana silica sand deposits use as proppant for hydraulic fracturing operations in Louisiana. Further study is in a proposal stage and is planned to be submitted to the Louisiana Department of Economic Development for funding to look into all of the states sand deposits for potential use in hydraulic fracturing.





2014 Bayou Teche Paddle Trail and Historical and Cultural Map

Lisa Pond and Robert Paulsell of the LGS cartographic section designed and produced the *2014 Bayou Teche Paddle Trail and Historical and Cultural Map* for The TECHE Project in Lafayette, Louisiana.

The two-sided waterproof map shows canoe and kayak access points on Bayou Teche beginning at Port Barre traveling over 131 miles to Morgan City, Louisiana. Informative symbols show paddlers what to expect along their journey.

The reverse side, *Historical and Cultural Map of Bayou Teche,* highlights locations and events that have happened throughout the years along the bayou, as well as The Legend of the Teche and Natural History of the Bayou. Native American place names are shown in the language of the local Chitimacha tribe.

2014 Annual Remote Sensing and Geographic Information Systems (RSGIS) workshop

Robert Paulsell presented “GIS Support for Mapping of Late Quaternary Paleovalleys on the Outer Continental Shelf Offshore Louisiana” (Robert Paulsell, Paul V. Heinrich, Riley Milner, and Richard P. McCulloh) at the 2014 Annual Remote Sensing and Geographic Information Systems (RSGIS) workshop March 13, 2014 in New Orleans, Louisiana. The workshop highlights regional projects that utilize cutting edge GIS and GNSS technology. The workshop was held at the Hampton Inn & Suites Convention Center.

Pleistocene continental glaciation has repeatedly lowered global sea levels as much as up to 120 m below present levels. Alternating lowstands and highstands resulted in the deposition of shelf-phase deltas on the offshore Louisiana continental shelf and the formation incision of valleys within them. Geomorphic Stratigraphic surfaces associated with these deltas and buried within paleovalleys might contain represent archaeological deposits preserved paleolandscapes with potential cultural that significance have survived postglacial sea-level rise. Fluvial sediments filling these paleovalleys are potential sources of sand for long-term coastal nourishment restoration projects. This project is sponsored by the U.S. Bureau of Ocean Energy Management (BOEM) and comprises the digital synthesis and compilation of legacy paleovalley mapping of paleovalleys spanning nearly 40 years. Funding for this research project is provided by Bureau of Ocean Energy Management (BOEM) under Cooperative Agreement/Award No. M12AC00020 between BOEM and the Louisiana Geological Survey. BOEM manages non-energy minerals and sediment obtained from the ocean floor, including outer continental sands used for coastal restoration and protection. BOEM conducts extensive technical and environmental reviews of projects to minimize adverse impacts on marine, coastal, and human environments thus protecting billions of dollars of infrastructure as well as important ecological habitats.

An integral part of the project has been the development of a Geographic Information Systems (GIS) for visual representation, analysis, and computational support. The core of the GIS work has been to develop digital data from raster geophysical maps that exist as Portable Document Format (PDF) files. Many different geologists and geophysicists prepared these interpretations since ca. 1975.

The process of developing GIS data from legacy maps is detail-intensive. Initial steps were to determine which of the many maps contain information relevant to the study (e.g. ancient river valleys or paleovalleys). Initially, a preliminary .mxd project was developed populated with thematic data (base map) and other coastal geologic digital data. The next steps were to determine which of the many geophysical maps contain information relevant to the study (e.g. ancient river valleys or paleovalleys). Acceptable PDFs were saved as TIFF files and were georeferenced. These were then digitized into a vector format resulting in over 390 shapefiles. These data are point, polyline, and polygon feature types with attribute tables. Polygon features were constructed from the polyline data. Feature types are polygon (channels/valleys), polyline (thalwegs/channel banks), and point (tops and bases of channels).

Final additions to the GIS will include links to seismic data, well logs, and other geophysical data. Also, nomenclature issues will be addressed to standardize paleovalley descriptions. Ultimately, the GIS project will enable a good representation of the ancient stream systems preserved offshore Louisiana.

Gulf Coast Association of Geological Societies (GCAGS) Annual Convention

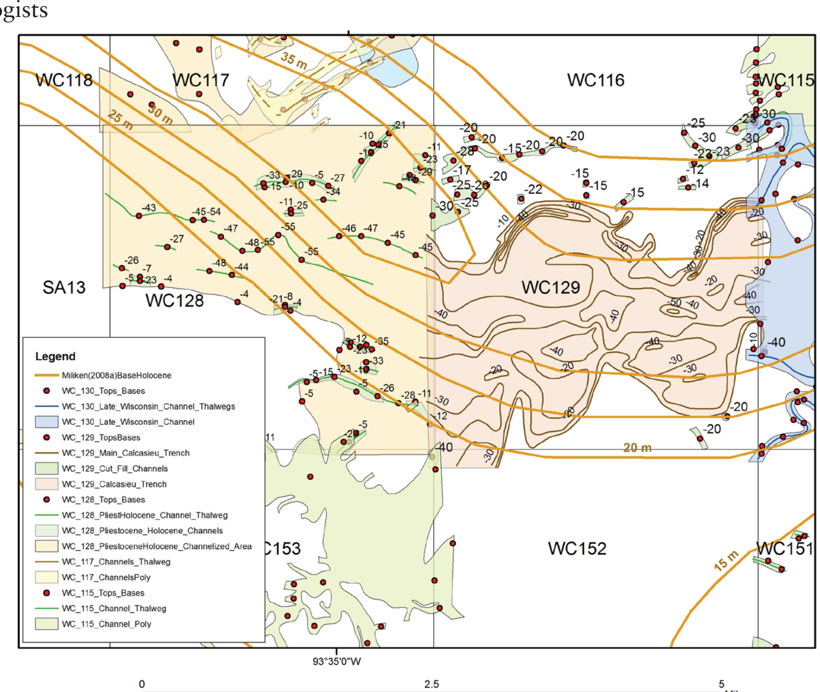
The GCAGS Annual Conventions are one of the most important professional meetings which relate to the research work done at the Louisiana Geological Survey (LGS). The 64th Annual GCAGS convention was held in Lafayette, Louisiana from October 5-7, 2014 and was hosted by the Lafayette Geological Society. LGS was well represented at this convention and had an exhibit booth displaying LGS publications and posters showing ongoing research projects. LGS research faculty and staff made four research presentations which were also published in the GCAGS Transactions. The references to the papers are given below:

Carlson, D., 2014, Is there a significant hydraulic connection between the Mississippi River, nearby oxbow lakes, and ground water within the Mississippi Alluvial Aquifer?: Gulf Coast Association of Geological Societies Transactions, v. 64, p.81-89

Carlson, D., C. Carter, and M. Horn, 2014, Is public perception of water quality accurate in north western Louisiana?: Gulf Coast Association of Geological Societies Transactions, v. 64, p. 91-104

John, C. J., B. J. Harder, and R. Bourgeois, 2014, Developing the untapped potential of geopressured-geothermal energy resources in the Gulf Coast: Gulf Coast Association of Geological Societies Transactions, v. 64, p. 547-549

Milner, L. R., and C. J. John, 2014, Potential for economic development of silica sand deposits in Louisiana for use as proppant in hydraulic fracking: Gulf Coast Association of Geological Societies Transactions, v. 64, p. 561-570



Example of good data correlation between geophysicists' interpretations.

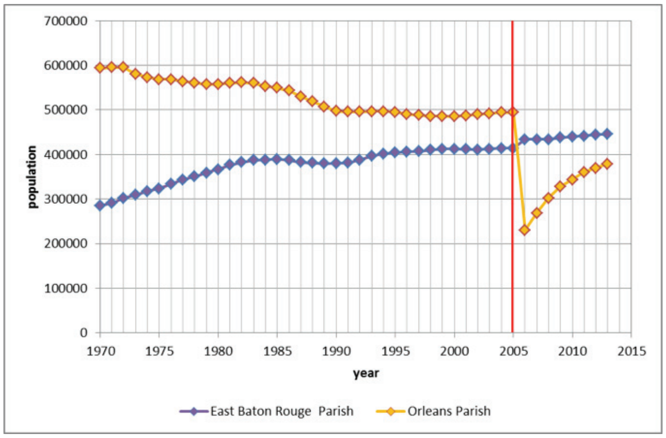


Figure 1. What population of East Baton Rouge and Orleans Parish (New Orleans) is between 1970 and 2013 (U.S. Bureau of Census, 1982, 1992, 2002, and 2011; Factfinder2.census.gov, 2013; and Louisiana.gov, 2014). Red line in this and following plots is approximately when hurricane Katrina occurred.

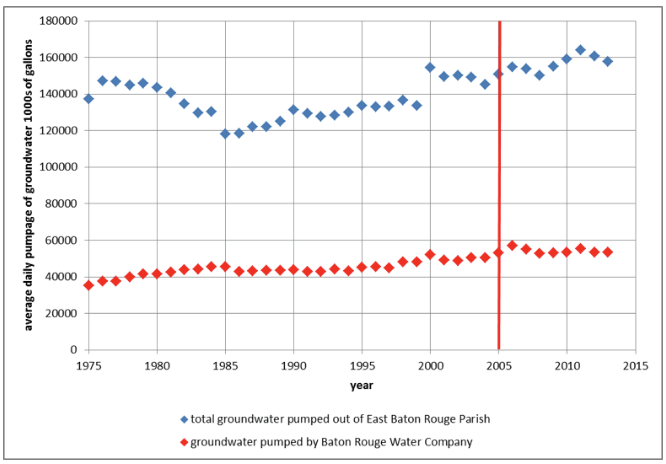


Figure 2. Dailey average amount of water pumped in East Baton Rouge Parish between 1976 and 2013 (Capital Area Ground Water Conservation Commission, 2014, Louisiana Department of Natural Resources, 2011 and 2014).

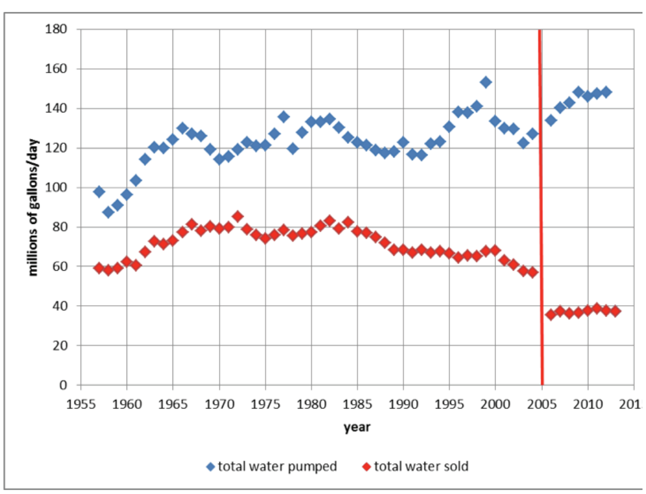


Figure 3 Daily average amount of water pumped and sold by New Orleans Water and Sewerage Board between 1957 and 2014. The sharp drop in daily water sold is between 2004 and 2006, before and after Hurricane Katrina (Sewerage and Water Board of New Orleans, 1957 to 2004 and 2006 to 2013a).

Water Use In The Nine Plus Years Since Katrina and State Of Baton Rouge And New Orleans

Douglas Carlson

It has been over nine years since hurricane Katrina passed near New Orleans and caused the out migration of 100,000s of people (Carlson, 2007; Geaghan, 2011; and Thoren, 2014). Many of these people came to live in Baton Rouge metropolitan area (Carlson, 2007; and Johnson, 2007). Have these two cities returned to pre-Katrina conditions in terms of their population and water use? The impact on Baton Rouge population was large initially (Carlson, 2007; and Johnson, 2007) but within a year the impact is minor (Figure 1), approximately 20,000, a 5% increase from the year before (U.S. Census 2011). By contrast the impact on New Orleans (Orleans Parish) was large (Figure 1). The population of New Orleans decreased by approximately 260,000 more than 50% decrease. After 2006 there has been a major increase of population, between 2006 to 2013, for New Orleans back to approximately 380,000 (Louisiana.gov, 2014). The rate of increase has been slowing (Figure 1) both in terms of number of people that have returned and relative increase of population (Thoren, 2014). For example between July 1 of 2006 and July 1, 2007 New Orleans population increased by approximately 38,000 17%, and for July 1, 2012 and July 1, 2013 New Orleans population increased by only 9,000 2.4% (Figure 1).

The pattern of water use has been somewhat similar to population for East Baton Rouge Parish where there was a minor increase groundwater used between 2005 and 2006 (Figure 2). The approximately 5% population increase in East Baton Rouge Parish impacted mainly use of public supply from groundwater. Daily pumpage of ground water increased between 2004 and 2006 by 9.6 million gallons per day (mgd) for all users of groundwater in the parish, a 7% increase. By comparison for the largest public water supplier in the parish the Baton Rouge Water Company (Lovelace, 1991; Lovelace and Johnson, 1996; and Sargent, 2002, 2007 and 2011) groundwater pumpage increased 6.8 mgd, 13% (Figure 2). Although this public water supplier supplied approximately 35% of all the groundwater used in the East Baton Rouge Parish, It needed to supply approximately 70% of the increase in demand between 2004 and 2006.

As with population the impact of Katrina on water use in New Orleans is significant. There is a major drop in the amount of water sold, a decrease of approximately 21 mgd (Figure 3), 37%. This decrease is significantly less than the population decrease which was approximately 53%. What is maybe surprising is that total water pumped was almost unchanged between 2004 and 2006 (Figure 3). There was a slight increase from 129 mgd to 134 mgd, an approximately 4% increase. What increased greatly was the amount of water that was pumped but not sold. This value increased from 16.5 billion gallons (45 mgd) in 2004 to 33.3 (91 mgd) billion gallons, approximately doubled.

It is strange that between 2006 and 2013 New Orleans (Orleans Parish) population has recovered from approximately 230,000 to 370,000 and approximately 60% growth over the seven years. By contrast volume of water sold, as indicated by meters, increased only slightly from 12.98 billion gallons sold in 2006 to 13.80 billion gallons sold in 2012 an approximately 7% increase. Water conservation probably accounts for the difference of population change and water sold change results. Between 1970 and 2005, population in New Orleans has decreased by approximately 15%. Between 1970 and 2004 water sold, as indicated by meters, decreased by 28%. It appears that conservation efforts have been successful, but per capita water sold to population has decreased far more quickly after Katrina than before Katrina (Figure 4).

However, there is a sharp rise in per capita consumption between 2004 and 2006 there is an increase of approximately 40%. Then per capita consumption decreased by 35% to 2013 to the lowest per capita consumption in 2013, almost 4000 gallon per year less than the lowest pre-Katrina value in 2004 (Figure 4). This is probably being driven by a major increase in water rates between 2006 and 2013 (Table 1).

What is most surprising is the amount of water lost for measured leaks and is used for unmetered uses such as extinguishment of fires, cleaning streets, flushing sewers, drains, and gutter, cleaning markets and other public buildings has remain almost constant between 2006 and 2012 (Figure 5), and at significantly larger value than for the seven years prior to Katrina 1998 to 2004. This confidence of the increase is over 99.9% which is significant (Conover, 1999; and Sprent and Smeeton, 2007). The loss of water that is not metered and sold appears to not to be influenced by the fact that over 100,000 leaks were fixed (Table 2). This is a rather surprising result.

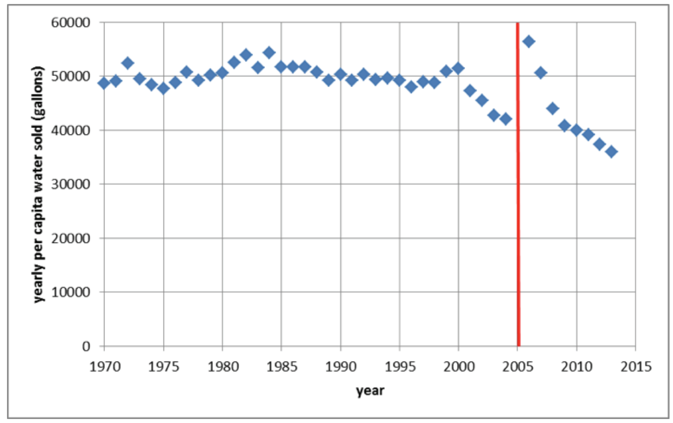


Figure 4. New Orleans per capita yearly water sold between 1970 and 2013 (Sewerage and Water Board of New Orleans, 1970 to 2004 and 2006 to 2013a).

Table 1 Water and sewer rates between 2006 and 2012.

year	first 3,000 gallons	next 17,000 gallons	next 980,000 gallons	all gallons over 1,000,000	sewer rate per 1000 gallons
2006	2.31	2.31	2.07	1.59	4.04
2007	1.94	3.31	2.60	2.19	4.04
2008	2.35	4.01	3.15	2.65	4.04
2009	2.47	4.21	3.31	2.78	4.04
2010	2.59	4.42	3.48	2.92	4.04
2011	2.69	4.60	3.62	3.04	4.04
2012	2.69	4.60	3.62	3.04	4.04
2006 to 2012 increase	0.31	2.29	1.55	1.45	0.00
percentage increase	13%	99%	75%	91%	0%

It is also rather surprising that although over 60,000 water main leaks were fixed between December of 2008 and July 2013, Table 2, The amount of either measured water loss from leaks or free water appears to remained relatively unchanged between 2006 and 2013, Table 3. Lastly, it is strange that when leaks were measured the volume of lost water after Katrina is significantly less than in the years shortly before Katrina (Figure 6).

Table 2 number of leaks within New Orleans water mains repaired since Katrina

date	number of water main leaks fixed	source of data
December 31, 2008	61,043	Sewerage and Water Board of New Orleans, 2009b
June, 30, 2010	80,855	Sewerage and Water Board of New Orleans, 2010b
June 3, 2011	113,244	Sewerage and Water Board of New Orleans, 2011b
July 31, 2012	125,796	Sewerage and Water Board of New Orleans, 2011b
July 31, 2013	125,796	Sewerage and Water Board of New Orleans, 2011b

In summary, it appears that Katrina and associated migration of population into Baton Rouge area had only a temporary impact and even at a year a minor impact. By contrast New Orleans has recovered partly; approximately two thirds of population loss has been recovered. By contrast impact on water system has remained fairly constant between 2006 and 2013. The system has had over 100,000 leaks fixed but the results between 2006 and 2013 do not appear to indicate this work has impact either volume of water that is distributed for free or measured leaks (Figure 5 and 6).

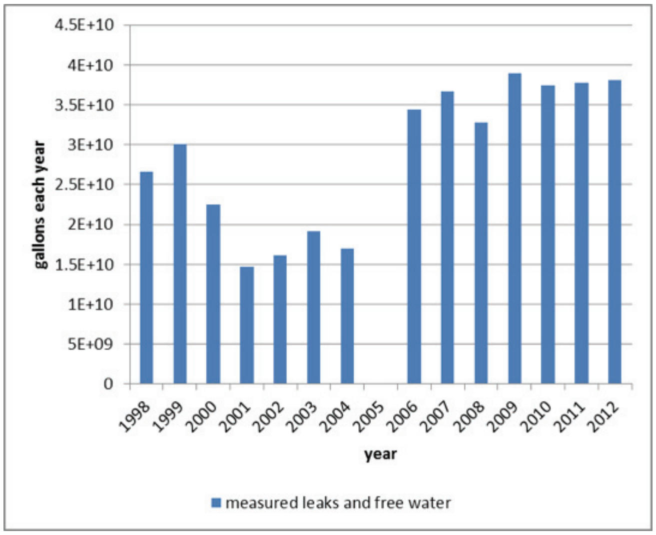


Figure 5. New Orleans public water that is unmetered and measured as leaking from the system for the seven years before and after 2005, the year of hurricane Katrina (Sewerage and Water Board of New Orleans, 1998 to 2004 and 2006 to 2013a).

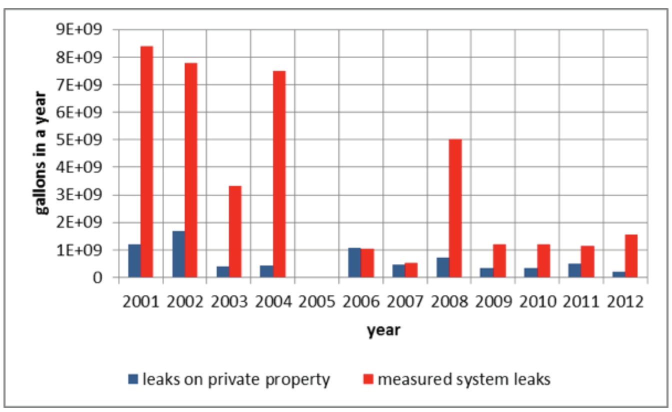


Figure 6. Measured water loss in New Orleans public system.

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LGS Geophysical Surveys of Area Archeological Sites

M. Horn

LGS recently conducted geophysical field surveys in localities of archeological interest. Electrical resistivity measurement and geomagnetometry were applied in search for anthropogenic artifacts that include remnants of building structures and cemetery burials that are currently concealed by flood sediment, topsoil, and vegetative cover. In most instances the presence of such features is inferred from old maps or existing physical markers, such as fences and monuments, while in some situations the information is almost entirely anecdotal with few or no reliable markers. These geophysical investigations have produced useful results and suggest improvements in future survey strategy and data processing.

Application of electrical resistivity surveys to finding natural and anthropogenic features concealed in the near subsurface has a long history of success (VanNostrand & Cook, 1966; Aitken, 1974; Reynolds, 1997; Bevan, 1998; Gaffney et al, 2003; Butler, 2005). Archeological sites are conducive to electrical surveying because the area of such sites is typically small enough to be practical for traversing with high-resolution (< 1.0 m) electrode arrays (Figure 1). Furthermore, the close relationship between electrode spacing and signal penetration depth permits "focusing" the measurement to near-surface depths that presumably encompass archeological features. Detection of artifacts relies upon detecting contrasts in the near subsurface electrical current resistance and susceptibility to induced electrical polarization in natural vs. disturbed rock or sediment. In a back-filled excavation, such as a burial or trench, the back-fill region typically has a lower electrical resistivity than the host because the introduction of porosity increases accommodation for water, either as pore-fill or as moisture adsorbed onto individual grains, resulting in an overall increase in electrical conductivity. Conversely, compacted material, such as wall footings and frequented travel paths, tends to have a greater electrical resistivity.

Figure 1. LGS resistivity and IP meter with electrodes arranged in a Wenner array.

Geomagnetometry also has a history of success history in archeological investigation and, aside from ground-penetrating radar, is the most commonly applied remote sensing technique in these settings, primarily because of the fruitful returns from relatively minimal investment of time and effort (Aitken, 1974; Reynolds, 1997; Bevan, 1998; Gaffney et al, 2003; Butler, 2005). For these studies the proton-precession magnetometer is often assembled in a gradiometer configuration (Figure 2) to (a) correct for diurnal magnetic field variations during the survey and (b) effectively remove signals from sources of greater breadth than is typical of artifacts in the near subsurface. The sensitivity of the proton-precession magnetometer permits detection of a range of concentrations of magnetic and paramagnetic substances such as magnetite and maghemite, both of which occur naturally and in man-made ceramics and steel. A low-elevation magnetometer sensor will routinely detect magnetic and paramagnetic components in buried items such as pottery, brick, metal tools, structural fixtures, and weaponry, as well as excavation back-fill in which the natural magnetic susceptibility of the host has been disturbed. However, the instrument cannot distinguish between items of archeological significance vs. less important items such as remnants of more recent fencing, construction, signage, or scattered metal (steel) rubbish.

Figure 2. LGS proton precession magnetometer in gradiometer configuration.

Results

LGS has conducted electrical resistivity and magnetometery surveys at a number of sites of archeological interest. One study attempted to locate an abandoned cemetery noted on early 20th century survey maps (near Empire, La.), but at present lacks markers or monuments of any kind. While resistivity data were inconclusive, gradiometer data show a pattern of recti-linear anomalies in a location consistent with map indications of a cemetery (Figure 3).

Conversely, in a field study of Highland Cemetery near LSU campus, a map of subsurface electrical resistivity shows areas of anomalously low resistivity that correlate to areas of suspected burials (Figure 4), whereas magnetometer measurements were rendered ineffective in the burial search by the abundance of unimportant metal "garbage" associated with modern fencing and signage.

In a third study at Fort Pike State Historic Site near New Orleans, a gradiometer survey revealed the foundational footings of a (no longer extant) brick structure that once housed military personnel and supplies during the Revolutionary and Civil Wars (Figure 5).

LGS continues to improve these field techniques and apply them to archeological sites such as cemeteries, battlefields, and plantation homesteads in the search for known or suspected artifacts. The techniques can also be applied to more modern questions of near-surface stratigraphy, soil engineering properties, pipeline locations, lost boundary markers, and water-table depths.

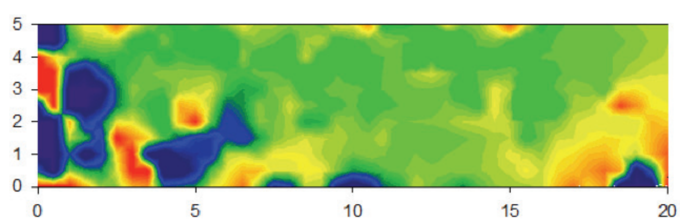

Figure 3. Magnetic gradometer map (scales in meters) of study area near Empire, La., shows rectilinear anomalies corresponding to an area of burials noted on a ca. 1924 property survey map.

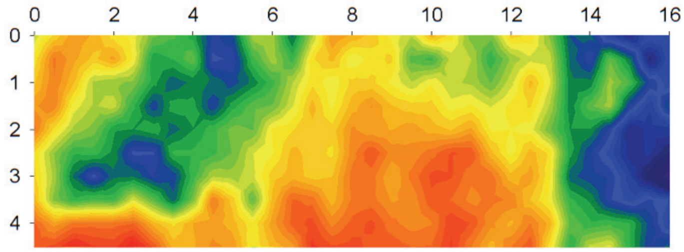

Figure 4. Electrical resistivity map of a portion of Highland Cemetery near LSU (scales in meters) shows areas of low electrical resistivity (yellow-red) corresponding to areas of suspected burials.

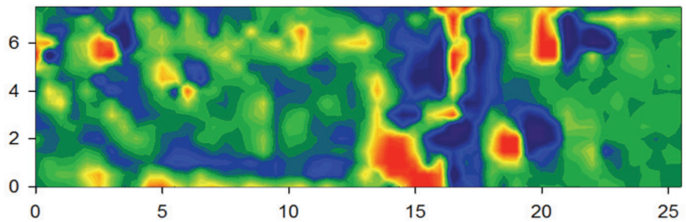

Figure 5. Gradiometer map of a portion of Ft. Pike Historical Site near New Orleans (scales in meters) weth rectilinear anomalies (shades of light green to red) corresponding to wall footings of brick structures no longer standing.

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Fort Pike State Historic Site near New Orleans. A gradiometer survey revealed the foundational footings of a (no longer extant) brick structure that once housed military personnel and supplies during the Revolutionary and Civil Wars.

Relative Sea Level Rise In Louisiana Dependence On Subsidence

Douglas Carlson

One of the major concerns in Louisiana is the loss of land along the Louisiana coastline (Figure 1). This happens to be caused by a variety of physical phenomena (Craig et al., 1979; and Peland et al, 2002). One of these causes of land loss is relative sea level rise (Cheramie, 1999; and Penland et al., 2002). There are two components causing this relative rise of sea level. One is global sea level rise and two is local subsidence. The first is a result of rising global temperature (Figure 2). There have been many reports indicating the global temperature has generally been rising over the past 130 years (Andronova and Schlesinger, 2000; Meadows and Meadows, 2006; Hanson et al., 2007; and Morice t al., 2012). However, other studies (Andronova and Schlesinger, 2000; Held, 2013; Ollier, 2013; Brenchley, 2014; and Rose, 2014) indicate that it appears that recently in the last 10-18 years the earth's temperature has remained approximately constant (Figure 3). At the present time there are two theories 1) is that human activities are the main cause of global warming, and it will it continue into the near future (Cliver et al., 1998; Easterbrook, 2006; Spencer, 2009; Riese, 2014; and Rose, 2014) or has global cooling started? Those who think that global warming will continue think that increasing carbon dioxide concentration in the atmosphere due to human activity is driving the earth's temperature upwards (Meadows and Meadows, 2006; Stott et al., 2006; and Hanson et al., 2007). Those who think that the earth is entering a period of global cooling focus on variations in solar radiation as the driver to push temperatures downwards (Reid, 1997; Andronova and Schlesinger, 2000; Archibald, 2008; Abdussamatov, 2012; Abdussamatov, 2013; Held, 2013; and Ollier, 2013), or ocean currents are a major factor driving temperatures downward (Swanson and Tsonis, 2009; and Held, 2013). Does this mean the ongoing loss of land along Louisiana coast will stop? In brief the answer is likely no, because of the second cause of relative sea level rise, local subsidence.

Louisiana is often thought of as a geologically inactive area because there are very few earthquakes recorded in history. There have been only 43 felt earthquakes between 1843 and 1994 (Stevenson and McCulloh, 2001). Between 1978 and 2013 there have been 25 earthquakes with a magnitude over 2.5 within Louisiana (Homefacts, 2014). In thirty years between 1974 and 2003 only one of the 21,080 earthquake magnitude 3.5 or greater than 3.5 that occurred in the United States occurred in Louisiana (USGS, 2004). This view is reasonable, because Louisiana as a part of the Atlantic-Gulf Coast of the United States which is considered "passive" continental margin that was formed during the Triassic-Jurassic splitting of the supercontinent Pangea (Diegel et al., 1995; and Stephens, 2009).

However, the Louisiana coast has been active for millions of years as revealed by a series of faults, many of them are growth faults (Diegel et al., 1995; McCulloh, 2001; and Stephens, 2009), that are approximately parallel to the coast. These faults have been active off and on since the middle of the Jurassic Period, approximately the past 160 million years (Dokka et al., 2006; and Stephens, 2009) as indicated by variable displacement of sediments of differing ages and a total wedge of sediment that near the coastline is over 40,000 feet thick (Frezon et al., 1983; Miller, 1988; and Breton et al., 2011). It is the movement of faults in south Louisiana that is a major contributor to relative sea level rise due to the associated subsidence. The subsidence and relative sea level rise is causing the loss of land throughout south Louisiana (Gagliano et al., 2003; and Gagliano, 2005).

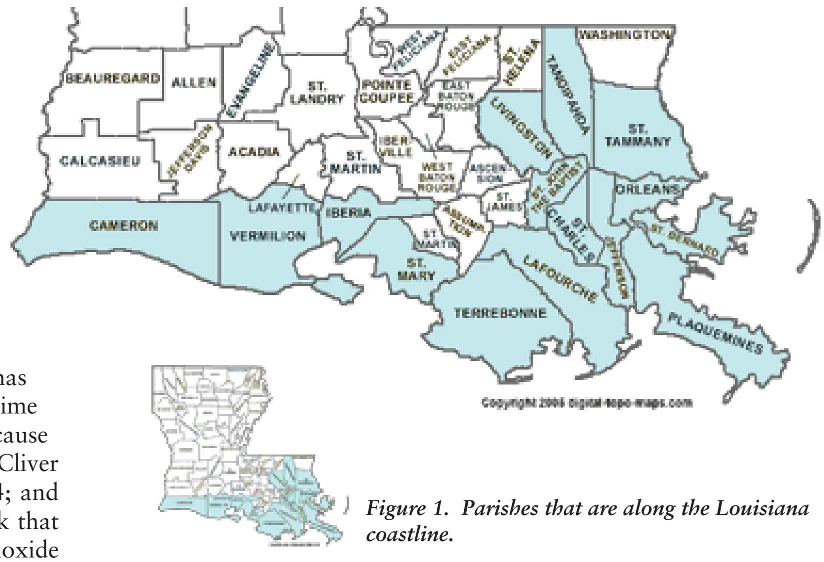

Figure 1. Parishes that are along the Louisiana coastline.

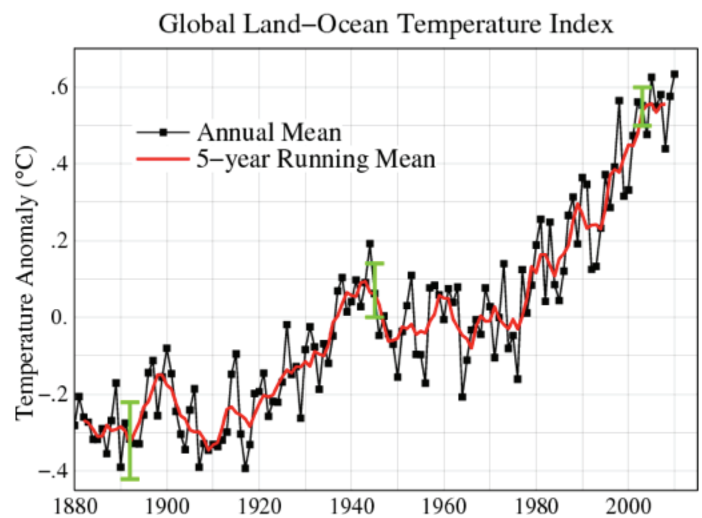

Figure 2 Global temperature measured between 1880 and 2010 (Wikimedia.org, 2011).

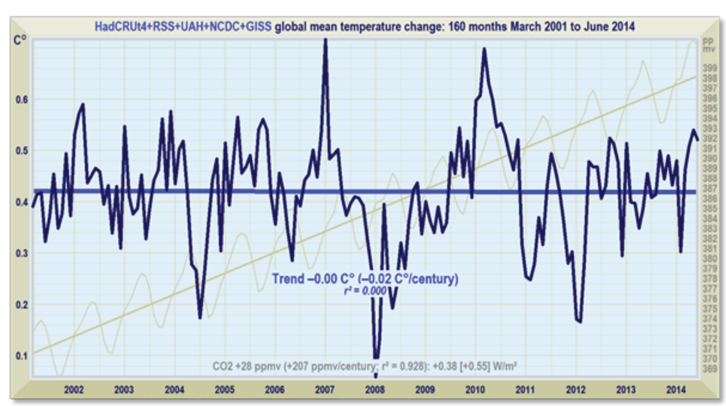

Figure 3 Global temperature between 2001 and 2014 (Monchkton, 2014).

The rate of relative sea level rise has been recently measured at 21 stations throughout south Louisiana by United States Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration (NOAA) for approximately the past fifty years (Louisiana Coastal Area Science & Technology Offices, 2012; and NOAA, 2013). The results range between 0.15 inch/yr to 1.01 inch/yr (Table A1). The largest rate of sea level rise is at USACE site number 01670, Southwest Pass at East Jetty of 1.01 inch/yr, while the smallest rate of sea level rise is at USACE site number 73650, Calcasieu River and Pass near Cameron of 0.15 inch. The overlap of when both stations were in operation is January 1953 to January 2004, 51 years out of the total 55.5 years that one or the other of these stations were in operation. This alone indicates that subsidence is significant contribution to global sea level rise otherwise the relative sea level rise rate should be similar not differing by a factor of almost seven. Another large study at 27 gaging sites by Turner (1991) observed again relative sea level rises for gages operating for over 20 years in south Louisiana which are similar, between 0.17 inch/yr to 1.07 inch/yr (Table A2). Still another earlier study yields similar results for relative sea level rise rates along coastal Louisiana: 0.15 inch/yr to 0.70 inch/yr , Table A3 (Penland et al., 1989). The relative rise of sea level for the Louisiana gages is significantly larger than what has been observed at other coastlines that are not experiencing subsidence such as the Atlanta coast of the United States, Maine to Florida, (Table A4) or Gulf Coast outside the Louisiana (Tables A5 & A6). The results in Tables A4, A5 and A6 are generally within the range of global sea level rise of 0.01 inch/yr to 0.12 inch/yr observed for many studies (Gornitz et al., 1982; Barnett, 1984; Gornitz, 1995; Church and White, 2006 and 2011; Cazenave and Llovel, 2010; and Ollier, 2013).

It has been observed that rate of sea level rise has been accelerating between 1870 and 2004 (Church and White 2006 and 2011; and Rahmstorf and Vermeer, 2011). However, if different periods of time are selected 1930-2004 there is no observed acceleration (Houston and Dean, 2011). By contrast, a number of studies of recent sea level rate of rise indicate little or no acceleration of the rate of sea level rise. Ollier (2013) notes that TOPEX/POSEIDON satellite data between 1993 and 2000 indicates there has been a slight rise in sea level while European Evisat satellite data indicates falling seal level since 2002 and GRACE satellites data shows a slight decrease of sea level between 2002 and 2007. However, Cazenave and Lloyel (2010) noted for recent intervals of 1993 to 2007, and 2003 to 2007 that altimetry–based rate of sea level rise is 3.3 $\pm$ 0.4 mm/yr and 2.5 $\pm$ 0.4 mm/yr.

It appears that Louisiana rates of relative sea level, Tables 1A, 2A, and 3A, are different from what is observed along the Atlantic coast or other parts of the Gulf of Mexico Coast both of which are considered to be tectonically quiet coast because do not have an offshore subduction zone (Diegel et al., 1995; and Stephens, 2009). The results were compared, Figure 4. Comparison of relative sea level rise rates are determined by using two techniques which do not require a normal distribution of data, Mean test and Mann-Whitney Ranks test (Conover, 1999; and Sprent and Smeeton, 2007). A statistical comparison indicates that Louisiana results are significantly different from either Atlantic coast or other Gulf of Mexico Coast sites, see Table 1. In all of these comparisons of Louisiana sites to other coast sites yield p values of 4.51 x 10-12 to 4.8 x 10-5, far below the standard of p = 0.05 (5 x 10-2) which indicates the confidence of difference exceeds 95% and therefore is significant (Conover, 1999; and Sprent and Smeeton, 2007). It is apparent that relative sea level rise in Louisiana is far larger than elsewhere along the Gulf of Mexico coast or Atlantic coast (Figure 4). The confidence of this difference is statistically significant for all sets of data comparisons considered except between the three Louisiana data sets. Relative sea level rise and associated subsidence has been observed by Turner (1991) has not varied significantly over the period of gage records (1909-1988). This indicates that time intervals earlier data sets, Table A2 or Table A3 collected mainly between 1948 and 1988 or 1931 to 1983 and the later set of data, Table A1, collected mainly between 1955 and 2013 is an insignificant factor in Louisiana coast relative sea level rise. There is a significant difference between Louisiana results and results from Atlantic coast or Gulf of Mexico coast sites. These results indicate that subsidence must be a significant factor causing relative sea level rate of rising to be on average about 210% larger than Atlantic coast or 200% larger than elsewhere on Gulf of Mexico coast within the United States. So, average relative sea level rise in Louisiana approximately three times that elsewhere in the United States along the Atlantic and Gulf of Mexico coast.

However, as can be seen not only are the average value of relative sea level rise far larger in Louisiana than elsewhere but the range is far larger as well, Figure 4. The Louisiana data sets have standard deviation significantly larger than either of the other non-Louisiana data sets (Table 2), approximately five times larger. Therefore, there is probably a general regional pattern where relative sea level rise is larger in limited areas in Louisiana than elsewhere. Generally, the largest rates of relative sea level rise are concentrated in southeastern Louisiana and in area of the Mississippi bird's foot delta (Figure 5). Penland et al., (1989) notes the relative sea level rise in Terrebonne Parish is 10 times larger than average sea level rise across the globe. Relative sea level rise in Plaquemines Parishes, extreme southeast Louisiana, is approximately 0.87 inch/yr (Figure 5) which is approximately 10 to 20 times larger than the typical value of global relative sea level rise of 0.04 inch/yr to 0.09 inch/yr noted by Turner (1991).

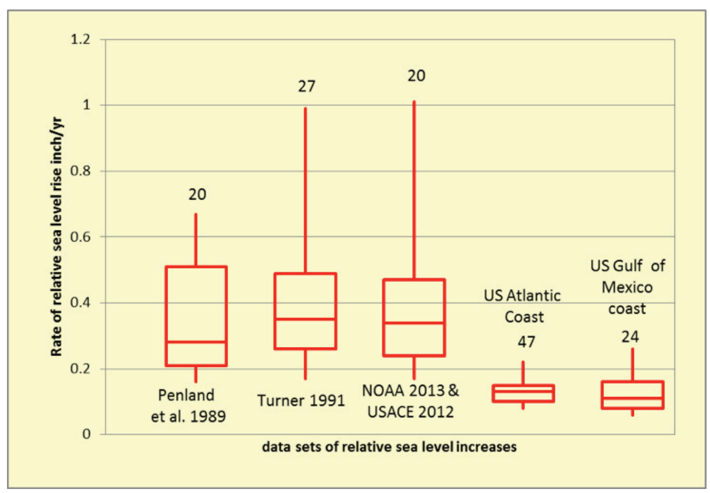

Figure 4 A comparison of relative sea level rise in Louisiana to sea level rise along Atlantic coast and elsewhere along Gulf of Mexico coast within the United States. Number above top of each box & whiskers plot is the number of gaging sites included in each data set.

Table 1. Below is the comparison between three sets of Louisiana relative sea level rise data and Atlantic and Gulf of Mexico relative level rise data set for site elsewhere in the United States. The p value indicates the fractional chance the two data sets are similar. Any value of p that is less than 0.05 (5 x 10-2) indicates the two data sets are significantly different. Significant differences have p values in red bold italic letters.

Median Test p values of tests					
	Penland et al 1989	Turner 1991	NOAA 2013 & USACE 2012	Atlantic data	Gulf of Mex. Data
Penland et al 1989		0.674	0.752	***7.21×10^{-7}***	***4.8×10^{-5}***
Turner 1991	0.674		0.567	***4.51×10^{-10}***	***1.72×10^{-5}***
NOAA 2013 & USACE 2012	0.752	0.567		***7.21×10^{-7}***	***4.8×10^{-5}***
Atlantic data	***7.21×10^{-7}***	***4.51×10^{-10}***	***7.21×10^{-7}***		0.739
Gulf of Mex. Data	***4.8×10^{-5}***	***1.72×10^{-5}***	***4.8×10^{-5}***	0.739	
Mann-Whitney Ranks Test p values of tests					
Penland et al 1989		0.613	0.735	***1.81×10^{-9}***	***1.93×10^{-6}***
Turner 1991	0.613		0.747	***4.51×10^{-12}***	***2.74×10^{-8}***
NOAA 2013 & USACE 2012	0.735	0.747		***6.75×10^{-10}***	***7.0×10^{-7}***
Atlantic data	***1.81×10^{-9}***	***6.63×10^{-12}***	***6.75×10^{-10}***		0.492
Gulf of Mex. Data	***1.93×10^{-6}***	***2.74×10^{-8}***	***7.0×10^{-7}***	0.492	

Table 2 Summary of data sets

	number	average mm/yr	standard deviation mm/yr
Penland et al., 1989	20	9.10	4.26
Turner, 1991	27	10.01	5.15
NOAA 2013 & US-ACE 2012	20	10.46	6.69
Atlantic data	47	3.30	1.01
Gulf of Mex. data	24	3.38	1.58

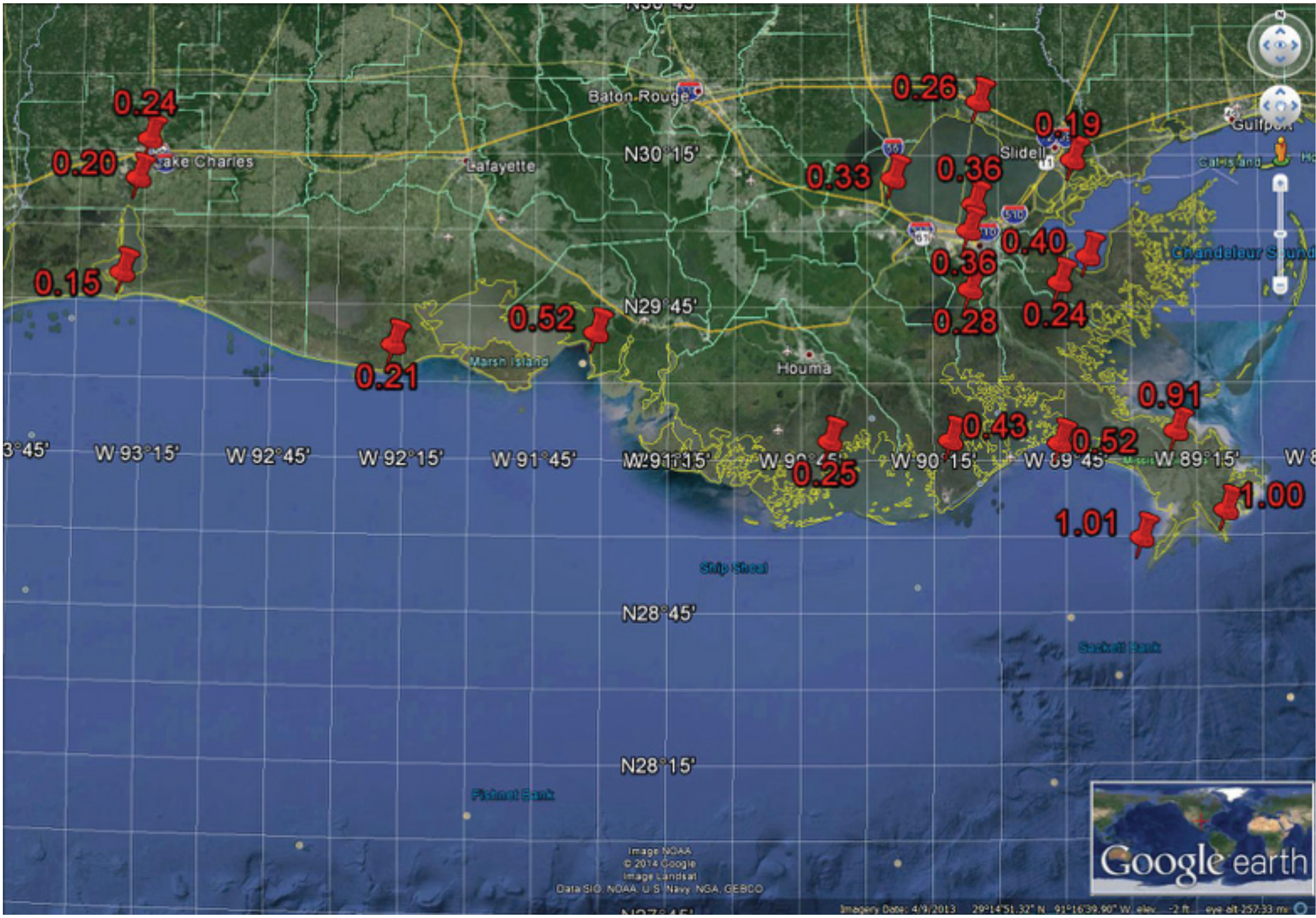

Figure 5. Relative sea level rise throughout Louisiana for data in Table 1. All the values displayed on the above map are relative sea level rise in inch/yr.

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Appendix A

Rates of relative sea level rise as measured at various sets of tidal gaging stations

Table A1 Summary of relative sea level trends for USACE and NOA gages in Louisiana (Louisiana Coastal Area Science & Technology Offices, 2012; and NOAA, 2013)

gage name	USACE gage ID number	Latitude (degrees-minutes-seconds)	Longitude (degrees-minutes-seconds)	period of record	Linear trend over entire period of record (inch/yr)
Bayou Barataria at Barataria	82750	29-44-29	90-07-56	Jan 1950-Nov 1992	0.28
Bayou Lafourche at Leeville	82350	29-14-52	90-12-32	Nov 1955-Apr 2000	0.43
Bayou Petit Cailou at Cocodrie	76305	29-14-43	90-39-48	Mar 1969-Aug 2009	0.25
Bayou Terre Aux Boeufs at Delacroix	85780	29-45-50	89-47-32	May 1975-Aug 2005	0.24
Calcasieu River and Pass at Lake Charles	73550	30-13-05	93-15-12	Jan 1950- Jul 2003	0.24
Calcasieu River and Pass near Cameron	73650	29-46-30	93-20-46	Jan 1950-Aug 2005	0.15
East CoteBlanche Bay at Luke's Landing	88800	29-35-48	91-32-35	Feb1957-Oct 2002	0.52
Eugene Island				1939-1974	0.38
Freshwater Canal at Freshwater Bayou Lock (South)	76593	29-33-09	92-18-21	Jul 1968- Aug 2009	0.21
Grand Isle				1947-2013	0.36
Intracoastal Waterway at Calcasieu Lock (West)	76960	30-05-19	93-17-40	Jan 1951-Dec 2009	0.21
Lake Pontchartrain at Frenier	85550	30-06-22	90-25-17	Jan 1950-Dec 2002	0.33
Lake Pontchartrain at Manderville	85575	30-21-31	90-05-45	Aug 1957-Jul 2002	0.26
Lake Pontchartrain at West End	85625	30-01-18	90-06-57	Jan 1950-Dec 2009	0.36
Mississippi River at New Orleans (Carrollton)	01300	29-56-05	90-08-10	Jan 1950-Dec 1998	0.36
Mississippi River at Venice	01480	29-16-33	89-21-10	Jan 1953-Aug 2005	0.91
Mississippi River at West Pointe a la Hache	01400	29-34-16	89-47-49	Jan 1950-Dec 2009	0.52
Mississippi River Gulf Outlet at Shell Beach	85800	29-51-00	89-41-00	Jun 1961-Dec 2002	0.40
Rigolets near Lake Pontchartrain	85700	30-10-02	89-44-13	Jan 1950-Aug 2001	0.19
South Pass at Port Eads	01850	29-00-53	89-09-57	Jan 1953-Dec 2004	1.01
Southwest Pass at East Jetty	01670	28-55-38	89-29-12	Jan 1953-Jan 2004	1.01

Table A2 Summary of relative sea level trends along Gulf of Mexico coast of the United States within Louisiana only (Turner, 1991)

station name	year range	MSL trend (inch/yr)
Atchafalaya Bay near Eugene Island	33	0.33
Bayou Black at Greenwood	35	0.49
Bayou Boeuf at B. Boeuf Lock (E) near Morgan City	26	0.36
Bayou Cheureuil near Chegby	23	0.29
Bayou des Allemands at des Allemands	30	0.21
Bayou Lafourche at Leesville	23	0.22
Bayou Rigaud at Grand Isle	28	0.26
Bayou Sale at Luke's Landing	23	0.44
Bayou Teche at W. Calumet Floodgate	29	0.36
Belle River near Pierre Pass	23	0.39
Calcasieu River & Pass at Hackberry	37	0.28
Calcasieu River & Pass near Cameron	38	0.29
Intercoastal waterway at Vermilion Lock (E Staff)	37	0.21
Intercoastal waterway at Wax Lake W.	25	0.61
Lake Pontchartrain at Little Woods	45	0.35
Lake Pontchartrain at Mandeville	49	0.17
Lake Pontchartrain near South Shore	31	0.30
Lake Pontchartrain at West End	47	0.17
Lake Verret Attakapas Landing	25	0.52
Lower Atchafalaya River at Berwick Lock (W)	24	0.48
Lower Atchafalaya River at Morgan City	47	0.50
Lower Atchafalaya River below Sweet Bay Lake	24	0.47
Mermentau River at Catfish Point Control Structure	31	0.28
Schooner Bayou at Control Structure (E staff)	37	0.24
Six mile Lake at Verdunville	31	1.07
South Pass Bar near Port Ends	32	0.50
Wax Lake Outlet at Calumet	38	0.83

Table A3 Summary of relative sea level trends along Gulf of Mexico coast of the United States within Louisiana only (Penland et al., 1989)

station name	parish	period of record	MSL trend (inch/yr)
Calumet	Saint Mary	1942 to 1983	0.70
Cameron	Cameron	1942 to 1983	0.26
Grand Isle	Jefferson	1947 to 1978	0.51
Greenwood	Terrebonne	1948 to 1983	0.50
Eugene Island	Saint Mary	1944 to 1983	0.63
Frenier	St. John the Baptist	1931 to 1977	0.15
Hackberry	Cameron	1943 to 1983	0.22
Houma	Terrebonne	1946 to 1983	0.52
Little Woods	Orleans	1931 to 1977	0.43
Mandeville	Saint Tammany	1931 to 1983	0.19
Mermentau River	Cameron	1949 to 1983	0.26
Morgan City	Saint Mary	1933 to 1983	0.53
Port Eads	Plaquemines	1944 to 1983	0.50
Schooner Bayou-East Auto	Vermilion	1942 to 1983	0.25
Schooner Bayou-East Staff	Vermilion	1942 to 1983	0.24
South Shore	Orleans	1949 to 1983	0.39
Vermilion Lock East Auto	Vermilion	1942 to 1983	0.20
Vermilion Lock East Staff	Vermilion	1943 to 1983	0.21
Vermilion Lock West	Vermilion	1942 to 1983	0.31
West End	St. John the Baptist	1931 to 1983	0.17

Table A4 Summary of relative sea level trends along Atlantic coast of the United States (NOAA, 2013)

station name	first year	last year	year range	MSL trend (inch/yr)
Annapolis, Maryland	1928	2013	85	0.14
Atlantic City, New Jersey	1911	2013	102	0.16
Baltimore, Maryland	1902	2013	111	0.12
Bar Harbor, Maine	1947	2013	66	0.09
Beaufort, North Carolina	1953	2013	60	0.11
Boston, Massachusetts	1921	2013	92	0.11
Bridgeport, Connecticut	1964	2013	49	0.11
Cambridge, Maryland	1943	2013	70	0.15
Cape May, New Jersey	1965	2013	48	0.18
Charleston, South Carolina	1921	2013	92	0.12
Chesapeake Bay Bridge Tunnel, Virginia	1975	2013	38	0.23
Chesapeake City, Maryland	1972	2013	41	0.15
Colonial Beach, Virginia	1972	2010	38	0.19
Daytona Beach Shores, Florida	1925	1983	58	0.09

Outreach Activities

Earth Science Week: Earth Science Week is sponsored annual by the American Geosciences Institute (AGI) and its member societies. At the request of the LGS, Governor Jindal issued a proclamation declaring October 12-18, 2014 as Earth Science Week in Louisiana. The theme for the week was "Mapping Our World". LGS received 50 educational kits from AGI which were distributed to school earth science teachers through the program coordinator of the East Baton Rouge Parish School System, Division of Standards, Assessment and Accountability.

Rockin' At The Swamp: LGS participated in "Rockin' At the Swamp", a one-day educational outreach event for schools organized by Baton Rouge Parks and Recreation which was held on March 8, 2014 . The LGS exhibit booth displayed rocks and minerals found in Louisiana and other places and thin sections. Fossils specimens were also displayed. The LGS booth proved to be one of the star attractions for the hundreds of school students and adults attending the event. The event also featured gem and mineral vendor booths and natural science exhibits.


United States of America
State of Louisiana
Governor
Bobby Jindal
Proclamation

WHEREAS, the earth sciences are integral to the discovery development, and conserving of mineral, energy, and water resources; and

WHEREAS, the earth sciences provide the basis for mitigating wetland loss and natural hazards such as earthquakes, floods, coastal erosion, hurricanes, landslides, droughts, and subsidence; and

WHEREAS, the earth sciences are critical to environmental and ecological issues ranging from water and air quality to waste disposal; and

WHEREAS, geological factors of resources, hazards, and environmental are vital to land management and land use decisions made in Louisiana; and

WHEREAS, the Louisiana Geological Survey, since its establishment in 1934, has served the state and its citizens with valuable and relevant earth science investigations and information.

NOW, THEREFORE, I, Bobby Jindal, Governor of the State of Louisiana, do hereby proclaim October 12-18, 2014, as

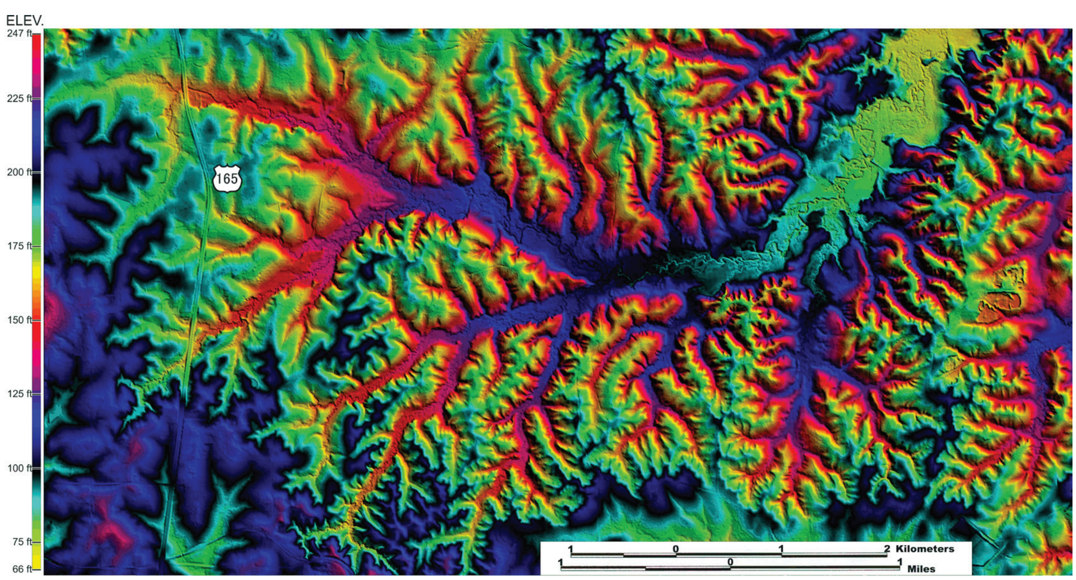
EARTH SCIENCE WEEK
in the State of Louisiana.

In Witness Whereof, I have hereunto set my hand officially and caused to be affixed the Great Seal of the State of Louisiana, at the Capitol, in the City of Baton Rouge, on this the 12th day of October A.D., 2014

Attest By The Governor

Secretary of State

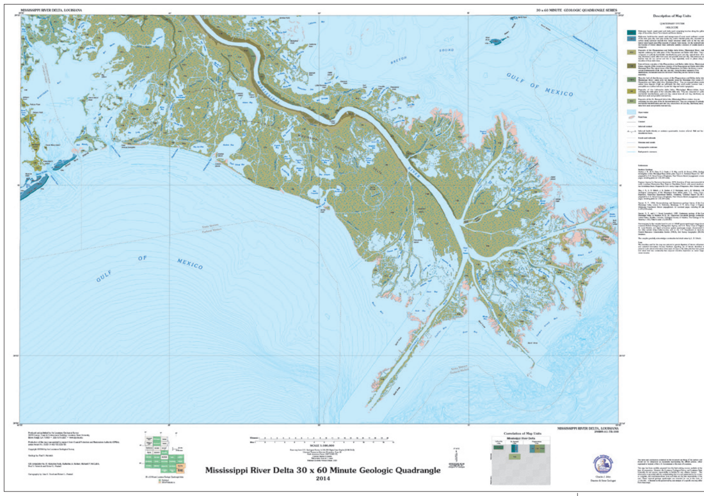
Governor of Louisiana



Rectilinear disposition of alluvial courses suggestive of fracture control, southeastern Grant Parish, revealed in a view of mosaicked LIDAR digital elevation models.

LGS Resource Center

The LGS Resource Center consists of a core repository and log library. It is located behind the old Graphic Services building on River Road. Most of our cores are from the Smackover and Wilcox Formations. The core facility has more than 30,000 feet of core from wells mostly in Louisiana. The well log library contains over 50,000 well logs from various parishes in the state. The Core Lab is equipped with climate controlled layout area, microscopes, and a small trim saw. The core and log collections are included as part of the LSU Museum of Natural History as defined by the Louisiana Legislature and is the only one of its kind in Louisiana.The LGS Resource Center is available for use by industry, academia and government agencies, and others who may be interested. Viewing and sampling of cores can be arranged by calling Patrick O'Neill at 225-578-8590 or by email at poneil2@lsu.edu. Please arrange visits two weeks in advance. A list of available cores can be found at the LGS web site (www.lgs.lsu.edu).



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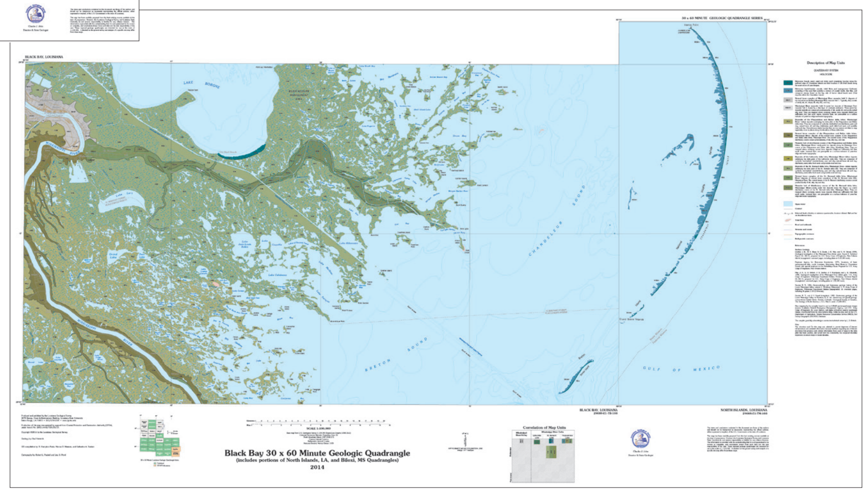

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