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The Houston Ridge: An Ancient Shoreline in Calcasieu Parish, Louisiana

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A prominent feature of Southwest Louisiana is 19 mile-long (32 km-long), narrow, east-west trending ridge, which lies in northern Calcasieu Parish, Louisiana about 4 miles (6.4 km) north of Sulphur, Louisiana This ridge rises between 6 to 15 feet (2 to 4.6 m) above the surface of the northern edge of a low coast-parallel terrace, which is the surface of the Beaumont Alloformation of the Prairie Allogroup as mapped by Heinrich et al. (2002). Relict channels of the Sabine River and valleys occupied by the Houston River and West Fork of the Calcasieu River have cut the once-continuous Houston Ridge into several segments (Figure 1).

Geomorphology

Using Digital Elevation Models (DEM) constructed from LIght Detection And Ranging (LIDAR) data, the geomorphology of the Houston Ridge was remapped. The LIDAR DEMs, which are available from the Atlas: The Louisiana Statewide GIS web page at http://atlas.lsu.edu/, allowed the recognition, interpretation, and mapping of the very subtle landforms of various origins, which are associated with it. Many of these landforms are not otherwise either observable or mappable from aerial images and 1:24,000-scale topographic maps. From the analysis of the LIDAR DEMs, the Houston Ridge was subdivided into three major segments as shown in Figure 1.

The western segment of the Houston Ridge consists of a 9.8 mile-long (16 km-long) narrow, 1,600 to 2,600 feet (500 to 800 m), wide ridge extending westward to within 3.4 miles (5.6 km) of the eastern wall of the Sabine River valley at 30° 17' 17.15"N 93° 35' 43.60"W. The relict channels of an abandoned Sabine River course truncate the eastern end of this segment at 30° 18' 00.62"N 93° 25' 46.56"W. The crest of this ridge typically ranges in elevation from 30 to 36 feet (9 to 11 m) above mean sea level and rises 6 to 15 feet (2 to 4.5 m) above the surface of the adjacent Beaumont Alloformation. The LIDAR DEMs show that the surface of both the Houston Ridge and other parts of the Beaumont Alloformation has been extensively modified by the formation of innumerable pimple mounds. However, remnants of beach-like ridge and swale can be seen in the LIDAR DEMs within the eastern end of the Houston Ridge. The southern edge of this segment is a steep, slightly arcurate scarp. The northern edge of this segment is highly irregular and gently sloping with numerous channel-like embayments, which are often associated with fan-like topographic features, apparent in the LIDAR DEMs. Along this segment, a complete lack of relict fluvial landforms and evidence for fluvial sculpturing was seen in the LIDAR DEMS, except where a relict Sabine River channel has cut a piece off of the westernmost end of it.

A 3 mile-long (4.9 km-long) segment, within the middle of the Houston Ridge extends from where it has been cut by relict channels of the Sabine River at 30° 18' 15.94"N 93° 25' 59.83"W to where the valley of the Houston River cuts through this ridge at 30° 18' 7.41"N 93° 22' 50.49"W (Figure 1). This segment varies in width from 1,600 to 2,900 feet (500 to 900 m) wide and 25 to 28 feet (7.6 to 8.5 m) in elevation. The surface of this segment has been so severely modified by the formation of pimple mounds and dissection that only indecipherable fragments of its original constructional morphology remain.

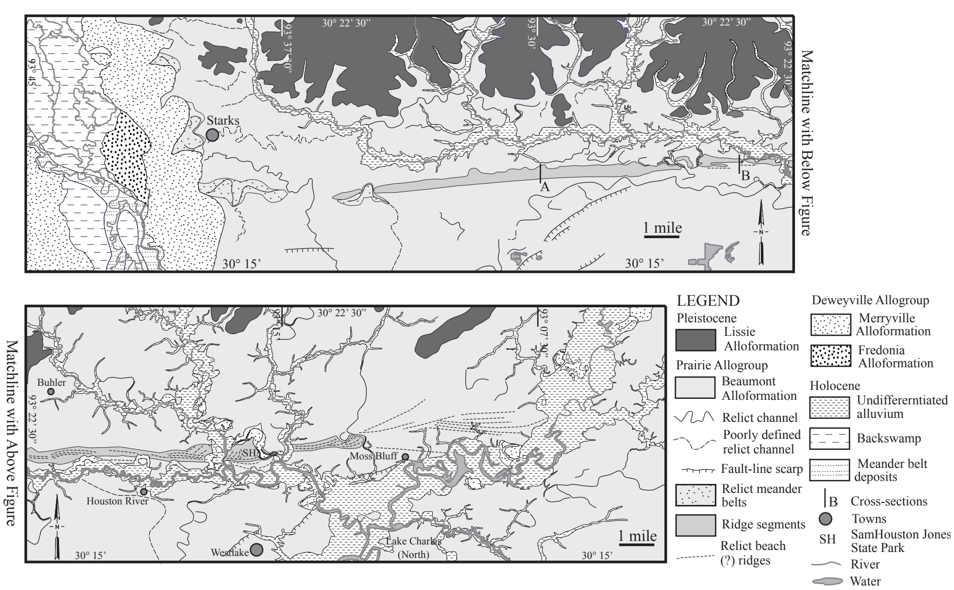

Figure 1. Geologic map of the Houston Ridge area showing distribution of landforms associated with it and the surface of the Beaumont Alloformation. Modified from Heinrich et al. (2002) using LIDAR DEMs and 1998 Digital Orthophoto Quarter Quadrangles.

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 eastern segment of the Houston Ridge consists of a 6.8 mile-long (11 km-long), which extends from the eastern valley wall of the Houston River at 30° 18' 05.49"N 93° 22' 41.49"W to and including Houston Jones State Park at 30° 18' 04.69"N 93° 15' 41.17"W (Figure 1). Where it has not been destroyed by the lateral migration of the Houston River, the southern edge of this segment of the Houston Ridge exhibits a sharp steep scarp. The northern edge drops gently down to the surface of the Beaumont Alloformation. Except where the valleys of the Houston River and West Fork of the Calcasieu River have either cut into or through it, a complete lack of any evidence of fluvial sculpturing of the Houston Ridge was found. Despite intensive modification of the surface of The Houston Ridge, LIDAR DEMs revealed the presence of poorly preserved ridges and swales on the surface of it. Both immediately east and west of where the valley of the West Fork of the Calcasieu River cuts through this ridge, the Houston Ridge exhibits recurved, poorly preserved, spit-like ridges as seen in LIDAR DEMs.

Starting south of the end of the Houston Ridge within Sam Houston Jones State Park, a lower and more poorly defined ridge extends for distance of about 9.1 miles (15 km) from immediately south of Sam Houston State Park at 30° 17' 57.96"N, 93° 16' 30.05"W to the west valley wall of the Calcasieu River at 30° 17' 15.85"N, 93° 07' 13.19W". The width of this segments ranges from 1,600 to 2,600 feet (500 to 800 m) to as much as 3,300 to 4,900 feet (1,000 to 1,500 m) at its easternmost end within Sam Houston Jones State Park. The surface of this ridge exhibits poorly preserved and deeply eroded coast-parallel ridge and swale topography as can be seen in the LIDAR DEMs (Figure 1). Some of these ridges exhibit recurved spit-like morphology. The Houston Ridge has poorly defined edges and a relief of 4 to 7 feet (1.2 to 2.1 m) above the level of the surface of the Beaumont Alloformation along its western end. Eastward, the relief disappears as the ridge drops in elevation and merges with the surface of the Beaumont Alloformation.

Graf (1966), Barrilleaux (1986), and Otvos (1991) have described the lithology of the sediments composing the Houston Ridge. In general, they describe the sediments comprising the Houston Ridge as consisting of sand, loamy sand, and sandy loam. Barrilleaux (1986) shows the sediments composing the Houston ridge as consisting of more than 75 percent fine to very fine-grained sand. This thesis noted that the sandy sediments composing the Houston Ridge become slightly finer grained, better sorted, and better rounded eastward along the ridge. Neither Graf (1966), Barrilleaux (1986), Otvos (1991), nor Otvos and Howat (1997) found any fossils within the sediments comprising the Houston Ridge. However, Aronow (1986) reported collecting an oyster shell, which was dated as being older than 40,200 BP, from the north side of the Houston Ridge, where the Houston River cuts through it, in SW1/4, Sec. 2, T.9S., R.10W.

An unpublished boring made as part of preparing Snead et al. (1997) penetrated 21 feet (6.3 m) of sandy sediments underlying the crest of the Houston Ridge within NW1/4, of Sec. 9, T.9S., R.11W. The sediments composing the Houston Ridge encountered in this drill hole, from top to bottom, consisted of 16.3 feet (5 m) of brown to brown yellow, highly weathered, massive loamy sand overlying 4.6 feet (1.4 m) of dark bluish gray, medium-grained sand with thin clay interbeds containing wood fragments. In this drill hole, 8.3 feet (2.5 m) of dark gray laminated clay containing shell fragments, wood fragments, and silt laminae separates the above sandy sediments from older, pedogenically altered Pleistocene sediments.

According to Barrilleaux (1986), the strip of the Beaumont Alloformation lying north of the Houston Ridge and south of where it pinches out against the edge of Lissie Alloformation consists interbedded red and gray clay, sandy clay, and silt. These sediments typically consist of less than 25 percent sand. One sample of these sediments recovered from a boring immediately north of the Houston Ridge yielded a couple of specimens of the agglutinated foraminifera, Ammonia beccarii (Barrilleaux 1986).

Internal Structure

Although Graf (1966), Barrilleaux (1986), Otvos (1991), and Otvos and Howat (1997) have studied the Houston Ridge using auger or drill holes, the information about the internal structure of it is quite limited. Because his borings failed to reach the base of these sediments, Graf (1966) only determined that the sandy sediments comprising this ridge are more than 10 to 15 feet (3 to 4.6 m) thick in places. Otvos (1991) and Otvos and Howat (1997), stated that the "Prairie sequence" comprising the Houston Ridge, as penetrated by Drill Holes no. 3 and 4 are 21 feet (6.3 m) thick. However, these papers fail to provide any precise details about the internal stratigraphy of the Houston Ridge. As previously noted, boring by the Louisiana State Geological Survey found 21 feet (6.3 m) of sandy sediments underlying the crest of it at one location.

The most detailed information concerning the internal structure of the Houston Ridge consist of two unpublished cross-sections of the western segment, Figures 2 and 3, made from borings by Mr. Clay Midkiff, Dr. Bob J. Miller, and Mr. B. A. Touchet in 1984 and 1985 (Miller 1985). Cross Section A shows the Houston Ridge consisting of a 18 foot-thick (5.5 m-thick) core of sand, loamy sand, and sandy loam surrounded on both sides by silty clay and clay. Extending southward from the base of this core is a 4 to 8 foot-thick (1.2 to 2.4 m-thick) tongue of sandy and loamy sediments. Cross Section B shows the Houston Ridge as consisting of a 10 foot-thick (3 m-thick) core of sand, loamy sand, and sandy loam overlying interlayered sandy sediments and clay surrounded by silty clay and clay. The interlayed sandy sediments and clays also extend southward as 5 to 7 foot-thick (1.5 to 2.1 m-thick) tongue, which grades into loamy fine sand. Cross sections A-A' and C-C' of Barrilleaux (1986) also illustrate a similar internal structure for the Houston Ridge.

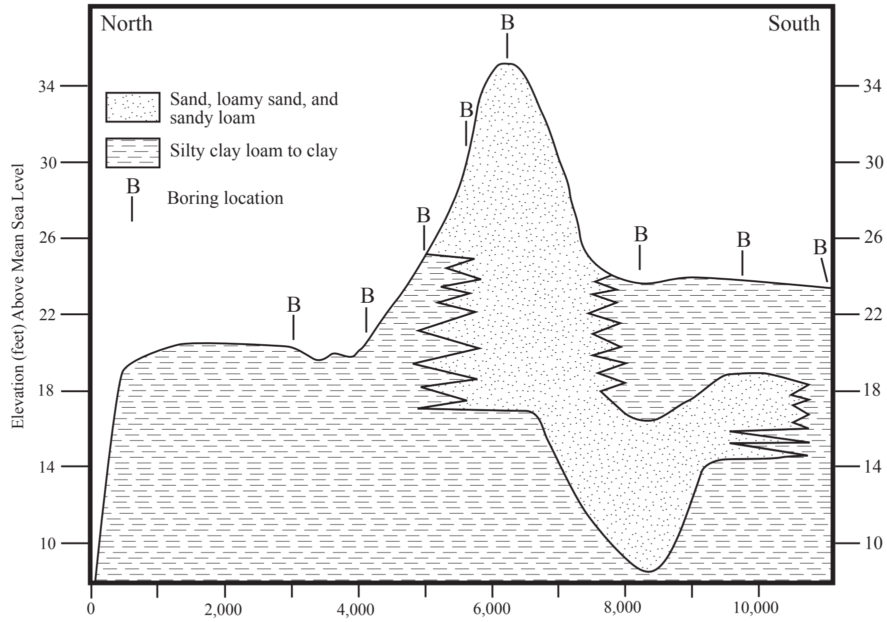

Figure 2. North-south Cross-section A of the Houston Ridge along the east edge of Sections 4 and 9, T.9S., R.11W., Calcasieu Parish, Louisiana. (Redrawn and modified, by permission, from Miller 1985)

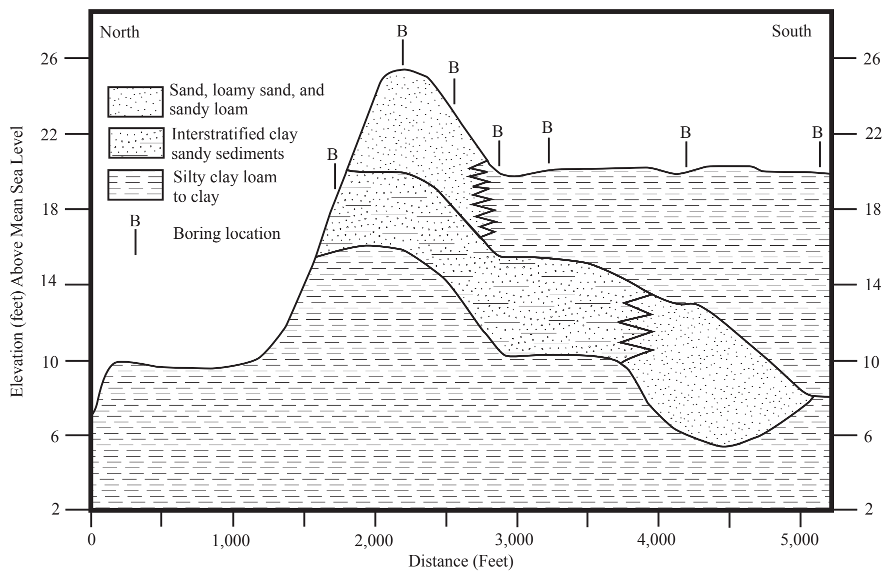

Figure 3. North-south Cross-section B of the Houston Ridge along the east edge of Sections 4 and 9, T.9S., R.10W., Calcasieu Parish, Louisiana. (Redrawn and modified, by permission, from Miller 1985)

Origin

Houston Ridge has been recognized as a barrier ridge and ancient shoreline in a number of geomorphic and geologic maps, including Bernard and LeBlanc (1965), Fisk and McFarlan (1959), Otvos (1972), Barrilleaux (1986), and Winker (1991). These authors map this landform as the eastern end of the coast-parallel barrier island - beach ridge system extending from South Texas into Calcasieu Parish called the "Ingleside Barrier Trend". Of these studies, only Graf (1966), Aronow (1986), and Barrilleaux (1986) discuss the physical character of the Houston Ridge in any detail.

In contrast, Otvos (1991) and Otvos and Howat (1997) dispute the identification of the Houston Ridge as being a relict barrier island. They argue that the Houston Ridge is a linear ridge, an "interfluve" created by the erosion of alluvial sediments of the Beaumont Alloformation because the sediments composing it are too muddy; the sediments composing it and underlying its "lagoon" lack fossils; diagnostic strandplain topography is absent from its crests; "ridge-parallel" river channels occur along its sides; and the Houston Ridge parallels regional faults and lineaments.

None of these observations provide convincing evidence for the Houston Ridge being a landform sculptured by erosion processes along pre-existing lineaments. Relative to the surface and sediments of the adjacent Beaumont, the Houston Ridge has significantly greater relief and contains a much higher percentage of sand. As a result of their higher elevation and greater permeability, the sediments composing the ridge have been subject to greater through-flow of water and have been more highly weathered than equivalent surface sediments of the Beaumont Alloformation. This greater degree of weathering is sufficient to explain the typical lack of fossils within the sediments of the Houston Ridge. Barrilleaux (1986) reported the presence of the agglutinated foraminifera, Ammonia beccarii from sediments inferred to have accumulated in a lagoon behind the Houston Ridge. In addition, the LIDAR DEMs show the remnants of ridge-like features along the crest of the Houston Ridge, as also reported by Barrilleaux (1986), which can be readily interpreted to the remains of severely degraded beach ridges and spits. The intense modification of the original surface morphology of the Houston Ridge by the formation of the pimple mounds and, as argued by Aronow (1986) by tree throws (the displacement of sediment by the toppling of trees) is severe enough to explain the extremely poor preservation to complete absence of relict beach ridges, spits, and other features characteristic of barrier islands and coastal beaches on the Houston Ridge. In addition, the observed internal structure of the Houston Ridge is more consistent with the internal structure of a beach ridge than a fluvial ridge. Finally, the examination of the LIDR DEMs failed to find any significant evidence of relict Sabine River courses, which could have sculptured the Houston Ridge, and of east-west lineaments, which would have guided the formation of it by erosion.

In conclusion, as proposed by Graf (1966) and Barrilleaux (1986), the Houston Ridge is a relict barrier island and valid segment of the Ingleside Barrier Trend. The LIDAR DEMs clearly show relict ridges, which although poorly preserved, are indicative of relict beach ridges and spits (Figure 1). The cross-sections of Miller (1985), Figures 2 and 3, are consistent with the gross distribution of lithologies, which would be found composing a relict barrier island.

As previously noted, an examination of the LIDAR DEMs revealed a series of parallel ridges, which end in spit-like features, extending from Sam Houston Jones State Park eastward to the western valley wall of the Calcasieu River valley (Figure 1). The lack of subsurface data precludes a definitive answer as to the origin of these ridges. They do have the appearance of a partially buried strandplain, within the Beaumont Alloformation, which formed during a younger and slightly lower sea level highstand than the Houston Ridge. However, detailed study of the sediments underlying these ridges will be needed to determine their origin.

Age

The age of the Houston Ridge has not been directly determined. Oyster shell collected by Aronow (1986) from the base of the Houston Ridge yielded a radiocarbon date of greater than 40,200 BP. Many samples of wood and shell collected from the Beaumont Formation in southeast Texas have yielded mainly "dead" radiocarbon dates, which are greater then 40,000 BP (McFarlan 1961, Otvos 1971, Aronow 1988). Given the lack of sea level highstands during the last glacial, Wisconsin, stage, it appears that the Houston Ridge could date to Marine Isotope Substage 5e, about 130,000 BP, when sea level was 9 feet (3 m) above present mean sea level. Such an age would suggest that the lower ridge system might represent a younger sea level highstand during Marine Isotope Substage 5a, about 85,000 BP, when sea level briefly peaked at slightly lower elevations (Muhs et al. 2004).

Summary

Enough is known about the Houston Ridge and can be seen using LIDAR DEMs to still regard it as a relict barrier island, which forms the eastern end of Ingleside Barrier Trend. At this time, it still remains to be directly dated although it is inferred having formed along the shoreline of the Gulf of Mexico when sea level was 10 to 20 feet (3 to 6 m) higher during the last interglacial period. Further detailed research of the Houston Ridge and the lower ridge system using ground-penetrating radar, cores, and optical dating, as done in South Carolina by Blum and Willis (2005) and Willis (2006) will be needed to understand their internal structure and development in any detail and provide a definite date as to when they formed.

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How New Orleans Diaspora Impacted Public Supply Use of Groundwater in the Baton Rouge Area

Douglas Carlson

Introduction

On August 29, 2005 Hurricane Katrina (Figure 1) struck the southeast coast of Louisiana near Buras, Louisiana (Graumann et al., 2005). As the storm moved north towards Biloxi, Mississippi, it first drove a storm surge from the east down the Industrial Canal into the lower ninth ward of New Orleans. Then the storm moved north and drove a storm surge from the north down the 17th street and London street canals into New Orleans (Graumann, et al. 2005). Within a few days approximately 80% of New Orleans was flooded and even larger share of St. Bernard and Plaquemines Parishes to the east and southeast of New Orleans were flooded due to breaks in various levees (Graumann et al, 2005; and Koningsmark, 2006a).

Figure 1. Satellite photo of Katrina on August 29, 2005 as the eye crossed into Mississippi (source of photo is photosfromkatrina.com, 2005).

This flooding and destruction of approximately 200,000 of housing units (Konigsmark, 2006a) drove out approximately 520,000 people or almost 40% of the population of the New Orleans metropolitan area (Konigsmark, 2006b; and World Almanac, 2007). Those who left New Orleans were dispersed throughout the United States as indicated by changes of address as reported to Federal Emergency Management Administration (FEMA) (Overberg, undated; FEMA, 2007). However, states near Louisiana and other areas within Louisiana received the largest share of those who have left New Orleans after Katrina (Nasser and Overburg, 2006). This population loss was not uniform throughout the New Orleans metropolitan area. Four parishes lost population between July of 2005 and July of 2006: St. Bernard –76%, Orleans –50%, Plaquemines –22% and Jefferson –4%, with a total loss of population in these four parishes of approximately 304,000 (Brown, 2007). However, four other parishes in New Orleans metropolitan area gained population in the same time interval: St. John the Baptist 5%, St. Tammany 5%, St. Charles 4% and St. James 3% with a total gain of population in these four parishes of approximately 16,000 (Brown, 2007). By comparison, between July 2005 and July 2006 the five parishes within the Capital Area Ground Water Conservation District (East Baton Rouge, East Felciana, Pointe Coupee, West Baton Rouge and West Feliciana) gain approximately 21,000 people (Brown, 2007). Lastly, in the other 51 parishes in Louisiana there has been a gain of approximately 47,000 people between July 2005 and July 2006 (Brown, 2007).

Initially the estimated population growth for the Baton Rouge Area, for September of 2005, was estimated at approximately 200,000 (Tanneeru, 2005); 235,000 (Huus, 2005); 300,000 to 400,000 (Godoy, 2006). Anyone of these estimates of new residents is a large increase for the Baton Rouge area which had population of 705,973 in the 2000 census (World Almanac, 2007). These additional new residents in the Baton Rouge area have impacted the city in a variety of ways. This increase of population increased traffic. Traffic counts estimated this increase is between 35% and 45%, which turn has increased commuting times to work (Tanneeru, 2005). In addition, to the immediate impact on traffic there was an impact on real-estate and the number of hotel-motel rooms occupied (Tanneeru, 2005). There was a significant increase in the both number of housing units sold compared to a year earlier and the price increase ranged from modest to more than doubling the price of house in a short time span (Perkins, 2005). Average house's price increased 27% to approximately $170,000 (Dunne, 2006a; and Godoy, 2006). The early impact of evacuees was also felt in the hospital system of a Baton Rouge with an increase both in patients and physicians in the area (Clark, 2005). The increase of low-income patients would stress community hospitals such as General due to inadequate reimbursements for Medicaid patients (Clark, 2005). Health care is not the only economic area impacted by evacuees. There has been an estimated increase in jobs of 10,000 in the Baton Rouge area in the first year after Katrina (Dunne, 2006b). These jobs have been largely concentrated in services, and business and medical fields (Dunne, 2006b).

Estimates for the permanent long-term increase of metropolitan Baton Rouge population are given at 25,000 to 50,000 additional people. This growth is likely to accelerate the Baton Rouge area towards being the economic center of Louisiana (Huus, 2005). It is apparent by the summer of 2006 that the Baton Rouge metropolitan area received the second or third largest number of Katrina evacuees (50,000 to 100,000) after the far larger cities of Houston (111,000) and Atlanta (70,000) (Godoy, 2006). However, these estimates are uncertain as indicated by another report that indicates population increase in Baton Rouge Area of 17,000 and in Houston of 90,000 (Konigsmark, 2006a). Still other estimates of the increase of population vary from approximately 5% as determine from school-enrollment records to 10% for census estimates to 20% from traffic counts (Dunne, 2006a). With the increase of population and economic activity the question to consider is how large and significant is the impact on resources, such as public supply use of groundwater in the Baton Rouge Area

Public Supply use of Groundwater Prior to Katrina

The Capital Area Ground Water Conservation Commission (CAGWCC) was established in 1974 by the Louisiana Legislature Act 678. The commission functions to protect quality of groundwater and to promote orderly development of groundwater resources (CAGWCC, 2006a). As part of its work the commission collects monthly pumpage data for major groundwater users with in the five parish area, which was started January of 1976 and is ongoing.

Public supply use of groundwater has largely been concentrated in East Baton Rouge Parish (Figure 2) where approximately 79% of all groundwater used is in the Capital Area Ground Water Conservation District (CAGWCD) in East Baton Rouge Parish. West Feliciana and West Baton Rouge Parishes account for approximately 13% of all groundwater used in the CAGWCD. Pointe Coupee and East Feliciana Parishes account for approximately 8% of all groundwater used for public supply in the CAGWCD.

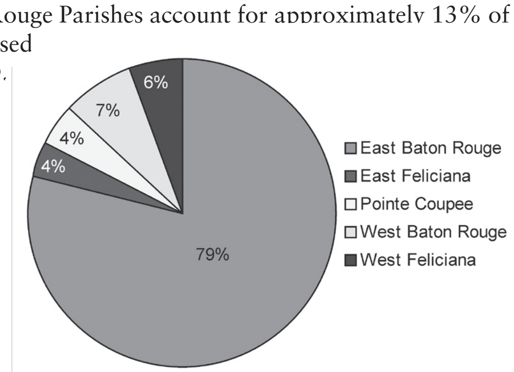

Figure 2. Distribution of groundwater use by public suppliers by parish within the CAGWCD for 2000 (Sargent, 2002)

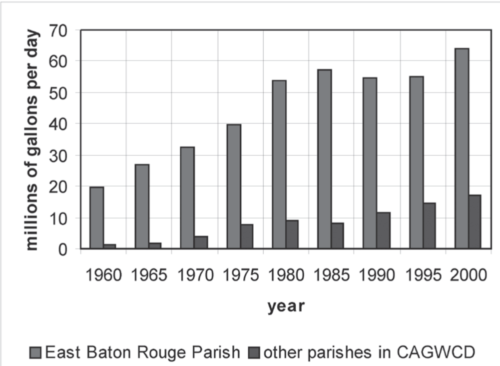

Figure 3. Public Supply use of groundwater in CAGWCD between 1960 and 2000 (Snider and Forbes, 1961; Bieber and Forbes, 1966; Dial, 1970; Cardwell and Walter, 1979; Walter, 1982; Lurry, 1987; Lovelace, 1991; Lovelace and Johnson, 1996; and Sargent, 2002)

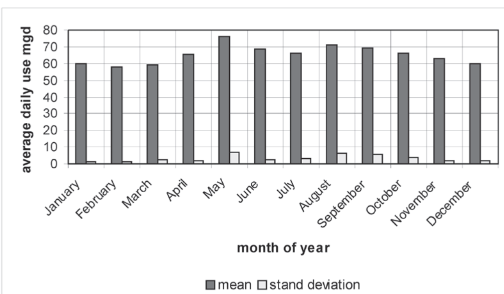

Figure 4. Average monthly public supply use of groundwater in East Baton Rouge Parish in the five years before hurricane Katrina.

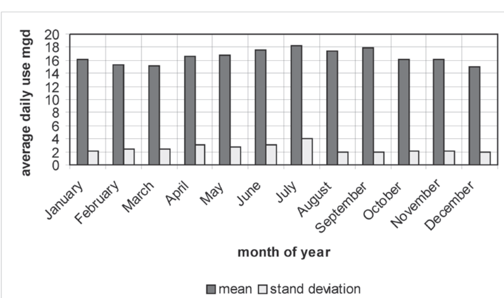

Figure 5. Average monthly public supply use of groundwater in the other four parishes of the CAGWCD in the five years before hurricane Katrina.

Groundwater use for public supply in the CAGWCD rapidly increased between 1960 and 1980 (Figure 3). Public supply use of groundwater between 1960 and 1980 increased from approximately 20 million gallons per day (mgd) to 55 mgd for East Baton Rouge Parish (Figure 3). Groundwater use for public supply has been fairly constant between 1980 and 2000 for East Baton Rouge Parish, with only a small increase from approximately 55 mgd to 64 mgd (Figure 3). By comparison the rate of increase for groundwater use by public suppliers is greater for the four other parishes in the CAGWCD. Groundwater use by public suppliers in the four other parishes increased from approximately 1.5 mgd in 1960 to 9 mgd in 1980 (Figure 3). Similar to East Baton Rouge Parish the rate of increase slowed for the other four parishes between 1980 and 2000. Public suppliers use of groundwater in the four other parishes increased from approximately 9 mgd in 1980 to 17 mgd in 2000 (Figure 3).

As indicated previously, the public supplier use of groundwater has been fairly constant in the CAGWCD between 1980 and 2000. Base on census data, July 1 2000 to July 1 2005 estimated population of decrease of approximately 0.8% (U.S. Bureau of Census, 2007) groundwater use by public suppliers is expected to be fairly constant between 2000 and 2005, the five years, before hurricane Katrina. However, although year to year changes in groundwater use are small there is clearly seasonal variation, for public supply use of groundwater (Figures 4 and 5). Seasonal variation of public supply use of groundwater in East Baton Rouge Parish has a high in May that is greater than 17.85 mgd than the low in February (Figure 4). For public supply use within East Baton Rouge Parish yearly variation is small as indicated by monthly standard deviations that are on average approximately 5% of the monthly mean values. Seasonal variation of public supply use of groundwater for the other parishes has the month of July as the maximum and December as the minimum (Figure 5). Variations from year to year are somewhat larger but still modest. The monthly standard deviations for public supply use are on average approximately 15% of monthly mean values.

Public Supply use of Groundwater after Katrina

Public supply use of groundwater in East Baton Rouge Parish after Katrina has increased from the typical average daily use in the five year previous to Katrina. The average daily pumpage for public supply in East Baton Rouge Parish prior to Katrina is approximately 65 mgd (CAGWCC, 2006b). In the first four months after Katrina public supply use of groundwater increased to an average of 75 mgd (CAGWCC, 2006b), an average increase of approximately 10 mgd (Figure 6) or 15%. By comparison the change of groundwater pumpage for public supply in the order four parishes is insignificant (Figure 7). The question to consider is "is the increase of public supply use of groundwater significant?" That is "Are the increases in use beyond yearly variation experienced over the past five years?"

Significance of Change of Groundwater Use

It appears that groundwater use for public supply in East Baton Rouge Parish has experienced a significant increase between September 2005 and December 2005. For each of the first four months after the Katrina the increase is more than two standard deviations above the five year monthly average, with an average increase of approximately 3.7 standard deviations. In general, if the value of pumpage differs by over two standard deviations above the mean it indicates that there is a confidence of difference for this increase that is over 95%. A confidence of 95% or larger is usually considered a significant difference (Kirk, 1990). Statistically the increase in pumpage of groundwater for public supply in East Baton Rouge Parish is significant for all four of the months after Katrina (Figure 8).

If rates of pumpage were completely random then there is only a 5% anyone month has a pumpage value 2 or more standard deviations over the mean values. For the four consecutive months of results to be explain by random chance this occurrence has only a (1/20)4 or less than 0.001% chance. The increase of groundwater use for public supply is significant, and probably not due to random chance, but probably the results of a population change. Results for the other four parishes are such that there are two months of increase and two months of decrease and all of these differences are less than one standard deviation from the five year average (Figure 8), hence they are insignificant differences. The drought of late 2005 was probably an insignificant event as indicated by public supply use of groundwater is less in both September, 2005 and October 2005 than five year average for the five parish area minus East Baton Rouge Parish.

Table 1
Estimated changes of parish populations after Katrina for CAGWCD parishes

Parish	October 2005	January 2006	May 2006	July 2006
East Baton Rouge	14.9%	6.7%	10.0%	4.7%
East Feliciana	n.a	n.a	-0.3%	1.1%
Pointe Coupee	n.a.	n.a.	-2.4%	1.6%
West Baton Rouge	12.5%	2.6%	0.9%	3.8%
West Feliciana	4.3%	2.35	-0.1%	2.3%
Source	Dunne (2006b)	Dunne (2006b)	Dunne (2006a)	Brown (2007)

n.a is not available

The difference of results between East Baton Rouge Parish and the other four parishes is reasonable when considering the estimated population changes from July, 2005, just before Katrina. East Baton Rouge Parish has consistently had the largest percentage of population increase after Katrina (Table 1). This can be seen in all of the estimated changes: October, 2005; January, 2006; May 2006 and July 2006 estimates.

Population in East Baton Rouge Parish increases by 10% for May 2006 and 5% for July 2006 (Dunne, 2006a; and Brown, 2007). By comparison the other four parishes grew far less: an average 0.5% loss in May 2006 and an average 2% increase in July 2006 (Dunne, 2006a; and Brown, 2007). This probably explains the difference in the increase of groundwater use by public suppliers.

Summary

Hurricane Katrina which struck the southeast coast of Louisiana on August, 29, 2005 caused major flooding in four southeastern parishes (Jefferson, Orleans, Plaquemines, and St. Bernard). This flooding caused over 300,000 people to be displaced from those four parishes. It has been estimated that approximately 20,000 settled in the CAGWCD as of July of 2006. This increase of population has impacted the Baton Rouge Area in variety of ways: increasing traffic, housing sales, house prices, number of jobs, school attendance and use of groundwater by public suppliers.

The increase of groundwater use by public suppliers in the first four months after Katrina was concentrated in East Baton Rouge Parish. In East Baton Rouge Parish increases in groundwater use by public suppliers has been on average about 15% for the first four months (September to December, 2005) after Katrina. This increase has been significant when compared with typical use in the five years prior to Katrina for the four months considered. By comparison groundwater use by public suppliers in the other four parishes (East Feliciana, Pointe Coupee, West Baton Rouge, and West Feliciana) has remained nearly constant. Consequently change of groundwater use by public suppliers has been insignificant for these four parishes.

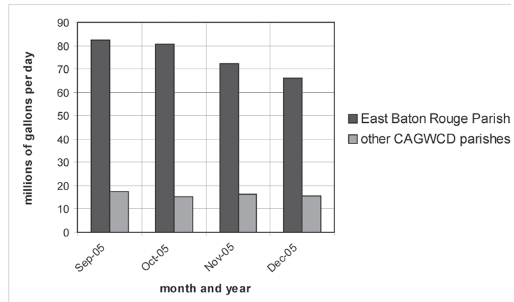

Figure 6. Groundwater use for public supply in CAGWCD after Katrina starting with the first whole month after the hurricane, September 2005, source of data is CAGWCC (2006b).

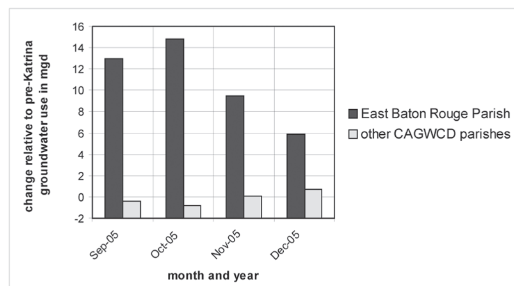

Figure 7. Change in groundwater use for public supply in CAGWCD after Katrina relative to five year monthly averages, source of data is CAGWCC (2006b).

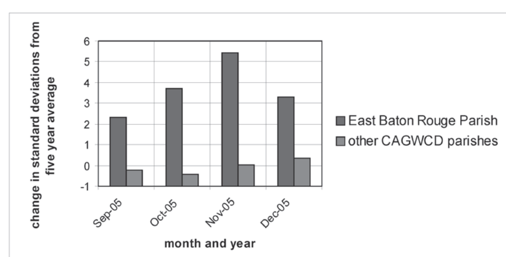

Figure 8. Relative change of groundwater use for public supply in CAGWCC after Katrina starting with the first whole month after the hurricane, September, 2005, source of data is CAGWCC (2006b).

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LGS Outreach Program

On March 19th L. Riley Milner gave a presentation on the geology of Louisiana to Ms. Janis Andrews' 3rd grade class at Trinity Episcopal Day School

On April 24th Thomas Van Biersel presented a talk on the groundwater cycle to Ms. Kim Musgrove's 2nd grade class at Trinity Episcopal Day School.

Warren Schulingkamp presented a talk on geology as a profession on February 16 at the Kenilworth Middle School during their Career Day Fair. His talk included an exhibit of minerals, rocks and geologic maps. He also worked as a judge for the oceanography section of the Regional Science Olympiad for middle and high school students held at Southeastern Louisiana University in Hammond, LA on April 21.

Pipeline Mapping Continues at the Louisiana Geological Survey

Petroleum, natural gas, and petrochemical products pipeline mapping continues at the Louisiana Geological Survey, LSU. The LGS has been mapping pipelines since 1940 and has migrated from traditional cartographic techniques to digital Geographic Information Systems (GIS). The status of statewide compilation of a "Pipeline Inventory" has progressed at a steady pace. Currently, Robert Paulsell is P.I. for a project, "Research and Development of Petrochemical Transmission Pipelines between Baton Rouge, LA and New Orleans, LA". Assisting on the project are Patrick O'Neil and Asheka Rahman. This project is funded through the Oil Spill Applied Research and Development Program, LSU.

A pipeline GIS is of prime importance to oil spill responders and environmental researchers. The data developed is vital for contingency planning and emergency response to disasters involving hazardous commodities transported by pipelines. Accurate digital pipeline maps with object-oriented relational database will enable increased emergency response efficiency by allowing emergency responders to quickly assess diameter, commodity transported, and operator of specific pipelines. Emphasis in this project is on transmission pipelines rather than those associated with gathering or distribution systems. Generally, the investigator considered transmission pipelines to be those with diameters of four inches or greater.

A method to digitally verify and/or create pipeline features has been developed by the Louisiana Geological Survey (LGS). Utilizing Global Positioning System (GPS) technology, point data were collected at pipeline warning sign locations that were observed near pipeline crossings of public roads. These GPS records contain accurate positional data, pipeline operator, and commodity transported by the pipeline. These point data were compared to existing hard copy maps and digital pipeline data. Pipeline features were developed with heads up digitizing techniques utilizing aerial and satellite imagery, GPS point data, digital and hard copy maps or diagrams submitted by operators, and reliable third party maps.

The digital pipeline data developed by the LGS are modeled after the data definitions created by the National Pipeline Mapping System (NPMS), Department of Transportation with a few modifications. Pipeline attribute tables are defined similarly with the addition of emergency contacts and links to chemical spill response pages. Moreover, the NPMS spatial margin of error is 500 feet. The use of submeter capable Global Positioning System (GPS) by the LGS has greatly improved upon this spatial tolerance. Pipeline data developed by the LGS are believed to be within 50-100 feet of true spatial location. GPS point data are collected at pipeline crossings of public roads where there are pipeline warning signs (Fig 1). Pipeline features are created with heads up digitizing techniques in ArcMap 9.2 (ESRI, Inc., Redlands, CA).

Pipelines are vulnerable to threats of terrorism and natural disaster. Natural forces, specifically hurricanes Katrina and Rita, caused several pipeline failures. Over 50,000 barrels of hazardous liquids (crude oil) were released in southeastern Louisiana due to Katrina with untold cubic feet of natural gas being lost. Rita heavily impacted pipelines in south west Louisiana. At least four major disruptions to natural gas pipelines caused more than $250,000 in damages to the natural gas pipeline infrastructure due to the hurricane. (http://primis.phsa.dot.gov/comm/StatePages/htmGen/LAdetaill.htm)

Much concern has been placed on pipeline safety and the Department of Homeland Security considers pipelines as part of our critical national infrastructure. The USA Patriot Act defines critical infrastructure as, "systems and assets, whether physical or virtual, so vital to the United States that the incapacity or destruction of such systems and assets would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters". The development of digital pipeline data is important for the planning and protection of these vital energy conduits. The development of these data is focused on the emergency response community. Louisiana's first responders need to know what petrochemical commodities may be threatening communities as well as themselves.

For more information contact Robert Paulsell at rpaulsell@lsu.edu.

Completion of the "Assessment of the Impact of Hurricane Katrina's and Rita's Storm Surges on the Southern Hills Aquifer System in Southern St. Tammany and Tangipahoa Parishes" Project

In April 2007, Thomas Van Biersel, Douglas Carlson and L. Riley Milner of LGS, with the assistance of student worker Elizabeth Mier (Fig. 1), completed the collection of 12 consecutive months of groundwater samples from private and public water supply wells affected by the storm surges of hurricanes Katrina and Rita. The LGS researchers have been conducting the monitoring of 25 water wells. The project, which is funded by the Louisiana Water Resources Research Institute at Louisiana State University, seeks to assess whether potential long-term impacts were caused by the flooding onto the regional groundwater resources. A report is now being prepared by the Principal Investigator's (PI's) and Miss Mier.

As part of this research the PI's with the assistance of Miss Mier have been conducting vertical resistivity sounding to determine whether the saltwater from the hurricane surges is migrating into the subsurface. Soundings have been collected at Fontainebleau State Park during the fall 2006. Additional soundings will be collected in May 2007 at Fontainebleau and Fairview Riverside State Parks.

The preliminary findings indicate that there appear to be no long-term impacts to the water supply wells and the aquifer. However, the study seems to indicate that saltwater intrusion into the shallow aquifer is occurring along the shoreline south of Slidell.

Figure 1. LGS' student worker Elizabeth Mier testing water at Fontainebleau State Park, Mandeville, Louisiana

2006-2007 Coastal Video Survey

As we all know, Louisiana's coastline is regressing at an astonishing rate. There are several causes to this phenomena and much interest and study is focused on the physical forces driving this devastating problem. The University of New Orleans and Louisiana State University have teamed up to document the coastal regression on video media. Dr. Shea Penland, University of New Orleans, Pontchartrain Institute for Environmental Science, and Karen Westphal, Louisiana State University, School for the Coast and Environment, Special Programs, are the project leaders with technical assistance from Robert Paulsell, Louisiana Geological Survey, LSU, and Dallon Weathers, UNO-PIES. Funding for the project comes from the Louisiana Department of Natural Resources. The Aerial Video of Louisiana Shoreline, 2006-7 is part of a series of video surveys conducted by Dr. Penland and Ms. Westphal over the past 20 years. The last video survey was conducted in 2001 with Paulsell serving as technical support on that series of flights also.

Figure 1. Karen Westphal instructs Dallon Weathers on camera opperations.

Figure 2. Eastern flight line of aerial video survey.

The video surveys were typically conducted from a Bell 206 helicopter with the port side aft door removed for camera and videographer (Fig 1). The camera angle is typically perpendicular to the aircraft flight line. The technical support personnel are responsible for in flight logistics such as GPS, video, and other equipment monitoring as well as flight tracking (Fig 2). The helicopter travels approximately 50 to 60 knots at an altitude of 300 to 600 feet. Higher altitudes are flown for along shore views that pan down the coast to give a wide perspective of the coast and marsh. Real time GPS data are displayed on the SVHS screen while the Red Hen software displays map background with windows containing GPS data and video and is an interactive tool in which the user can jump to a different area quickly. This immersive mapping technology is very useful for planning coastal restoration efforts.

Historically, analog video media were acquired and stored in SVHS format. The 2001 series was digitized and recorded on DVD media. The 2006-7 video series was recorded on 8 mm tape and SVHS tape. New mapping software from Red Hen Systems (Red Hen, Ft. Collins, CO) was utilizes in the collection of the spatial multimedia. The DVDs for this oblique aerial video of Louisiana's outer coastline should be ready for distribution by the end of summer 2007.

Conferences

First Annual Louisiana Groundwater Symposium

On March 8, 2007 the first annual groundwater symposium, hosted by the Louisiana Geological Survey and the Baton Rouge Geological Society (BRGS), was held on the Louisiana State University (LSU) Campus in the Auditorium of the Energy, Coast and Environment Building. The symposium was a success and there were numerous requests to continue next year.

Zahir "Bo" Bolourchi, Director of the Water Resources Programs of the Louisiana Department of Transportation and Development gave the keynote address entitled "Groundwater Policy: Why it is Important and Why We Should Care" to start the symposium. There were 15 technical papers presented by various members of both the Louisiana and United States Geological Surveys, Louisiana Department of Environmental Quality, Department of Natural Resources, as well as the faculty and students from LSU and the University of Louisiana at Lafayette and local environmental consultants. Symposium attendees inculuded people from surveys, state agencies, universities and environmenta consultants. This is the first of a planned series of annual groundwater symposiums.

LGS staff was involved in the symposium from its inception through planning and development of the technical program (Douglas Carlson, Clayton Breland, and Thomas Van Biersel). Three staff members of LGS presented papers at this symposium. L. Riley Miler setup the LGS booth displaying the current set of LGS 1:100,000 geologic maps. Lisa Pond and John Snead completed the layout and development of the symposium program. Reed Bourgeois of LGS developed the CD of symposium's transactions. In addition, Reed provided invaluable technical assistance during the symposium. The CD of the transactions is available through the LGS, see LGS publications web page (http://www.lgs.lsu.edu/pubs/catalog.html). The announcement for next years Louisiana Groundwater Symposium will appear within the BRGS's (www://brgs-la.org) and LGS's (www://lgs.lsu.edu) web pages, as well as other geological society web pages in due time.

Personnel News

LGS welcomes Warren Schulingkamp who joined the staff as Research Associate 4 in February. Warren has a B.S. degree in geology from LSU and an M.S. in geology from Utah State University. He has worked for over 12 years with Marathon Oil company as a petroleum geologist both onshore and offshore in the Gulf Coast. He will be researching the coal bed methane potential in North Louisiana in addition to contributing towards the work on the LGS Offshore Oil and Gas Atlas series of publications, and other oil and gas related research topics. He is married to Ruth and has three teenage children and the family has been living in Baton Rouge for many years.

The LGS welcomes the addition of Marty Horn, PhD, to the position of Assistant Professor of Research. He joined LGS in January 2007 after leaving an academic position in the LSU Department of Geology & Geophysics since August 2002.

Horn earned a B.S. in Geophysics at the University of Oklahoma in 1982, an M.S. in Geology at the Arizona State University in 1986, and a PhD in Mathematical Sciences–Geology at the University of Texas at Arlington. While at OU, he studied under Professors Harvey Blatt, Patrick Sutherland, Judson Ahern, and John Wickham in the Exploration Geophysics degree track. Upon graduation from OU, he then digressed from petroleum-related geology to take up graduate studies in volcanology and petrology at ASU and UTA. His research focused on numerical modeling and field study of petrologic and volcanologic topics. While at UTA, he taught courses in Mineralogy, Petrology, and Volcanology.

In 2002, Horn was recruited by Brooks Ellwood of LSU Geology & Geophysics to direct the LSU Geology Field Camp near Colorado Springs. During that time, Horn's research interests shifted back to "thin-skin" structure and sedimentary stratigraphy as he began reconnaissance mapping and researching ground water and stratigraphy problems along the southern Rocky Mountain Front Range in Colorado and New Mexico.

While a graduate student at UTA, Horn was employed part-time by Snyder Oil Co. of Fort Worth, Texas as part of a team whose exploration focus in the 90's was the Cotton Valley trend of north Louisiana. He has taken the opportunity with LGS to return to full-time research and resume work on north Louisiana oil & gas reserves and to contribute to ongoing surface mapping projects for Louisiana.

Horn, his wife Karen, and their 1.5 year-old son, live in Baton Rouge near LSU.

Reed Bourgeois

John Johnston

Reed Bourgeois (Computer Analyst) and John Johnston (Asst. Director) completed 10 years and 15 years of service with Louisiana State University recently and were presented with LSU Service Awards during the LGS Staff meetig on March 16, by LGS Director and State Geologist Dr. Chacko John.

Clayton Breland (Asst. Professor-Research) resigned from LGS at the end of February to take up a position with the Louisiana Department of Natural Resources.

LGS Director Chacko John who is also the President-elect of the Association of American State Geologists (AASG) organized and attended the Spring liaison meeting of the AASG from March 4-7, 2007 in Washington, D.C. He was assisted in the numerous details of organizing and conducting this meeting by Ann Tircuit (Administrative Coordinator) and Reed Bourgeois (Computer Analyst).

Papers Published

Van Biersel T., Carlson D. and Milner L.R., 2007, Impact of Hurricane Storm Surges on the Groundwater Resources, Environmental Geology Online First DOI:10.1007/s00254-007-0694-x, pp. 14.

Heinrich, Paul V., 2007, South Africa's Concretions of Controversy. South African Lapidary Magazine. vol. 39, no. 1, pp. 7-11. (1 April 2007)

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Carlson, Douglas, 2007, Comparison of Estimated Hydraulic Conductivity Values with Traditional Aquifer Test Results, p. 17-31.

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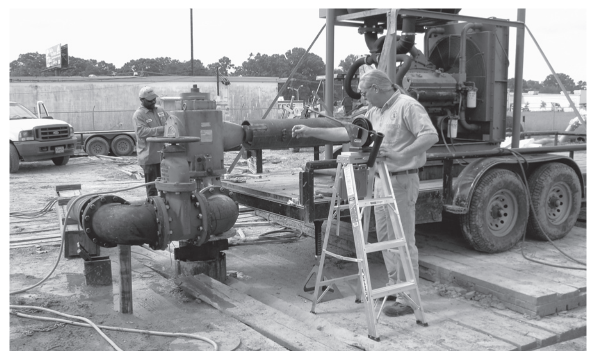
Carlson, Douglas, 2007, Lignite's Occurrence within Aquifers of Northern Louisiana, p. 43-52.



Thomas Van Biersel, Reed Bourgeois and Riley Milner (photograph), in collaboration with Layne Christensen Company (Prairieville Office), have been monitoring pump tests with a LGS pressure transducer. The pump tests were performed on a new water supply well being installed in Baton Rouge. The data will be analyzed and used in a groundwater model of the Southern Hills Aquifer System being developed and digitized by Prof. Van Biersel.

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LGS RESOURCE CENTER

The LGS Resource Center is located on the LSU Campus and consists of a core repository and well log library. The core facility has over 30,000 feet of core from wells in Louisiana, Alabama, Arkansas, Florida, Mississippi, and Texas. The well log library contains over 50,000 well logs, most of them from Louisiana. The LGS Resource Center is available for use by industry, academia, government agencies and those who may be interested. Details of current holdings are posted on the LGS website www.lgs.lsu.edu under Publications and Data. For more information contact Patrick O'Neill at 225/578-8590 or by email at poneil2@lsu.edu.

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