Physical, Biological and Ecological Sciences

G. Paul Kemp
Louisiana State University
School of the Coast & Environment
&
LSU Hurricane Center

Panel Session I:
National Science Board Task Force on Hurricane Science and Engineering
Boulder, Colorado
February 7, 2006

LSU Research & Operations Support - Katrina

The LSU Hurricane Center

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Hurricane Preparedness and Protection

- focus on surge rather than winds
- redundancy or defense in depth?
  - One expects failure while the other successfully meets different types and levels of threat at different places.
- Does defense in depth have a time dimension?
  - storm time-scale (hours)
  - ecosystem time-scale (seasonal to decades)
  - engineering time-scale (decades to centuries)

Support for Katrina Response – Pre-landfall

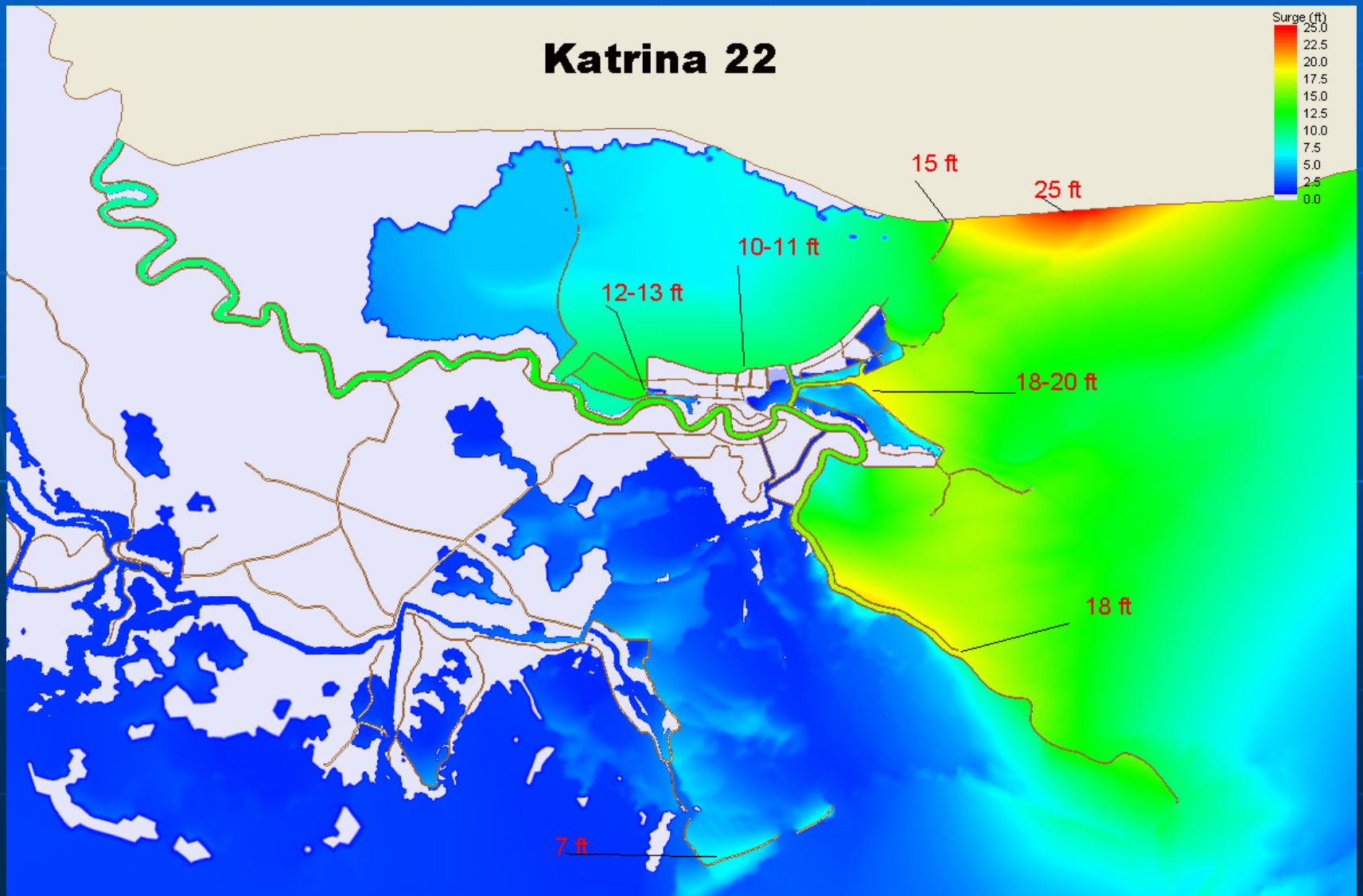
LSU Hurricane Center activated Friday afternoon Aug 26

- Satellite storm tracking
  Meteorological support
- Storm surge modeling (www.hurricane.lsu.edu/floodprediction)
- Damage estimates
- Consultation on traffic routing, evacuation and sheltering decisions
- Briefings every 2-3 hours

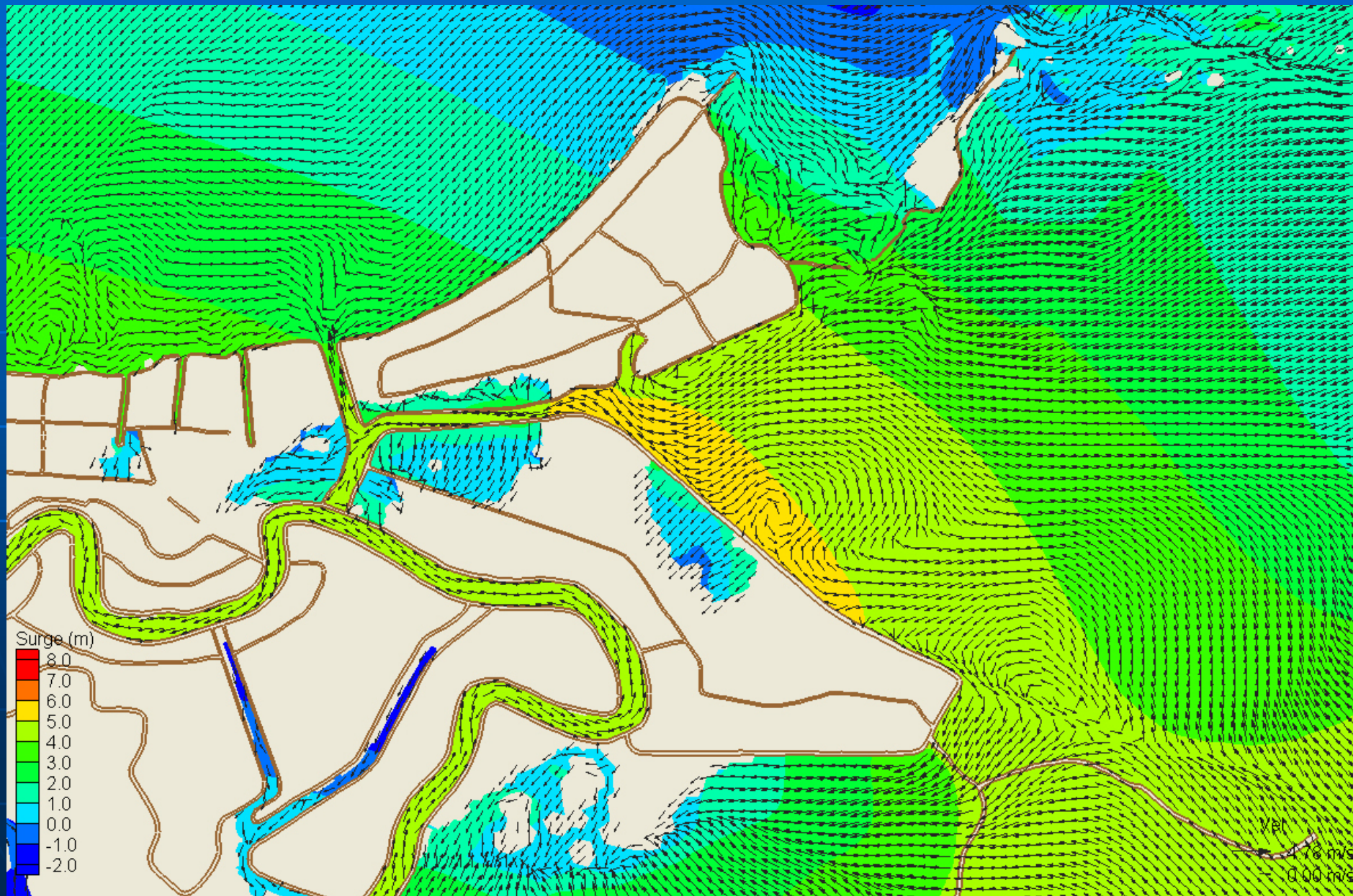
OPERATIONAL NEAR-REAL-TIME SURGE FORECASTING FOR HURRICANE KATRINA

National Hurricane Center Advisory Information			Predicted Storm Characteristics at Closest GNO Approach 30° N				Surge Analysis Complete	
Advisory Number	Advisory Date:Time (UTC)	Time to Landfall (h)	Eye Center Location (km)	Central Pressure (mB)	Max Sustained Wind (m/s)	Speed (km/h)	Date:Time (UTC)	Elapsed Time (h)
16	8/27/05 0900	51	13.0 East	968	47	19	8/27/05 1930	10.5
17	8/27/05 1500	45	27.8 East	957	54	21	8/27/05 2000	5.0
18	8/27/05 2100	39	18.5 East	941	61	21	8/27/05 2700	6.0
22	8/28/05 1200	24	33.3 East	920	69	21	8/28/05 2000	8.0
25	8/29/05 0300	9	48.2 East	963	50	24	8/29/05 0930	6.5
31	8/30/05 1500	-27	59.3 East	937	56	31	Post Storm	

LSU ADCIRC Forecast 24 hours before landfall



Surge Snapshot

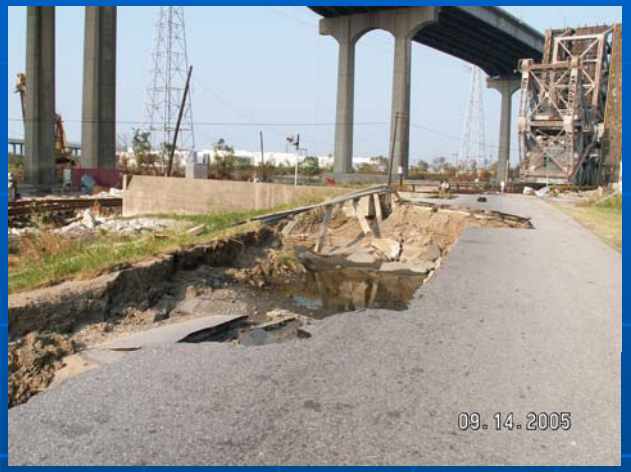


Support for Katrina Response – Post-Landfall

Staffed the ‘LSU’ workstation at the Louisiana Emergency Operations Center 24/7 for next 3 weeks

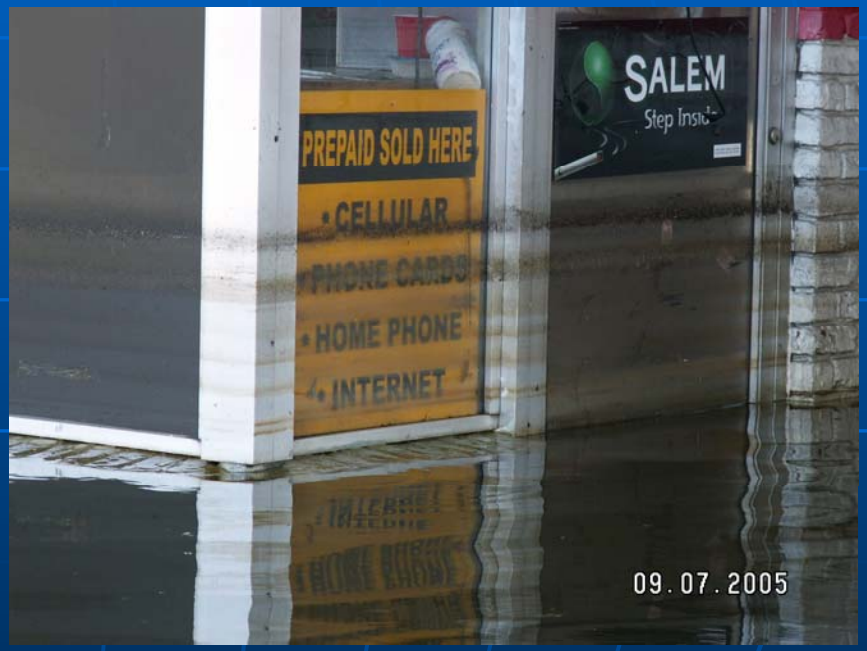
- Post-Landfall Activities
  - Intensive Field Survey Initiative for High Water Marks
  - Map and Document Breaches and Levee Conditions
  - Stood up GIS/Remote Sensing/Mapping capability in less than 24 hours
  - Meteorological support
  - Upgrading surge model to account for levee damage state
  - Water quality sampling – results shared with EPA
  - FEMA Data Clearinghouse – LSU allocated 20 Terrabytes of space

Overtopping and Floodwall Breaching West Bank of the Industrial Canal



Surge on Lakefront west of 17th St. Canal
11 to 12 ft

Conditions in New Orleans September 7 Near Tulane Ave.



Bonnabel Boat Launch

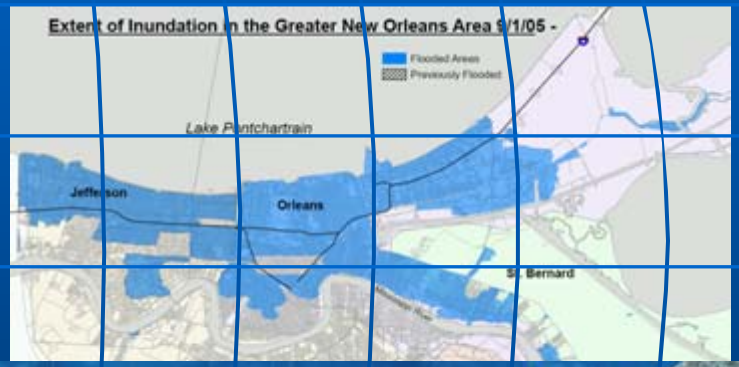
New Orleans Yacht Club
Conferring on high water marks
Steve Maynard,
David Biedenborn

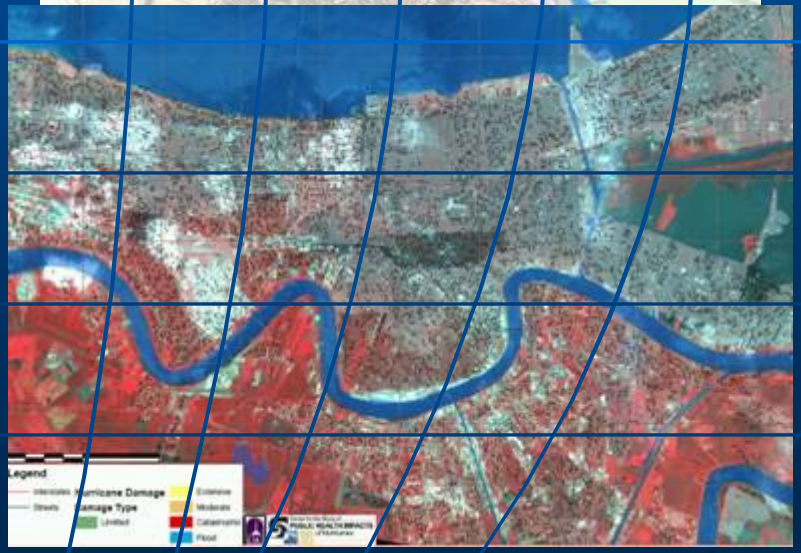
GIS Mapping and Imagery Support Collaborating LSU Centers

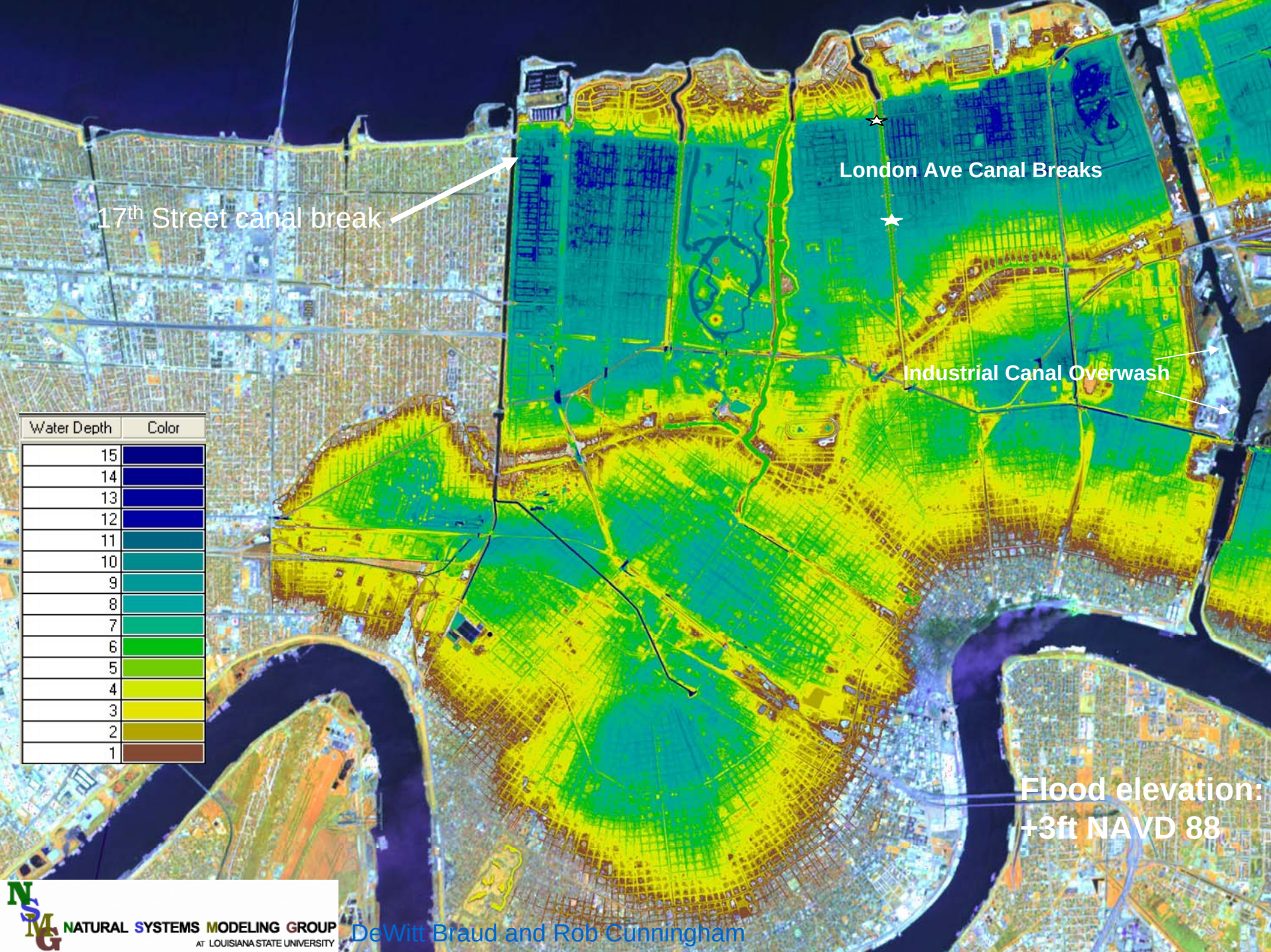
- LSU Center for the Study of Public Health Impacts of Hurricanes (CSPHIH)
- Louisiana Geological Survey
- LSU CADGIS lab
- LSU World Health Organization Collaborating Center (WHOCC)
- LSU Hurricane Center
- LSU Coastal Studies Institute
- LSU Earth Scan Lab
- Southern Regional Climate Center

GIS Mapping and Imagery Support Completed Map Requests

- 911 calls on indexed New Orleans atlas for FBI and state police
- Extent of flooded and damaged areas with road overlay
- Hospital and nursing home locations with lat/longs
- Pumping stations and levee failures
- Hostile areas
- Shelters, staging areas and aid station locations
- Docking areas
- State Lands, Topographic maps, New Orleans maps, many more






17th Street canal break
London Ave Canal Breaks
Industrial Canal Overwash
Flood elevation:
+3ft NAVD 88
Water Depth
Color
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
NATURAL SYSTEMS MODELING GROUP
AT LOUISIANA STATE UNIVERSITY
DeWitt Braud and Rob Cunningham

ADCIRC Surge Forecast Accuracy as Katrina Approached

Zone			Forecasts: Hours to Louisiana Landfall					
West to East	No. Obs.	HWM (SE)	51	45	39	*24*	9	(-27)
Lake West	5	2.20 (0.48)	2.16	1.66	2.30	*2.24*	1.94	2.71
		RMSE	0.34	0.62	0.37	*0.30*	0.38	0.66
		% Error	*15*	*20*	*15*	*15*	*17*	*12*
Jefferson	4	2.45 (1.02)	2.49	2.10	2.94	*3.14*	2.60	3.73
		RMSE	0.37	0.34	0.28	*0.23*	0.26	0.34
		% Error	*15*	*14*	*12*	*9*	*11*	*14*
Orleans Metro	20	3.63 (0.43)	1.99	2.28	2.73	*3.40*	2.77	3.49
		RMSE	1.69	1.39	0.99	*0.35*	0.92	0.33
		% Error	*47*	*38*	*27*	*10*	*25*	*9*
East Orleans	9	4.18 (0.50)	2.76	2.90	3.43	*4.06*	3.35	4.18
		RMSE	1.57	1.41	0.99	*0.45*	1.02	0.63
		% Error	*38*	*34*	*24*	*11*	*24*	*15*

OVERTOPPING IS SURVIVABLE BUT BREACHES …

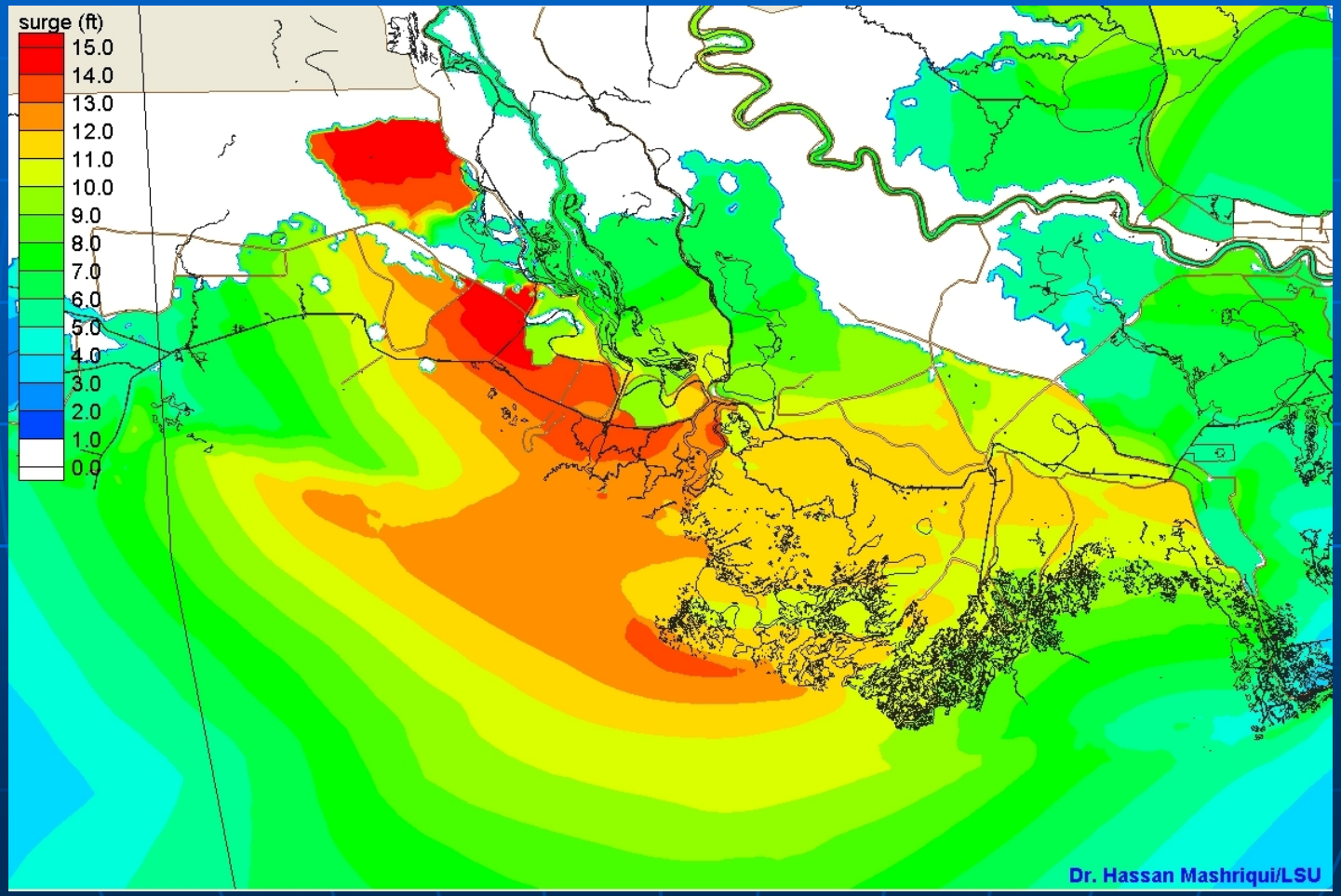
Zone	Mean Flooded Land Elevation NAVD88(m)	Mean Water Surface Elevation NAVD88(m)	Mean Depth of Flooding (m)	Flooded Area (ha)	Percent of Area Flooded	Volume of Flood (m^3)	Percent Flood Volume
Observed Flooding from Overtopping and Breaches							
Orleans Metro	**-0.53**	**0.91**	**1.44**	**8,521**	**100**	**122,367,327**	**100**
East Orleans	**-1.75**	**-0.46**	**1.29**	**6,091**	**100**	**78,539,845**	**100**
St. Bernard	**0.75**	**3.66**	**2.91**	**8,325**	**100**	**241,977,351**	**100**
Total All Sources				**22,937**	**100**	**442,884,523**	**100**
Forecast Flooding from Overtopping							
Orleans Metro	**-1.67**	**-1.07**	**0.60**	**2,458**	**29**	**14,888,742**	**12**
East Orleans	**-2.20**	**-1.54**	**0.66**	**3,685**	**60**	**24,361,620**	**31**
St. Bernard	**-0.15**	**0.41**	**0.56**	**3,383**	**41**	**18,861,091**	**8**
Total Overtopping				**9,526**	**42**	**58,111,453**	**13**
Estimated Flooding from Breaches							
Orleans Metro			**0.84**	**6,063**	**71**	**107,478,585**	**88**
East Orleans			**0.63**	**2,406**	**40**	**54,178,225**	**69**
St. Bernard			**2.35**	**4,942**	**59**	**223,116,260**	**92**
Total Breaches				**13,411**	**58**	**384,773,070**	**87**

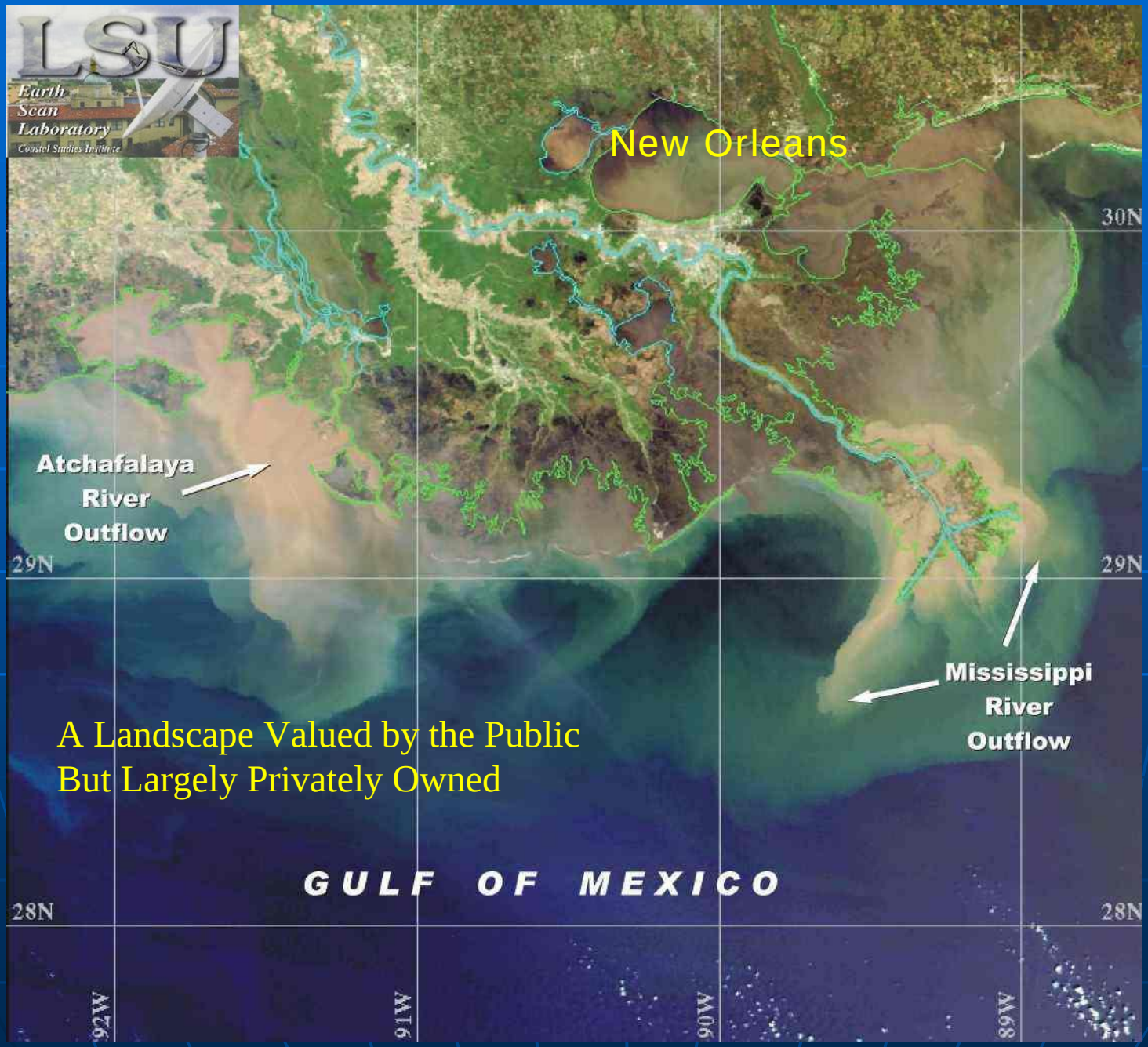
Wetlands & the Levees

The Difference Between This…

And This...
An
IS THIS!
5 2:10PM

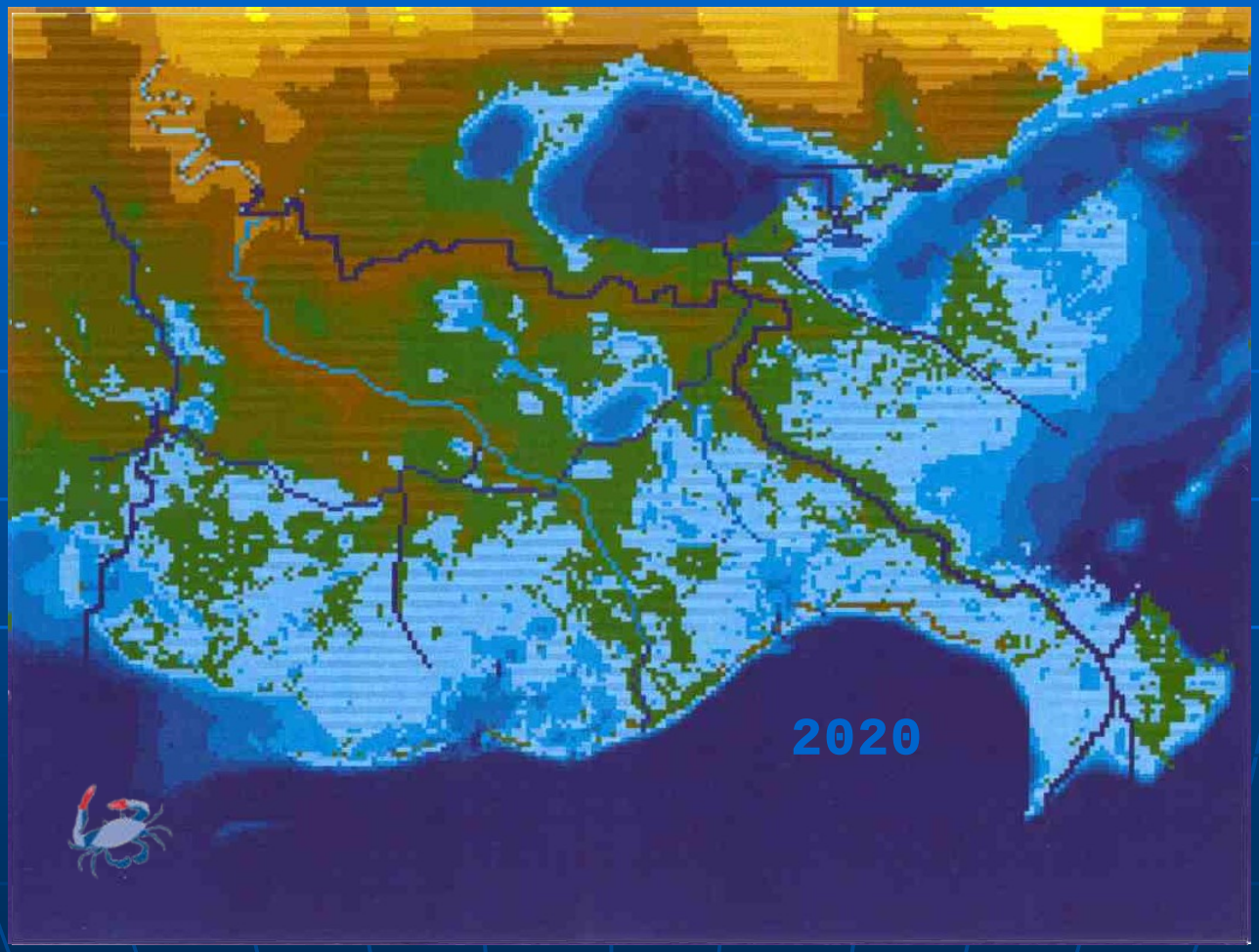
Katrina West ADCIRC MEOW





WIDTH OF SCENE IS 300 KM

Past and Projected Wetland Loss in the Mississippi Delta (1839 to 2020)



And We are Losing the Race…..

CLEAR
Coastal Louisiana Ecosystem Assessment and Restoration

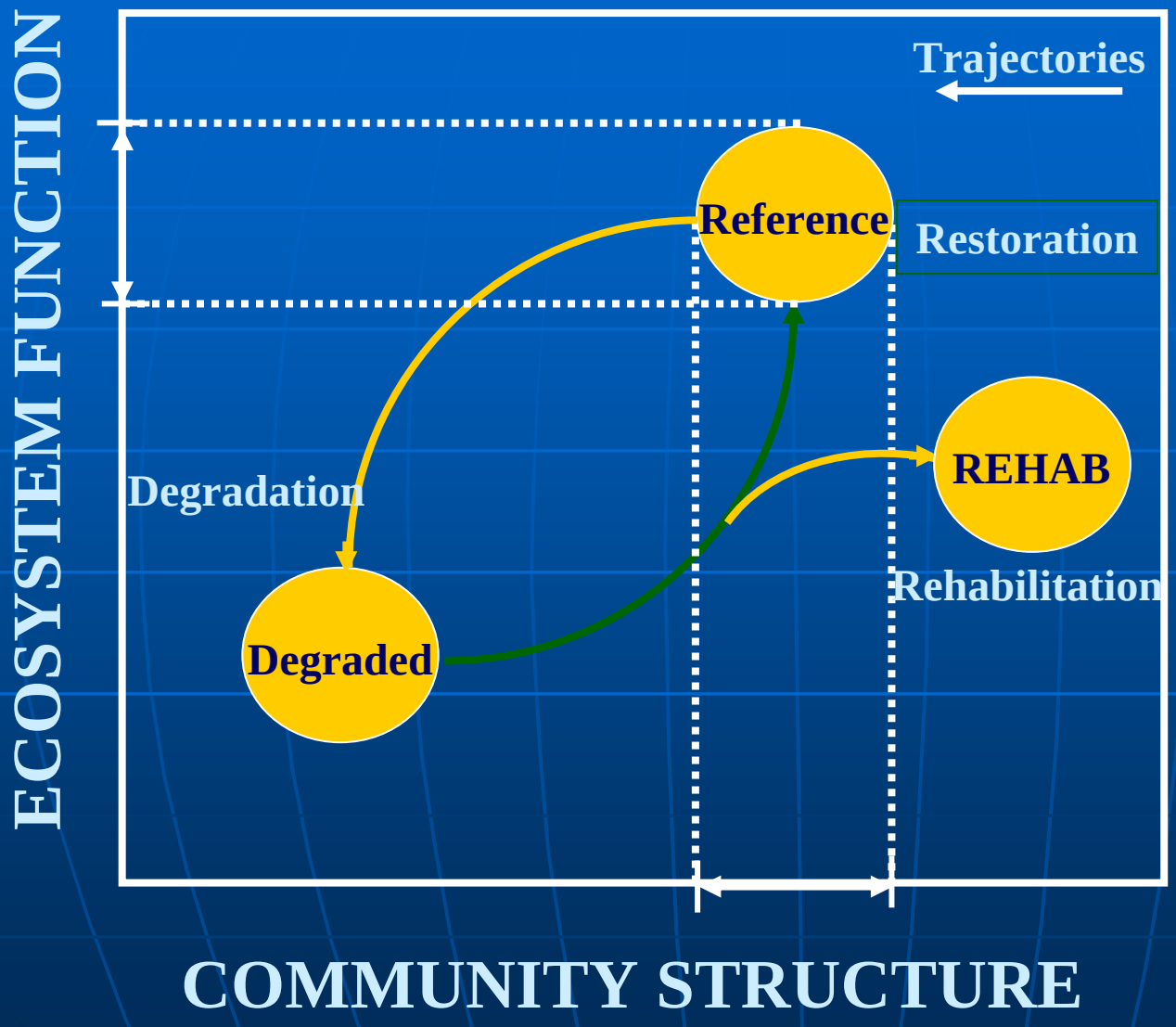
Led by Robert Twilley, LSU
under the
Louisiana Coastal Area Study

Build Elevation
and Ecological Resilience!

Forcing in Coastal Wetland Systems Is Different

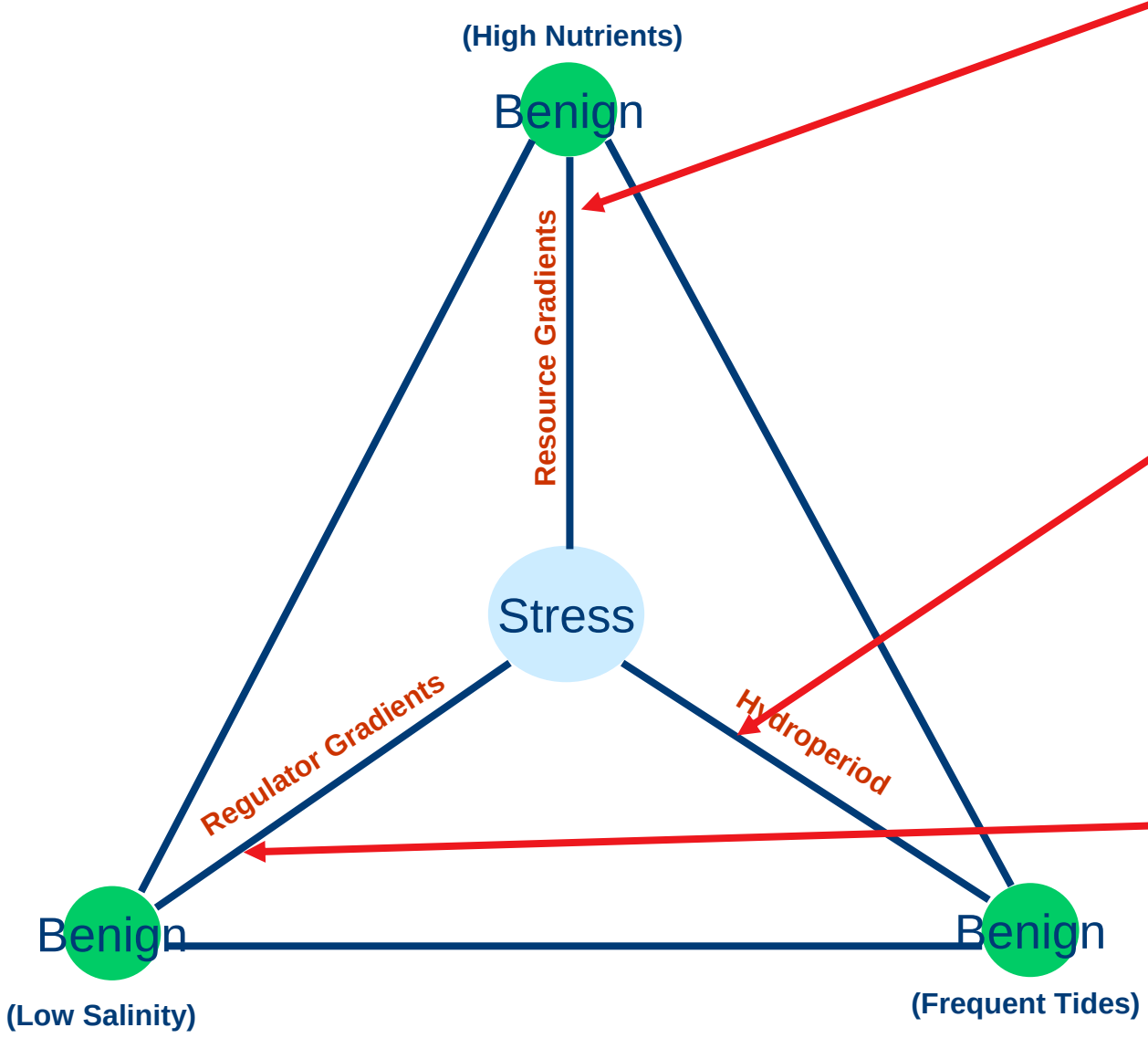
Event	Timescale	Impact
River switching	1,000 yrs	Deltaic lobe formation Net advance of deltaic landmass
Major river floods	50-100 yrs	Channel switching initiation Crevasse splay formation Major deposition
Major storms	5-20 yrs	Major deposition Enhanced production
Average river floods	Annual	Enhanced production Freshening (lower salinity) Nutrient input Enhanced 1º and 2º production
Normal storm events (Frontal passage)	Weekly	Enhanced production Organism transport Net material transport
Tides	Daily	Drainage/marsh production Low net transport

ECOSYSTEM REHABILITATION



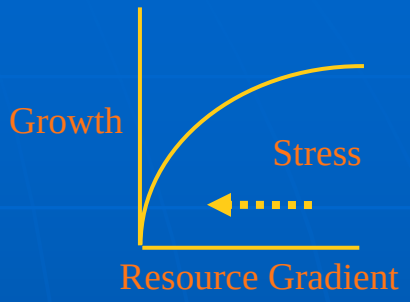
Community Structure: Biodiversity, Habitat Diversity, Wetland Acreage, Habitat Use

Ecosystem Function: Primary Productivity, Habitat Suitability, Nutrient Removal, Shoreline Protection,

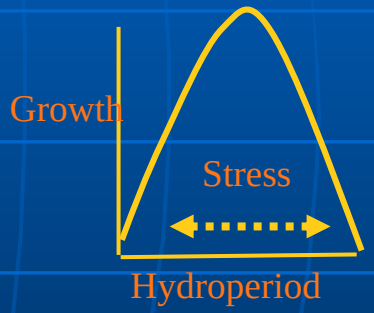


Production Envelope: Surface area is proportional to levels of net primary productivity

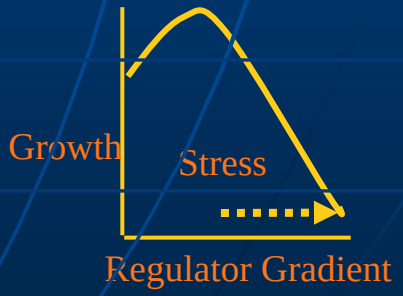
Resource Gradients
(light, nutrients, space

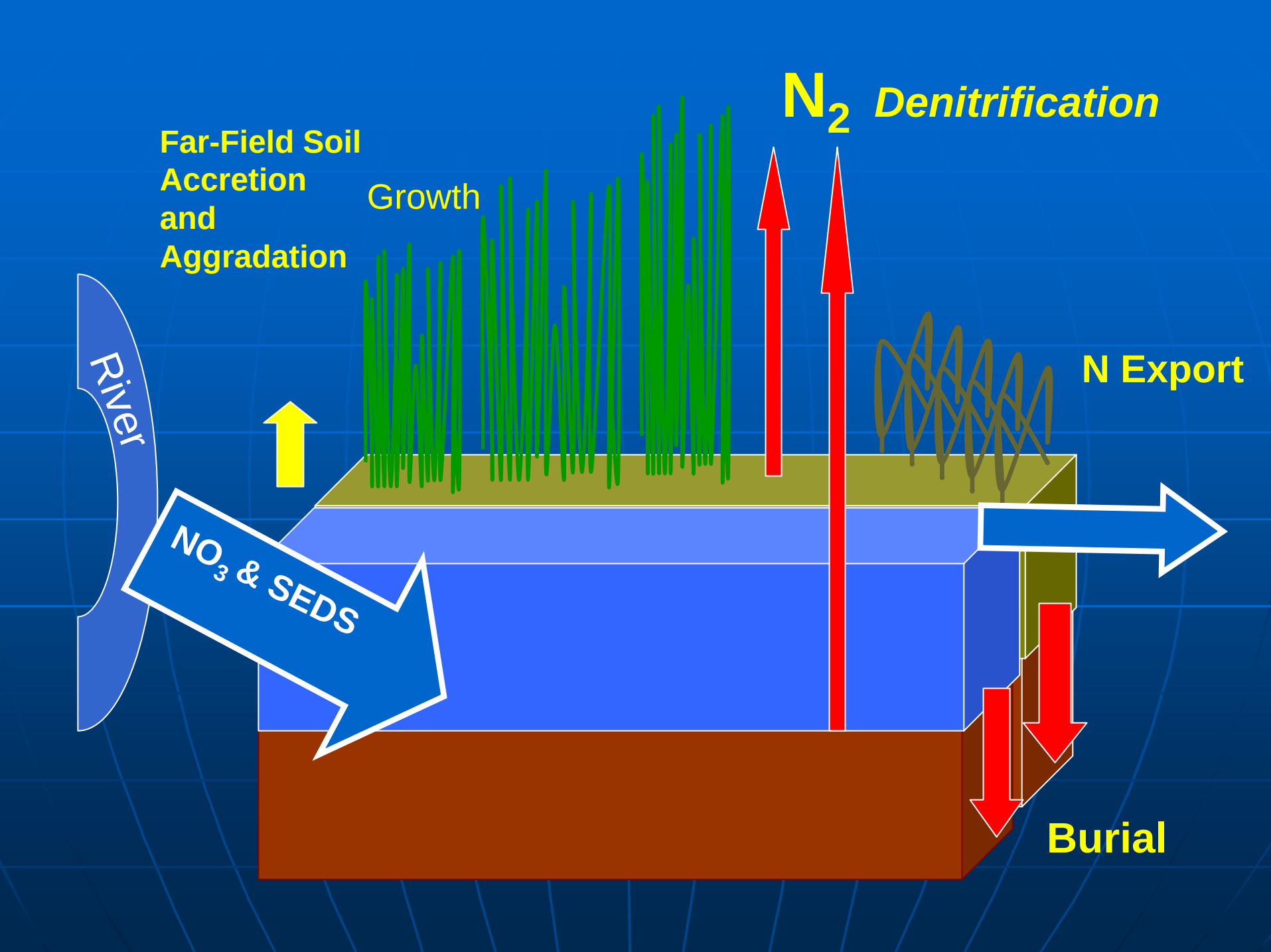


Hydroperiod Gradien
(frequency, duration)



Regulator Gradients
(salinity, sulfide, pH)




N_2 Denitrification
Far-Field Soil Accretion and Aggradation
Growth
River
NO_3 & SEDS
N Export
Burial

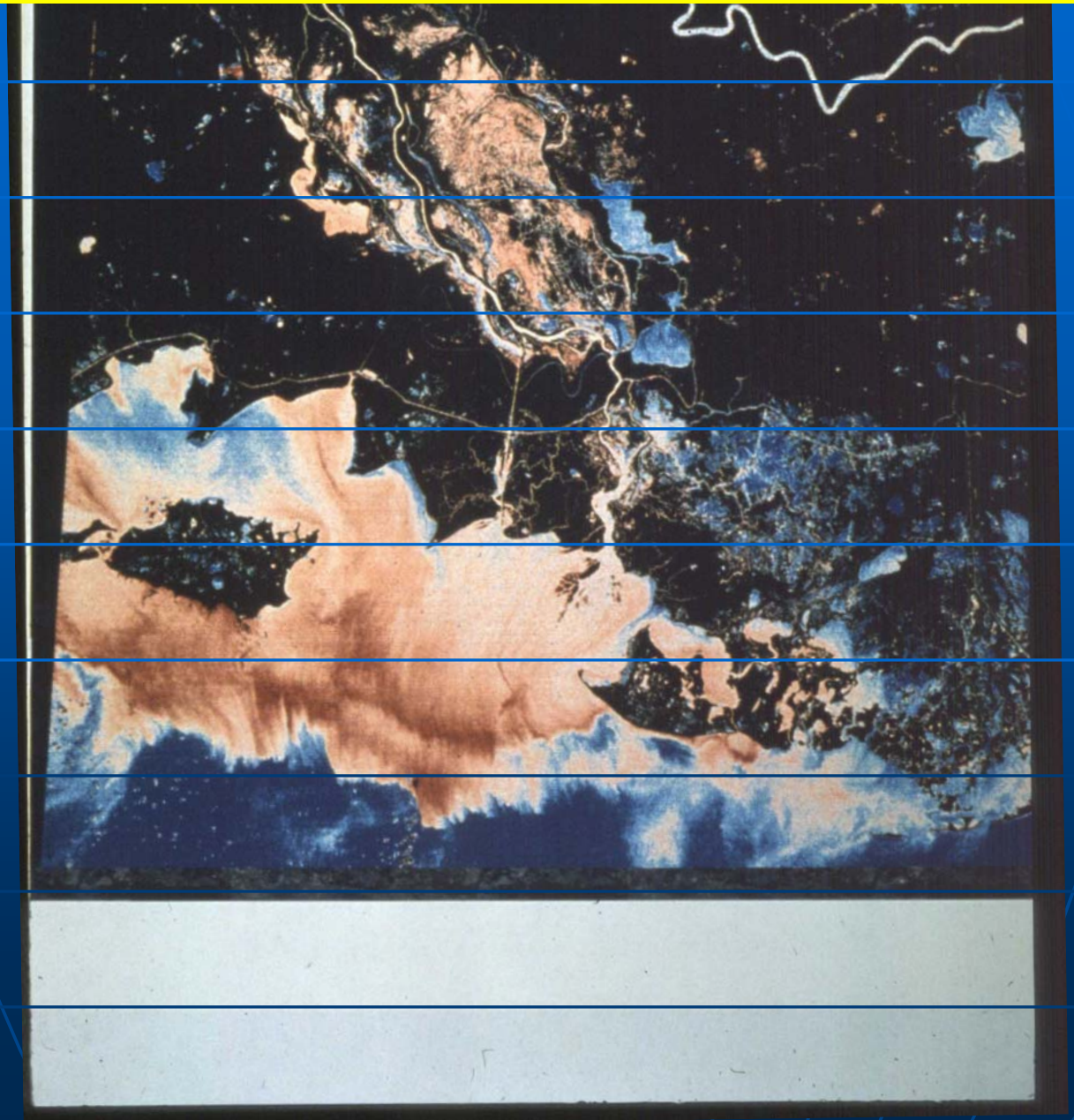
Restarting Landbuilding Fast with Pipelines and Slow with Diversions

- Creating New Land in Open Water
  - Subtidal processes
  - Intertidal processes
    - Non- vegetated
    - Vegetated
- ‘Rebuilding’ Existing Lands
  - Rehabilitating marshes
    - Increased plant productivity
    - Stimulating elevation response

The System We Have Built….
- Sediment and Nutrients Discharged to Deep Water

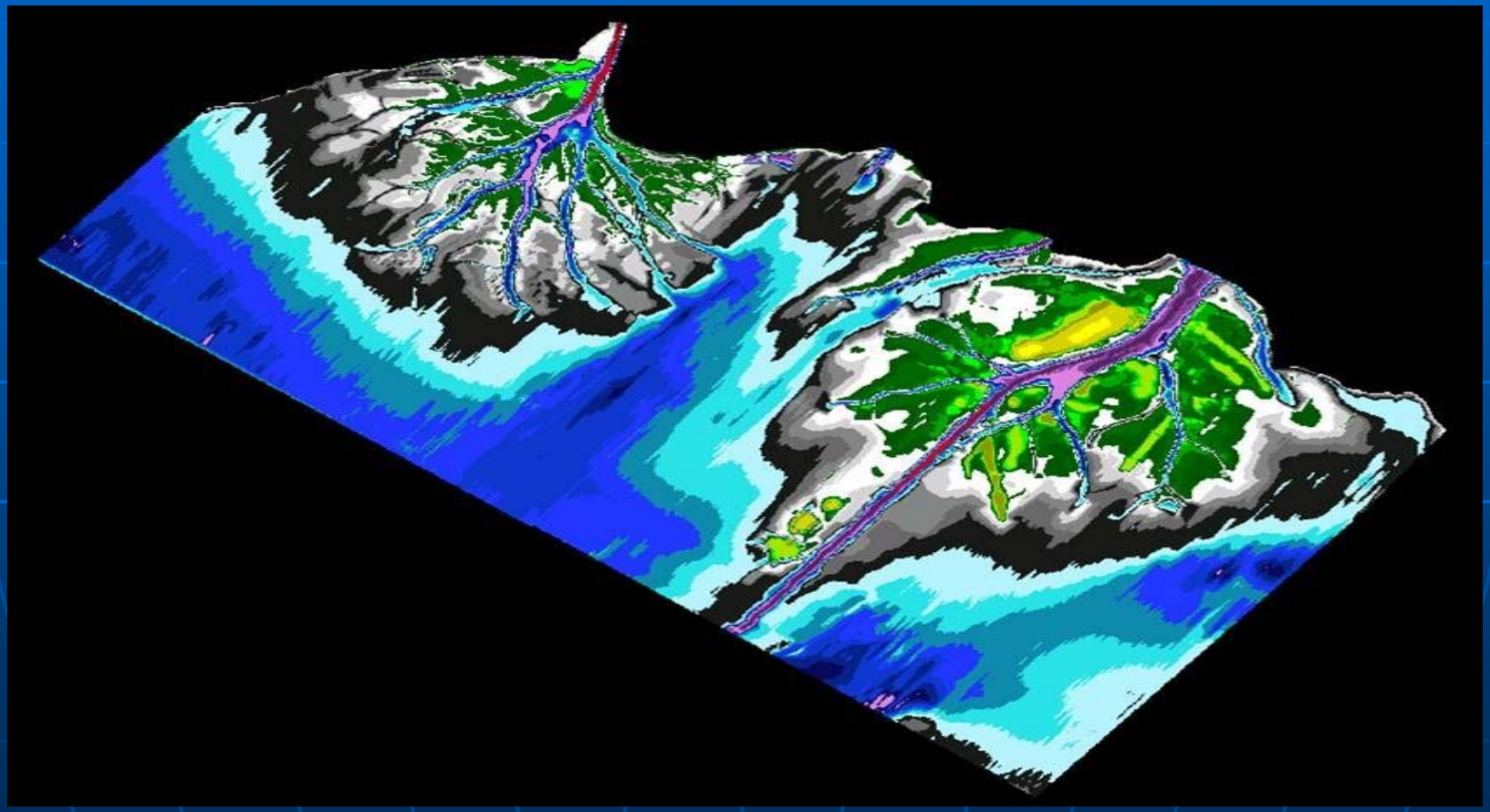
The System We Could Have More Of….

- Sediment and Nutrients Discharged to Shallow Water

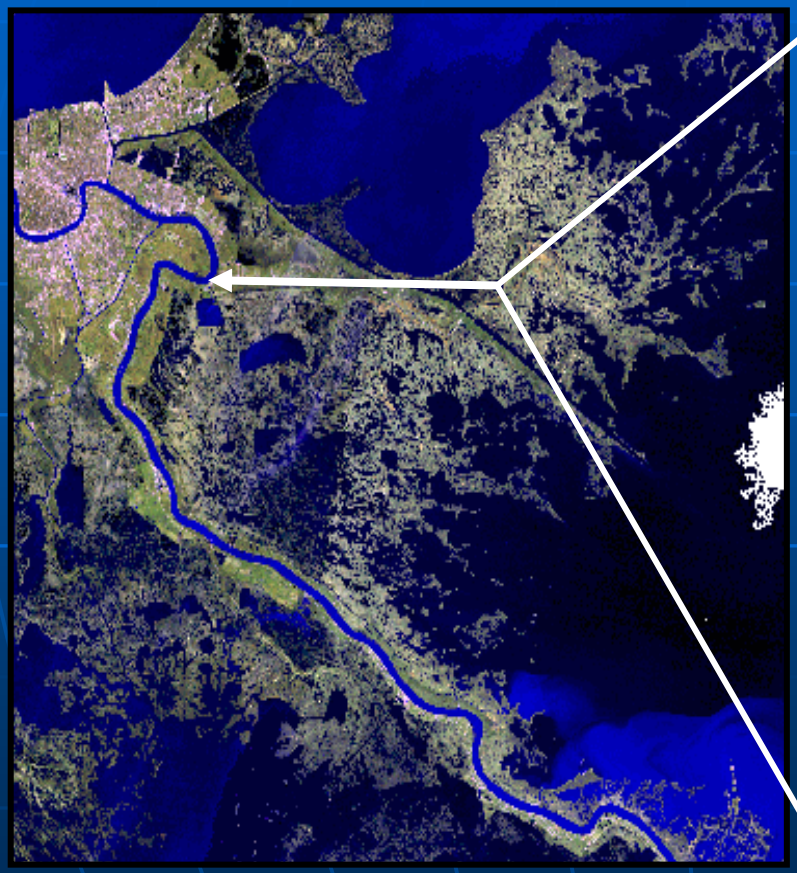


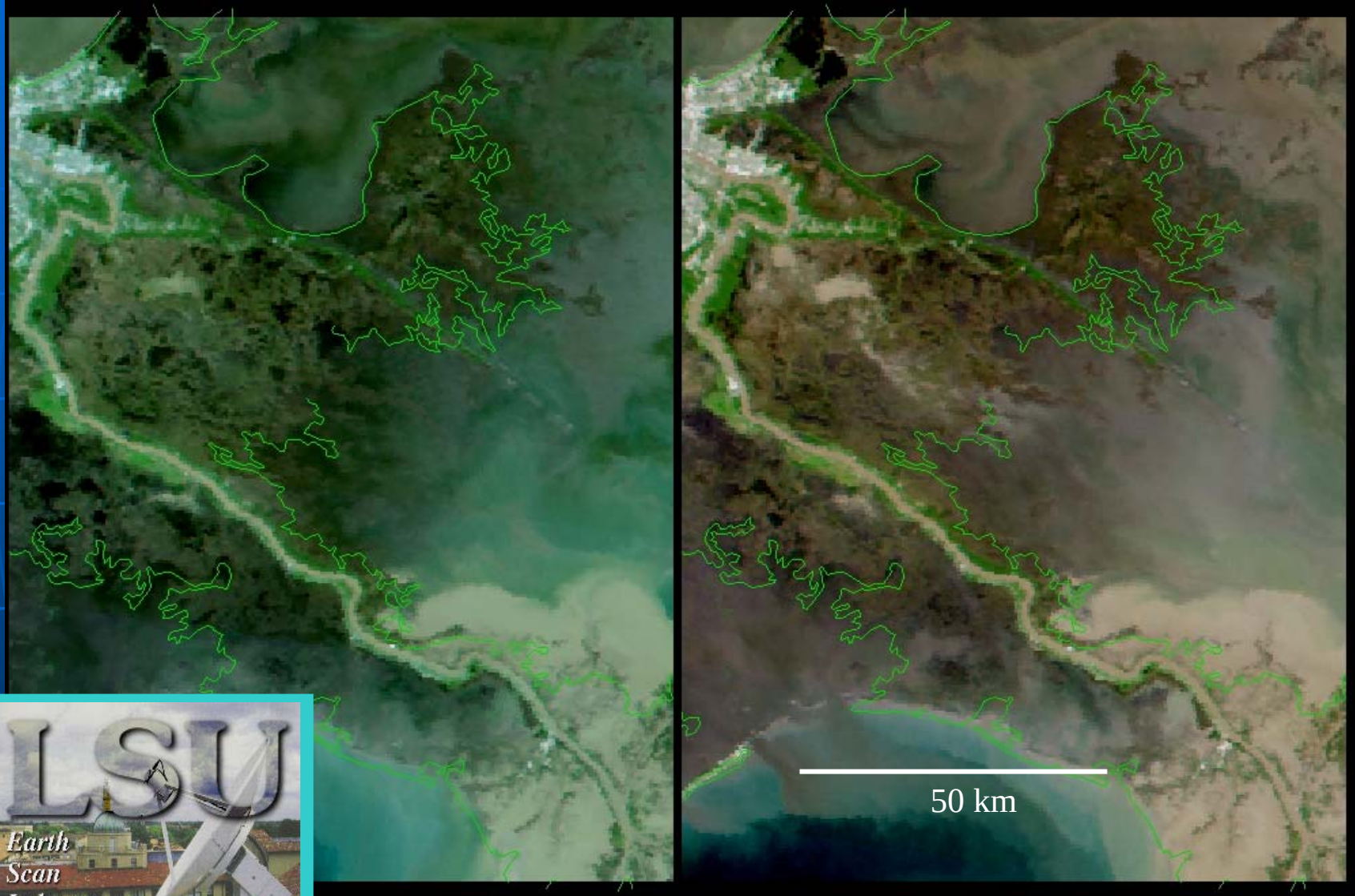
'91 11 12

Wax Lake and Atchafalaya Deltas 1994



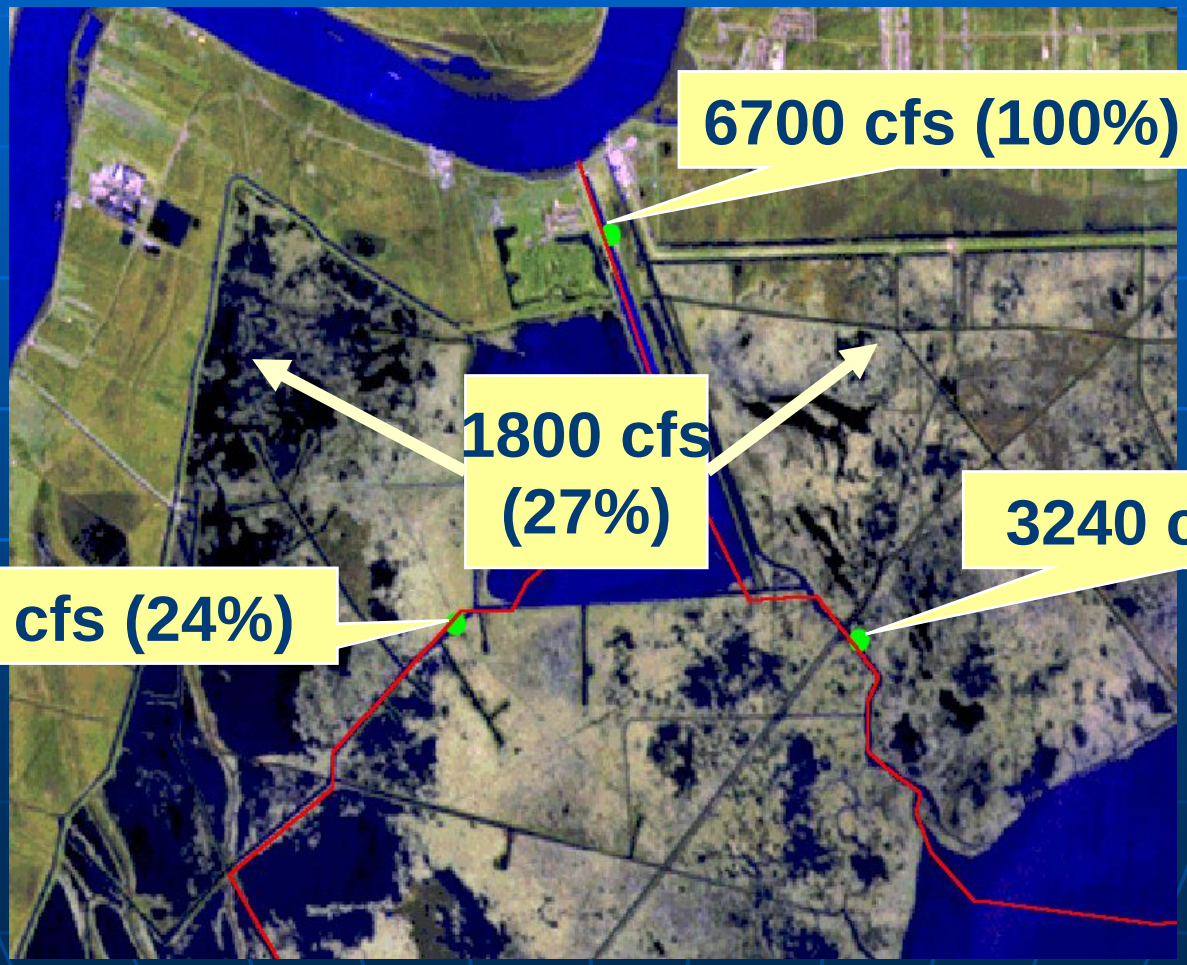
Caernarvon Freshwater Diversion Since 1991





50 km

Sheet Flow Through Mass Balance



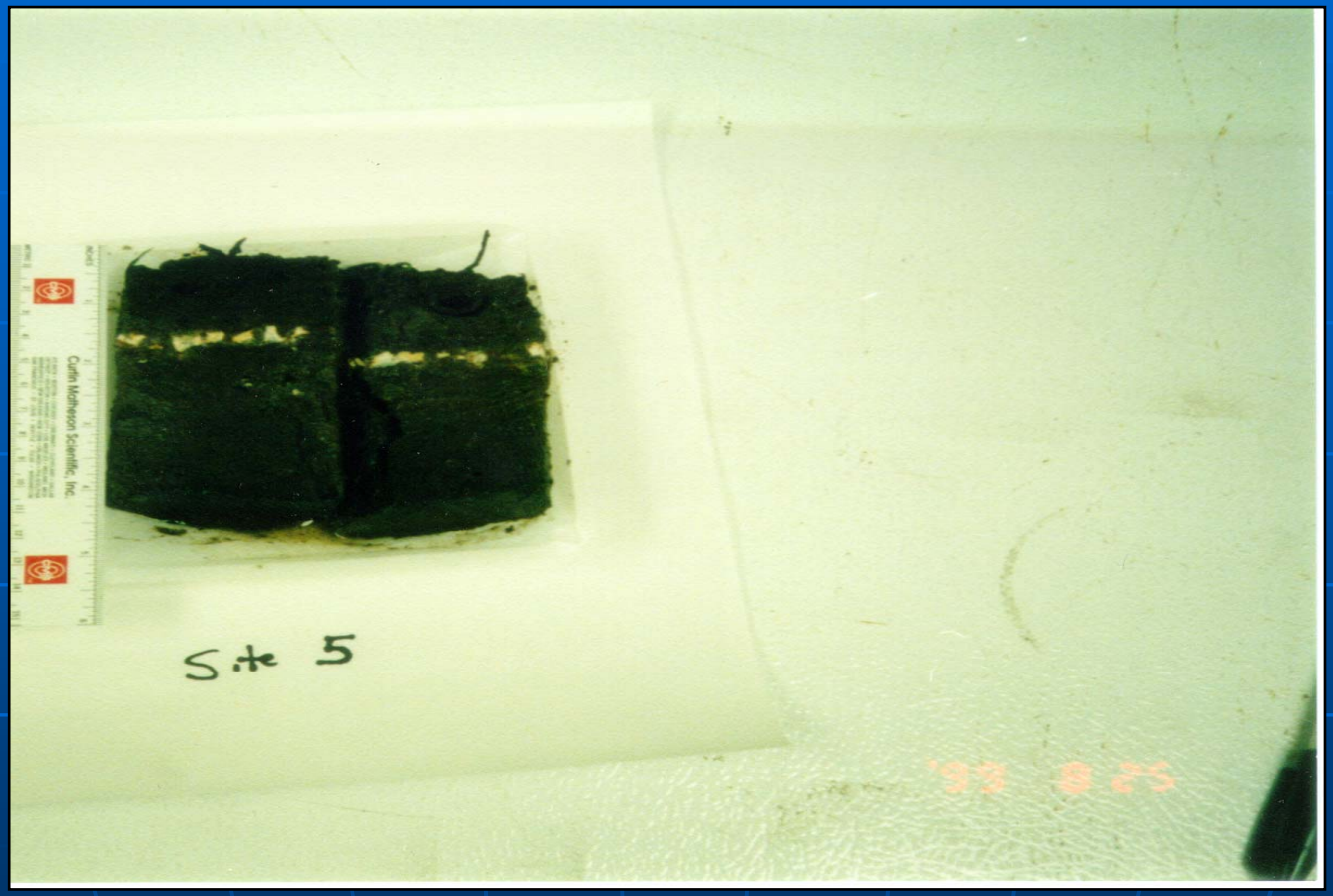
Accretion at Reference Area:

-Algal

Accretion at Site 432:

-Mineral

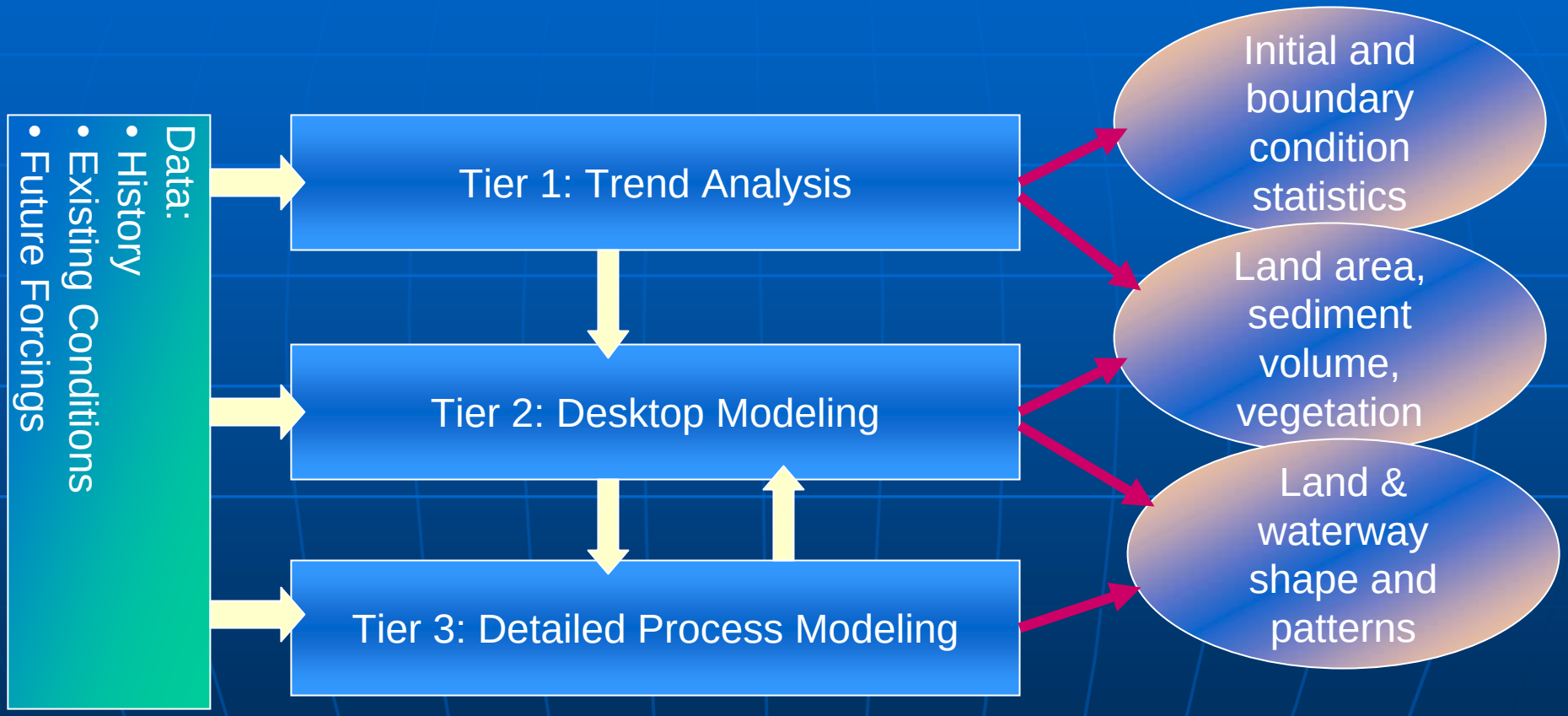
Sediment accumulation above marker horizon



CAERNARVON DIVERSION

- Reduction
  - Nitrate From 1.5 to 0.1 mg/l
  - Suspended Sediments from 200 to 40 mg/l
    Nutrient and Suspended Sediment
- Marsh Productivity Increased by 2-3 Times
- Enhanced Sedimentation on Marsh Surface Leads to Better Marsh Survival
- Stimulation of Food Chain and Fisheries

Tiered Solutions



CLEAR APPROACH

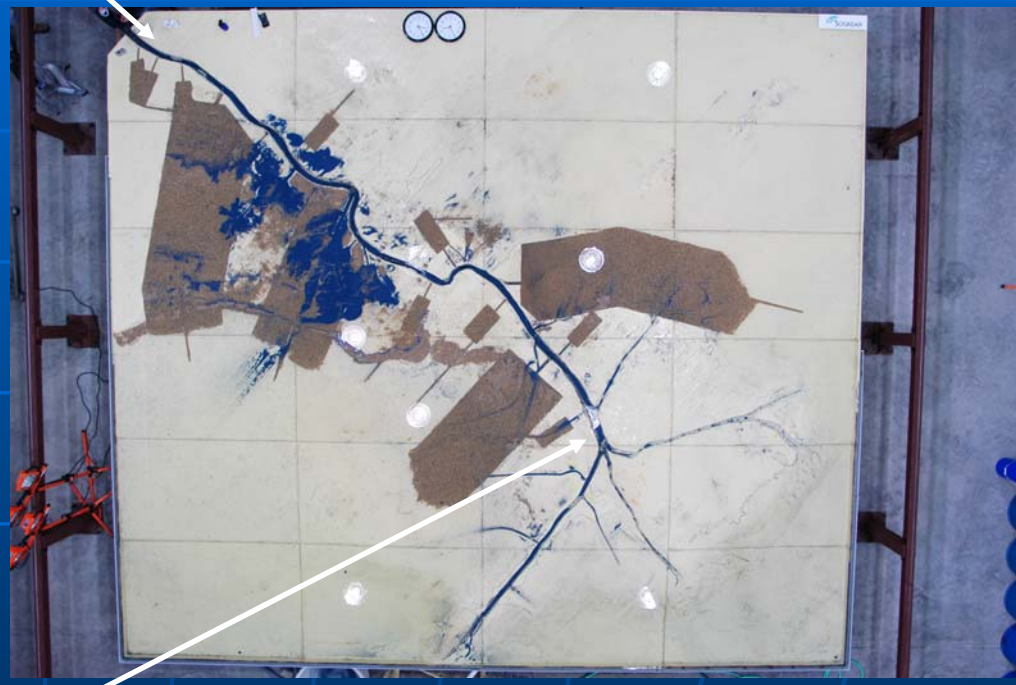
Use modeling tools to attack uncertainty from different directions.

Look for convergence and divergence in forecasts

- Statistical Models
- Physical Models
- Numerical Models
  - General Engineering Models
  - Specialized Research Models

Physical Models

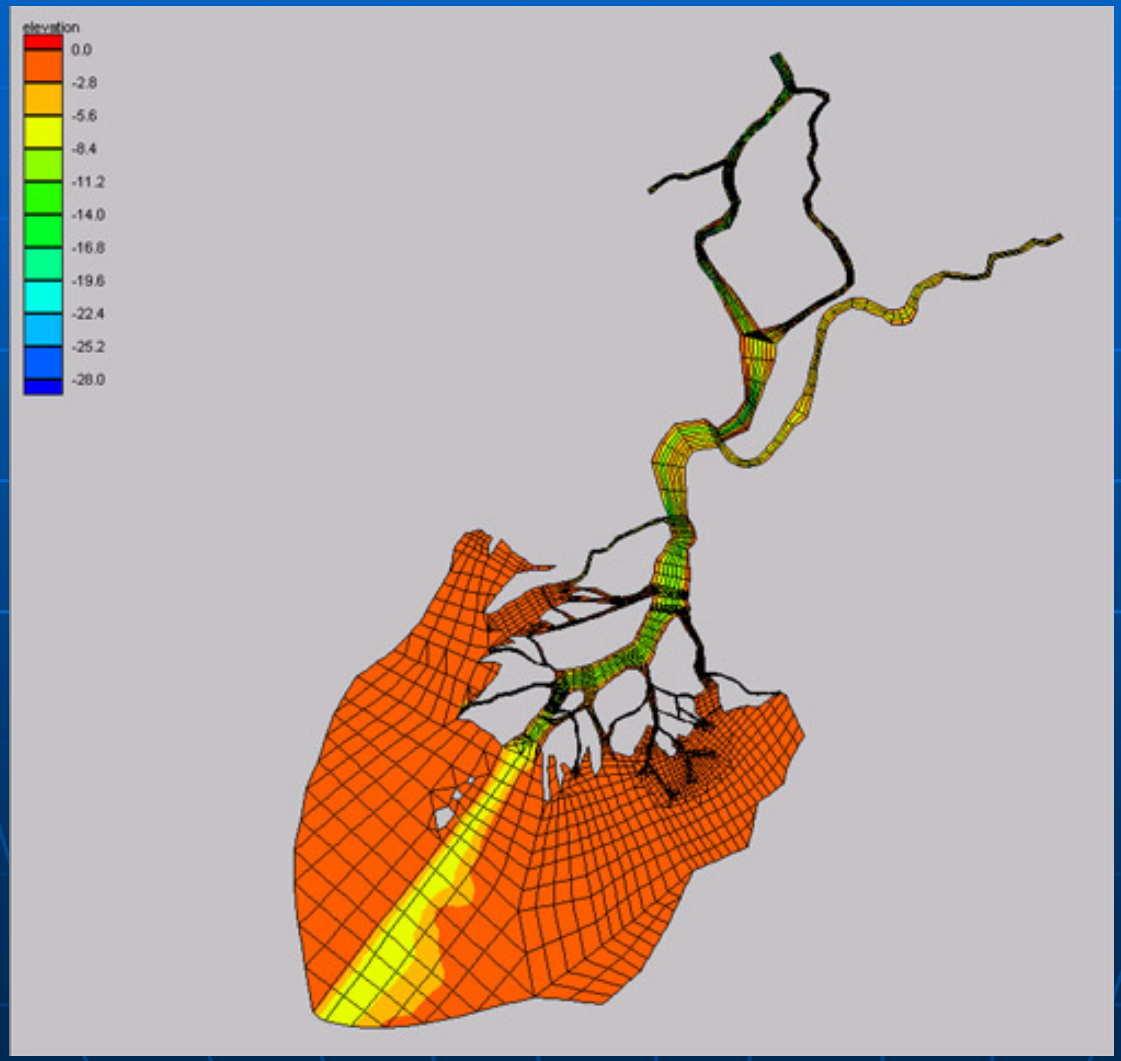
Pointe-a-la-Hache



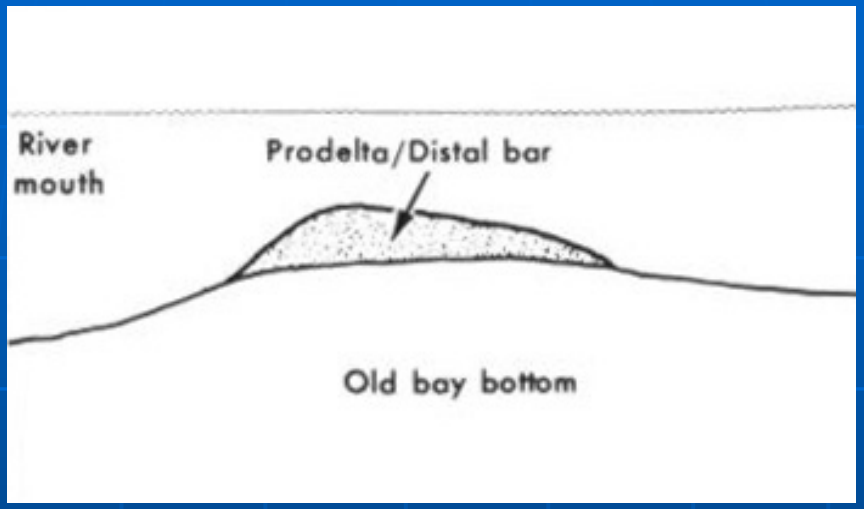
Head-of-Passes

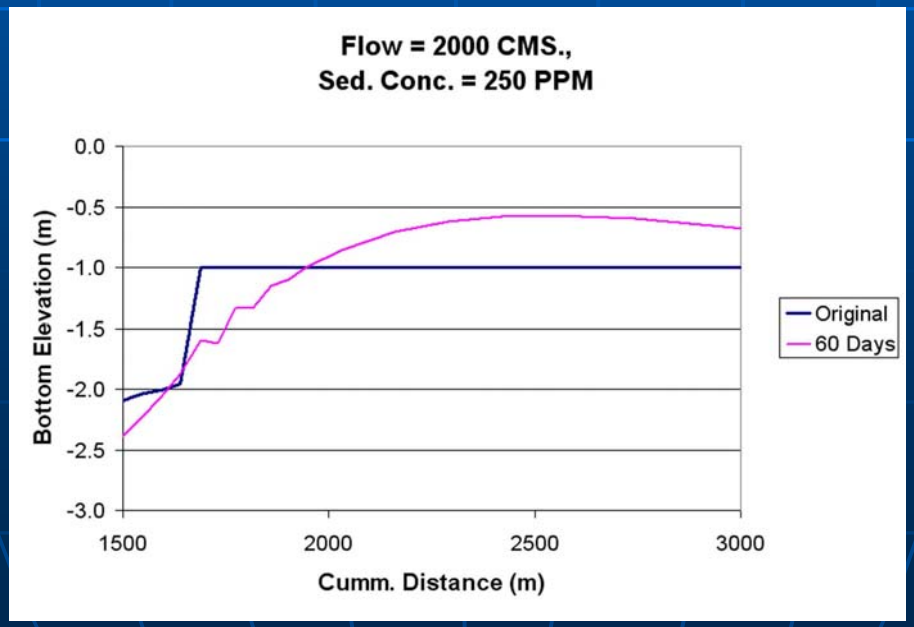
The total model platform dimension is 8.46 m x 7.41 m = 62.69 m^2 reproducing a prototype surface area of about 9,027 km^2 equivalent to 3,526 square miles. Simulate 100 years in 50 hours, sea level rise

Engineering Numerical Models

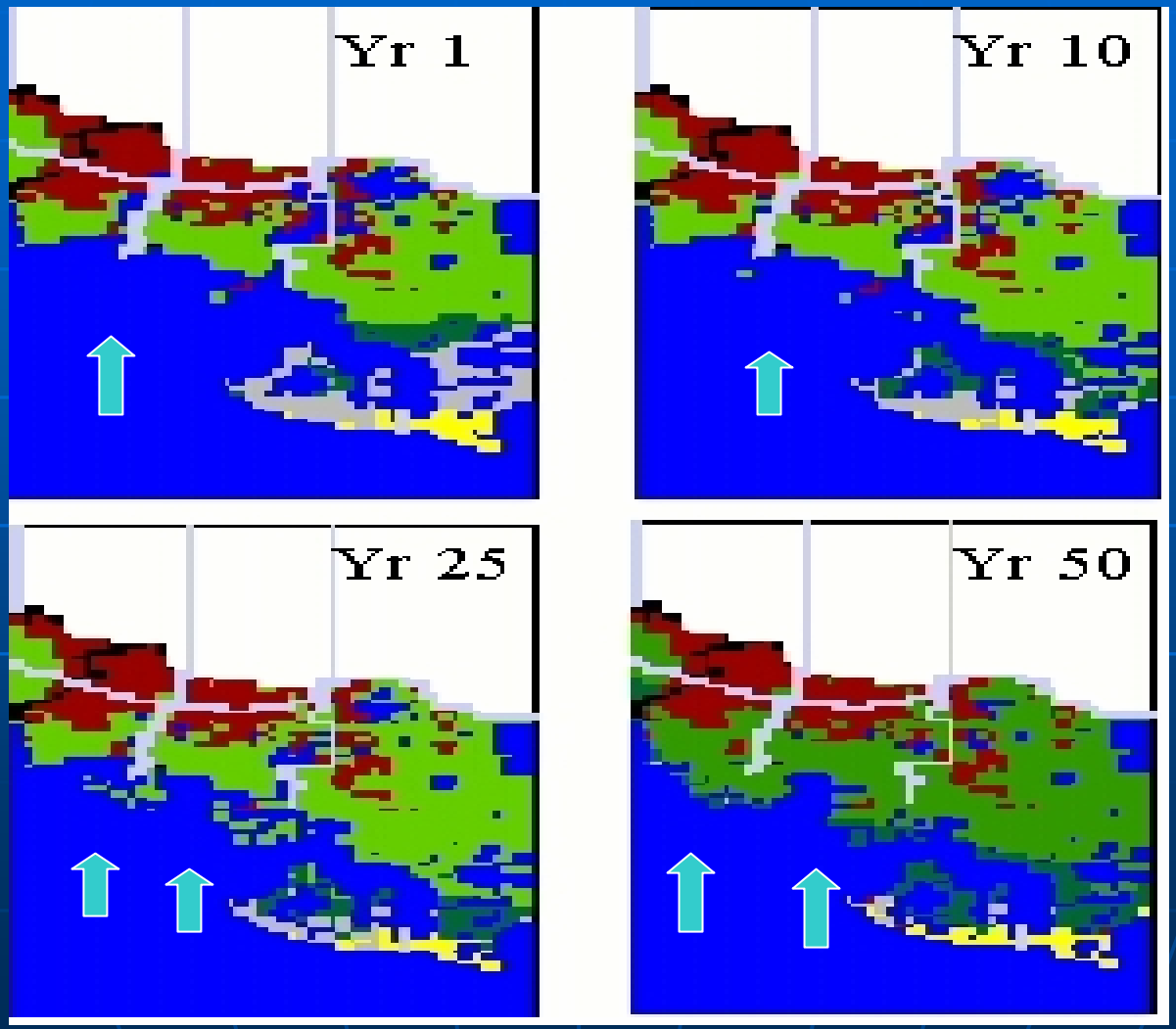


Delta Lobe Simulation Using TABS





MDM Landscape Model – Martin et al. 2000 (Brown=Swamp,Lt Green=Fresh, Dk Green=Intermediate, Grey=Brackish, Yellow=Salt Marsh)
Includes basin processes: sed transport, wind wave suspension, tides



Sample Education Activities

- Numerous service learning activities
- Landscape Architecture Senior thesis
  - class project refocused to design of rebuilding efforts
- Mechanical Engineering Sophomore Design
  - Design of attic escape kit, assuming no power available, must include communications
- Disaster Science and Management Activities
- Hurricane Engineering www.HurricaneEngineering.lsu.edu
  - Forensic engineering project

Research Question 1

Genesis and morphology of hurricanes

Support work that can establish better understanding of the frequency, periodicity and intensity of storms and the link with climate change, if any. Forecasting models that do a better job on intensity, and anything that can further improve track forecasting.

Research Question 1

Manner in which society prepares for and reacts to consequences perceived *before* landfall.

Storm surge is the most serious consequence of hurricanes so improvement in the time and space resolution and accuracy of surge forecasts will pay huge dividends.

Flood fighting can be extremely effective. Storm surge models can identify weak spots in flood defenses that can be bolstered as storm approaches.

Systems that can be moved and erected quickly that go beyond the usual sandbagging.

Research Question 1

Opportunities for actions at the time of landfall that could reduce societal disruption and displacement.

Sensors in levees and floodwalls and in flood-prone areas can identify emerging problems that can be prioritized for quick action as soon as emergency response crews can get to them.

So the flooding situation should be understood in real-time by quick-response crews with the training, equipment and information necessary to keep small issues from becoming large ones.

Research Question 1

Understanding impacts after storm passes.

Power and communications disruptions are predictable consequences of every hurricane (or any other) emergency. The ability to re-establish communications first with and among emergency personnel and, second, with the public must be a priority of technology research.

Most modern electronic water level gages and wind monitoring equipment seems to fail at an alarming rate under storm conditions. We have less gage data available for Katrina than for Betsey in 1965 when we had mechanical gages. This is critical information necessary for mounting search and rescue operations and for rapid reconstruction of events.

Research Question 2

New modalities for research that maintain strength of core disciplines while encouraging productive collaboration at the boundaries.

I don't see that research focused on hurricanes threatens the strength of core disciplines. The immediate response capability did not emanate from the core disciplines at LSU, however, because there was no federal funding that would encourage a focus on hurricane science.

State funding had been acquired that saved many lives. Should academic groups be leading operations efforts or engaged in more of a supportive role. Is there funding to support the appropriate role and agency buy-in on the other side?

Research Question 3

More work focused on

(1) wave interactions with coastal defense structures,

(2) with the interaction between surge and natural features, ie. marshes, coastal forests, shallow estuaries, natural and artificial ridges, and

(1) with the ecological response and resilience of natural systems. Post-storm collection of perishable information is vital to advance understanding.

Research Question 3

The lack of funding and need for a national program was seemingly understood by the federal government two years ago.

On October 25, 2004, the National Windstorm Impact Reduction Act was signed into law. This law authorized creation of a National Windstorm Impact Reduction Program, modeled in part after the successful National Earthquake Hazard Reduction Program.

Unfortunately, the wind program has never received any appropriations. This program was supposed to focus primarily on engineering and meteorological aspects of extreme wind events. It was not specific to hurricanes and did not strongly address social, behavioral, and economic issues, but was certainly a step in the right direction.