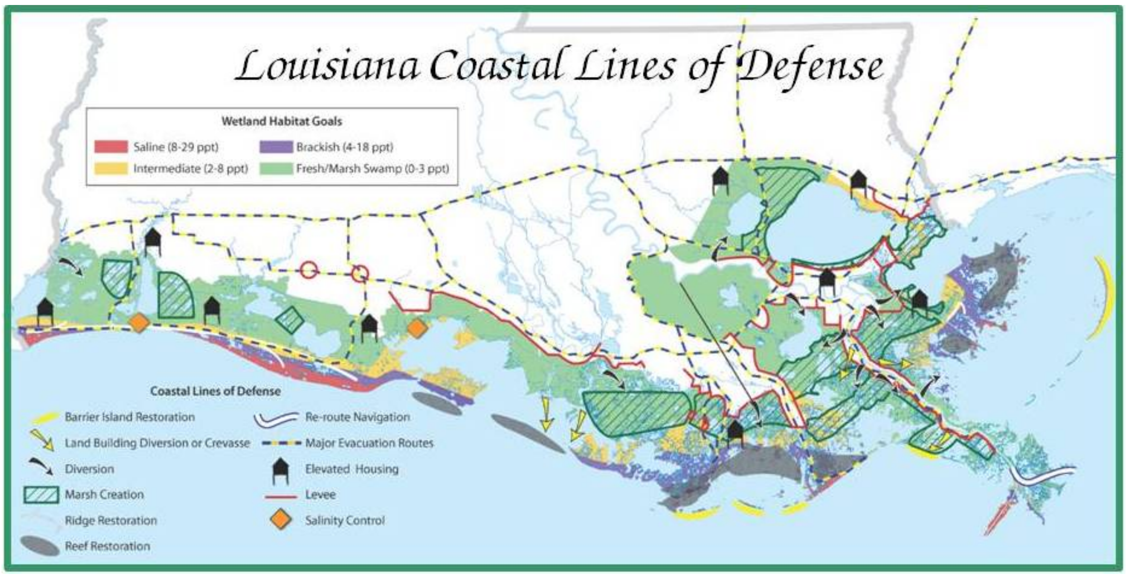
Comprehensive Recommendations Supporting the Use of the Multiple Lines of Defense Strategy to Sustain Coastal Louisiana

2008 Report (Version I)

This report recommends integrated coastal projects and levee alignments for the entire coast of Louisiana with the overriding goal of improving hurricane flood protection and sustaining the coastal estuaries.



Summary Map of Multiple Lines of Defense

"It may be hubris to think we could ever engineer our way out of this fix, when nature seems so aligned against us. It is certainly hubris to think we could do it without taking nature's assistance when it is offered."

Quote from comments on the draft report by David Yeargin

Funding provided by the McKnight Foundation
Report is available at MLODS.org, SaveOurLake.org, or CRCL.org

SAVE OUR COAST
LAKE PONTCHARTRAIN BASIN FOUNDATION

Coalition to Restore Coastal Louisiana

Introduction

South Louisiana has many natural resources and coastal assets that together are the basis of the coastal economy. The underlying support for this economy is a culturally rich, blue-collar workforce and a reliance on natural capital (i.e., goods and services provided by ecosystems), hence, the common reference to Louisiana's working coast (Gramling, 2004; Laska et al., 2005). As reinforced after Hurricanes Katrina and Rita, impacts to Louisiana's coastal economy lead to fluctuations in the national economy. The disruption of south Louisiana's economic resources and infrastructure, such as energy, seafood and shipping, resulted in reduced supply, increased prices and a short-term destabilization of the economy throughout the nation. Flood protection and coastal restoration play a vital role in the economic, cultural and physical well being of Louisiana's coastal communities and infrastructure.

The Multiple Lines of Defense Strategy (MLODS) has been adopted by the State of Louisiana in its development of the *Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast*. This report describes additional recommendations supporting the use of the MLODS to sustain coastal Louisiana. The MLODS has also been adopted by the USACE in its ongoing development of the Louisiana Coastal Protection and Restoration Plan (LACPR). Thus, this report should be considered as additional input to this ongoing evaluation adding robustness and external input. The overriding goal of all these efforts is to promote convergence on a set of optimal recommendations for coastal Louisiana, regardless of point of origin, that are based on sound science and engineering.

Coastal Land Loss Maps

Significant documentation exists describing the dramatic land change in south Louisiana, which is primary a conversion of wetlands to open water (Boesch et al.; 1994, Coast 2050, 1998; LCA, 2004). These reports primarily rely on two different sources of analysis of land change:

The U.S. Geological Survey (USGS) has used computer programs to map land change (loss or gain) using digital satellite imagery for the specific time period (see Barras et al., 2006). The maps depict land loss or land gain for the following time periods:

1956 to 1978
1978 to 1990
1990 to 2000
2000 to 2004
2004 to 2005 (This period includes Hurricanes Katrina and Rita.)

The USACE uses manual interpretation by overlaying historical USGS quadrangle maps or aerial photography of different times to manually trace shifts in shoreline position. Polygons of land loss are digitized and then depicted on composite maps (Britsch and Dunbar, 1996). The USACE maps depict land loss only. The time periods mapped by the USACE are:

1932 to 1956
1956 to 1974
1974 to 1983
1983 to 1990
1990 to 2001

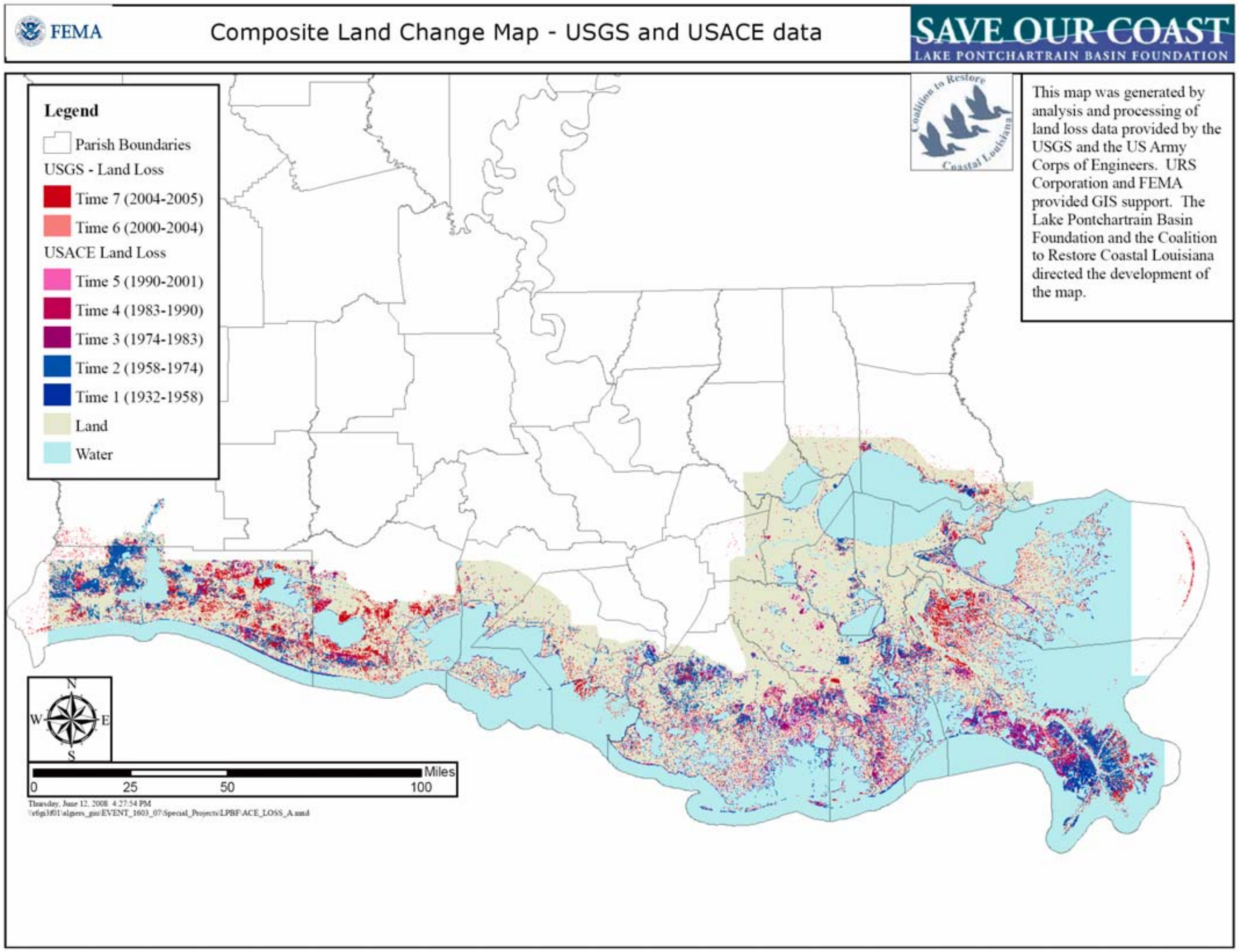


Figure 2: Composite Land Change Map of both the USGS and USACE land change data sets for seven time incremental periods from 1932 to 2005 (post-Hurricanes Katrina and Rita). Older land loss is depicted as "cold colors" (blue) and more recent loss is depicted as "hot colors" (red). Note the USGS data classification for burned or flooded agriculture (formerly marsh) was reclassified as water, which increases the land loss shown in some regions.

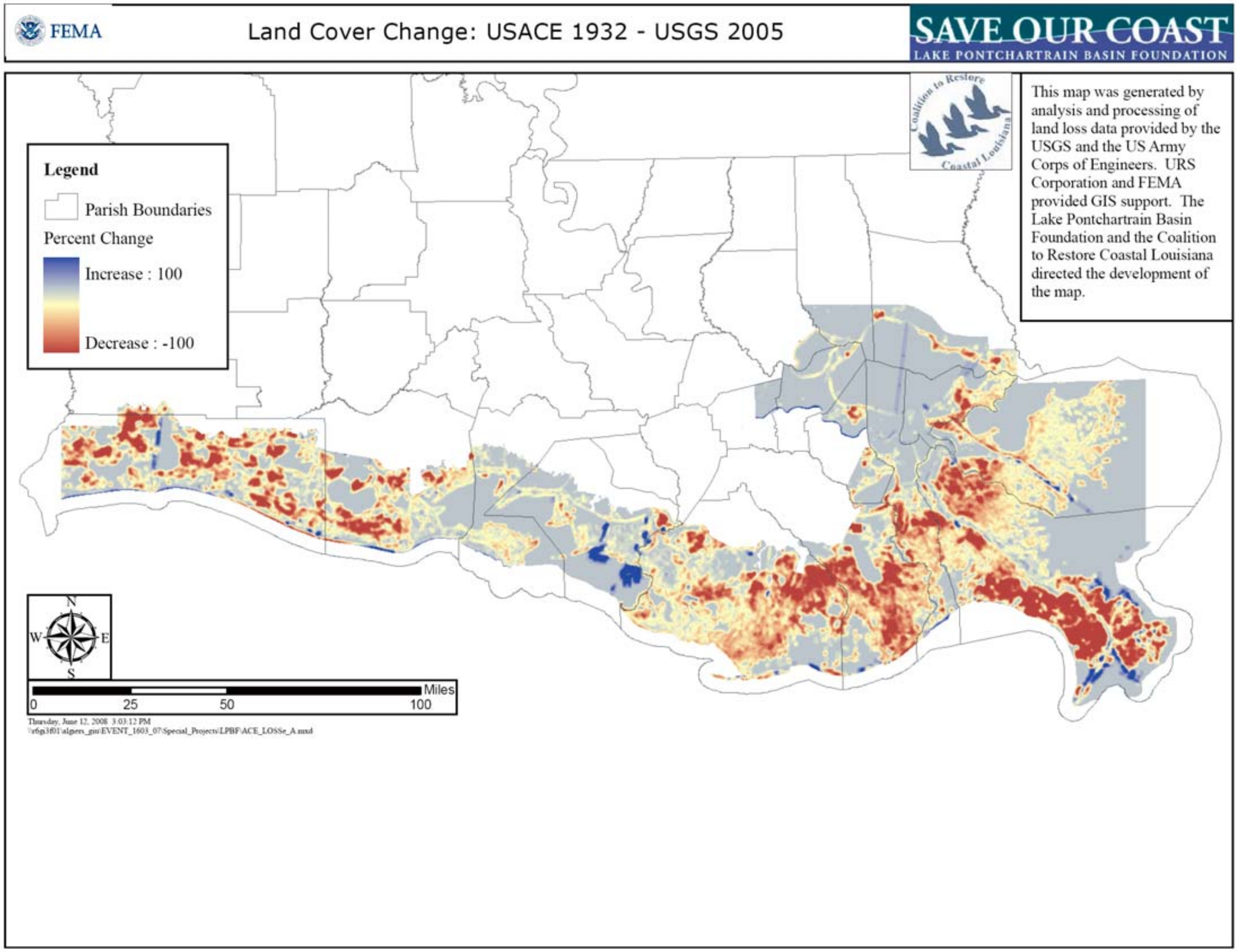


Figure 3: Percent Land Changes from 1932 to 2005 (post Hurricanes Katrina and Rita). Map created using 1932 percent land from the USACE data and 2005 land percent from the USGS data. Percent land was calculated over one square mile at every data point (25 meters). Blue indicates land gain and red indicates land loss. Note the USGS data classification burned or flooded agriculture (formerly marsh) was reclassified as water, which decreases the percent land in some regions.

In 2007, the USGS provided to the Lake Pontchartrain Basin Foundation (LPBF) the Geographic Information Systems (GIS) files of the land loss data. This data was the "unfiltered data" depicting complete land loss and not the smoothed (filtered) data set used for printing of land loss maps. The USACE land loss data is posted as high resolution Adobe-pdf files on their website (http://www.mvn.usace.army.mil/). The pdf files were carefully converted to GIS shape files by decomposing the pdf pixel colors and using the latitude and longitude tick marks posted on the maps (see Appendix D for a more complete explanation). Having the two different land change data sets in GIS format allows for compilation of the data and new forms of analysis. This work is progressing but two maps are presented here for general reference for the report. **Figure 2** is a composite map showing the seven time periods of land loss from both the USGS and the USACE. **Figure 3** is the overall land loss as a percent change from 1932 to 2005 (post-Hurricane Katrina). Note that there are inherent mapping errors in the initial mapping and additional error introduced in the re-mapping and compilation of these data sets. In some places, the map registration is clearly shifted slightly, and so these maps cannot be used for specific mapping. However, they are intended to show regional patterns of land change.

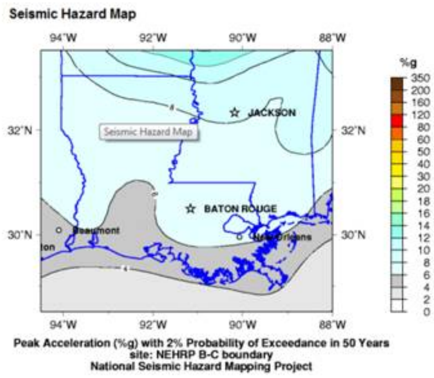
Evaluation of Risk - Hurricanes and Surge Maps

Risk from natural hazards varies across the U.S. due to the local environment. The West Coast has earthquakes. The East Coast and the Gulf Coast have hurricane risk. As can be seen in **Figure 4,** Louisiana has far lower risk from earthquakes than California due to the natural geologic conditions and due to the tendency for California populations to be located in high risk areas because of other benefits that coincide with these regions. In general, these high-risk California cities were settled and prospered due to large valleys and natural harbors, which are a direct result of the active fault zones that pose the earthquake risk. California primarily reduces risk through strong encouragement and enforcement of high construction standards for earthquake-resistant homes and buildings but also has a strong education system that teaches children the basics of earthquakes and how to understand and cope with this risk. A recent popular publication by the California Earthquake Authority is titled "Putting Down Roots in Earthquake Country" and includes "The Seven Steps to Earthquake Safety". These practices are important risk mitigation models to consider for Louisiana (see below). Education of flood risks in Louisiana should begin in elementary and high school curriculums. Since extreme natural hazards are common on all U.S. coastlines, Louisiana can learn and improve upon programs such as in California and other coastal regions.

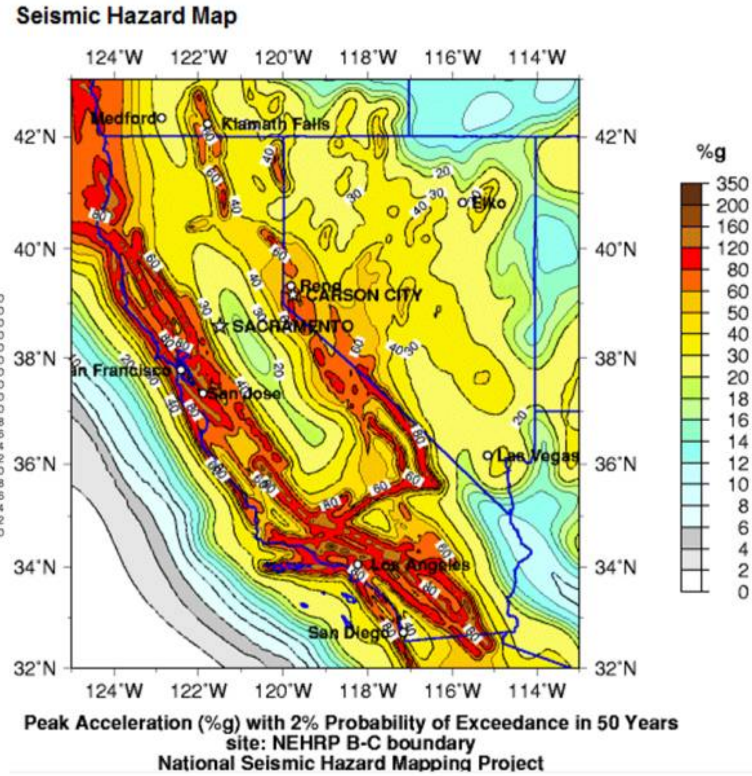
California Building Standard Commission website
http://www.bsc.ca.gov/apprvd_chngs/appStan.htm

Examples of California earthquake education programs
http://www.scec.org/education/
http://cse.ssl.berkeley.edu/SegwayEd/lessons/earthquake_country/5eqcountry.homepage.html

Coastal Louisiana has natural hazards due to occasional severe weather along a flat, low-lying coast. It is the low-lying delta coast which provides both the natural wetland resources that are a basis for the local communities but yet also underlie the natural hazards such as the risk posed from storm surge due to hurricanes. **Figure 5** is a USGS map of predicted hurricane landfalls over a 100 year period. Louisiana, the entire Gulf Coast and the East Coast have a high risk of hurricane landfall. More intense hurricanes (like earthquakes) are less frequent but are more difficult to predict because they occur less often. Based on the historical record, the USACE categorizes the storm surge from Hurricane Katrina as a 1 in 396 year event. This is due to the combined characteristics of its intensity and physical size. By contrast, Hurricane Rita which had similar wind strengths is considered a 1 in 90 year storm surge event. **Figure 6** illustrates the importance of the atmospheric pressure and size of the storm to estimate the surge potential. The combined characteristics and resulting surge of Hurricane Katrina suggest is it a rare event and on average should only occur in this region once every 400 years. Smaller storms are much more likely to occur. Long-term sustainability or resiliency of coastal residents and communities depends upon anticipating the effects of both the large, infrequent storms and the more common, smaller storms.



Louisiana



California

Figure 4: Seismic (Earthquake) Hazard Maps of Louisiana and California. Maps are approximately the same scale. Note the higher risk hazard and the areal extent of the hazard areas in California with the location of San Francisco, Los Angeles, and San Diego within the highest risk areas. California addresses risk through high construction standards for earthquake resistant homes and buildings. (Source: USGS at http://earthquake.usgs.gov/regional/states/)

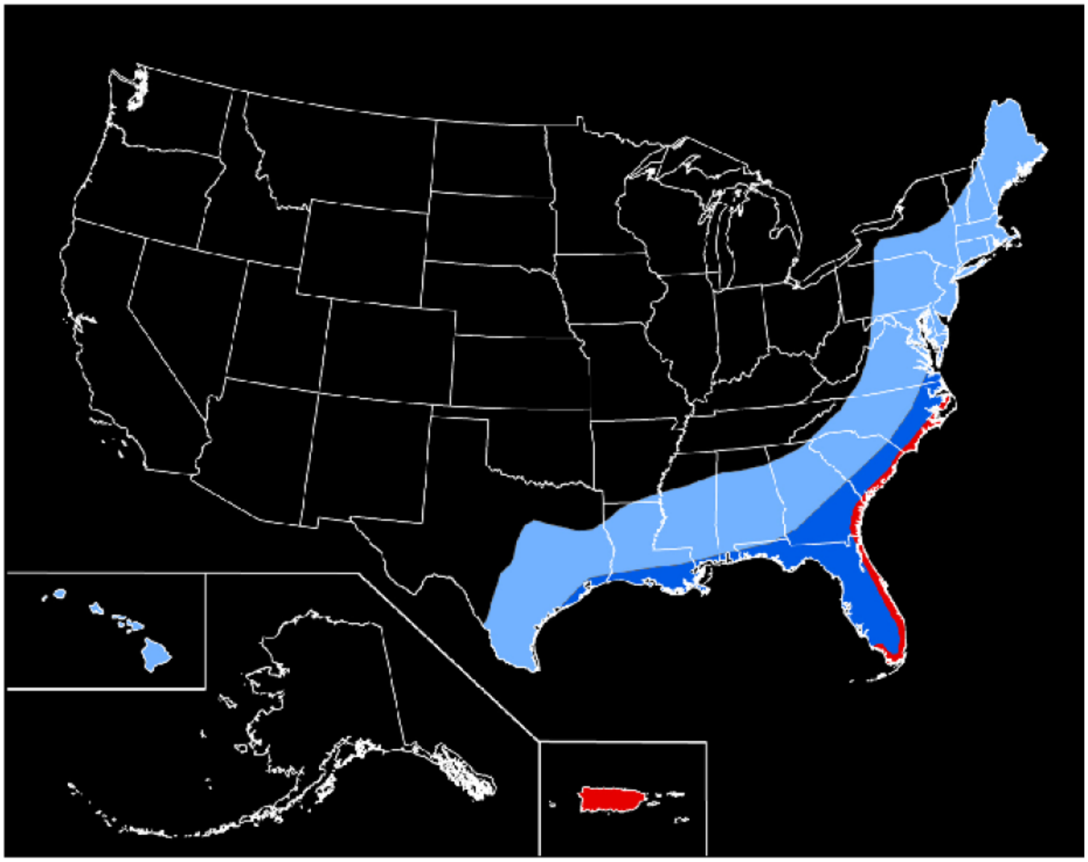


Figure 5: Expected Landfall of Hurricanes within a 100 year Time Period. The number of hurricanes expected to occur during a 100 year period based on historical data—light blue area, 20 to 40; dark blue area, 40 to 60; red area, more than 60. Inset maps not to scale. Source: the National Atlas and the USGS (Source: USGS http://www.usgs.gov/hazards/hurricanes/)

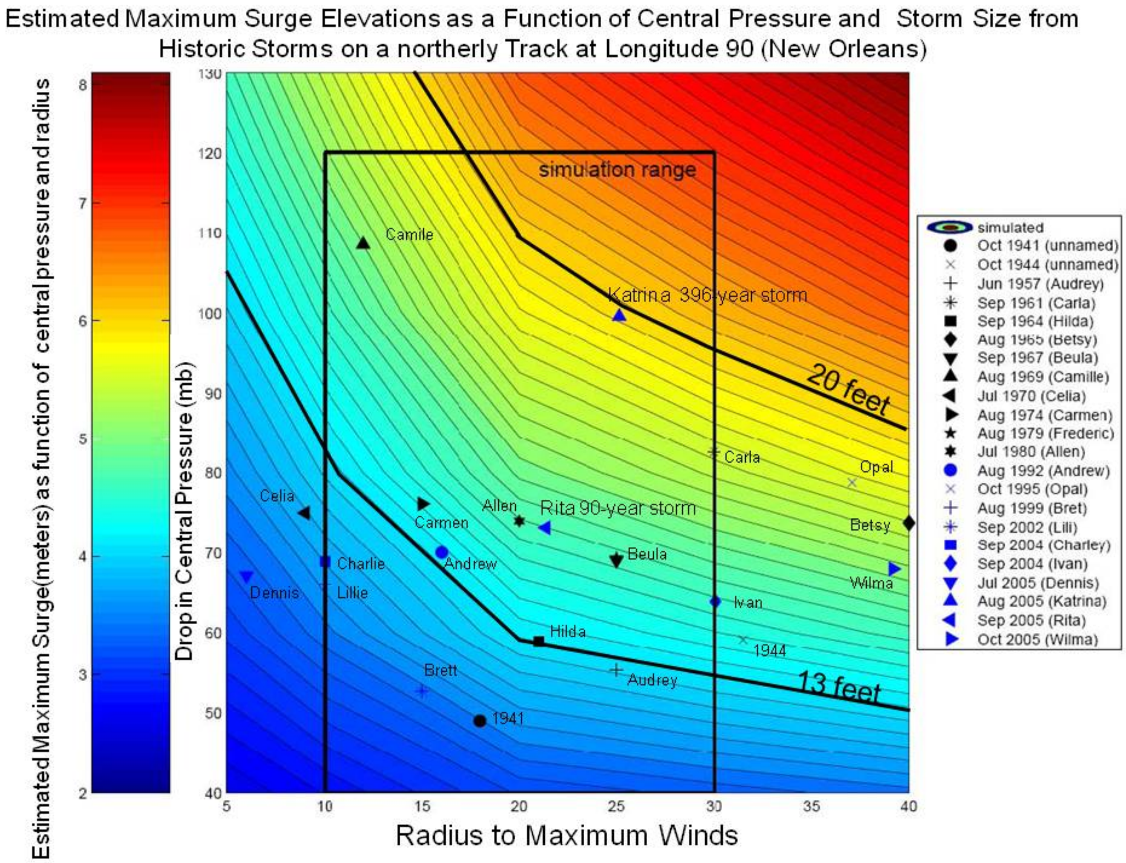


Figure 6: Graph of Gulf Coast Historical Hurricanes by Pressure and Size. Historical tropical systems in Louisiana using storm central pressure and storm radius with overlay of general surge height that might be expected based on ADCIRC models. These storm characteristics may be more effective to estimate the potential surge hazard rather than the wind speed only characterization of the Saffir-Simpson Scale. Note that Hurricane Rita is considered approximately a 1 in 90 year event and Hurricane Katrina is considered a 1 in 396 year event (Source: USACE, 2007 and IPET, 2006 report with annotation added).

Figure 7 gives the expected 1 in 4 chance (26%) that a 1 in 100 year event might affect an individual's home for the duration of a typical home mortgage of 30 years. **Figure 7** only considers flood threat from a hurricane. The actual chance of flooding is higher if you include other hazards, such as intense rainfall events or river flooding. The Greater New Orleans region, the North Shore, and even Baton Rouge have experienced major flooding unrelated to hurricanes (for example, the Comite & Amite River floods in 1983). This flooding is primarily is due to spring rain events such as the infamous May floods in New Orleans in the 1980's and 1995. These flood events were inside the levee system when the pump was overwhelmed. Cities such as New Orleans and Morgan City are also under threat of flooding from the Mississippi and Atchafalaya Rivers. On the North Shore of Lake Pontchartrain, there are no flood protection levees and flood events are typically due to rain events within the natural or manmade drainage systems (for instance, the Pearl River in 1979, 1980, and 1995). These non-hurricane type rain events are additional risks that are not just additive to the hurricane risk **(Figure 7)** but actually may be more likely with the presence of a levee if adequate drainage is not incorporated into the overall flood protection system. For this reason, pump capacity is essential and is included as a "Line of Defense" (see next section), and why elevating homes is also important since it directly addresses flood water from whatever the source or cause (see non-structural discussion).

Event Frequency[1]	Time Periods			
	Annual Chance	Chance Every 10 Years	Over Life of 30-year Mortgage	Over 100 year life of Infrastructure
50	2%	22%	45%	86.50%
100	1%	11%	26%	63.20%
500	0.20%	2.20%	5.80%	18.10%

1 This is the also called the return period and represents the likelihood of experiencing one or more events in the identified time period. The event might be a storm, a water level, or a failure, for example.

Figure 7: Risk on a 30-year Mortgage from a 100-year Hurricane. The expected chance of flooding a home from a "100 year" hurricane event during the term of a typical home mortgage (30 years) is approximately 1 in 4 (26%). The risk of flooding is higher if non-hurricane causes of flooding are also considered. Spring river flood events have occurred throughout the region and are not related to hurricane events. South Louisiana homeowners should recognize all risk of flooding cannot be eliminated but flood risk can be greatly reduced with home elevation, because it addresses flooding from multiple causes (Source: http://www.mvn.usace.army.mil/).

Ultimately, neither the State of Louisiana nor the USACE can eliminate all risk of flooding in south Louisiana. Therefore, all coastal Louisiana residents need to understand their personal risk exposure and further reduce and prepare for possible flooding. In many cases, the one action that can be done individually and addresses flood risk from multiple causes is home elevation. For this reason and many others, it is strongly recommended that residential construction with slab foundations "on-grade" (on the ground), be discouraged or prohibited gulf-ward of the 1000 year storm surge flood extent (see non-structural discussion).

Figures 8, 9, and 10 depict the preliminary LACPR modeling results for the statistical surge elevation of multiple storms and track for the return periods indicated. The LACPR draft report and modeling results are still a draft and are under review. Model results will likely change. Nevertheless, at this time, these maps best represent the gross patterns of surge for various hurricane tracks and characteristics. The individual planning maps are within the LACPR Draft Technical Report released in March 2008 (USACE, 2008). These composite maps were provided separately by the USACE personnel. Note that along the entire coast, the peak of maximum surge does not occur at the same location as the most inland movement of the surge flood. Rather, there is a separation of the maximum surge from the most landward extent of surge. This phenomenon of "detached peak surge" is a reflection of the resistance of the coast to surge which reduces the surge elevation as it moves inland. This pattern of surge is generally beneficial for Louisiana because levee alignments further inland may not encounter the maximum surge. Coastal restoration for flood protection that is, the natural Lines of Defense, is recommended within the area gulf-ward of the levee alignments to sustain or enhance this detachment of the surge.

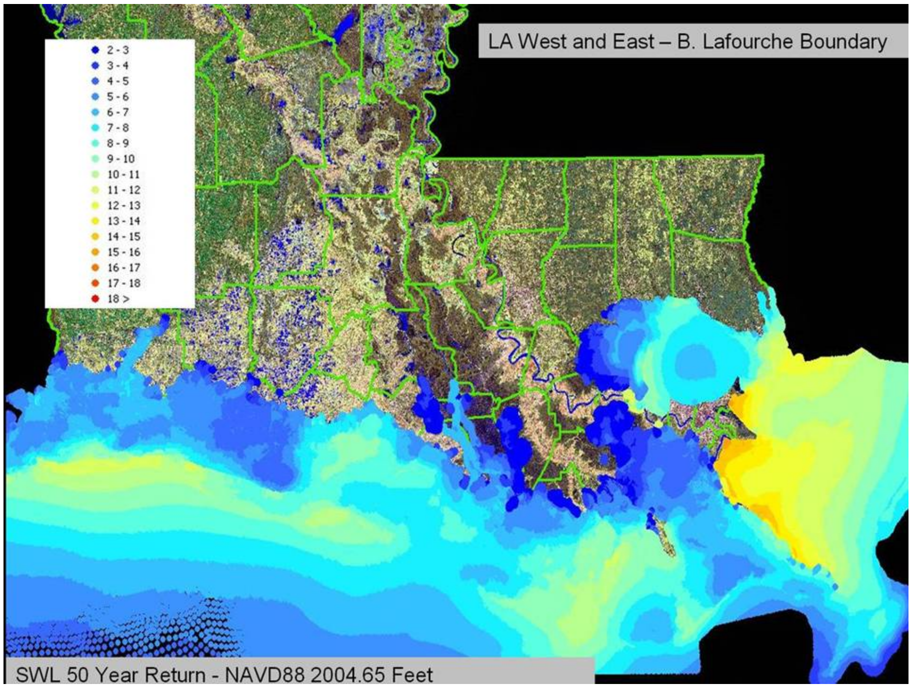


Figure 8: Preliminary composite map of the Statistical Maximum surge for numerous hurricane tracks and hurricanes representing a 50-year return period. Individual planning unit maps are within the USACE's LACPR Draft Technical Report (USACE, 2008). Note the pattern of "detached peak surge."

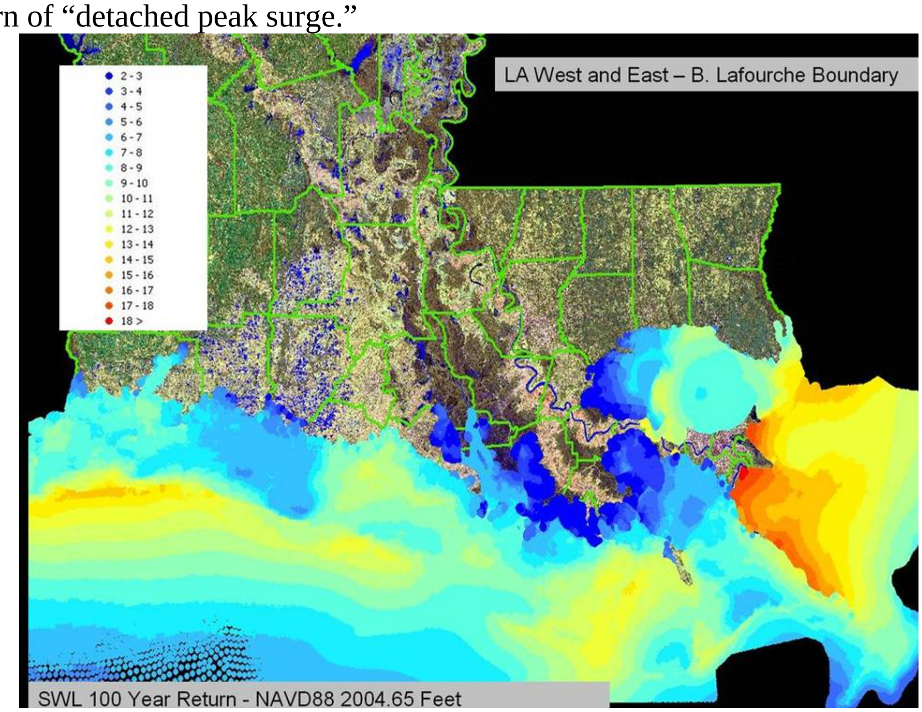


Figure 9: Preliminary composite map of the Statistical Maximum surge for numerous hurricane tracks and hurricanes representing a 100-year return period. Individual planning unit maps are within the USACE's LACPR Draft Technical Report (USACE, 2008). Note the pattern of "detached peak surge."

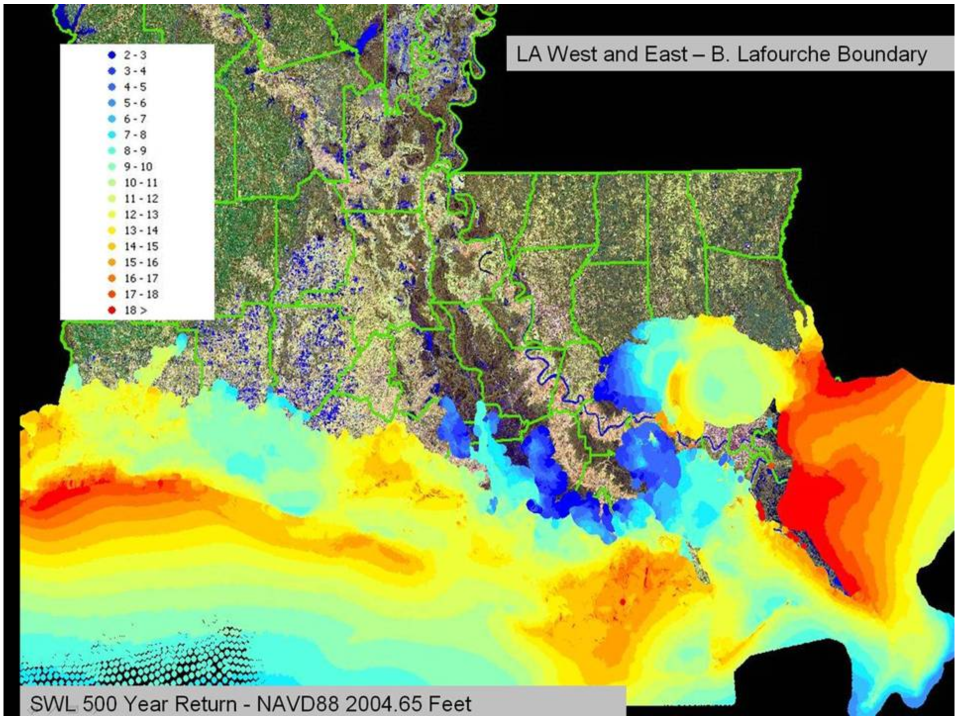


Figure 10: Preliminary composite map of the Statistical Maximum surge for numerous hurricane tracks and hurricanes representing a 500-year return period. Individual planning unit maps are within the USACE's LACPR Draft Technical Report (USACE, 2008). Note the pattern of "detached peak surge."

The proposed levee alignments are intended to provide, in conjunction with the coastal lines of defense, either 100 year or 400 year level of hurricane flood protection. This arrangement follows the *Louisiana's Comprehensive Master Plan for a Sustainable Coast* . The 100 year level has institutional and historical significance under USACE authorities or under FEMA coastal regulations and insurance. The 400 year level is less well defined scientifically due to the infrequency of these extreme storm events. Some level of protection greater than 100 year is appropriate for areas of higher density of population or assets, such as major metropolitan areas. Therefore, the higher level of protection should ultimately be equated to the long-term viability of these metropolitan areas and should be linked to benchmarks, such as the expected frequency to evacuate or related interruptions to commerce. We suggest that in the future, a city such as New Orleans should not need to require an evacuation more than once in ten years.

This report does not analyze or describe recommendations regarding the design, construction, or maintenance of engineered flood protection features, such as levees or flood walls, which is an extremely significant subject. The inadequacies of these structures were in large part a cause for the catastrophic events of Hurricane Katrina in Louisiana. This subject has been extensively analyzed in several post-Hurricane Katrina efforts with highly credible professionals. The lessons learned and all the newest science and engineering must be used for new and old levees or other engineered flood protection. Some key references to analyses of levee failures from Hurricane Katrina:

American Society of Civil Engineers (ASCE) and University of California at Berkeley, 2005, (November). Preliminary Report on the performance of the New Orleans Levee Systems in

Hurricane Katrina on August 29, 2005. Report No. UCB/CITRIS – 05/01. Ver 1.2. Accessed September 20, 2006: http://www.asce.org/files/pdf/katrina/teamdatareport1121.pdf

Independent Levee Investigation Team (ILIT), 2006 (July), Investigation of the performance of the New Orleans flood protection systems in Hurricane Katrina on August 29, 2005. Final Report. Accessed September 20, 2006: http://www.ce.berkeley.edu/~new_orleans/

LA Department of Transportation and Development, 2007, ‘Team Louisiana’: final Report- The Failure of the New Orleans Levee system During Hurricane Katrina see http://www.dotd.louisiana.gov/administration/teamlouisiana/

U.S. Army Corps of Engineers. Interagency Performance Evaluation Task Force (IPET), 2005 (December), Summary of field observations relevant to flood protection in New Orleans, LA. Interim report to Task Force Guardian. New Orleans Hurricane Protection Projects Data. Accessed September 20, 2006: https://ipet.wes.army.mil/NOHPP/_Post-Katrina/(IPET)%20Interagency%20Performance%20Evaluation%20TaskFo rce/Reports/ASCE_NSF%20Report%20Assessment_%20IPET_120505.pdf# search=%22.%20Summary%20of%20Field%20Observations%20Relevant% 20to%20Flood%20Protection%20in%20New%20Orleans%22

---. 2006a (January), Performance evaluation plan and interim status, report 1 of a series, performance evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, draft final report. New Orleans Hurricane Protection Projects Data. Accessed September 20, 2006: https://ipet.wes.army.mil/ (Folder Post-Katrina/(IPET) Interagency Performance Evaluation Taskforce/Reports/IPET Report 1.pdf)

---. 2006b (March), Performance evaluation status and interim results, report 2 of a series, performance evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System New Orleans Hurricane Protection Projects Data. Accessed September 20, 2006: https://ipet.wes.army.mil/ (Folder Post-Katrina/(IPET) Interagency Performance Evaluation Taskforce/Reports/IPET Report 2)

2006c (June), Performance evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System. Draft Final Report of the Interagency Performance Evaluation Task Force. New Orleans Hurricane Protection Projects Data, Accessed September 20, 2006: ttps://ipet.wes.army.mil/ (Folder Post- Katrina/(IPET) Interagency Performance Evaluation Taskforce/Reports/IPET Draft Final Report)

Wooley, D. and Leonard Shabman, 2007, Decision-making Chronology for the Lake Pontchartrain & Vicinity Hurricane Protection project draft final report for the headquarters, U.S. Army Corps of Engineers submitted to the Institute for Water Resources of the U.S. Army Corps of Engineers at http://www.iwr.usace.army.mil/inside/products/pub/hpdc/hpdc.cfm

Report Planning Process

The Lake Pontchartrain Basin Foundation (LPBF) and the Coalition to Restore Coastal Louisiana (CRCL) formulated an assessment team to develop and promote the application of the Multiple Lines of Defense Strategy (MLODS), applying the best science and engineering to coastal restoration and flood protection. The assessment team is composed of highly qualified coastal scientists and engineers. This group is supplemented with additional expertise through universities and professional services. In addition, three technical workshops were held in November 2007 to solicit input and critique the draft report. Public comments that were solicited from August 2007 until January 2008 are included in the current version of this report. Comments will continue to be solicited to acquire the best information available and public input.

LPBF and CRCL have made a long-term commitment to apply this strategy to their coastal programs. This report is released as the "2008 Report (Version I)" but subsequent addenda or modifications may develop in 2008 and into the future. Significant new and pertinent information will be developed or released, which may require additional data or sections in the report. In order to incorporate public input and the best available science and engineering in this document, the report will be revised on a yearly basis or more frequently if the information acquired makes it necessary.