TWILLEY, LSU
DHS COASTAL RESILIENCE CENTER
RESEARCH PROJECT
YEAR 3 PERFORMANCE REPORT
AND
FINAL PROJECT REPORT

Project Title: Integrated Modeling Approaches with Application to Pre- and Post-Disaster Planning for Creating More Resilient Communities

Principal Investigator Name/Institution:
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Project Start and End Dates: 1/1/2016 – 6/30-2018

Short Project Description:

Communities can improve their ability to reduce repetitive losses associated with flooding from coastal storms by improving how flood risks are incorporated in mitigation planning immediately following an event. Post-disaster recovery planning can be a driving force behind mitigation and recovery planning that will improve public safety and economic recovery.

Summary Abstract:

We propose that an integration of coastal modeling tools linked to innovative design/planning approaches, together with effective outreach to both emergency managers and land use planners is needed to provide crucial community-level data for effective pre- and post-disaster planning. Beyond large-scale models or those that only demonstrate one aspect of hazard impact (e.g. storm surge), communities need clear guidance on exactly which vulnerable infrastructure and populations may be threatened and/or protected (pre-disaster planning and rapid response), and accurate post-event impact in order to make crucial land use and redevelopment decisions quickly. The ability to leverage this type of community-specific data provides the opportunity to avoid loss and rebuild for maximum future risk reduction. The trans-disciplinary LSU partnership builds on the strengths of several research centers and outreach institutions that incorporate science of coastal flooding with new techniques in community resilience planning. This collaborative effort provided transformational products to vulnerable communities to actively address improved flood prediction, protection, and response. We incorporated established modeling outputs into a new consequence model showing how flood risk (both from storms and SLR) will impact people, industry, and infrastructure. This much needed information was used to enhance pre- and post-disaster planning efforts. Louisiana Sea Grant, SDMI and CSS engaged federal, state and local planners and emergency managers to

incorporate these products into planning efforts. Beyond the targeted work being undertaken with established partner community(ies), the products were leveraged to develop integrated approaches for university-based design studio courses and design/outreach entities addressing these issues. The products and concepts developed from this project demonstrated utility during Louisiana 2016 Flood and hurricane season of 2017 (Hurricanes Harvey, Irma and Maria).

PROJECT NARRATIVE:

1. Research Need:

This project responds to the HSE problems defined by the need to assess future coastal flood risks and to create more flood resilient communities in the future. Our project proposes novel techniques to allow vulnerable communities to plan, react, and recover more quickly and effectively in areas facing repetitive disturbance. The goals of the program are to improve emergency response with regard to protecting vulnerable infrastructure and populations, and to reduce repetitive loss by providing accurate impact data to community planners in the immediate aftermath of an event. This program focuses on significant reduction in risk with the use of high-fidelity storm surge data and impact scenario viewers during the pre-disaster planning and rapid reaction to storms, and accurate information useful to post-disaster recovery planning. The transition of these models is proposed in a community design format with local planners in a 'Resilience Institute'. The proposed project solidly supports the mission and goals of the DHS Strategic Plan QHSR. In particular, the proposal supports DHS's Mission 5 (Strengthen National Preparedness and Resilience) to create tools and partnerships that ensure effective, unified planning and response operations in the during extreme weather events.

2. History:

The Mississippi River Delta (MRD), like most deltaic coasts around the world, have rates of sea level rise plus high rates of deltaic subsidence that amplify the risks to coastal flooding today that represents what most other coastal cities will experience in future decades. The persistent impacts of relative sea level rise together with natural hazards such as hurricanes severely threatened infrastructure that is critical to the livelihood and economic well-being of Louisiana and the nation. The seafood industry, energy sector, and shipping/navigation industries in this coastal region represent some of the most significant contributions to the national economies of the USA. Given that many of these industries are fixed to coastal locations, there is limited capacity for the business community and workforce to migrate inland even under scenarios of increased future flooding risk. This fixed location is typical of many industries that are located in coastal regions that have access to marine transportation and unique natural resources. These industries located along coastal regions are also made up of small towns, rural areas, and major cities – all of which are vital to the workforce and service industries of these industries, but who struggle to become more resilient in the face of rising seas and storminess. With accelerated sea level rise and natural hazard impacts projected over the next century, subsequent disruptions to business, critical infrastructure, and individuals will challenge the ability of coastal communities and industries to meet increasing demand for goods and services to supply the nation's economy. Therefore, it is critical that vulnerable coastal communities and industries have access to quality information and processes that protect assets and reduce the cycle of repetitive loss. This includes a range of strategies, from improved predictive capabilities and communications that guide strategic protection of assets and populations during an event to

coordinated plans that improve the quality and efficiency of recovery. Simply put, the driving forces behind hazard response and recovery planning are public safety and economic recovery.

Recognizing the need for community-level hazard impact models, LSU, in collaboration with UNC, developed a high-accuracy tool that presents storm surge modeling forecasts and real-time surge information in an effective, user-friendly, and visually appealing way. This tool, known as Coastal Emergency Risk Assessment (CERA), has been a critical and important first step in the process of real-time forecasting and an essential precondition for conveying accurate information to industry and community leaders. CERA provides 3-5 ensemble runs during an active tropical storm for each advisory, based upon information on track conditions provided by the NOAA National Hurricane Center (NHC). CERA has added features, which have been used such as during Joaquin and Hurricane Isaac, to provide flood projections based on modifications of the NHC forecasted track – including runs within the eastern and western boundaries of the NHC central track. In addition, modifications in wind speed have been included, along with these multiple tracks, to give emergency managers a glimpse of 'what if' scenarios of hurricane track forecasts. While CERA provides high-resolution detail of storm surge, it does not link this information to industry, infrastructure, or vulnerable populations. We propose that an integration of coastal modeling tools linked to innovative design/planning approaches, together with effective outreach to both emergency managers and land use planners is needed to provide crucial community-level data for effective pre- and post-disaster planning. Beyond large-scale models or those that only demonstrate one aspect of hazard impact (e.g. storm surge), communities need clear guidance on exactly which vulnerable infrastructure and populations may be threatened and/or protected (pre-disaster planning and rapid response), and accurate post-event impact in order to make crucial land use and redevelopment decisions quickly. The ability to leverage this type of community-specific data provides the opportunity to avoid loss and rebuild for maximum future risk reduction.

We developed a unique collaboration among three LSU research centers (Coastal Sustainability Studio (CSS) and Stephenson Disaster Management Institute (SDMI)) and a research and outreach organization (Louisiana Sea Grant College Program (LSG)) to develop pre- and post-disaster planning and adaptation tools for coastal communities to increase resilience. These efforts are designed to enable vulnerable communities to plan, react, and recover more quickly and effectively in areas facing repetitive disturbance. The goals of the program are to improve emergency response with regard to protecting vulnerable infrastructure and populations, and to reduce repetitive loss by providing accurate impact data to community planners in the immediate aftermath of an event. This program focuses on significant reduction in risk with the use of high-fidelity storm surge data and impact scenario viewers during the pre-disaster planning and rapid reaction to storms, and accurate information useful to post-disaster recovery planning. Together this group will provide (1) planning tools that visualize aggregated risks to include hurricane force winds, storm surge, and inland flooding along with vulnerable populations based on socio-economic status; (2) modeling and visualization tools to communicate flood risks during a tropical cyclone event by identifying vulnerable populations and structures that are susceptible to storm surge; (3) provide post-landfall search and rescue grid system with prioritization based on socio-economic vulnerabilities; (4) develop methodology for helping community planning departments and recovery planning teams effectively utilize and implement changes to their built

environment through effective resilience based planning. User groups and Sea Grant outreach program were organized to facilitate awareness of products generated from this project, with focus on how to communicate vulnerable infrastructure and populations to regional planners. The trans-disciplinary LSU partnership builds on the strengths of each research center and outreach institution, and developed transformational products to vulnerable communities to actively address improved flood prediction, protection, and response.

We incorporated established modeling outputs into a new consequence model showing how flood risk (both from storms and SLR) will impact people, industry, and infrastructure. This much-needed information can be used to enhance pre- and post-disaster planning efforts. Louisiana Sea Grant and CSS engaged federal, state and local planners and emergency managers to incorporate these products into planning efforts. The new model, known as the Coastal Emergency Risk Assessment (CERA) Planning tool, incorporated many NOAA and other federal products (e.g., NOAA National Ocean Service, NOAA's River Forecast Centers, NOAA's National Centers for Environmental Information (NCEI), NOAA's Weather Prediction Center, and the NOAA National shoreline data, along with USGS, and USACE) to inform local consequence model results. User groups and Sea Grant outreach program are able to facilitate awareness of products generated from this project, with focus on how to communicate vulnerable infrastructure and populations to regional planners (with research funding from Sea Grant to enhance how flood risk is communicated to public).

The CERA visualization system and the website itself provide enhancements to DHS' mitigation programs and community preparedness plans, as well as a pathway to improved timely and accurate information to the public during hurricane threats. This tool has been modified using the results of a focus group described below to incorporate attributes across the landscape that will be vulnerable under different hurricane scenarios utilizing hindcasts of real storms in the region. Hurricane Isaac was used to test the ability of CERA Planning to capture those attributes of infrastructure that advisory panels recommended are needed by planners and emergency managers as critical to the resiliency of communities during extreme weather events. The CERA Planning tool has been utilized in design studios in Architecture at LSU to initiate the process of building approaches towards a Resilience Institute. The CERA Planning tool has been developed as partial support of graduate students in Stephenson Disaster Management Institute.

3. Results:

This project, starting with the establishment of a focus group of federal, state and local planners and emergency managers, evaluated what variables should be tracked in terms of consequences of storm surge to people, homes, and infrastructure to assist them in making critical decisions during and immediately following storm events. A list of end users involved in this process are listed in the transition section below. This aggressive outreach component was established to ensure local, state and federal planners and emergency mangers were aware of this project and its potential to influence their decision-making and planning processes. The project team has completed several outreach opportunities that include the State of Louisiana American Planning Association (APA), the Louisiana Emergency Preparedness Association's (LEPA) general session and the National Homeland Security Conference. In addition, direct outreach with

several federal agencies to include FEMA Region VI, U.S. Coast Guard, DHS Protective Services and the National Communication Center have also taken place. The Focus Group took place on September 21, 2016, with initial focus towards Louisiana and Region VI. **A**dditional users such as the National Communications Center were involved for input to continue to provide situational awareness for all communications infrastructure during tropical cyclones and U.S. Coast Guard – Sector New Orleans.

The first phases of developing CERA Planning was to modify a 143,000-point infrastructure database for the State of Louisiana and historical storms to determine effectiveness of consequences to inform planning process. A FEMA's Hazard Mitigation Grant Program to GOHSEP funded GIS Hazard Mitigation project to accomplish the following:

1) the collection of 6-inch high resolution imagery for the entire state; and
2) collection of critical infrastructures for all 64 parishes;
3) additional imagery consisting of 4-inch resolution for all cities in the state with a population of at least 10,000 and 3-inch resolution for the metropolitan areas of New Orleans and Baton Rouge was also captured in 2014.

The LSU team worked with the State to first develop the state's 144k point infrastructure database as the basis on which to build the consequence model. Additional work was performed with individual agencies such as DHS Protective Service and USCG District 8 on refining additional infrastructure requirements. Critical infrastructure from the data base was shared with a focus group agreed to focus discussion on what would be best approach in developing critical infrastructure for the CERA Planning tool, using initial data sets that were identified for consequence model. The focus group recommended that available parcel data and building footprints data be added to the consequence model. The also emphasized that critical to the locals would be the status of water utilities, sewer treatment plants and any surge that would disrupt their operations. Without the ability to provide potable water, a community has little ability to recover and sustain their populations following a major disturbance. The focus group continued to develop critical infrastructure from the FEMA data set that would address the following groups:

Safety: Nursing homes/hospitals, Fire/police (Brant has this)

Water: Drinking water and sewerage infrastructure

Energy: pipelines and energy generation (yet there was issue of this information being made public)

Accessibility: airports, roads, ports, rail, evacuation routes – and in particular major roads and evacuation routes with elevations/flood depths/topo maps so emergency managers can get from point A to point B.

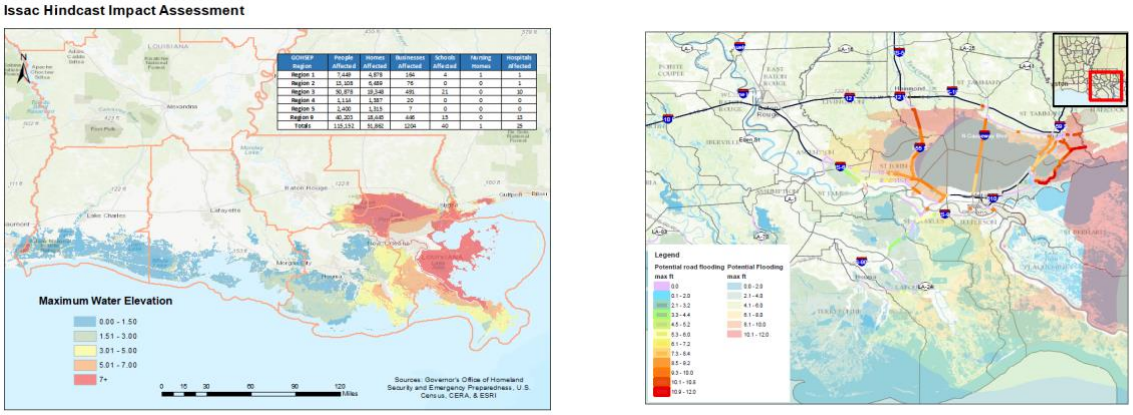
Telecommunications: telephone and cable.

The development of CERA Planning first utilized a consequence model developed at SDMI that is based on social vulnerability of communities along coastal Louisiana. This consequence model was designed and built as an automated model in ArcGIS to interpret outputs of CERA to analyze the consequences of expected storm surge. The consequence model has roots in emergency management, serving during Hurricane Isaac to understand decision making process when storm surge results were provided to state and parish government officials. Output from CERA was placed in hindcast on critical infrastructure and business assets that were threatened

from flooding to understand potential impacts to LaPlace and other local communities (Figure 1). The process of exporting CERA website information to consequence analysis of SDMI in hindcast of storm surge predictions help to focus conversations on vulnerability of community operations and recovery to flooding. Cyberinfrastructure was developed to transfer information from CERA to Consequence Model (GIS platforms) to expand the utility of products associated with critical infrastructure along the coast. Along with this effort was a build out the Storm Surge Vulnerability Index for at risk parishes, such as Vermillion and Camaron parishes. Again, the idea was to 'distill' the 144k data set on critical infrastructure to set of criteria that would define community vulnerability during an event that would utilize information from CERA to help decision making based on flood predictions and potential infrastructure damage. This vulnerability and mapping exercise, again using both Storm Surge Vulnerability Index maps of parishes in southwest Louisiana, and hindcast consequence maps of Hurricane Isaac, were outputs used by emergency managers for Federal, State and Local governments to help identify the critical infrastructure that should help lead a planning tool.

A second approach to developing CERA Planning was to incorporate results of the SDMI consequence model directly into CERA. Rather than exporting CERA output into a GIS consequence model, the project moved to using the discussion of critical infrastructure with the SDMI consequence model dealing with emergency operations to focus on infrastructure during the recovery phase that planners should pay particular attention during mitigation strategies to reduce repetitive losses. This modeling process involved loading selective datasets from the FEMA data set described above (the 144k data points of infrastructure sponsored by FEMA grant) directly into CERA. A hindcast storm run for Hurricane Isaac 2012 on the latest ADCIRC mesh for Louisiana (2017, collaboration with Center for Coastal Resiliency@ LSU, Scott Hagen) was developed with several of the critical infrastructure attributes described above (SWEAT). An example of such a mapping exercise developed using CERA directly to demonstrate CERA Planning is shown in Figure 2.

Figure 1. Maps based on consequence modeling using CERA hindcast of Hurricane Isaac to determine how information on flooding of critical infrastructure would assist with emergency



operations that identify vulnerability of community operations following storm impacts. (left panel) State wide assessment by region of people, homes, hospitals and businesses affected. (right panel) Highways in the Lake Pontchartrain area impacted by Hurricane Isaac.

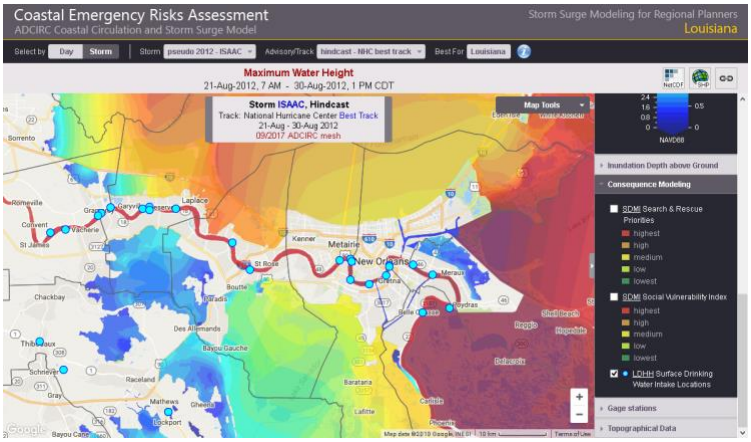
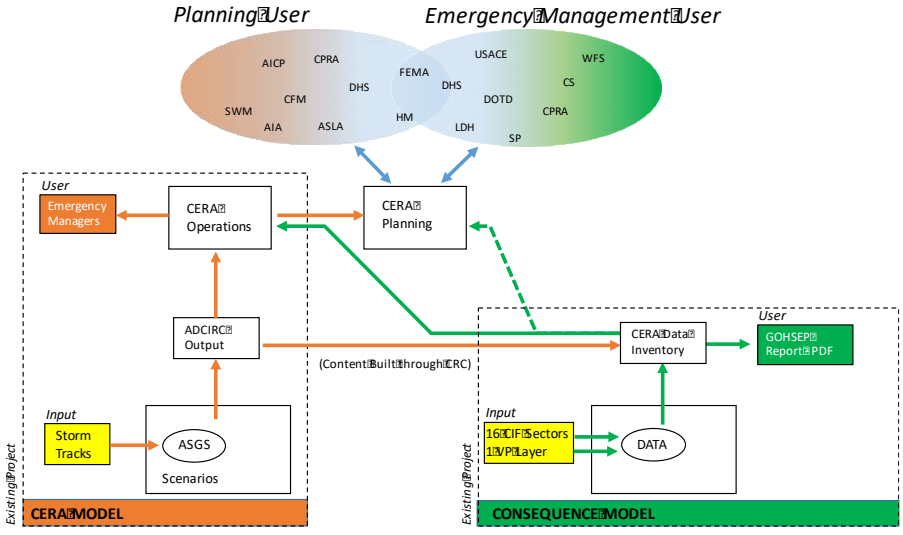


Figure 2. Hindcast of Hurricane Isaac with critical infrastructure using water intake locations to define community vulnerability during a storm surge event.

The CERA Planning tool (Figure 3) is based on cyberinfrastructure scripts that incorporate information on critical infrastructure and transferring infrastructure data to GIS platforms that is defined as the original Consequence Model of this CRC project. The output of this hindcast of Hurricane Isaac and other vulnerability scenarios of southwest parishes, user groups help to define the transition from vulnerabilities based on emergency management to discussion of how to mitigate future losses with better design. Based on discussions with advisory groups, critical infrastructure was slowly imported directly into CERA website that were focus of interactions with planning community. Model integration between the consequence model data inventory and the CERA storm surge visualizations were tested using hindcasts of Hurricane Isaac. Linkages were also proposed with HAZUS, but not implemented in this study. Two courses in Architecture have been taught engaging the CERA tools from this grant to test feasibility of infrastructure selected to planning designs, but have yet to be implemented fully as a course focus due to lack of tool completion in time for use in course development. Part of the delay in sequencing various components of this project was the requests during the 2016 and 2017 Louisiana and Texas floods in which an exercise for the Governor and Unified Command Group



requested scenarios developed using ADCIRC and the Consequence Model (see impact section below). These products actually accelerated completion of partnerships with GOHSEP and the LA National Guard as part of the hurricane planning exercise by developing products for the 2017 hurricane season.

Figure 3. Diagram demonstrating the integration of information on consequence model and content provided by CERA Model using ADCIRC simulations of storm surge during extreme weather events as planning tools for both emergency managers and planners.

4. End Users and Transition Partners:

This project, starting with the establishment of a focus group of federal, state and local planners and emergency managers, assisted in determining what variables should be tracked in terms of consequences of storm surge to people, homes, and infrastructure to assist them in making critical decisions during and immediately following storm events. These end users continue to provide contacts to transition information into the proper combination of consequence modeling into the CERA Planning tool.

- Federal Emergency Management Agency (FEMA) - Federal Preparedness Coordinator
- Federal Emergency Management Agency –Region VI Hurricane Program Manager
- Department of Homeland Security (DHS) Federal Protective Services - Protective Service Advisor
- National Weather Service (NWS) – Slidell/New Orleans Forecasting Office
- Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) – Deputy Director for Preparedness, Response and Interoperability
- Louisiana Coastal Protection and Restoration Authority (CPRA) – Michael Ellis, Executive Director
- Louisiana Department of Wildlife and Fisheries (LDWF) – Patrick Banks, Deputy Director
- Louisiana Office of Community Development (OCD) – Pat Forbes, Secretary
- Louisiana National Guard, - MAJ Robert Fudge
- US Coast Guard – Sector New Orleans - Port Security Specialist
- Local Planners –
  - Bob Rivers, Planning Director – City of New Orleans
  - Louisette Scott, Planning Director – City of Mandeville, LA
  - Chris Pulaski, Planning Director – Terrebonne Parish, LA
  - Doug Burguires, Assistant Planning Director, Lake Charles, LA
  - Jennifer Gerbasi, Terrebonne Parish Recovery Planner
  - Frank Duke, Director – East Baton Rouge Parish Planning Commission
  - Lynne Dupont, GIS Coordinator – New Orleans Regional Planning Commission
  - Jamie Setze, Director – Capital Area Planning Commission
- Emergency Managers –
  - Dev Jani, Deputy Directory – City of New Orleans
  - Dexter Accardo, Director - St. Tammany Parish OHSEP
  - John Rahaim, Director – St. Bernard Parish
  - Earl Eues, Director, Terrebonne Parish

- Sea Grant Agent - Kevin Savoie, Camaron Parish
- National Sea Grant Office

5. Project Impact:

This project, starting with the establishment of a focus group of federal, state and local planners and emergency managers, will determine what variables should be tracked in terms of consequences of storm surge to people, homes, and infrastructure to assist them in making critical decisions during and immediately following storm events. Each of the agencies described above have been involved in the development of CERA and its use during several recent hurricane events, such as Hurricane Isaac. These agencies made commitments through attendance at workshops dedicated to training on CERA products, and technology updates prior to hurricane season, that continue the partnerships that exist to efforts by CERA and SDMI to provide emergency management quality information during storm events. In addition, SDMI has established relationships with local partner communities that served as case studies for the Consequence Model production and targeted planning efforts. There was an attempt during the program to integrate these two advisory groups, first responders and community planners, to help in the transition of CERA into a planning tool. However, the development of Consequence Model by SDMI and the CERA model with Sea Grant continued to evolve in separate advisory circles. In addition, the planning community with Coastal Sustainability Studio, while helpful at the initial stages of defining critical infrastructure for post-mitigation planning, stayed focus on issues that evolved from Louisiana Floods of 2017 and did not connect with the CERA Planning tool development.

Tool development for Consequence Model and the CERA Planning tool did develop and produced several products in software development, data management protocols using critical infrastructure data sets, and vulnerability indices that are representative of the technical developments of this project (Figure 3). The use of Hurricane Isaac hindcast as a focal point of how Consequence Model and CERA Planning could exchange information and provide different outputs of critical infrastructure vulnerability was very effective during the project (Figures 1 and 2). These products allowed for internal development of information that could be shared with user groups, such as SDMI continued discussions with emergency managers, and presentation on importance of planning to the annual conference of Louisiana Emergency Preparedness Association (LEPA). In addition, products of Consequence Model and CERA Planning were used in studios in Architecture at LSU to foster adaptations of flood risk into community planning. In addition, products of CERA Planning and Consequence Model were used in sophomore course in ‘Ecosystem Design’, which was part of a new minor in Delta Sustainability developed at LSU. Material from CERA Planning were also used to help frame some of the training for new members of Governor Coastal Commission on Restoration and Protection during January 2018 session. The mapping exercises of flood risks and critical infrastructure using Hurricane Isaac continued to have impact on training of emergency management, but has only limited impact on training of planning professions to support post-event mitigation techniques.

It was anticipated that CERA-Planning would be tested by professional planners, planning directors, and professional organizations at Louisiana Emergency Preparedness Association (LEPA) Conference in May 2018. The original concept was that this exercise would improve the integration of SWEAT infrastructure into the hindcast of Hurricane Isaac as prototype of CERA-Planning to be presented to planners. However, in spring 2018, it was decided that CERA Planning should focus on DHS sectors as guide to interact with planning tools that would help with mitigation efforts following major flood events. Discussion with NIST and FEMA, along with DHS leadership, focused CERA Planning on moving from state efforts in planning to more case studies using developed planning guides that are being incorporated at the federal level. Conference calls and webinar with NIST was organized during spring and summer 2018 to initiate the utility of CERA Planning into those techniques and guidelines. In addition, efforts have been initiated, at the request of FEMA, to test the application of CERA Planning with the mitigation planning guidelines that are being developed at Texas A&M by Dr. Phil Burke. Both of these efforts are in the stage of identifying coastal communities in Louisiana to apply the NIST and TAMU techniques, and test the application of CERA Planning to those case studies.

A final component of the Consequence Model was the development of a localized Storm Surge Social Vulnerability Index (SSVI). Portions of this tool were developed for Vermillion Parish, and expanded to other parishes in southwest Louisiana. SSVI includes a base map in which vulnerable populations are geographically identified, along with socio-economic data (include age, gender, income, and education etc.), housing characteristics, proximity to hospitals, fire stations, police stations to evaluate safety factors. The data is aggregated to determine overall vulnerability, and along with real time storm surge information is designed to improve disaster response operations such as targeted evacuations and search and rescue. Post-storm, the SSVI will assist emergency managers and planners in analyzing impacts to industry, infrastructure, and social systems, and provide critical information necessary for recovery and adaptation planning. The SSVI was used to help with initial stages of what critical infrastructure should be considered by working groups and in discussions with planning professionals. But the development of SSVI as a component of CERA Planning was not pursued based on feedback from CRC advisory comments and leadership discussions.

The Louisiana Flood of 2016 and Hurricane Season of 2017 captured the efforts of CERA Planning tool and discussion of how to use storm surge information in real time extreme flood events. There was discussion of importance in regional watershed planning associated with flood events during 2016 in Lafayette and greater Baton Rouge area in Louisiana. Several of the Principle Investigators of this project were involved with providing guidance to recovery plans associated with the 2016 Louisiana Flood. This included the development of strategies to link flood modeling and assessment with visualization tools such as CERA to guide recovery efforts. Robert Twilley was on planning team for Flood Symposium held on 7 Dec 2016 in Lafayette, LA. LSU CSS played a significant role in advising local planning commissions and professionals on mitigation strategies following the 2016 Flood. In addition, LSU CSS was recipient of large National Academy of Science grant to develop mitigation strategies to inland flooding as part of coastal resilience. These guidelines and grant opportunities are associated with this ability to apply storm surge models to mitigation planning strategies.

In addition, Consequence Model and CERA were active during Hurricane Harvey. Figure 4 shows some of the infrastructure vulnerability mapping provided by Consequence Model as to assets potentially threatened in Louisiana during the event. There were follow up site visits in Texas during January 2018Identify the needs of regional planners and users of the CERA tool:

- Coast Guard Sector Houston-Galveston gathered information about operational need for an organized GIS database of vulnerable coastal infrastructure including tanks and pipelines
- Rice University is building a database of Above Ground Storage Tanks (ASTs). The response of institutions in Texas to improving the integration critical infrastructure with storm surge modeling techniques captures the learning from CERA/ASGS operations and CERA Planning during Hurricane Harvey.

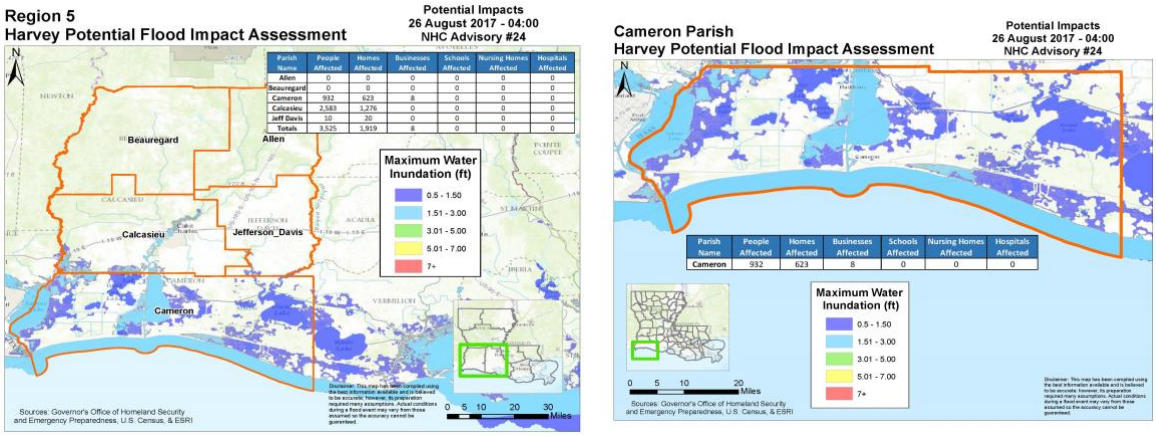


Figure 4. Pre-landfall estimates of potential impacts from flooding at regional and parish level associated with Hurricane Harvey in 2018. These predictions are based on CERA output being transferred to Consequence Model developed during this CRC project.

Tool development in this CRC project was very effective in transitioning two separate analysis of flood prediction and flood consequences into a more holistic approach. Two separate approaches in developing CERA and developing Consequence Model was finally integrated into a system of priority infrastructure and planning initiatives to develop a CERA Planning tool that is capable of providing insights during mitigation planning exercises following a major storm event (transition from pre to post disturbance utility). However, the application of this new tool was not realized during this CRC project. The change in strategy from continued developing of local planning guidelines, to using present guidelines that are emerging at the national level (and part of the DHS responsibility) is a much-improved approach to testing the utility of CRA Planning tool. This strategy will include the following.

1. Utilize discussions with CRC leadership to determine how the outcomes of consequence model and CERA Planning tool can be integrated into existing systems and training opportunities to improve planning actions creating more resilient communities such as those created by NIST Community Resilience program.
2. Collaborating with the APEX group would be helpful to the continued development of CERA Planning to make sure the selection of infrastructure used in model results has utility to those engaged in post-disturbance needs.

3. Using CERA-Planning to inform other tool development programs on what specific information may be most effective in changing the perspective of planning process. CERA Planning is a tool that is testing a variety of techniques to be more effective in communicating the risk of flooding on planning decisions.

6. Student involvement and awards:
   - A graduate research assistantship was funded on this project that was used to support Nick Robles. His contributions to the project was programming scripts that developed the Consequence Model, including programming to exchange information from CERA into GIS platforms to map flooding exposure and the location of key assets and critical infrastructure. His programming also supported the access of critical infrastructure assets from data bases into CERA to help develop CERA Planning tool.
   - Nick Robles completed the requirements for a Masters of Science
   - Undergraduate interns were supported in the LSU Coastal Sustainability Studio to assist with collecting and organizing GIS information on the 2016 Louisiana Flood.

7. Interactions with education projects: Describe your involvement with CRC's education partners over the life of your project, including student interns hosted at your institution, lectures and other activities conducted at partner institutions, etc.

   - The CERA Planning Tool was presented on a zoom conference in Computer Science at Johnson C Smith University (RETALK) on February 22, 2018. In addition, Jeff Carney of LSU CSS participated in lectures at UNC involving course in Mitigation Community Planning, led by Dr. Gavin Smith.
   - Dr. Twilley gave a guest lecture on coastal resilience of Mississippi River Delta at UNC Institute of Marine Science, hosted by Dr. Mike Piehler.

8. Publications:
   N/A

9. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	**Product Type** (e.g., software, guidance document)	**Delivery Date**	**Recipient or End User**
CERA Planning Web Site	Software	March 2018	Used to inform how storm surge exposure can be incorporated into NIST Community Resilience products
Python script for Consequence Model	Software	June 2017	Emergency Management Agencies such as LA GOHSEP (Governor's Office of Homeland Security and Emergency Preparedness)
Analysis of FEMA data set	Data platform – Statistical software	December 2016	Emergency Management Agencies such as LA GOHSEP (Governor's Office of Homeland Security and Emergency Preparedness)
Advisory Group Report	Guidance document	June 2017	Louisiana Planning Association to guide discussion of CERA Planning Tool
Consequence mapping script	Software	March 2018	Emergency Management Agencies such as LA GOHSEP (Governor's Office of Homeland Security and Emergency Preparedness)
Storm Surge Vulnerability Index (SSVI)	Software	June 2017	Emergency Management Agencies such as LA GOHSEP (Governor's Office of Homeland Security and Emergency Preparedness)

Table 2A: Documenting External Funding

Title	PI	Total Amount	Source
Improved Algorithms for Computing Storm Surge (STORM) (NSF)	Hartmut Kaiser	$206,560	National Science Foundation
Coastal SEES Project on Accelerated Flood Risk with Delta Degradation	Robert Twilley	$298,683	National Science Foundation
Port Resilience Index (NOAA)	Robert Twilley	$20,000	NOAA
Louisiana Community Resilience Institute I, II & III (Kresge, Sea Grant)	Jeff Carney	$50,000	KRESGE

Table 2B: Documenting Leveraged Support

Description (e.g., free office space; portion of university indirect returned to project; university-provided student support)	Estimated Total Value
Free Office Space	$28,000
Portion of university indirect returned to project	$26,480
Reduced rates on high performance computing	$25,000
Support of ASGS development by Louisiana Sea Grant	$75,000

Table 3: Performance Metrics:

TWILLEY PERFORMANCE METRICS

Metric	Year 1 (1/1/16 – 6/30/16)	Year 2 (7/1/16 – 6/30/17)	Year 3 (7/1/17- 6/30/18)
HS-related internships (number)			
Undergraduates provided tuition/fee support (number)			
Undergraduate students provided stipends (number)	1	1	1
Graduate students provided tuition/fee support (number)	1	1	1
Graduate students provided stipends (number)	1	1	1
Undergraduates who received HS-related degrees (number)			
Graduate students who received HS-related degrees (number)			
Graduates who obtained HS-related employment (number)			
SUMREX program students hosted (number)			
Lectures/presentations/seminars at Center partners (number)	1	2	3
DHS MSI Summer Research Teams hosted (number)			
Journal articles submitted (number)			
Journal articles published (number)			
Conference presentations made (number)	5	3	3
Other presentations, interviews, etc. (number)	6	2	3
Patent applications filed (number)			
Patents awarded (number)			
Trademarks/copyrights filed (number)			
Requests for assistance/advice from DHS agencies (number)	7	6	11
Requests for assistance/advice from other Federal agencies or	5	4	3
Total milestones for reporting period (number)	8		
Accomplished fully (number)	3		
Accomplished partially (number)	5		
Not accomplished (number)	0		

10. Year 3 Research Activity and Milestone Achievement.

Research Activities and Milestones: Final Status as of 2018
Reporting Period 7/1/2017 – 6/30/2018

Research Activities	Proposed Completion Date	% Completed	Explanation of why activity/ milestone was not reached
Determine which variables in the Louisiana model are available for other coastal states.	Dec 2017	100 %	
Build automation and integration between the Consequence Model and CERA website.	Mar 2018	100%	
Research Milestones			
Validate SSVI with operational data from historical storms	Dec 2017	100%	
Develop process to create the SSVI for other coastal parishes	Mar 2018	100%	

11. Year 3 Transition Activity and Milestone Status:

Transition Activities and Milestones: Final Status as of 2018
Reporting Period 7/1/2017 – 6/30/2018

Transition Activities	Proposed completion date	% completed	Explanation of why activity / milestone was not reached
Integrate CERA modeling and visualization tools that define how CERA consequence tool can improve regional planning	Mar 2018	100%	
Development of an annual Resilience Institute designed to connect decision makers in small coastal communities with planning and technical resources for resilient development. Integrate this effort with flood response programs to Louisiana 2016 flood	June 2018	25%	Resilience Institute format with selected mayors was performed; and planning for resilient development were performed as part of Louisiana 2016 flood; but the CERA Planning tool was not developed sufficient as utility to these institute and planning activities.
Discuss with NOAA and FEMA on how to utilize the feedback from user groups and operational exercises with	June 2018	100%	Discussions moved forward with how CERA Planning can be incorporated into the NIST

GOHSEP on how to expand the utility of products on regional and national level			Community Resilience program. Plans were developed to establish case study with community in coastal Louisiana (see explanation for not completing workshop at LEMA).
Discuss with leadership of APA how to utilize community resilience workshop products on regional and national level	Mar 2018	100%	
Host workshop at LEMA annual meeting in May 2018 that trains hazard mitigation planning on use of tool for flood vulnerability	June 2018	0%	Decisions were made to move the focus of CERA Planning from state level emergency management conference to case study of coastal community using NIST Community Resilience planning tools.
Transition Milestones			
Produce and test integrated design and planning strategies for risk prone coastal communities	June 2018	25%	CERA Planning tool is being coordinated with case study of coastal community using NIST Community Resilience planning tools.
Produce guidelines on an annual Resilience Institute that describes how CERA, with integrated consequence modeling tools, can be used as planning and technical resource for resilient development for FEMA and GOHSEP (LA Governor's Office of Homeland Security and Emergency Preparedness). CERA uses standardized interfaces for web mapping and data distribution; updates will continue to work with clients and provide data via export functions in the CERA interface (export buttons), OpenDap data distribution services or FTP data services to ensure that our clients can benefit from our results.	June 2018	75%	CERA Planning tool is being coordinated with case study of coastal community using NIST Community Resilience planning tools. Using this federal planning document together with storm surge exposure from CERA Planning, a more national technical resource will be formulated. CERA and Consequence Model were used during Hurricane Harvey as example of model development utility; CERA interface with other utility by clients was expanded during the 2017 Hurricane Season