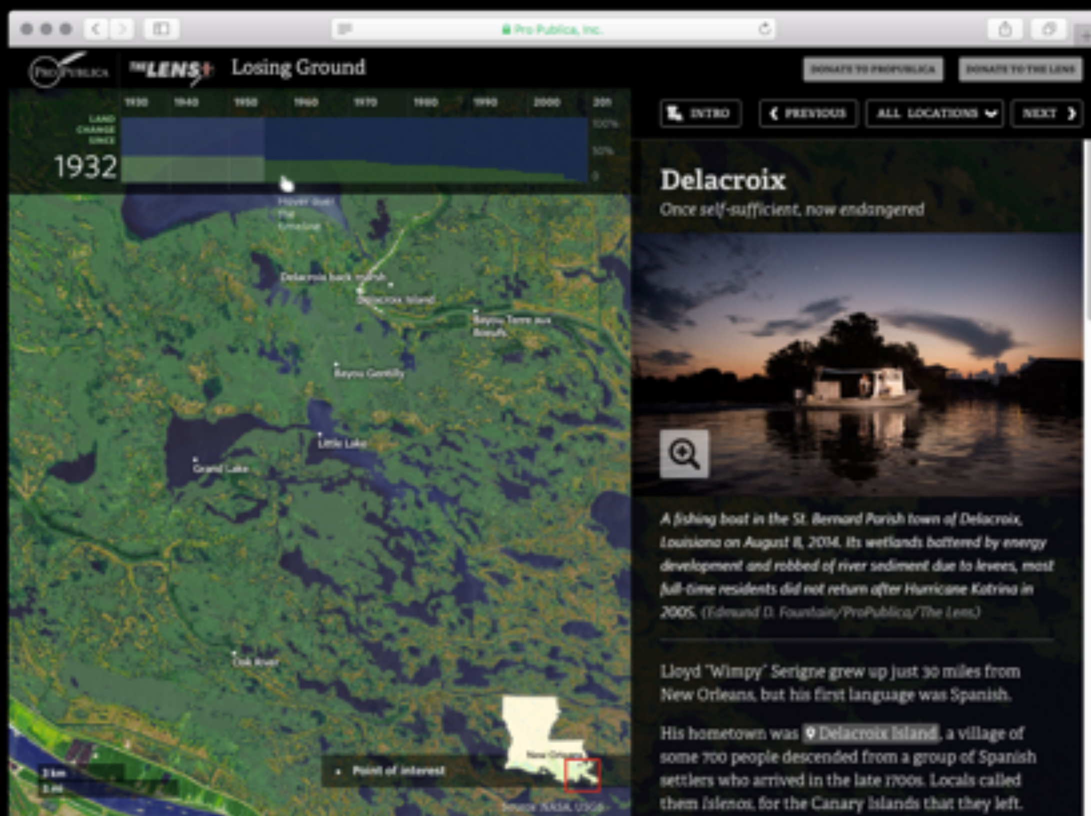
Immersive, Local, Science-Driven Journalism.

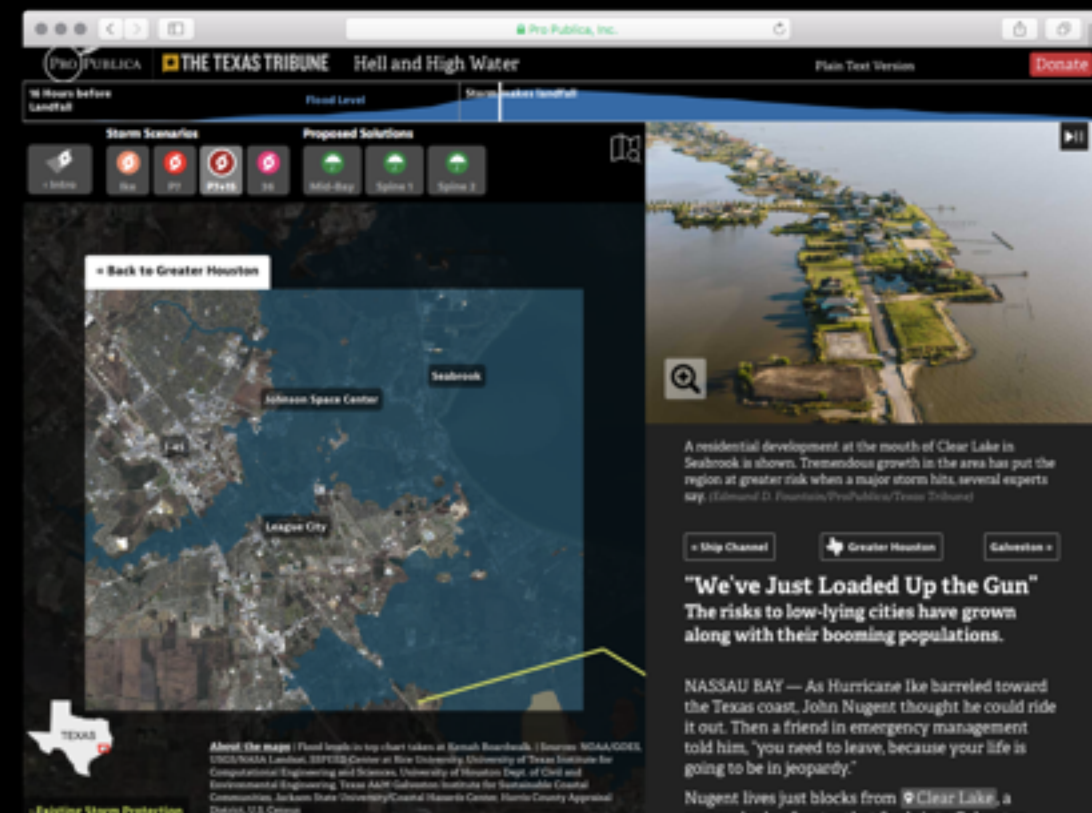
Al Shaw
al.shaw@propublica.org

@A_L



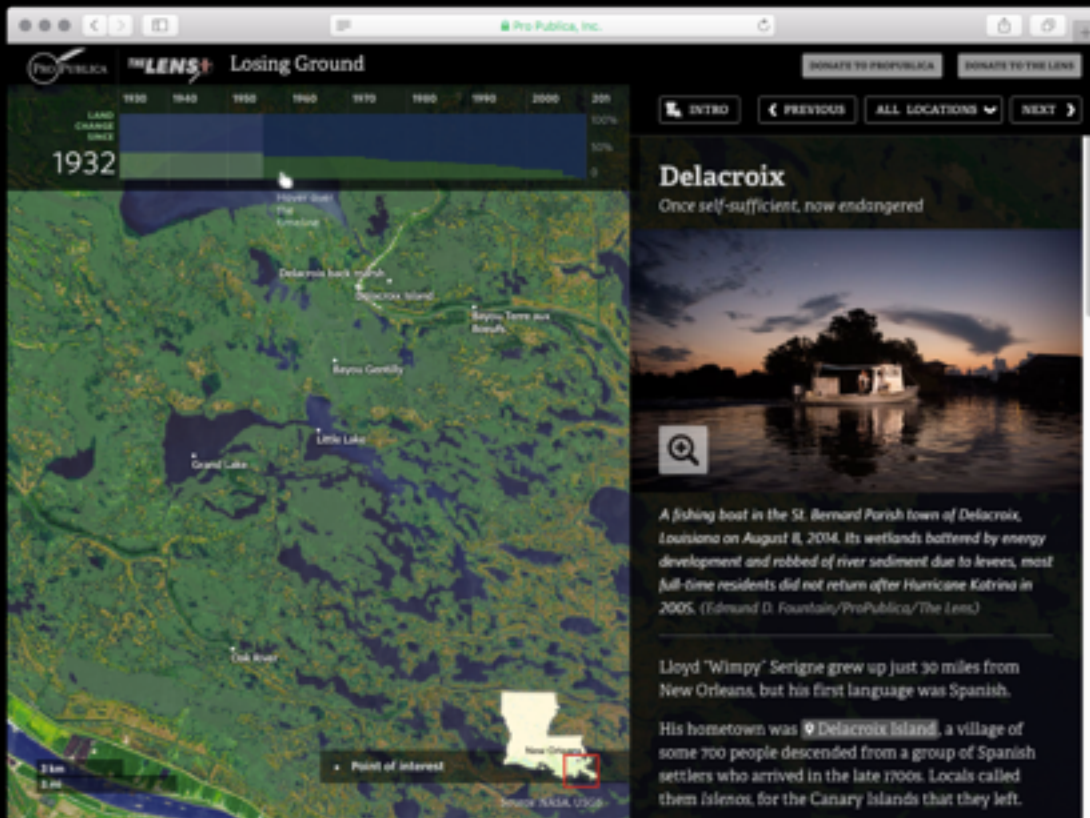
Losing Ground
INTRO
PREVIOUS
ALL LOCATIONS
NEXT
1932
Delacroix
Once self-sufficient, now endangered
A fishing boat in the St. Bernard Parish town of Delacroix, Louisiana on August 8, 2014. Its wetlands battered by energy development and robbed of river sediment due to levees, most full-time residents did not return after Hurricane Katrina in 2005. (Edmund D. Fountain/ProPublica/The Lens)
Lloyd "Wimpy" Serigne grew up just 30 miles from New Orleans, but his first language was Spanish.
His hometown was Delacroix Island, a village of some 700 people descended from a group of Spanish settlers who arrived in the late 1700s. Locals called them Isleños, for the Canary Islands that they left.

2014

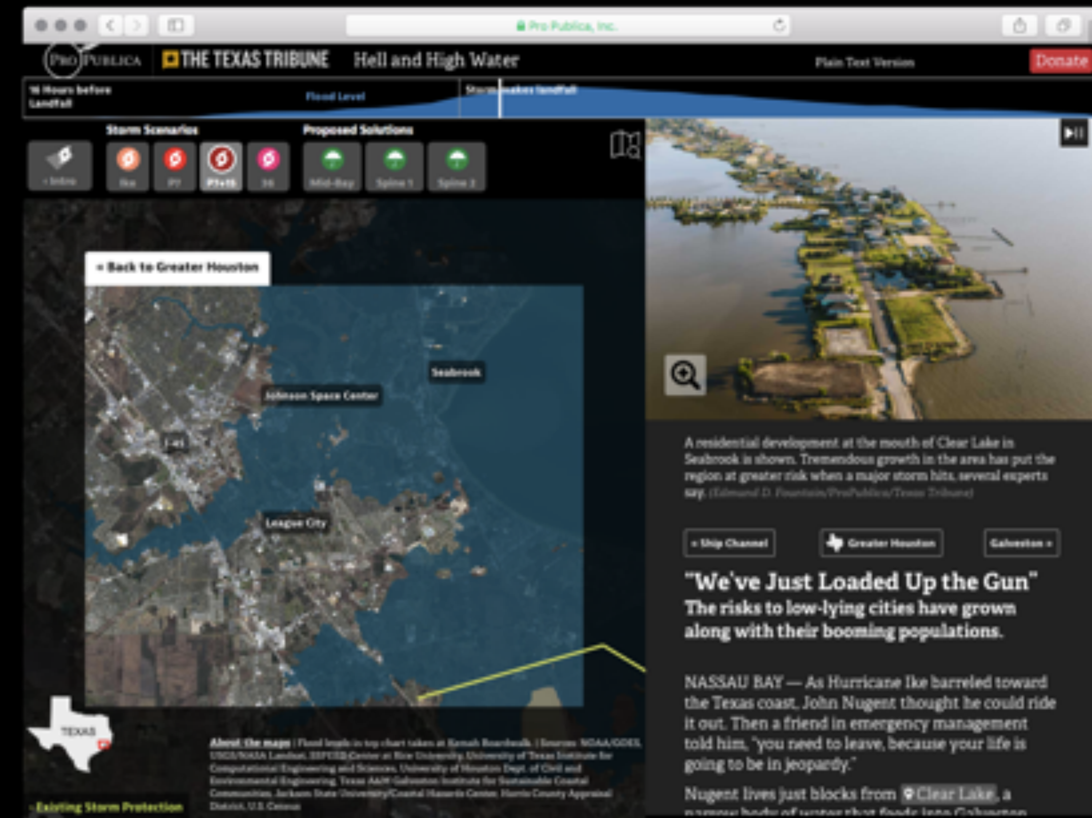


THE TEXAS TRIBUNE
Hell and High Water
Plain Text Version
Donate
Storm Scenarios
Proposed Solutions
Back to Greater Houston
Johnson Space Center
Seabrook
League City
TEXAS
A residential development at the mouth of Clear Lake in Seabrook is shown. Tremendous growth in the area has put the region at greater risk when a major storm hits, several experts say.
"We've Just Loaded Up the Gun"
The risks to low-lying cities have grown along with their booming populations.
NASSAU BAY — As Hurricane Ike barreled toward the Texas coast, John Nugent thought he could ride it out. Then a friend in emergency management told him, "you need to leave, because your life is going to be in jeopardy."
Nugent lives just blocks from Clear Lake, a

2016

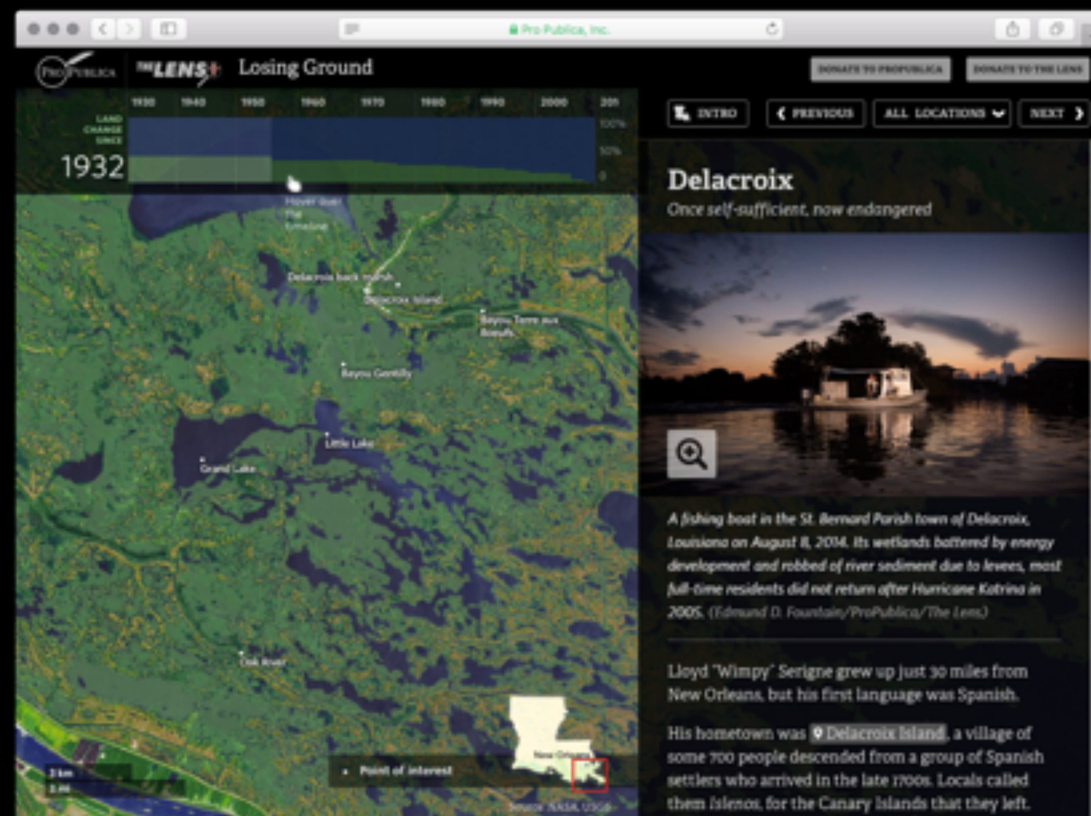


2014



2016

- National newsroom’s interactive chops
- Local newsroom’s domain knowledge
- Relationships with researchers


Pro Publica, Inc.
Losing Ground
1930
1940
1950
1960
1970
1980
1990
2000
LAND CHANGE SINCE
1932
100%
50%
0
Delacroix back marsh
Delacroix Island
Bayou Terre aux Boeufs
Bayou Gentilly
Little Lake
Grand Lake
Point of interest
INTRO
PREVIOUS
ALL LOCATIONS
NEXT
Delacroix
Once self-sufficient, now endangered
A fishing boat in the St. Bernard Parish town of Delacroix, Louisiana on August 8, 2014. Its wetlands battered by energy development and robbed of river sediment due to levees, most full-time residents did not return after Hurricane Katrina in 2005. (Edmund D. Fountain/ProPublica/The Lens)
Lloyd "Wimpy" Serigne grew up just 30 miles from New Orleans, but his first language was Spanish.
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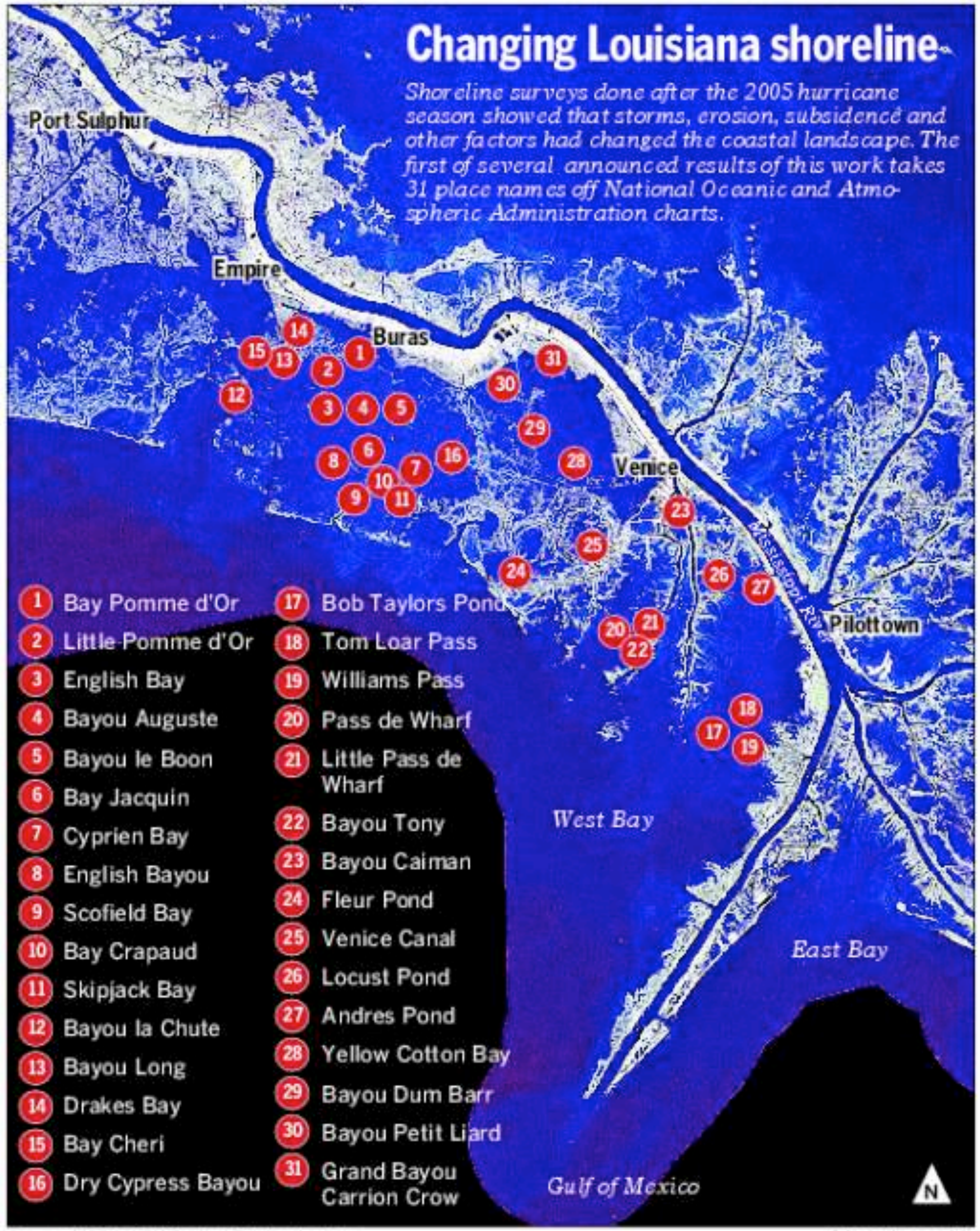
2014

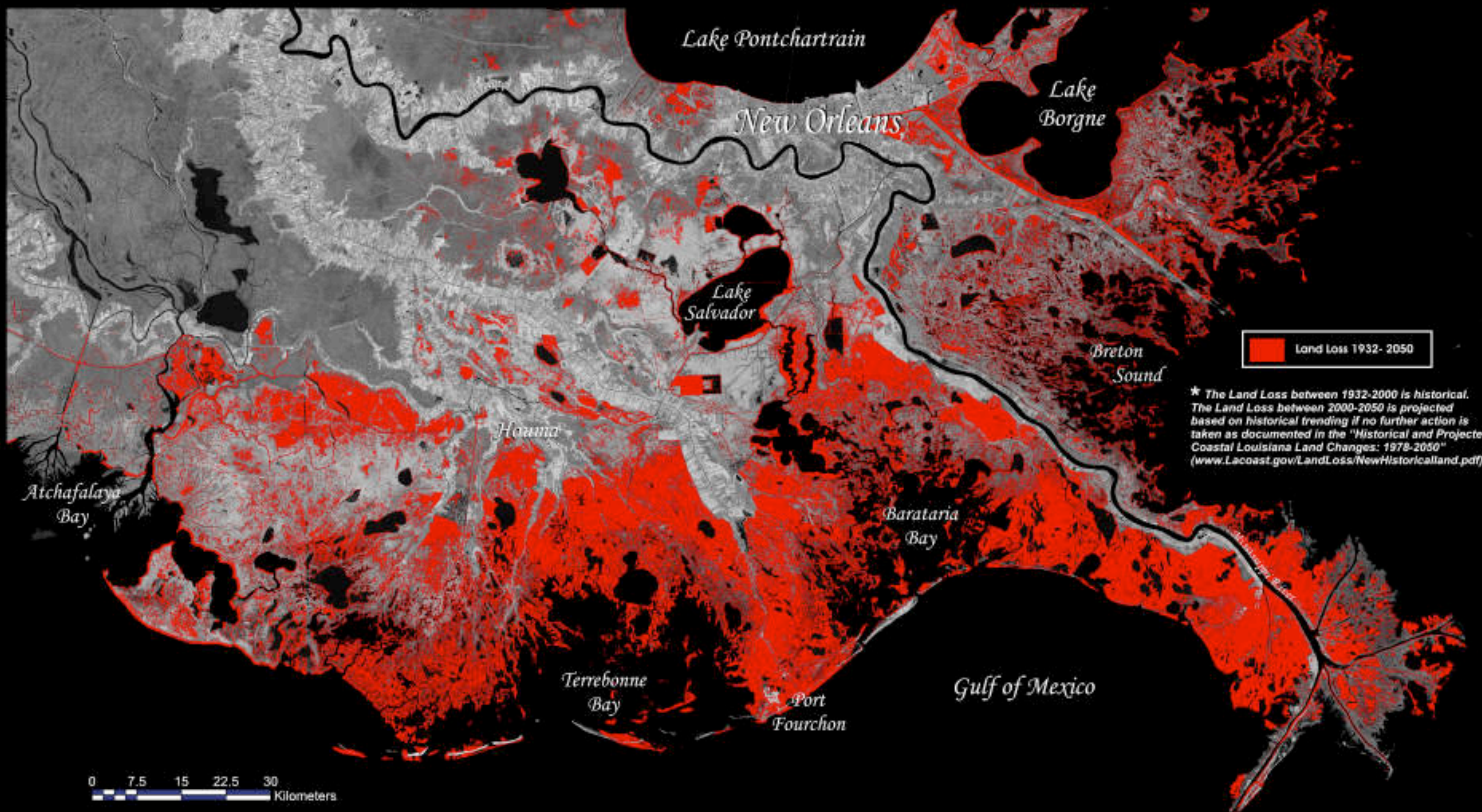


Source: NOAA, LSU Coastal Studies Institute

Advocate graphic

Southeast Louisiana Land Loss

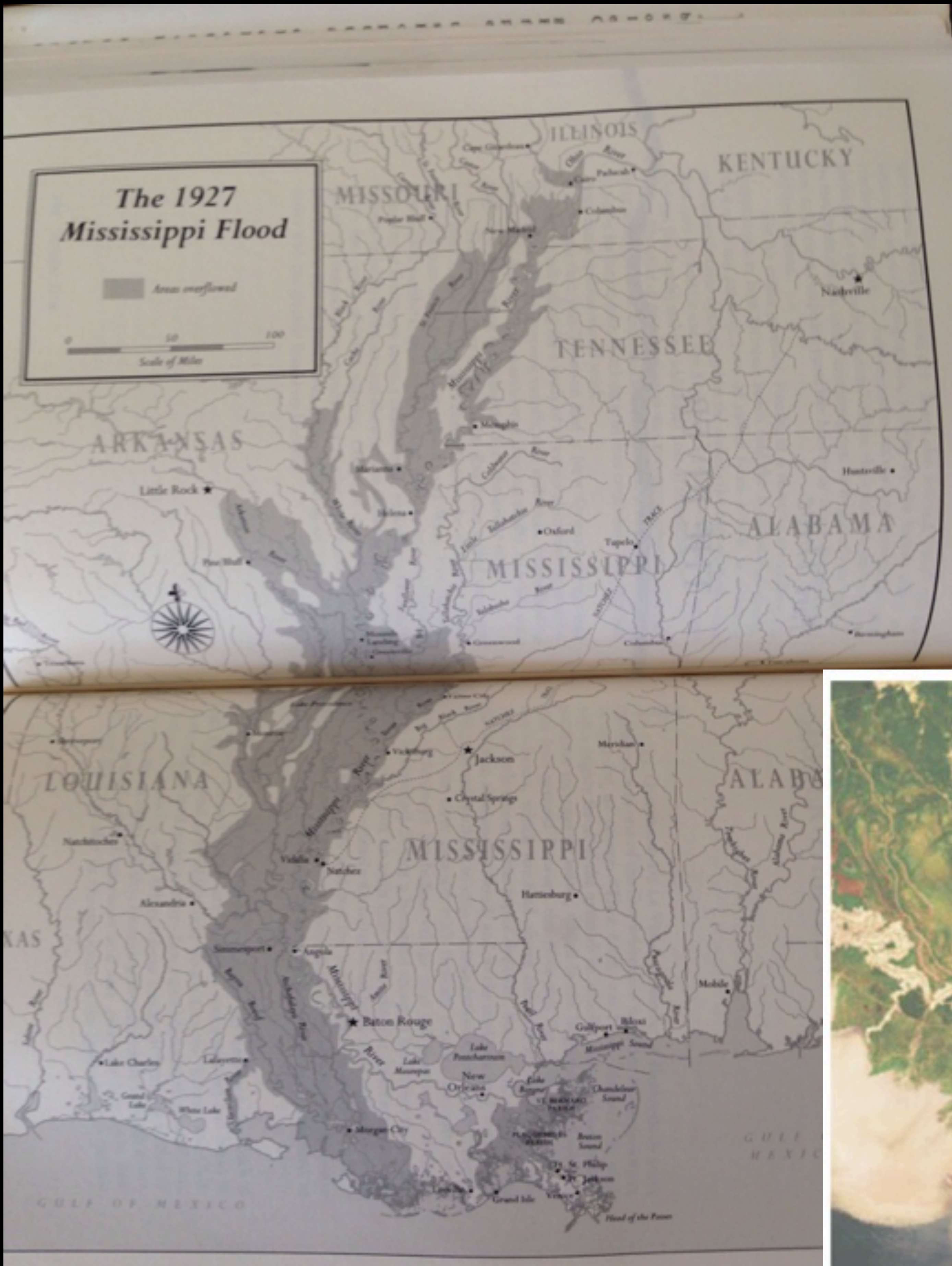
**Historical and Projected Land Loss in the Deltaic Plain*

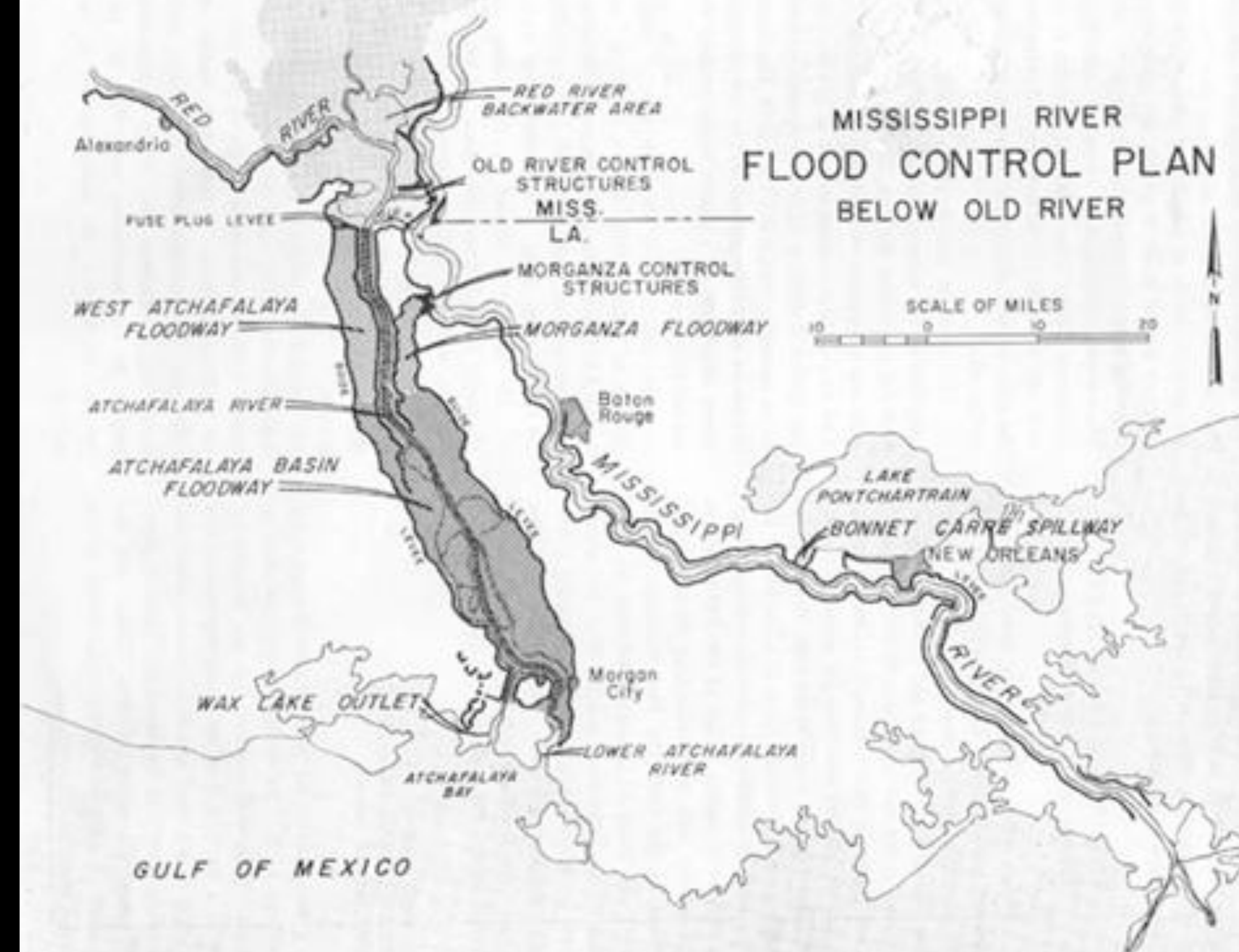


http://www.nwrc.usgs.gov/factshts/2005-3101/2005-3101.htm

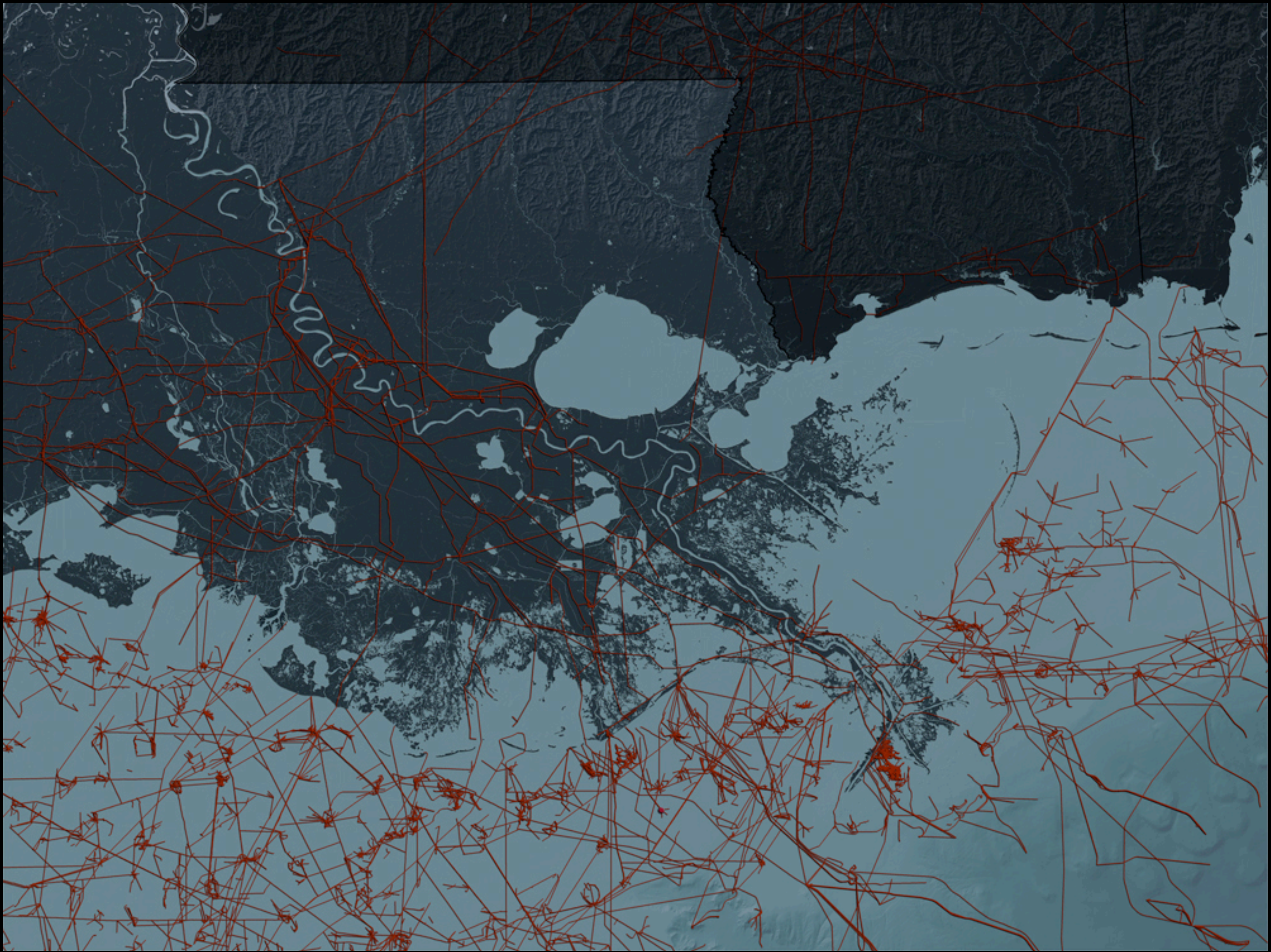
primarily
Louisiana

Why?


The 1927 Mississippi Flood
Areas overflowed
Scale of Miles
KENTUCKY
MISSOURI
ILLINOIS
TENNESSEE
ARKANSAS
MISSISSIPPI
ALABAMA
LOUISIANA
Little Rock
Nashville
Memphis
Jackson
Vicksburg
Natchez
Baton Rouge
New Orleans
Morgan City
Alexandria
Hattiesburg
Mobile
Gulfport
Biloxi
Lake Pontchartrain
GULF OF MEXICO


MISSISSIPPI RIVER
FLOOD CONTROL PLAN
BELOW OLD RIVER
RED RIVER BACKWATER AREA
OLD RIVER CONTROL STRUCTURES
MISS.
LA.
MORGANZA CONTROL STRUCTURES
MORGANZA FLOODWAY
SCALE OF MILES
RED RIVER
Alexandria
FUSE PLUG LEVEE
WEST ATCHAFALAYA FLOODWAY
ATCHAFALAYA RIVER
ATCHAFALAYA BASIN FLOODWAY
Baton Rouge
MISSISSIPPI
RIVER
LAKE PONTCHARTRAIN
BONNET CARRE SPILLWAY
NEW ORLEANS
Morgan City
WAX LAKE OUTLET
LOWER ATCHAFALAYA RIVER
ATCHAFALAYA BAY
GULF OF MEXICO


SEDIMENT WASTED
SEDIMENT STARVED WETLANDS
SEDIMENT WASTED



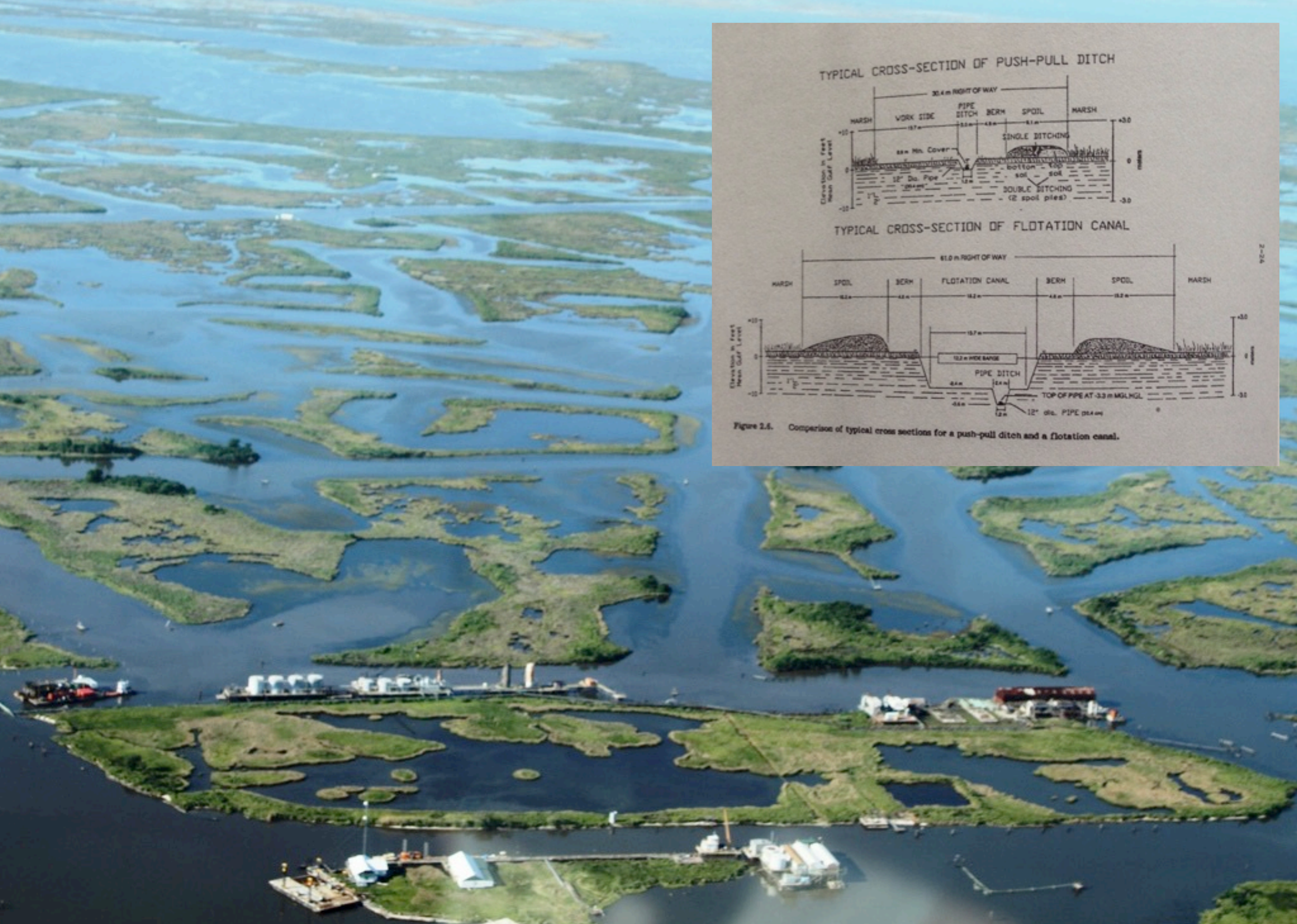
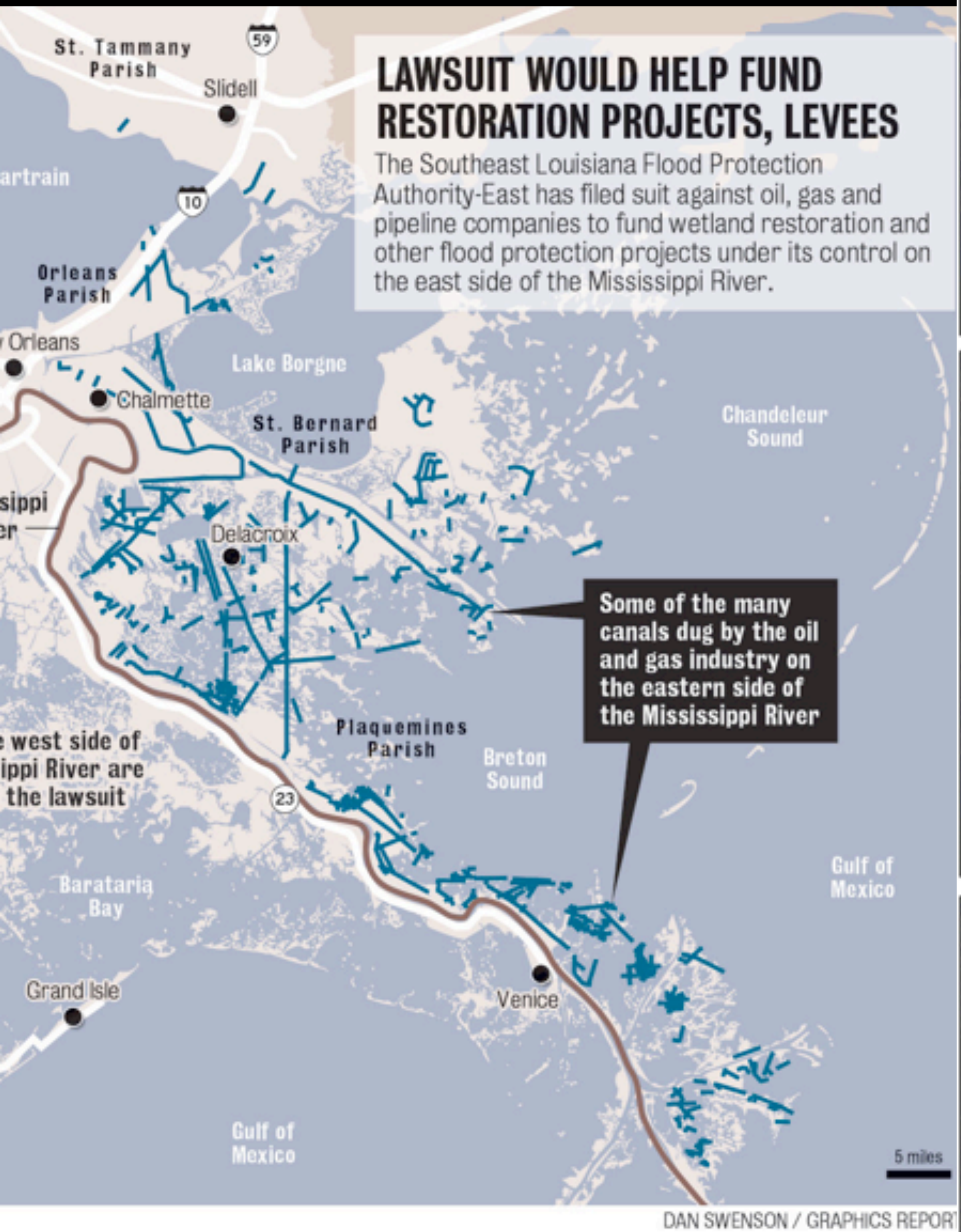
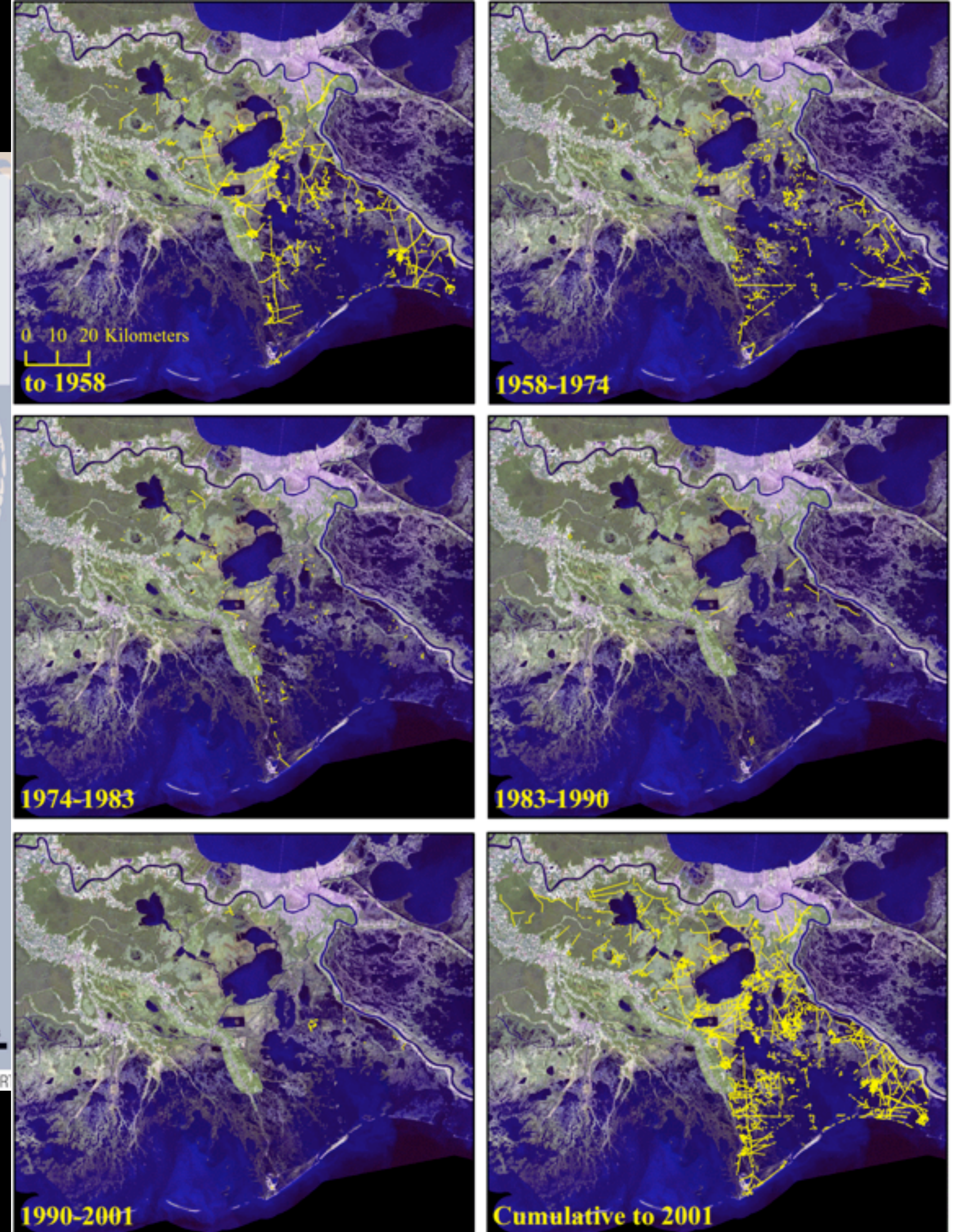


Figure 2.6. Comparison of typical cross sections for a push-pull ditch and a flotation canal.

Flickr: Gulf Restoration Network


LAWSUIT WOULD HELP FUND RESTORATION PROJECTS, LEVEES
The Southeast Louisiana Flood Protection Authority-East has filed suit against oil, gas and pipeline companies to fund wetland restoration and other flood protection projects under its control on the east side of the Mississippi River.
St. Tammany Parish
Slidell
59
10
artrain
Orleans Parish
y Orleans
Chalmette
Lake Borgne
St. Bernard Parish
Chandeleur Sound
sippi
er
Delacroix
Some of the many canals dug by the oil and gas industry on the eastern side of the Mississippi River
e west side of
ippi River are
the lawsuit
Plaquemines Parish
Breton Sound
23
Barataria Bay
Gulf of Mexico
Grand Isle
Venice
Gulf of Mexico
5 miles
DAN SWENSON / GRAPHICS REPORT


0 10 20 Kilometers
to 1958
1958-1974
1974-1983
1983-1990
1990-2001
Cumulative to 2001

1956 *1972* *2013*

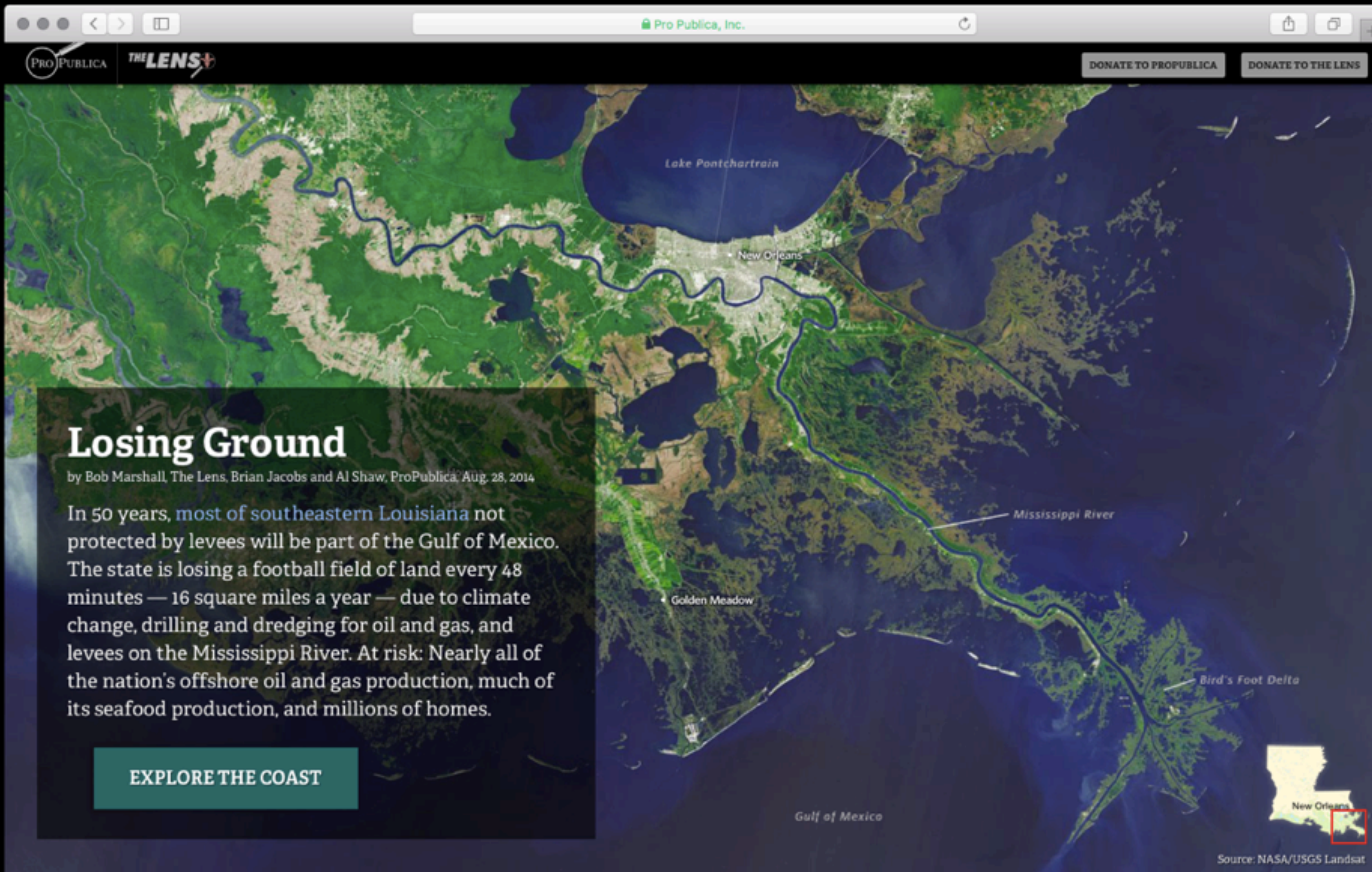
“Wagon wheel,” Venice, La.

USGS Aerials


Onyx


Lake Pontchartrain
New Orleans
Houma
Golden Meadow
1922 Coastline
2014

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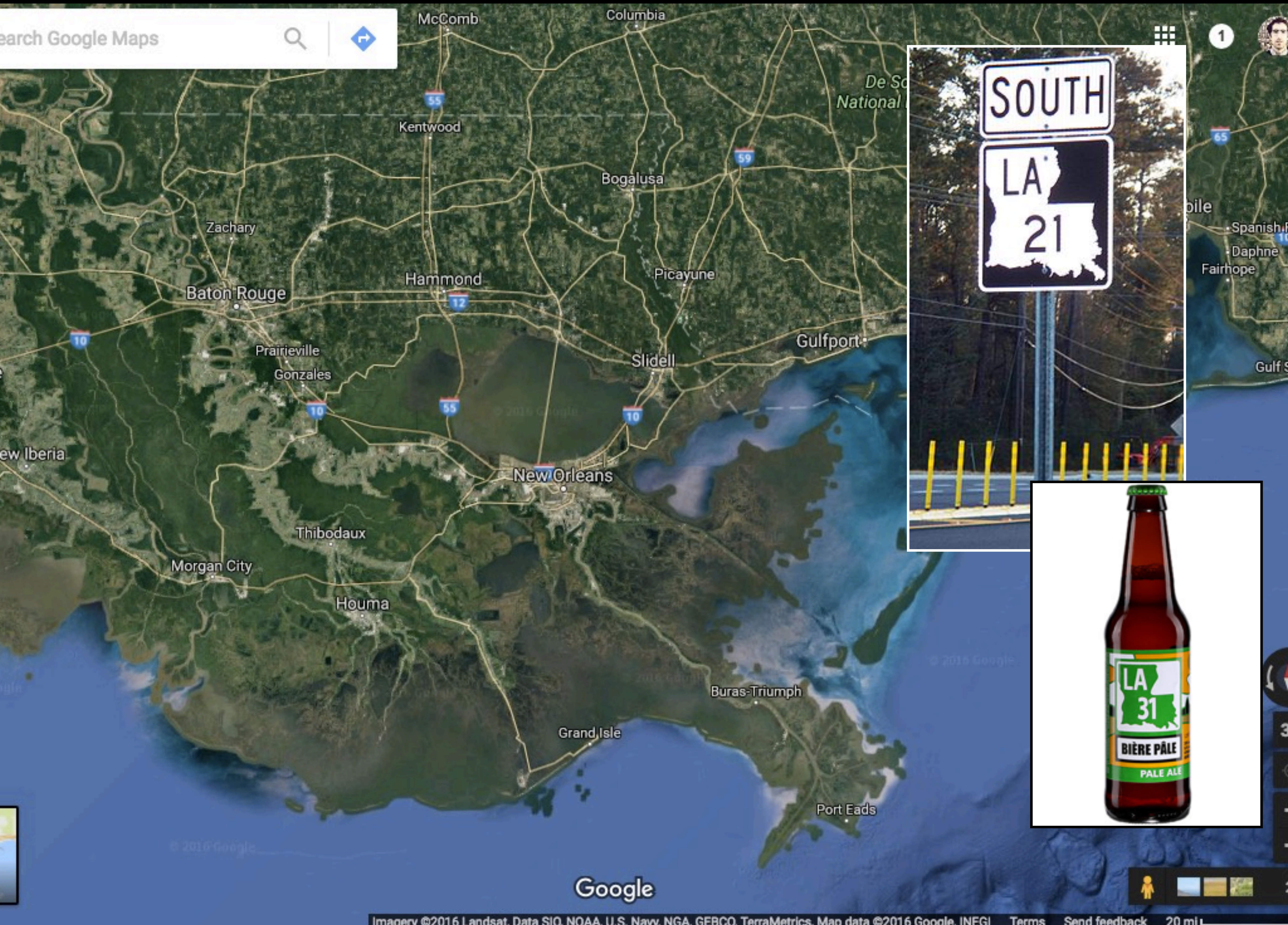
Losing Ground
by Bob Marshall, The Lens, Brian Jacobs and Al Shaw, ProPublica, Aug. 28, 2014
In 50 years, most of southeastern Louisiana not protected by levees will be part of the Gulf of Mexico. The state is losing a football field of land every 48 minutes — 16 square miles a year — due to climate change, drilling and dredging for oil and gas, and levees on the Mississippi River. At risk: Nearly all of the nation's offshore oil and gas production, much of its seafood production, and millions of homes.
EXPLORE THE COAST
Lake Pontchartrain
New Orleans
Mississippi River
Golden Meadow
Bird's Foot Delta
Gulf of Mexico
New Orleans
Source: NASA/USGS Landsat



earch Google Maps
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Columbia
Kentwood
Bogalusa
De So
National
Zachary
Picayune
Hammond
Baton Rouge
Gulfport
Prairieville
Gonzales
Slidell
ew Iberia
New Orleans
Thibodaux
Morgan City
Houma
Buras-Triumph
Grand Isle
Port Eads
bile
Spanish
Daphne
Fairhope
Gulf S
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59
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Google
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LA
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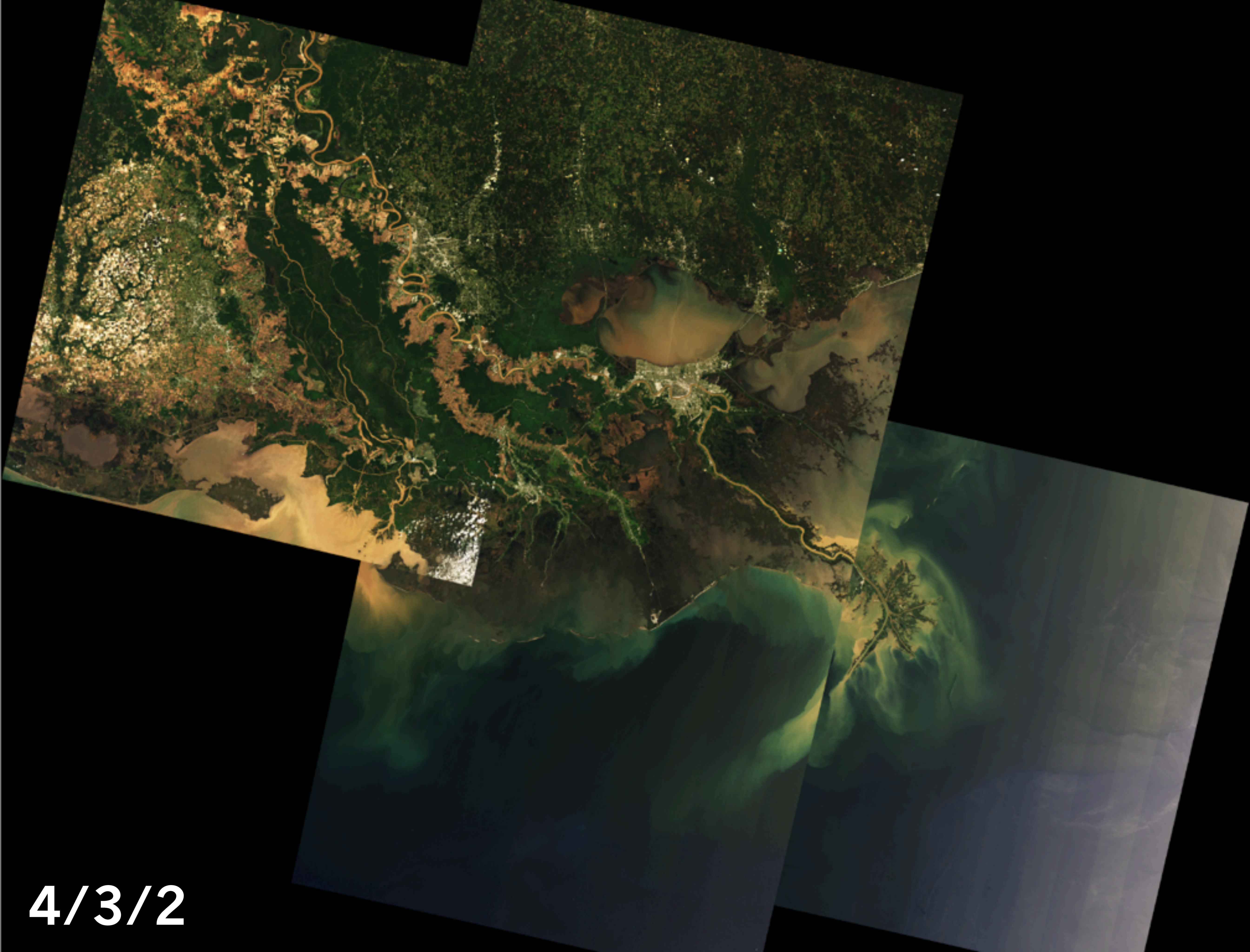
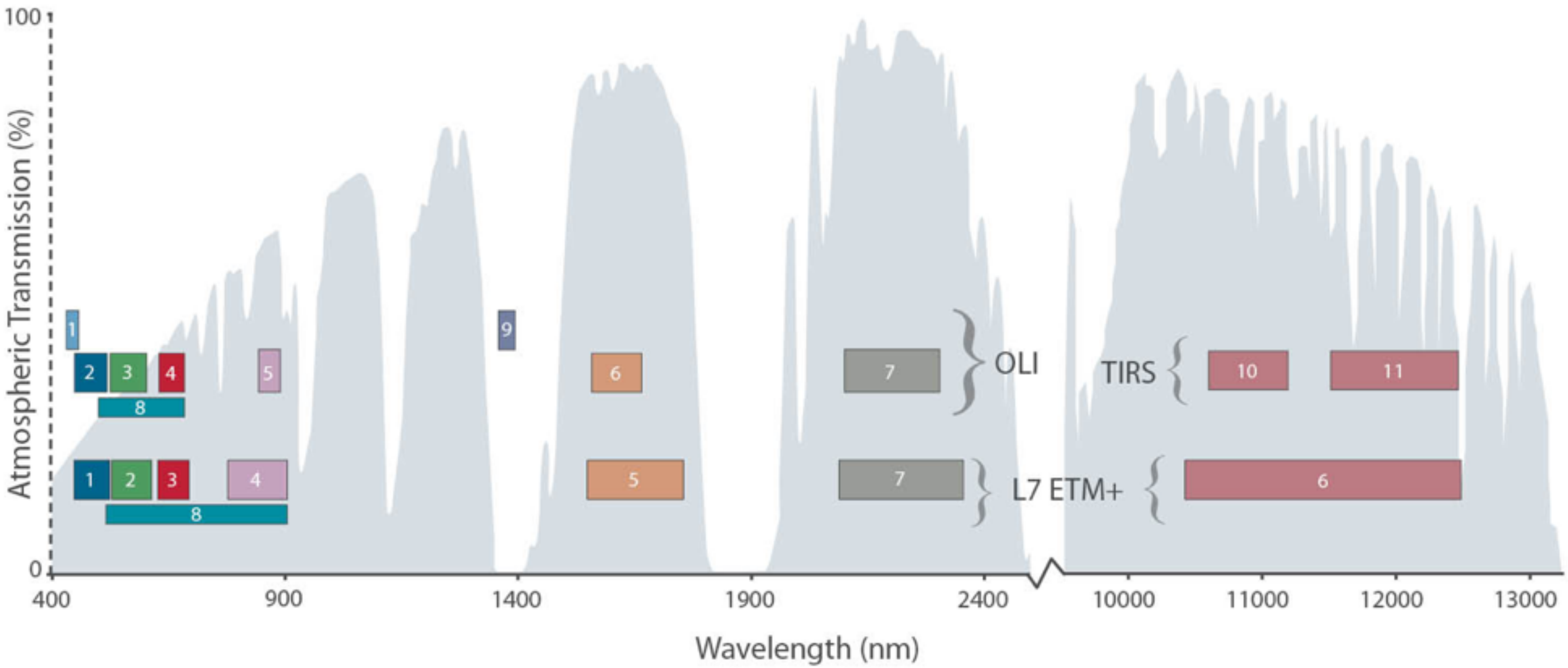
BIÈRE PÂLE
PALE ALE



4/3/2

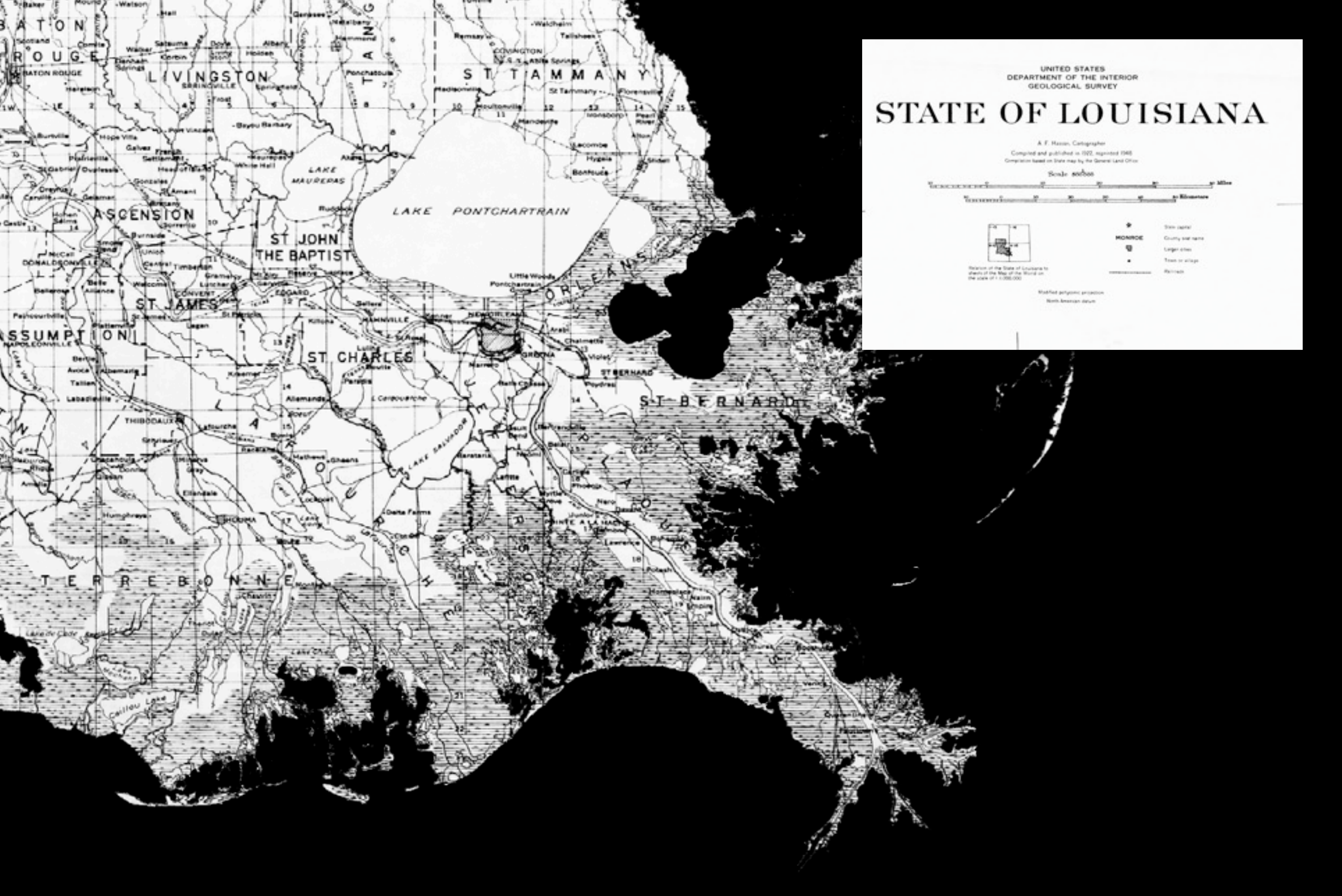
Landsat 8



NASA


7/5/3

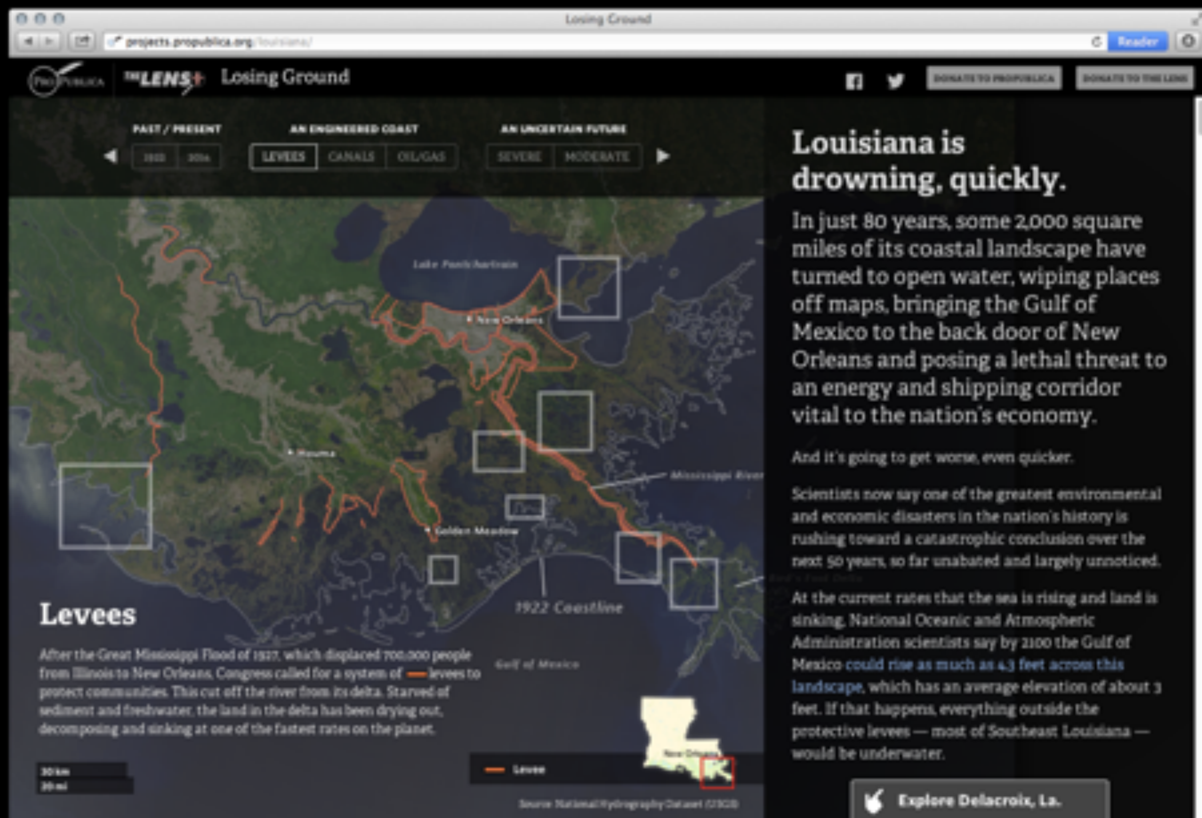

4/3/2 + 5 mask

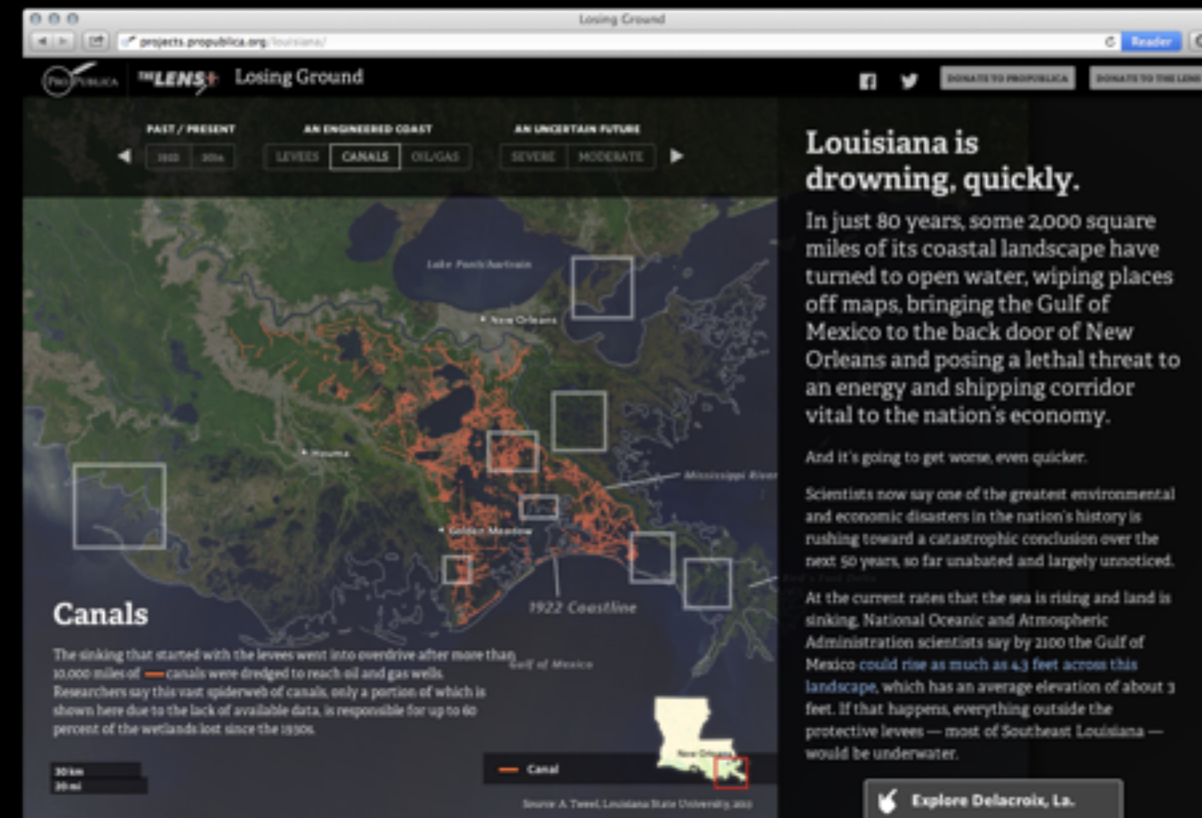


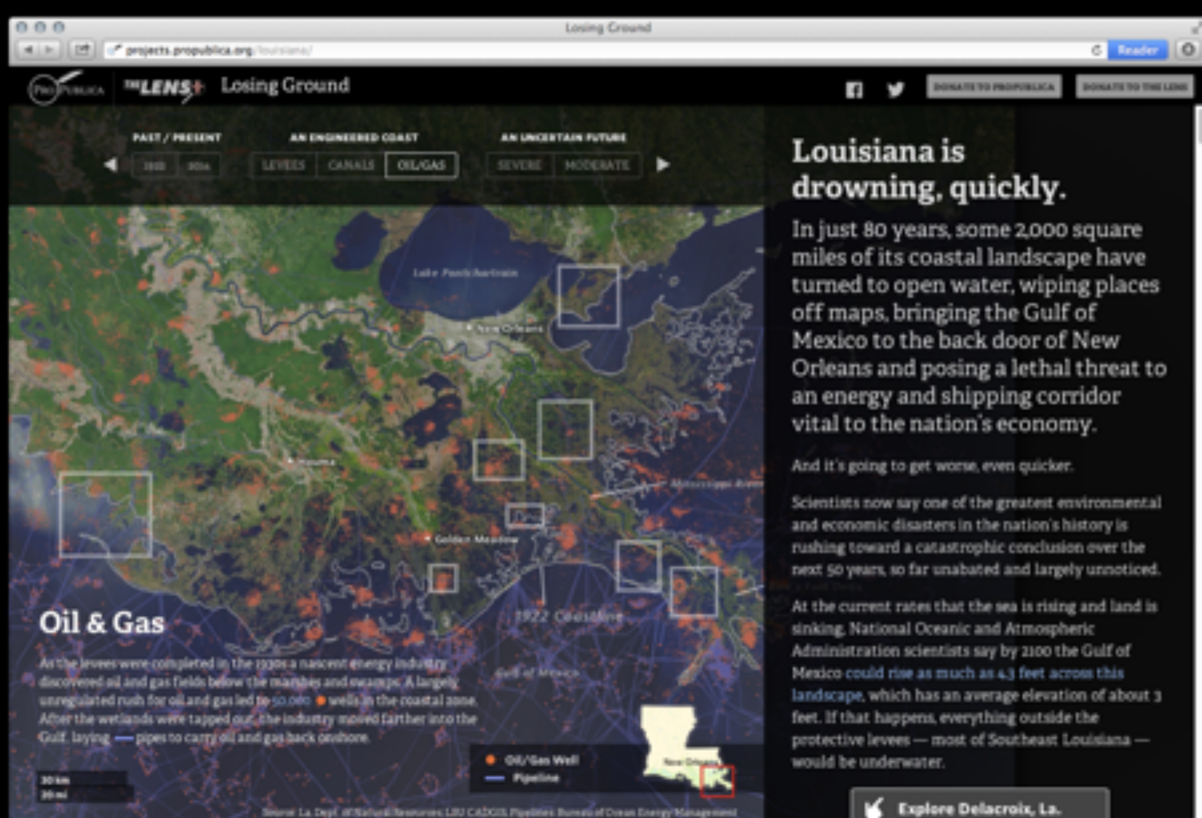
1922

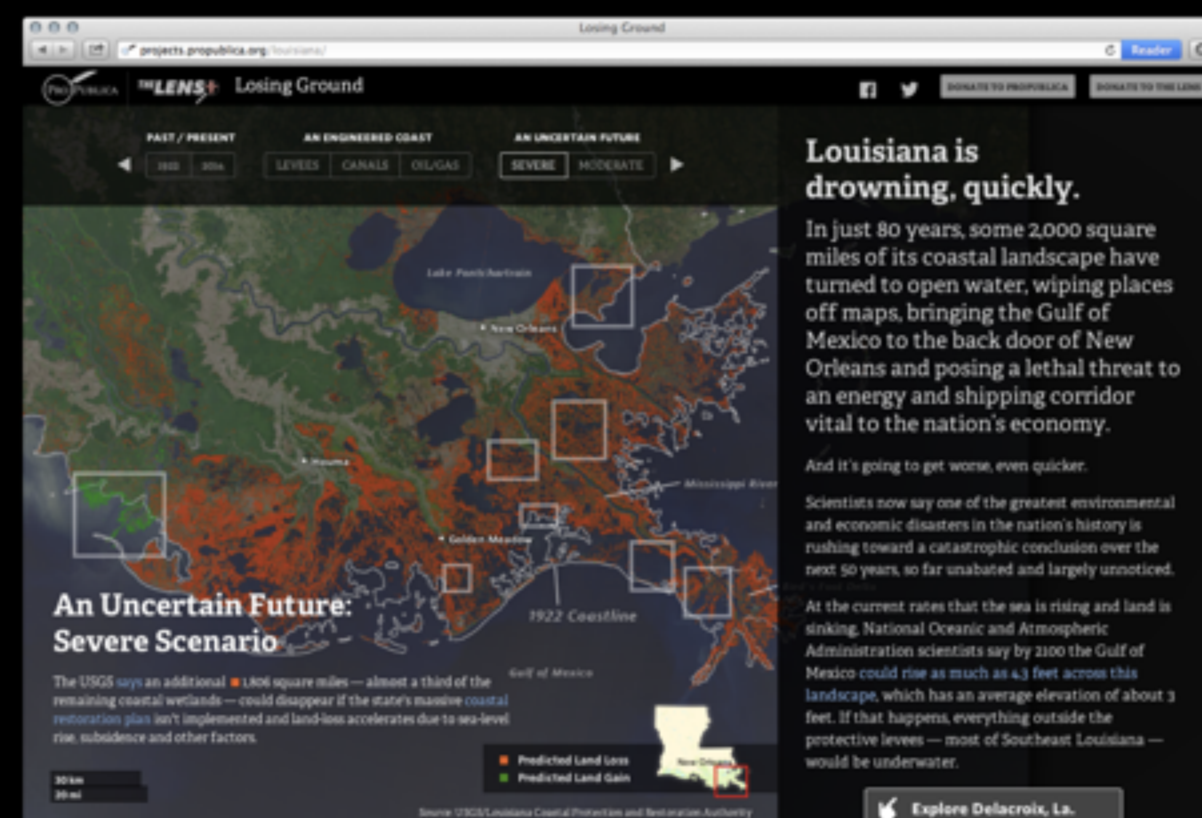
USGS via LSU


30 km
20 mi


Losing Ground
projects.propublica.org
THE LENS
Losing Ground
PAST / PRESENT
AN ENGINEERED COAST
AN UNCERTAIN FUTURE
LEVEES
CANALS
OIL/GAS
SEVERE
MODERATE
Louisiana is drowning, quickly.
In just 80 years, some 2,000 square miles of its coastal landscape have turned to open water, wiping places off maps, bringing the Gulf of Mexico to the back door of New Orleans and posing a lethal threat to an energy and shipping corridor vital to the nation's economy.
And it's going to get worse, even quicker.
Scientists now say one of the greatest environmental and economic disasters in the nation's history is rushing toward a catastrophic conclusion over the next 50 years, so far unabated and largely unnoticed.
At the current rates that the sea is rising and land is sinking, National Oceanic and Atmospheric Administration scientists say by 2100 the Gulf of Mexico could rise as much as 4.3 feet across this landscape, which has an average elevation of about 3 feet. If that happens, everything outside the protective levees — most of Southeast Louisiana — would be underwater.
Explore Delacroix, La.
Levees
After the Great Mississippi Flood of 1927, which displaced 700,000 people from Illinois to New Orleans, Congress called for a system of levees to protect communities. This cut off the river from its delta. Starved of sediment and freshwater, the land in the delta has been drying out, decomposing and sinking at one of the fastest rates on the planet.
Lake Pontchartrain
New Orleans
Houma
Golden Meadow
Mississippi River
1922 Coastline
Gulf of Mexico
30 km
20 mi
Levee
Source: National Hydrography Dataset (USGS)


Losing Ground
CANALS
Louisiana is drowning, quickly.
Canals
The sinking that started with the levees went into overdrive after more than 10,000 miles of canals were dredged to reach oil and gas wells. Researchers say this vast spiderweb of canals, only a portion of which is shown here due to the lack of available data, is responsible for up to 60 percent of the wetlands lost since the 1930s.
1922 Coastline
Gulf of Mexico
30 km
20 mi
Canal
Source: A. Tweel, Louisiana State University, 2013
Explore Delacroix, La.


Losing Ground
OIL/GAS
Louisiana is drowning, quickly.
Oil & Gas
As the levees were completed in the 1930s a nascent energy industry discovered oil and gas fields below the marshes and swamps. A largely unregulated rush for oil and gas led to 50,000 wells in the coastal zone. After the wetlands were tapped out, the industry moved farther into the Gulf, laying pipes to carry oil and gas back onshore.
Oil/Gas Well
Pipeline
30 km
20 mi
Explore Delacroix, La.


Losing Ground
SEVERE
Louisiana is drowning, quickly.
An Uncertain Future: Severe Scenario
The USGS says an additional 1,806 square miles — almost a third of the remaining coastal wetlands — could disappear if the state's massive coastal restoration plan isn't implemented and land-loss accelerates due to sea-level rise, subsidence and other factors.
1922 Coastline
Gulf of Mexico
Predicted Land Loss
Predicted Land Gain
30 km
20 mi
Source: USGS/Louisiana Coastal Protection and Restoration Authority
Explore Delacroix, La.

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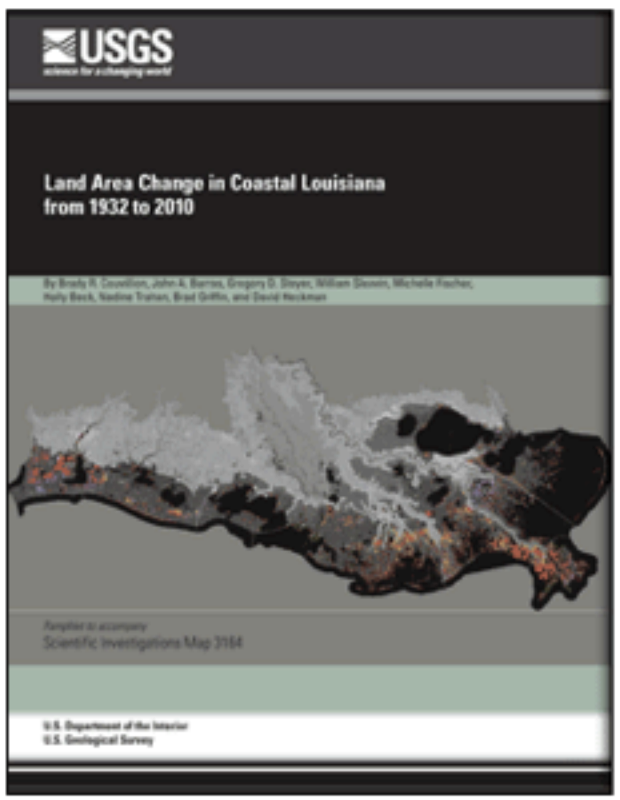
Land Area Change in Coastal Louisiana from 1932 to 2010

By Brady R. Couvillion, John A. Barras, Gregory D. Steyer, William Sleavin, Michelle Fischer, Holly Beck, Nadine Trahan, Brad Griffin, and David Heckman



Abstract

Coastal Louisiana wetlands make up the seventh largest delta on Earth, contain about 37 percent of the estuarine herbaceous marshes in the conterminous United States, and support the largest commercial fishery in the lower 48 States. These wetlands are in peril because Louisiana currently undergoes about 90 percent of the total coastal wetland loss in the continental United States. Documenting and understanding the occurrence and rates of wetland loss are necessary for effective planning, protection, and restoration activities.

The analyses of landscape change presented in this report use historical surveys, aerial data, and satellite data to track landscape changes. Summary data are presented for 1932–2010; trend data are presented for 1985–2010. These later data were calculated separately because of concerns over the comparability of the 1932 and 1956 datasets (which are based on survey and aerial data, respectively) with the later datasets (which are all based on satellite imagery).

These analyses show that coastal Louisiana has undergone a net change in land area of about -1,883 square miles (mi^2) from 1932 to 2010. This net change in land area amounts to a decrease of about 25 percent of the 1932 land area. Persistent losses account for 95 percent of this land area decrease; the remainder are areas that have converted to water but have not yet exhibited the persistence necessary to be classified as "loss." Trend analyses from 1985 to 2010 show a wetland loss rate of 16.57 mi^2 per year. If this loss were to occur at a constant rate, it would equate to Louisiana losing an area the size of one football field per hour.

First posted June 1, 2011

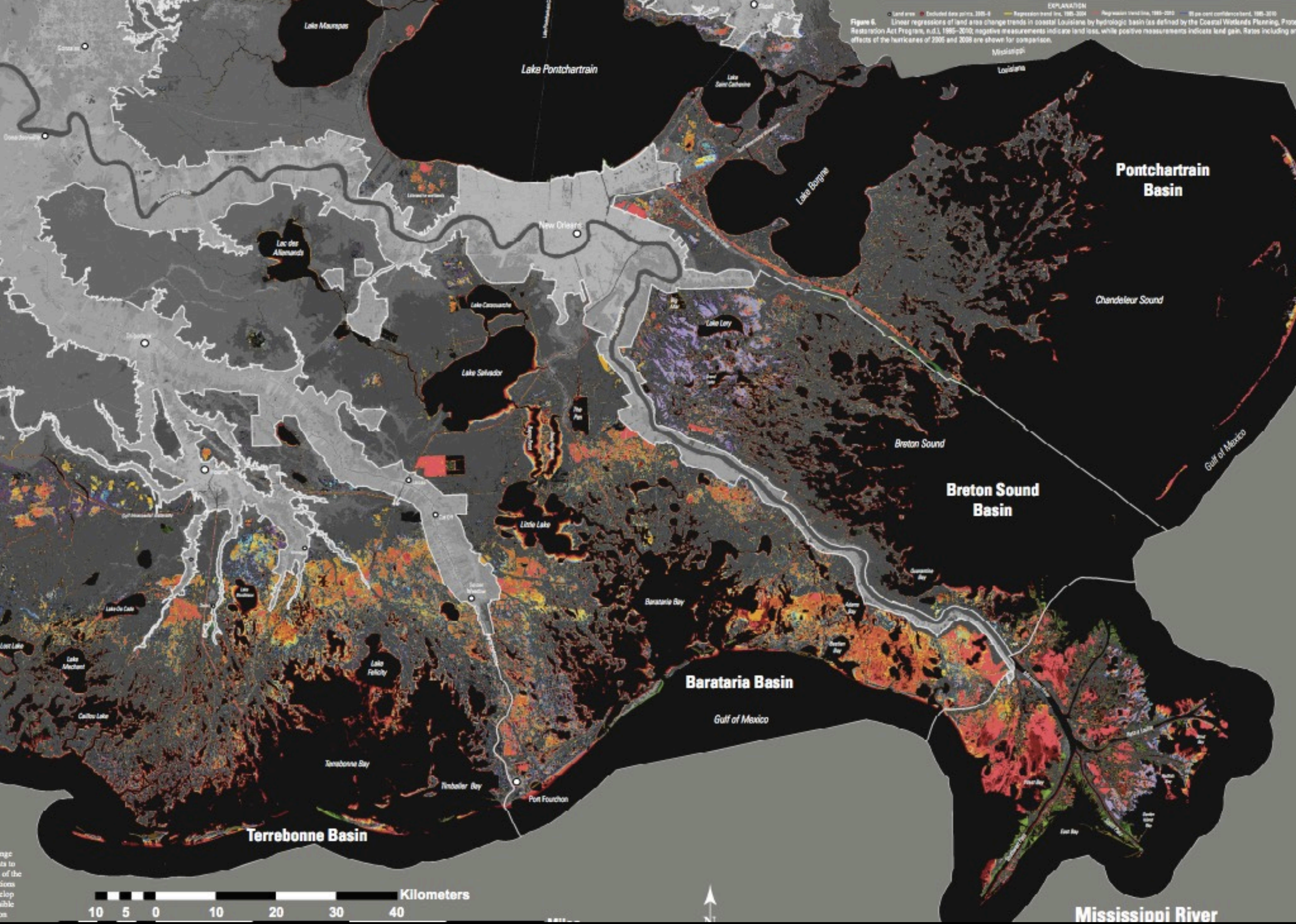
- **Pamphlet** PDF (1.92 MB)
- **Map** PDF (16.2 MB)
- **Downloads** Directory
  Refer to the readme file for more information.

For additional information contact:

USGS National Wetlands Research Center
700 Cajundome Blvd.
Lafayette, LA 70506

http://www.nwrc.usgs.gov/

Part or all of this report is presented in Portable Document Format (PDF); the



http://pubs.usgs.gov/sim/3164/

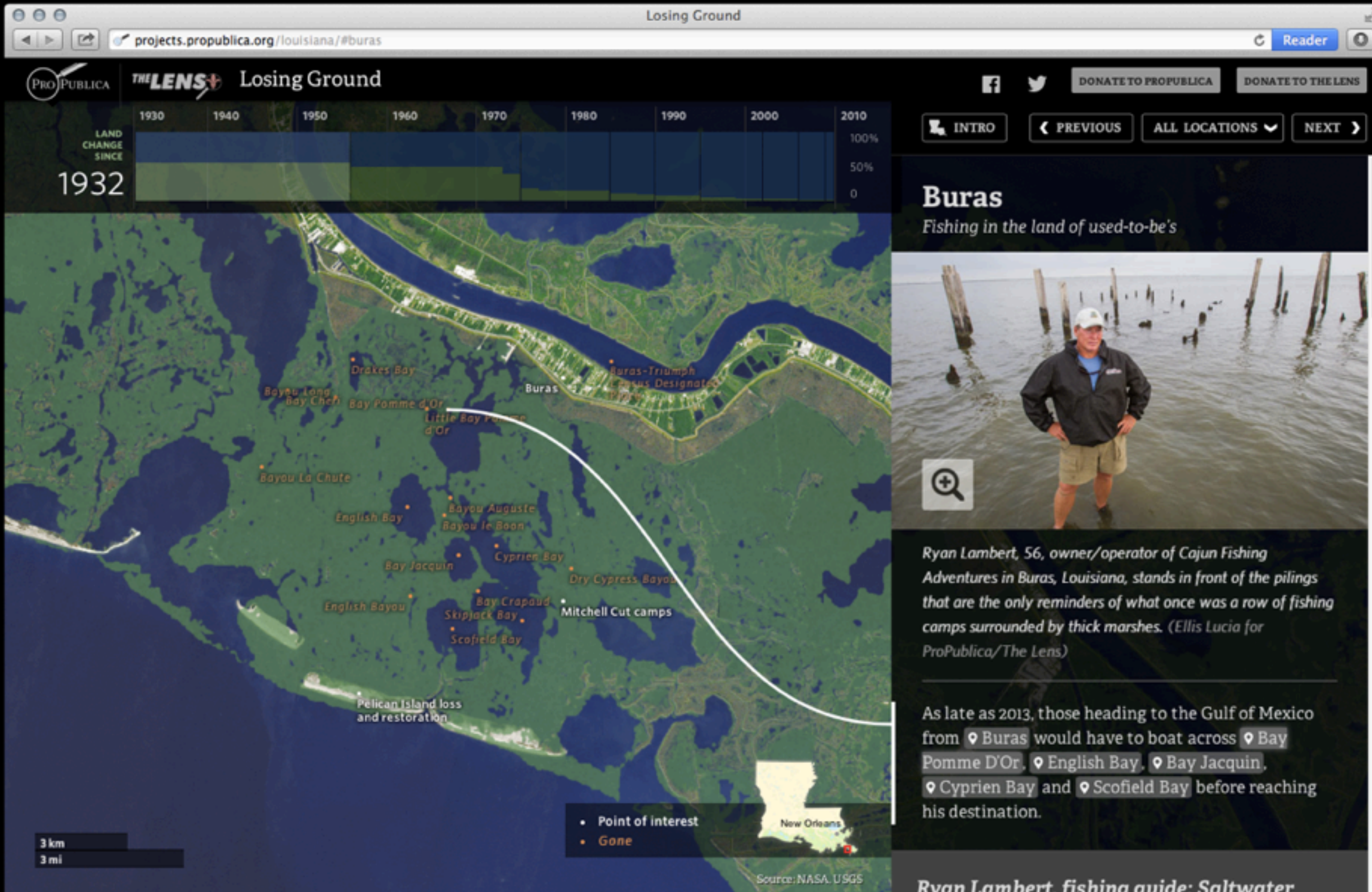
http://pubs.usgs.gov/sim/3164/


Drakes Bay
Bay Pomme d'Or
Little Bay Pomme d'Or
Buras
Bayou La Chute
English Bay
Bayou Auguste
Cyprien Bay
Bay Jacquin
Dry Cypress Bayou
English Bayou
Bay Crapaud
Skipjack Bay
Scofield Bay
Mitchell Cut camps
Pelican Island loss and restoration
Point of interest
Gone
New Orleans
3 km
3 mi
Source: NASA, USGS

1932


Drakes Bay
Bay Pomme d'Or
Little Bay Pomme d'Or
Buras
Buras-Triumph Census Designated
Bayou La Chute
English Bay
Bayou Auguste
Cyprien Bay
Bay Jacquin
Dry Cypress Bayou
English Bayou
Bay Crapaud
Skipjack Bay
Scofield Bay
Mitchell Cut camps
Pelican Island loss and restoration
Point of interest
Gone
New Orleans
3 km
3 mi
Source: NASA, USGS

2010


Losing Ground
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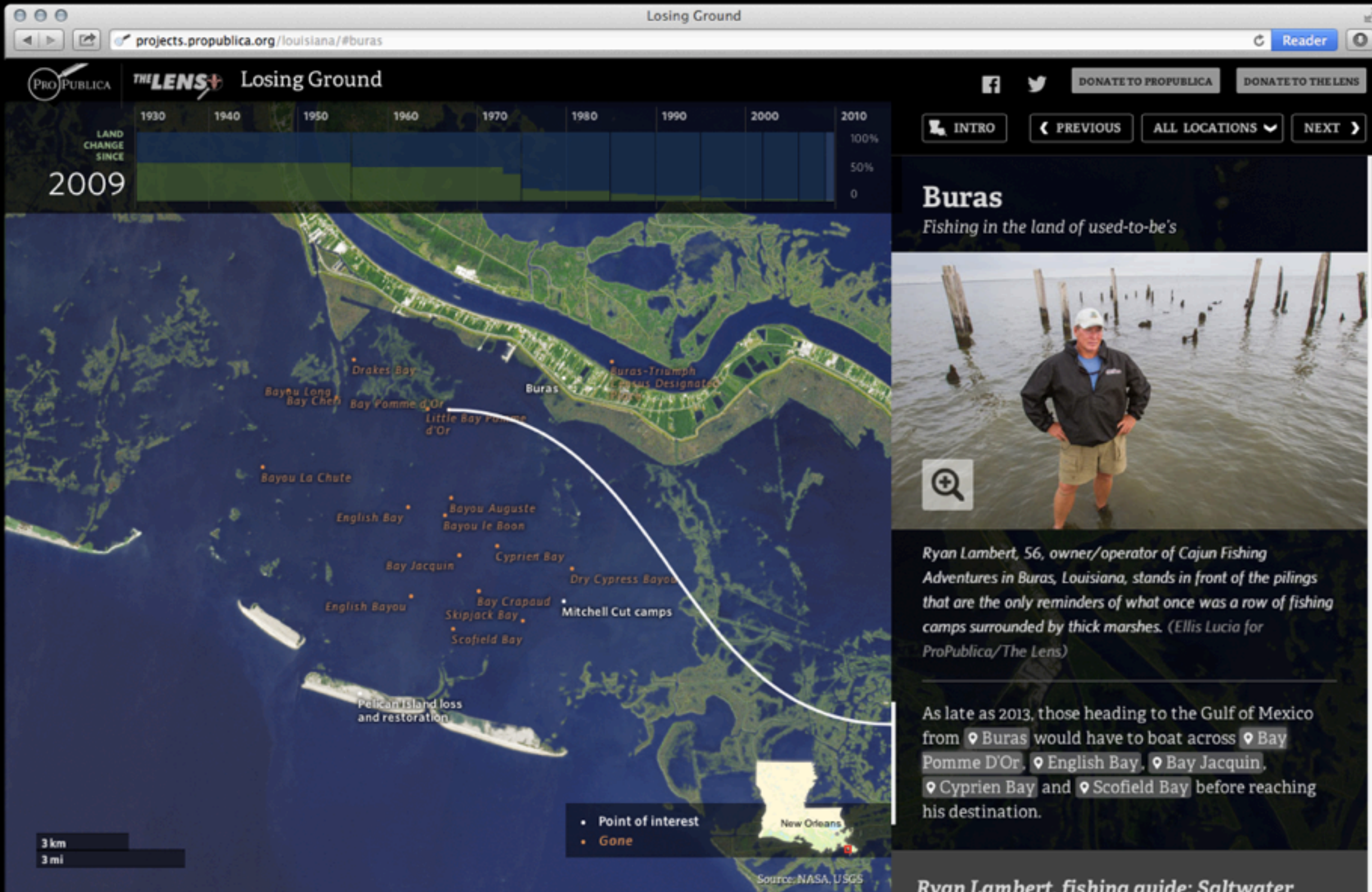
Reader
ProPublica
The Lens
Losing Ground
DONATE TO PROPUBLICA
DONATE TO THE LENS
1930
1940
1950
1960
1970
1980
1990
2000
2010
LAND CHANGE SINCE
1932
100%
50%
0
INTRO
PREVIOUS
ALL LOCATIONS
NEXT
Buras
Fishing in the land of used-to-be's
Ryan Lambert, 56, owner/operator of Cajun Fishing Adventures in Buras, Louisiana, stands in front of the pilings that are the only reminders of what once was a row of fishing camps surrounded by thick marshes. (Ellis Lucia for ProPublica/The Lens)
As late as 2013, those heading to the Gulf of Mexico from Buras would have to boat across Bay Pomme D'Or, English Bay, Bay Jacquin, Cyprien Bay and Scofield Bay before reaching his destination.
Ryan Lambert, fishing guide: Saltwater
Drakes Bay
Bay Pomme d'Or
Buras
Bayou La Chute
English Bay
Bayou Auguste
Bayou le Boon
Cyprien Bay
Bay Jacquin
Dry Cypress Bayou
English Bayou
Bay Crapaud
Skipjack Bay
Scofield Bay
Mitchell Cut camps
Pelican Island loss and restoration
Point of interest
Gone
New Orleans
3 km
3 mi
Source: NASA, USGS



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THE LENS
Losing Ground
DONATE TO PROPUBLICA
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1930
1940
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LAND CHANGE SINCE
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100%
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0
INTRO
PREVIOUS
ALL LOCATIONS
NEXT
Drakes Bay
Bayou Long
Bay Chene
Bay Pomme d'Or
Little Bay Pomme d'Or
Buras
Bayou La Chute
English Bay
Bayou Auguste
Bayou le Boon
Bay Jacquin
Cyprien Bay
Dry Cypress Bayou
English Bayou
Bay Crapaud
Skipjack Bay
Mitchell Cut camps
Scofield Bay
Pelican Island loss and restoration
Point of interest
Gone
New Orleans
3 km
3 mi
Source: NASA, USGS
Buras
Fishing in the land of used-to-be's
Ryan Lambert, 56, owner/operator of Cajun Fishing Adventures in Buras, Louisiana, stands in front of the pilings that are the only reminders of what once was a row of fishing camps surrounded by thick marshes. (Ellis Lucia for ProPublica/The Lens)
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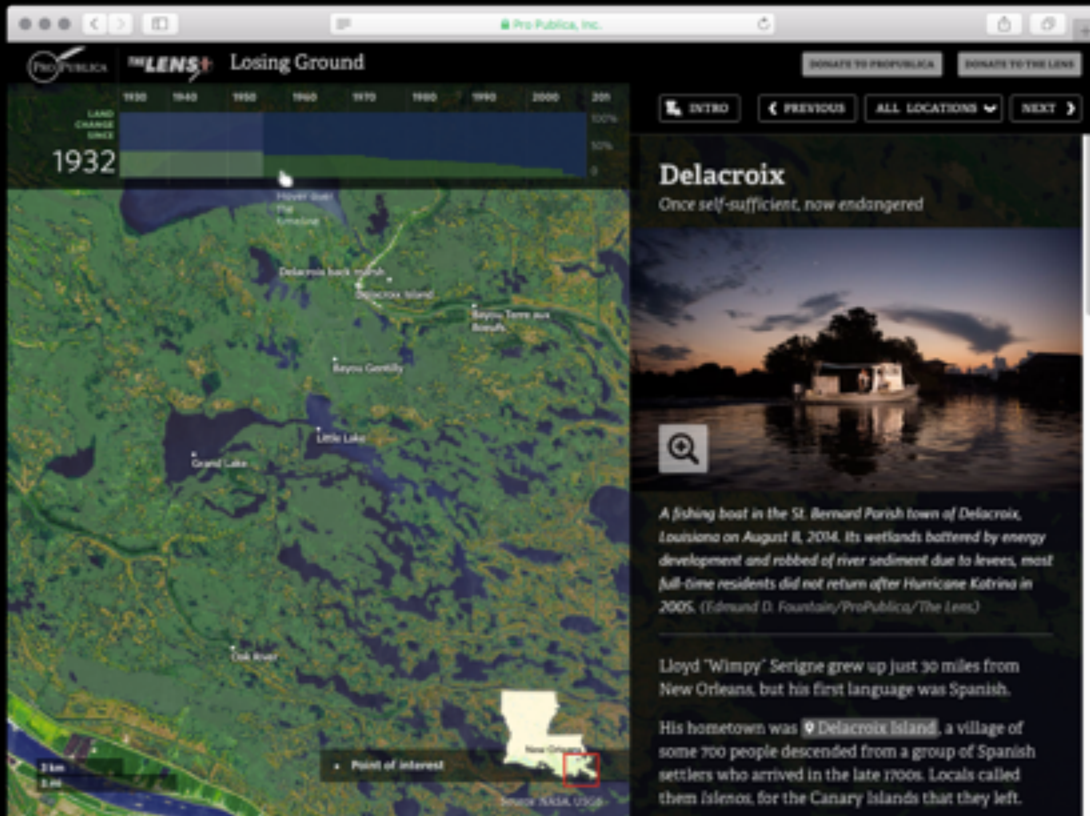
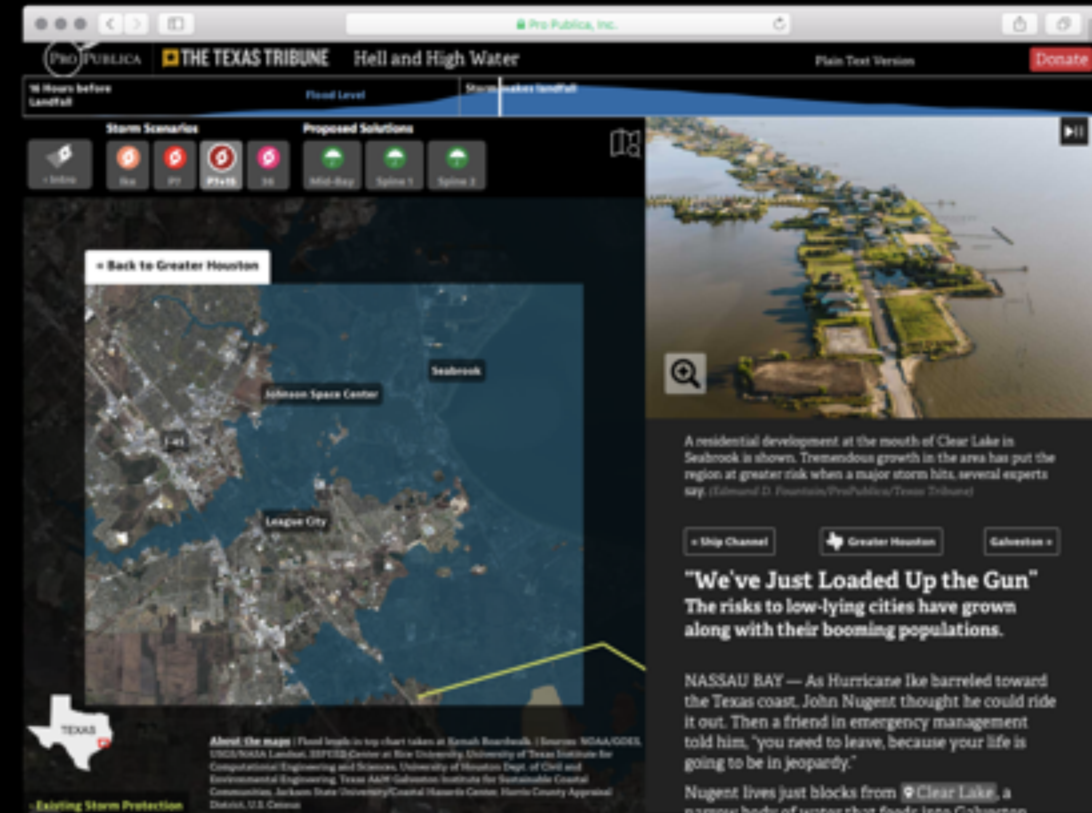
Ryan Lambert, fishing guide: Saltwater



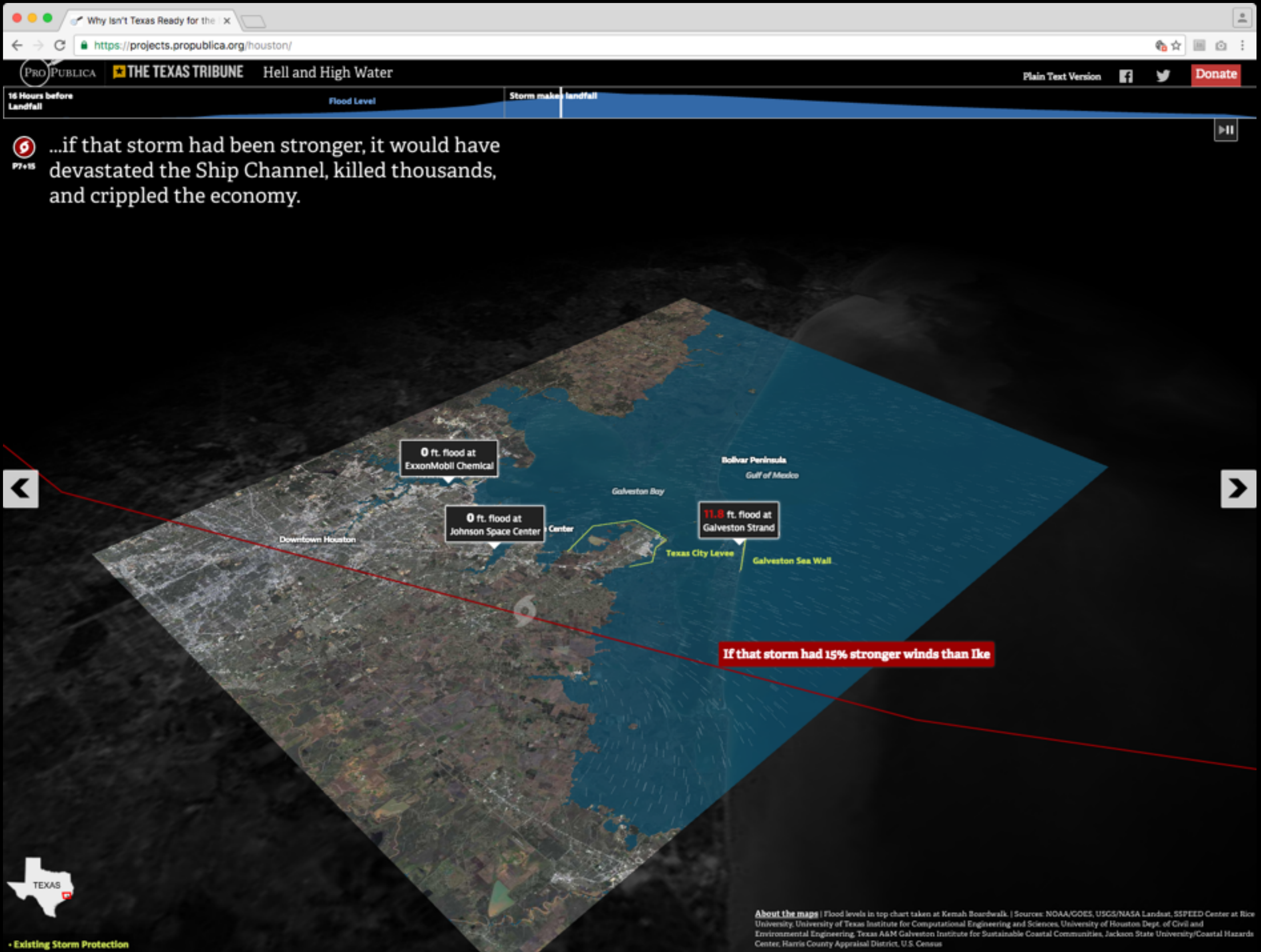


2014

2016

- National newsroom's interactive chops
- Local newsroom's domain knowledge
- Relationships with researchers

Great stories are hiding in plain sight — in academic papers.


Why Isn't Texas Ready for the
https://projects.propublica.org/houston/
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THE TEXAS TRIBUNE
Hell and High Water
Plain Text Version
Donate
16 Hours before Landfall
Flood Level
Storm makes landfall
...if that storm had been stronger, it would have devastated the Ship Channel, killed thousands, and crippled the economy.
0 ft. flood at ExxonMobil Chemical
0 ft. flood at Johnson Space Center
11.8 ft. flood at Galveston Strand
Bolivar Peninsula
Gulf of Mexico
Galveston Bay
Downtown Houston
Texas City Levee
Galveston Sea Wall
If that storm had 15% stronger winds than Ike
TEXAS
• Existing Storm Protection
About the maps | Flood levels in top chart taken at Kemah Boardwalk. | Sources: NOAA/GOES, USGS/NASA Landsat, SSPEED Center at Rice University, University of Texas Institute for Computational Engineering and Sciences, University of Houston Dept. of Civil and Environmental Engineering, Texas A&M Galveston Institute for Sustainable Coastal Communities, Jackson State University/Coastal Hazards Center, Harris County Appraisal District, U.S. Census

Nat Hazards (2015) 77:1183–1203
DOI 10.1007/s11069-015-1652-7

ORIGINAL PAPER

Vulnerability of an industrial corridor in Texas to storm surge

Daniel W. Burleson · Hanadi S. Rifai · Jennifer K. Proft · Clint N. Dawson · Philip B. Bedient

Received: 18 September 2014 / Accepted: 3 February 2015 / Published online: 12 February 2015

Abstract A conceptual framework for evaluating the vulnerability of industrialized coastal regions to storm surge was developed and implemented to evaluate the vulnerability of the Houston Ship Channel Industrial Corridor (HSC-IC) in Texas to storm surge. In the study, Hurricane Ike scenarios were modeled with SWAN + ADCIRC that involved changing the landfall location of the hurricane along the coast and incorporating the effect of increased wind speed. The storm surge data from the various landfall scenarios were cross-linked with geospatial and environmental data associated with facilities within the industrial region. This work uniquely combines the potential releases from storage tanks, records of past historical releases, and risk management planning to characterize environmental vulnerabilities using storage information and geospatial data. The resulting framework for vulnerability implemented within the HSC-IC found a relationship between storm surge and the total area inundated at a given storm surge level and between storm surge and the total number of storage tanks. Using the developed framework, it was possible to combine releases from storage tanks, records of past historical releases, and risk management planning to characterize environmental vulnerabilities on a facility by facility basis and for the modeled surge levels.

Keywords GIS · Hurricane · Risk management · Environmental impact

Risk Analysis DOI: 10.1111/j.1539-6924.2012.01840.x

Perspective

Examining the 100-Year Floodplain as a Metric of Risk, Loss, and Household Adjustment

Wesley E. Highfield,* Sarah A. Norman, and Samuel D. Brody

Delineating the Reality of Flood Risk and Loss in Southeast Texas

Samuel D. Brody[1]; Russell Blessing[2]; Antonia Sebastian, M.ASCE[3]; and Philip Bedient, F.ASCE[4]

Urban Studies at 50 Urban Studies
50(4) 789–806, March 2013

Examining the Impacts of Development Patterns on Flooding on the Gulf of Mexico Coast

Samuel Brody, Heeju Kim and Joshua Gunn

[Paper first received, November 2011; in final form, April 2012]

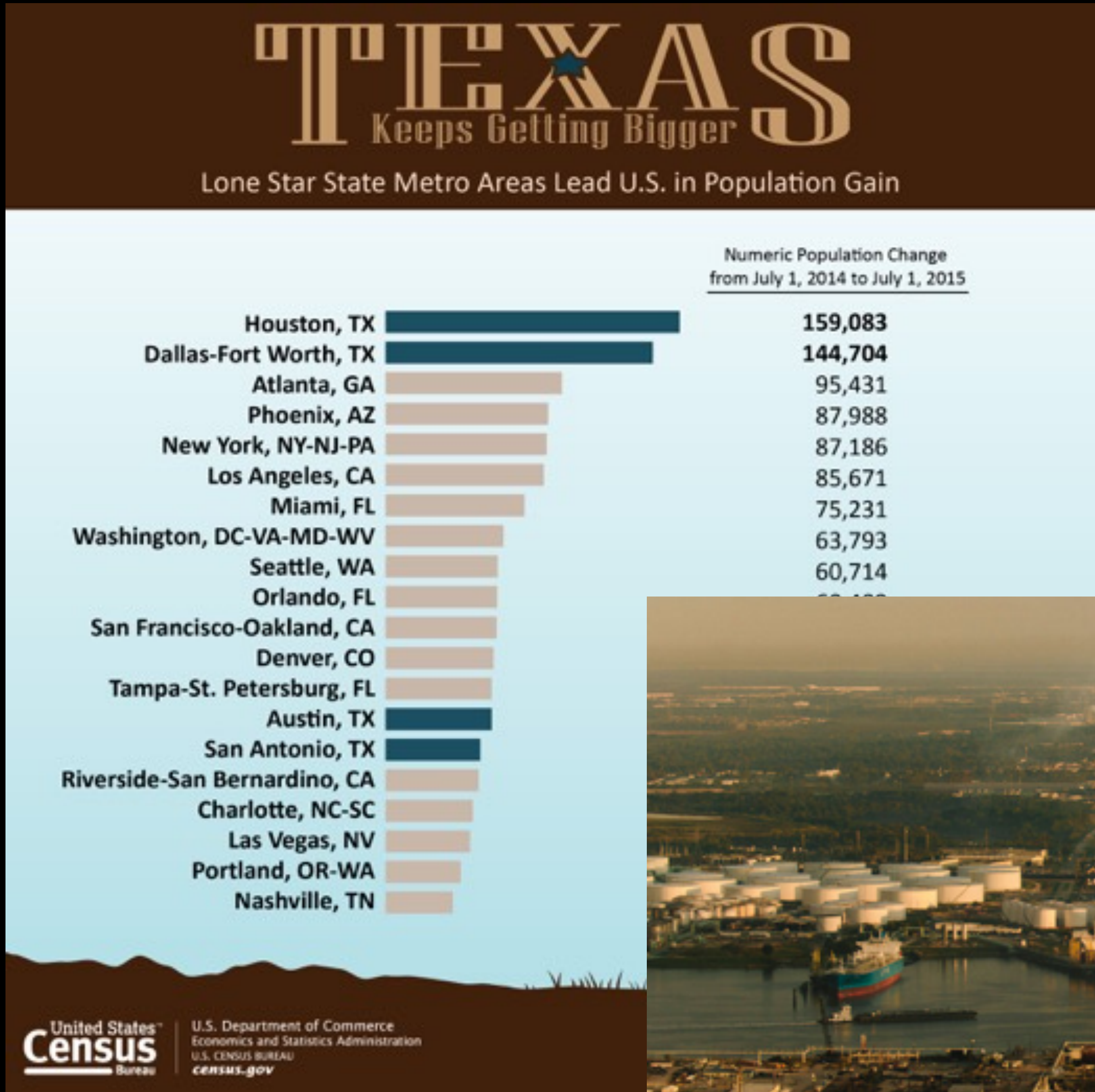
Journal of Environmental Planning and Management
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/cjep20

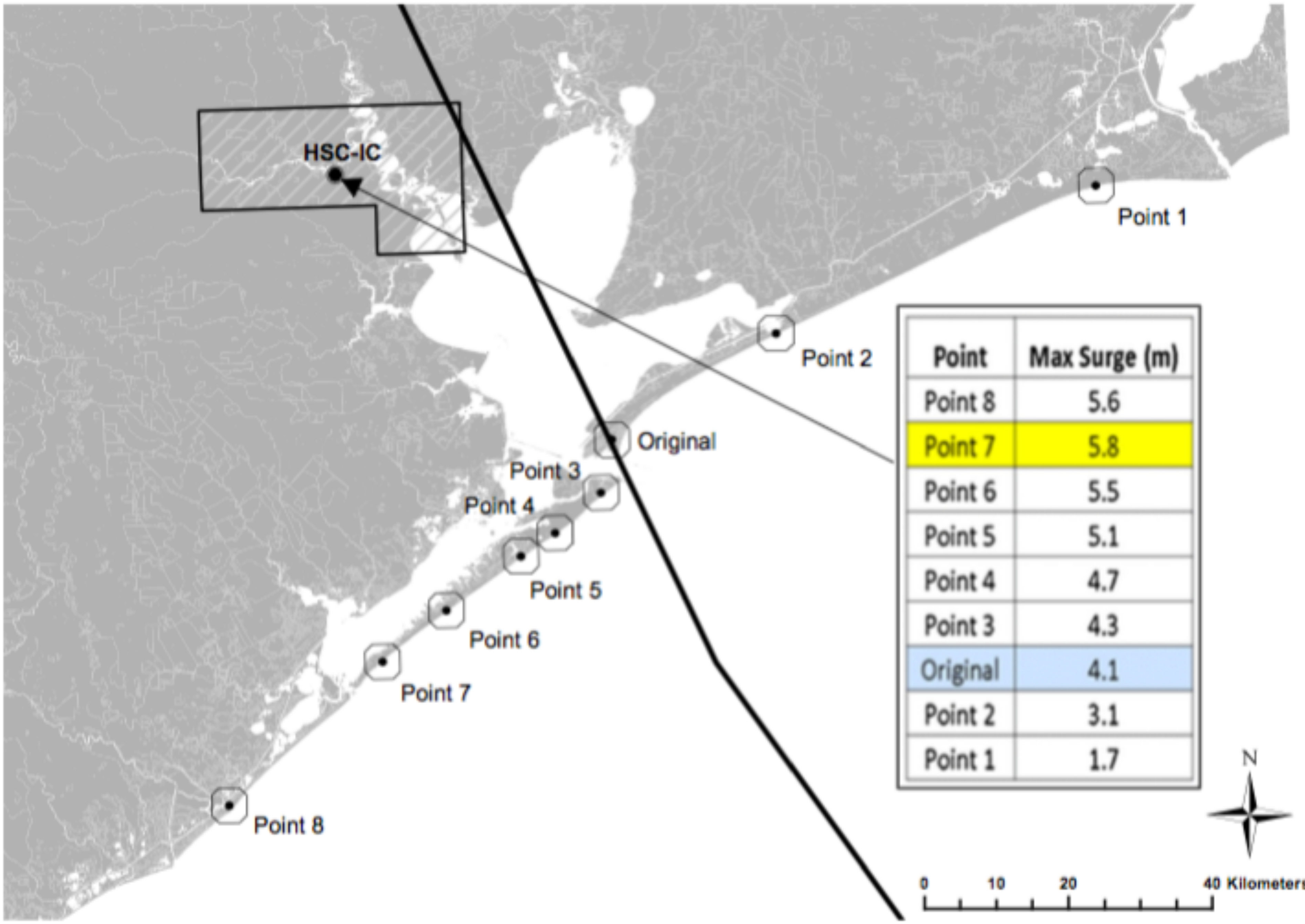
Examining the impact of land use/land cover characteristics on flood losses

Samuel Brody [a] , Russell Blessing [b] , Antonia Sebastian [c] & Philip Bedient [c]
[a] Departments of Marine Sciences/Urban Planning , Texas A&M University, 200 Seawolf Pkwy , Galveston , TX , 77553 , USA
[b] Center for Texas Beaches and Shores , Texas A&M University at Galveston , Galveston , TX , 77553 , USA
[c] Department of Civil and Environmental Engineering , Rice University , Houston , TX , USA
Published online: 06 Jun 2013.

Structural Integrity of Storage Tanks

Jamie E. Padgett, Ph.D.
Assistant Professor


TEXAS
Keeps Getting Bigger
Lone Star State Metro Areas Lead U.S. in Population Gain
Numeric Population Change
from July 1, 2014 to July 1, 2015
Houston, TX
159,083
Dallas-Fort Worth, TX
144,704
Atlanta, GA
95,431
Phoenix, AZ
87,988
New York, NY-NJ-PA
87,186
Los Angeles, CA
85,671
Miami, FL
75,231
Washington, DC-VA-MD-WV
63,793
Seattle, WA
60,714
Orlando, FL
San Francisco-Oakland, CA
Denver, CO
Tampa-St. Petersburg, FL
Austin, TX
San Antonio, TX
Riverside-San Bernardino, CA
Charlotte, NC-SC
Las Vegas, NV
Portland, OR-WA
Nashville, TN
United States Census Bureau
U.S. Department of Commerce
Economics and Statistics Administration
U.S. CENSUS BUREAU
census.gov

Point	Max Surge (m)
Point 8	5.6
Point 7	5.8
Point 6	5.5
Point 5	5.1
Point 4	4.7
Point 3	4.3
Original	4.1
Point 2	3.1
Point 1	1.7

Fig. 3 Landfall locations for SWAN + ADCIRC modeling of Hurricane Ike. The *solid black line* represents the original track of Hurricane Ike. The *table* shows the change in storm surge for the simulated landfall locations of Hurricane Ike at the indicated point in the HSC-IC

Coastal Engineering 88 (2014) 171–181

Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: www.elsevier.com/locate/coastaleng

Characterizing hurricane storm surge behavior in Galveston Bay using the SWAN + ADCIRC model

Antonia Sebastian [a,*], Jennifer Proft [b], J. Casey Dietrich [d], Wei Du [b], Philip B. Bedient [a], Clint N. Dawson [b,c]

[a] Department of Civil and Environmental Engineering, Rice University, Houston, TX, United States
[b] Institute for Computational Engineering Sciences, The University of Texas, Austin, TX, United States
[c] Department of Aerospace Engineering and Engineering Mechanics, The University of Texas, Austin, TX, United States
[d] Department of Civil, Construction, and Environmental Engineering, North Carolina State University, Raleigh, NC, United States

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Hydrograph

ABSTRACT

The SWAN + ADCIRC shallow-water circulation model, validated for Hurricane Ike (2008), was used to develop five synthetic storm surge scenarios for the upper Texas coast in which wind speed was increased and landfall location was shifted 40 km westward. The Hurricane Ike simulation and the synthetic storms were used to study the maximum water elevations in Galveston Bay, as well as the timing and behavior of surge relative to the hurricane track. Sixteen locations indicative of surge behavior in and around Galveston Bay were chosen to for analysis in this paper. Results show that water surface elevations present in Galveston Bay are dominated by the counterclockwise hurricane winds and that increasing wind speeds by 15% results in approximately 23% (+/−3%) higher surge. Furthermore, shifting the storm westward causes higher levels of surge in the more populated areas due to more intense, higher shore-normal winds. This research helps to highlight the vulnerability of the upper Texas Gulf Coast to hurricane storm surge and lends insight to storm surge and flood mitigation studies in the Houston–Galveston region.

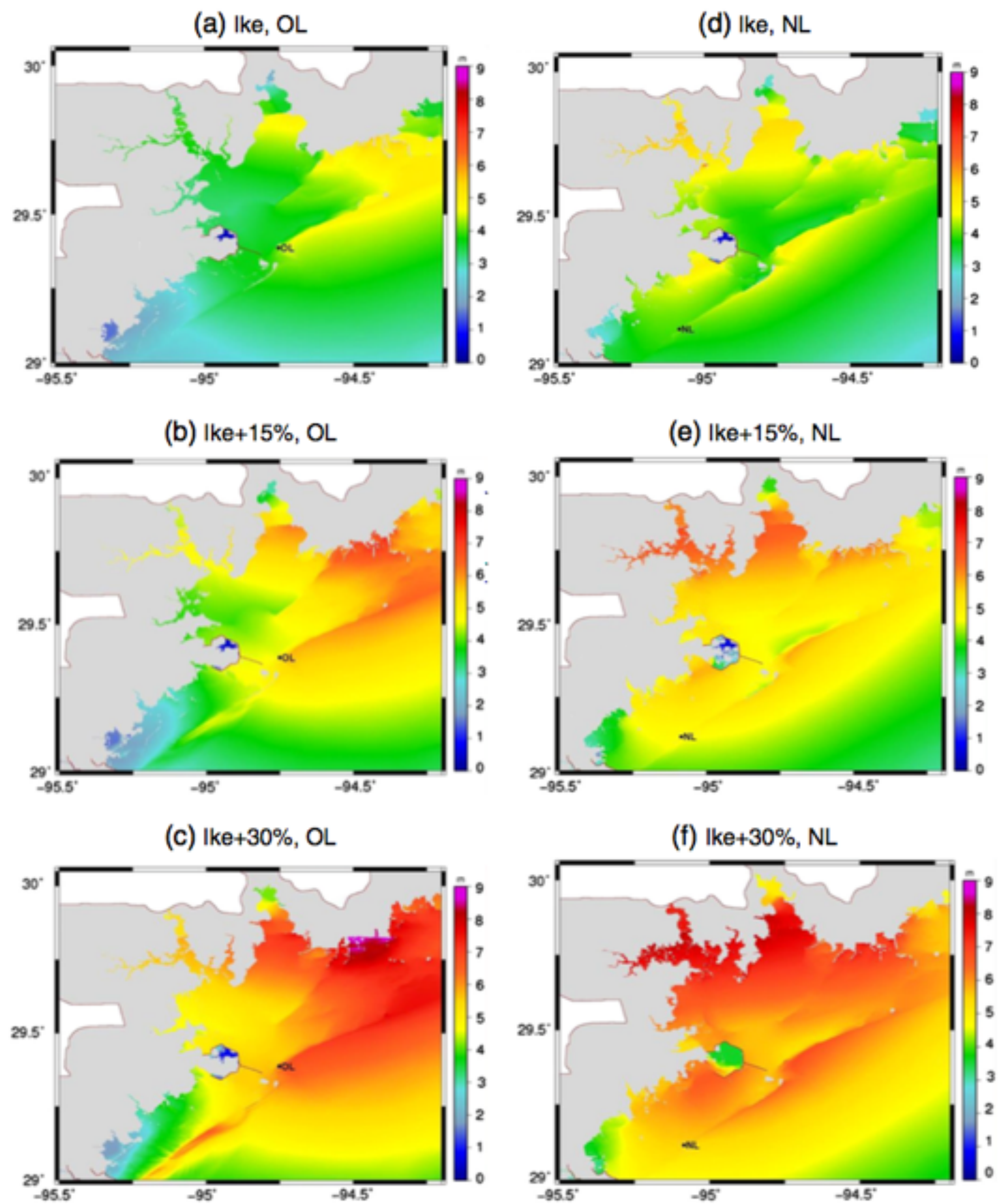


Fig. 9. Maximum water surface elevations from ADCIRC + SWAN for the Hurricane Ike original, +15%, and +30% wind scenarios at the original landfall (OL) and new landfall (NL) locations. a. Ike, OL. b. Ike + 15%, OL. c. Ike + 30%, OL. d. Ike, NL. e. Ike + 15% NL. f. Ike + 30%, NL.

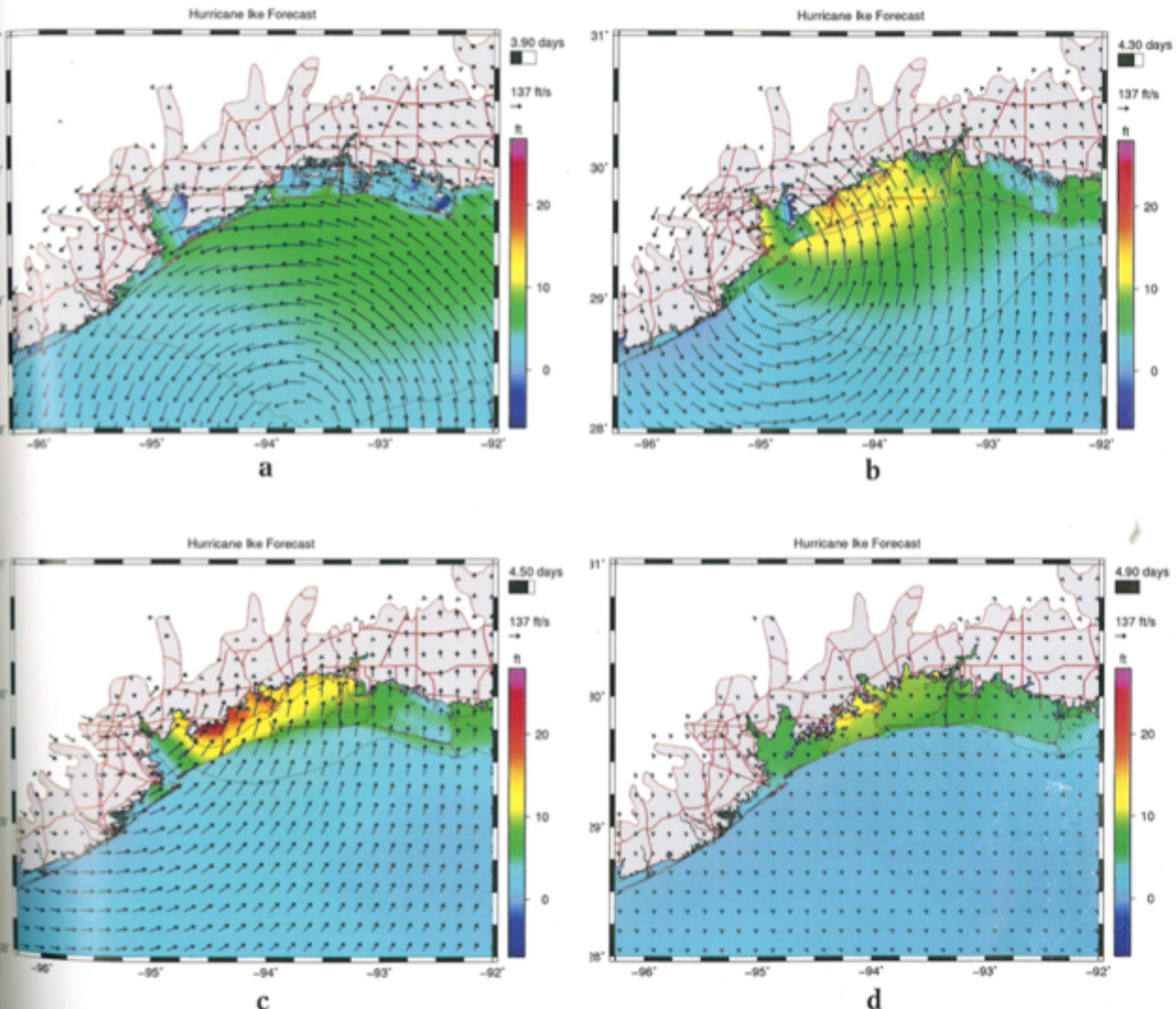
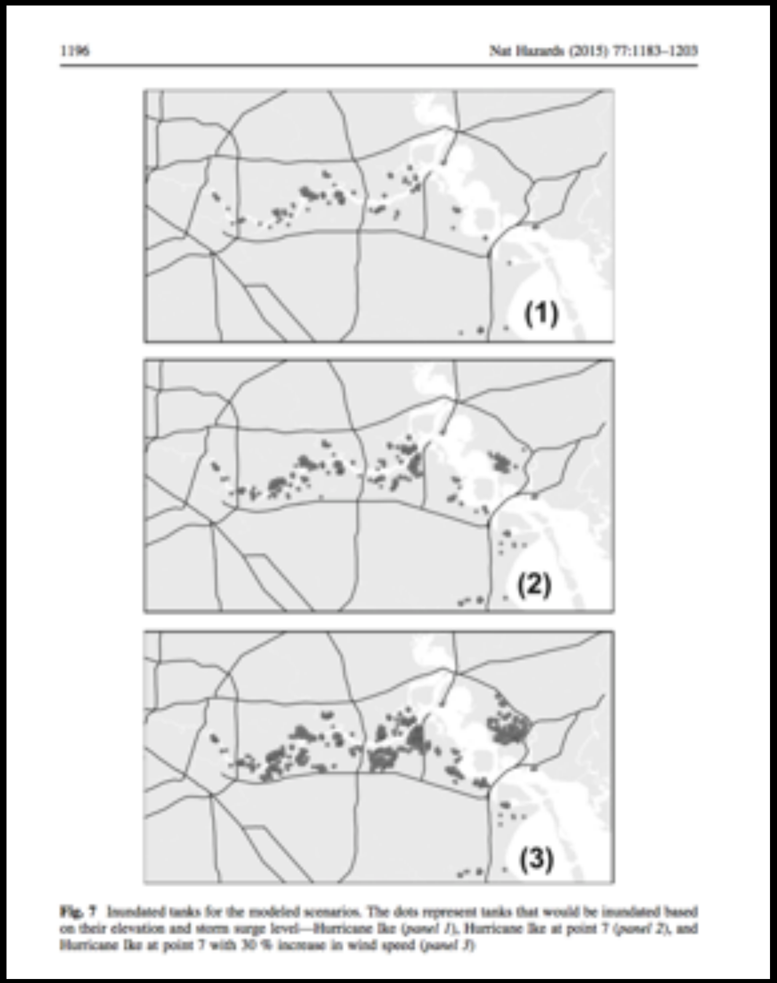


Figure 5.6a–d. The ADCIRC model maps the progression of Hurricane Ike as it makes landfall, showing wind vectors and inundation levels along the Texas coast.

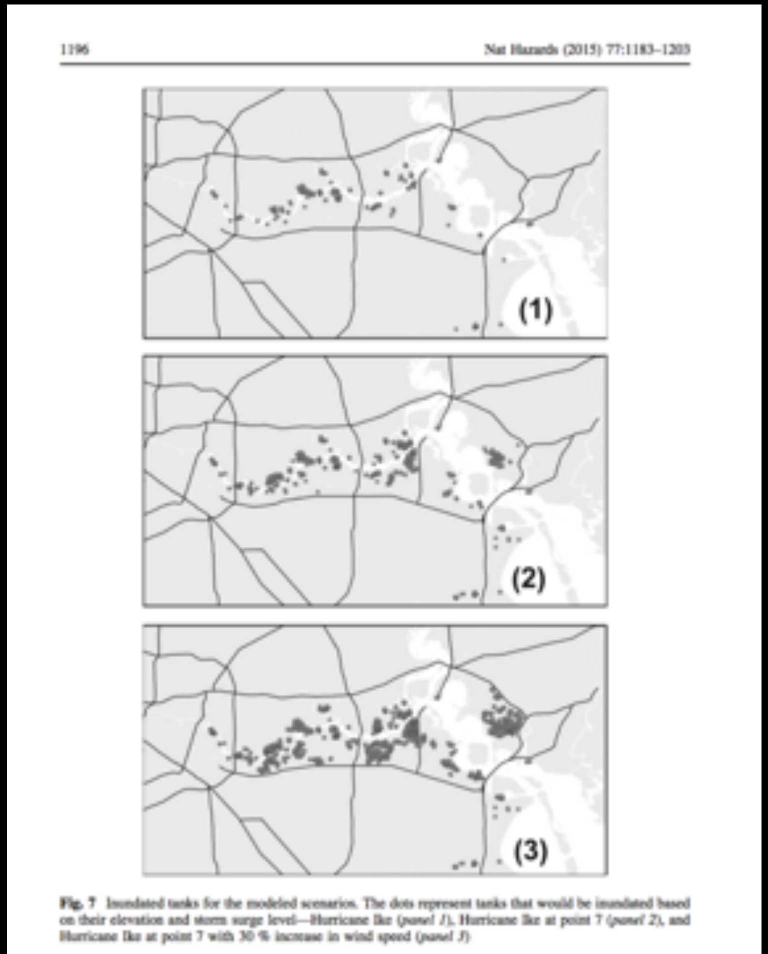


(1)

(2)

(3)

Fig. 7 Inundated tanks for the modeled scenarios. The dots represent tanks that would be inundated based on their elevation and storm surge level—Hurricane Ike (*panel 1*), Hurricane Ike at point 7 (*panel 2*), and Hurricane Ike at point 7 with 30 % increase in wind speed (*panel 3*)



1196 Nat Hazards (2015) 77:1183–1203

(1)

(2)

(3)

Fig. 7 Inundated tanks for the modeled scenarios. The dots represent tanks that would be inundated based on their elevation and storm surge level—Hurricane Ike (*panel 1*), Hurricane Ike at point 7 (*panel 2*), and Hurricane Ike at point 7 with 30 % increase in wind speed (*panel 3*)

FIGURE E-1, MID-BAY GATE STRATEGY

Coastal spine system - interim design report

June 2015

Authors: S.N. Jonkman *(TU Delft)*, K.T. Lendering *(TU Delft)*, E.C. van Berchum *(TU Delft)*, A. Nillesen *(D.efac.to)*, L. Mooyaart *(RHDHV)*, P. de Vries (*RHDHV*), M. van Ledden (*RHDHV*), A. Willems *(Iv Infra)*, R. Nooij *(Iv Infra)*

Date: June 20, 2015

Version: 0.6 (Final Draft)

TU Delft | Iv-Infra | Royal HaskoningDHV Enhancing Society Together | TEXAS A&M UNIVERSITY | Defacto Urban & Landscape design

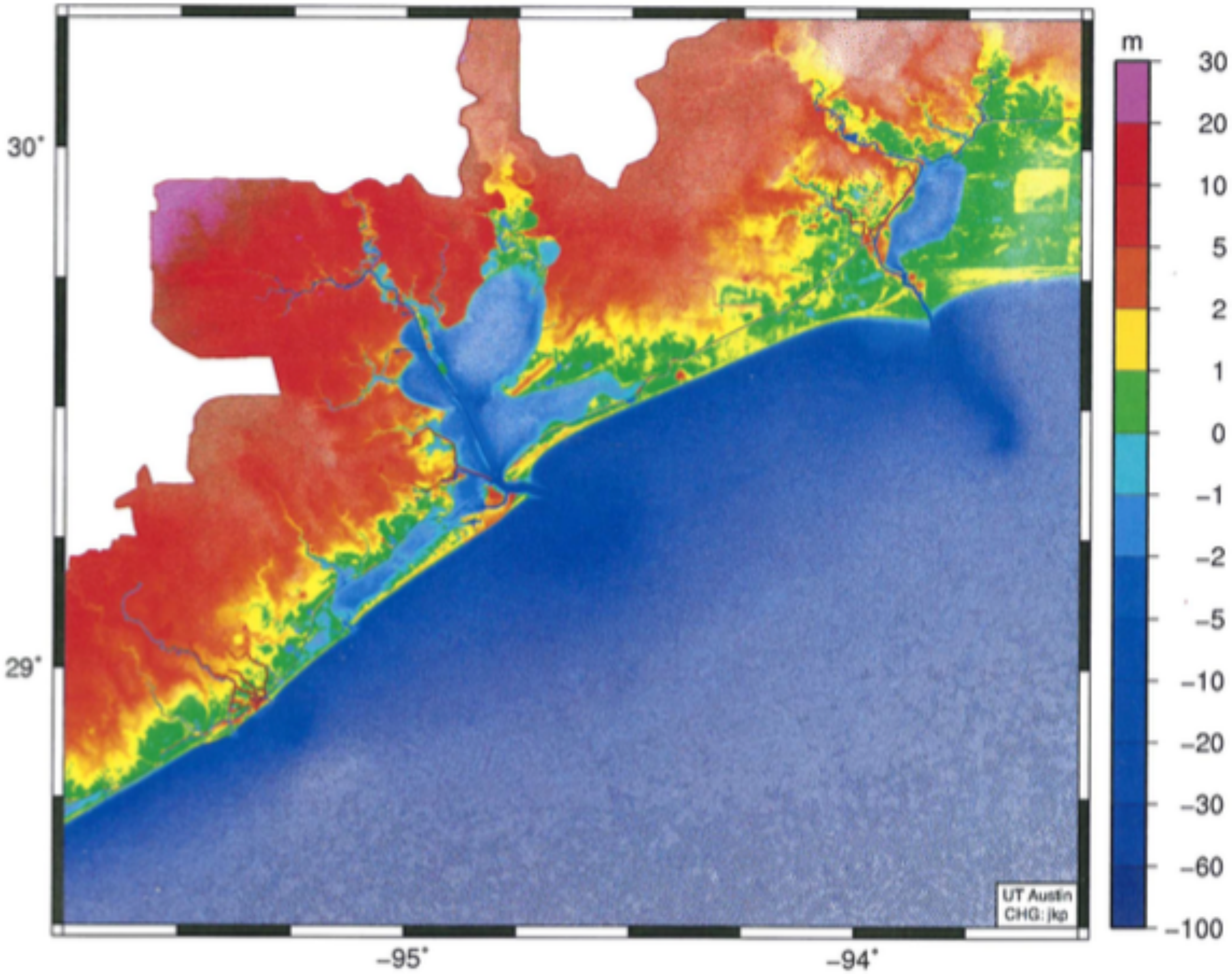
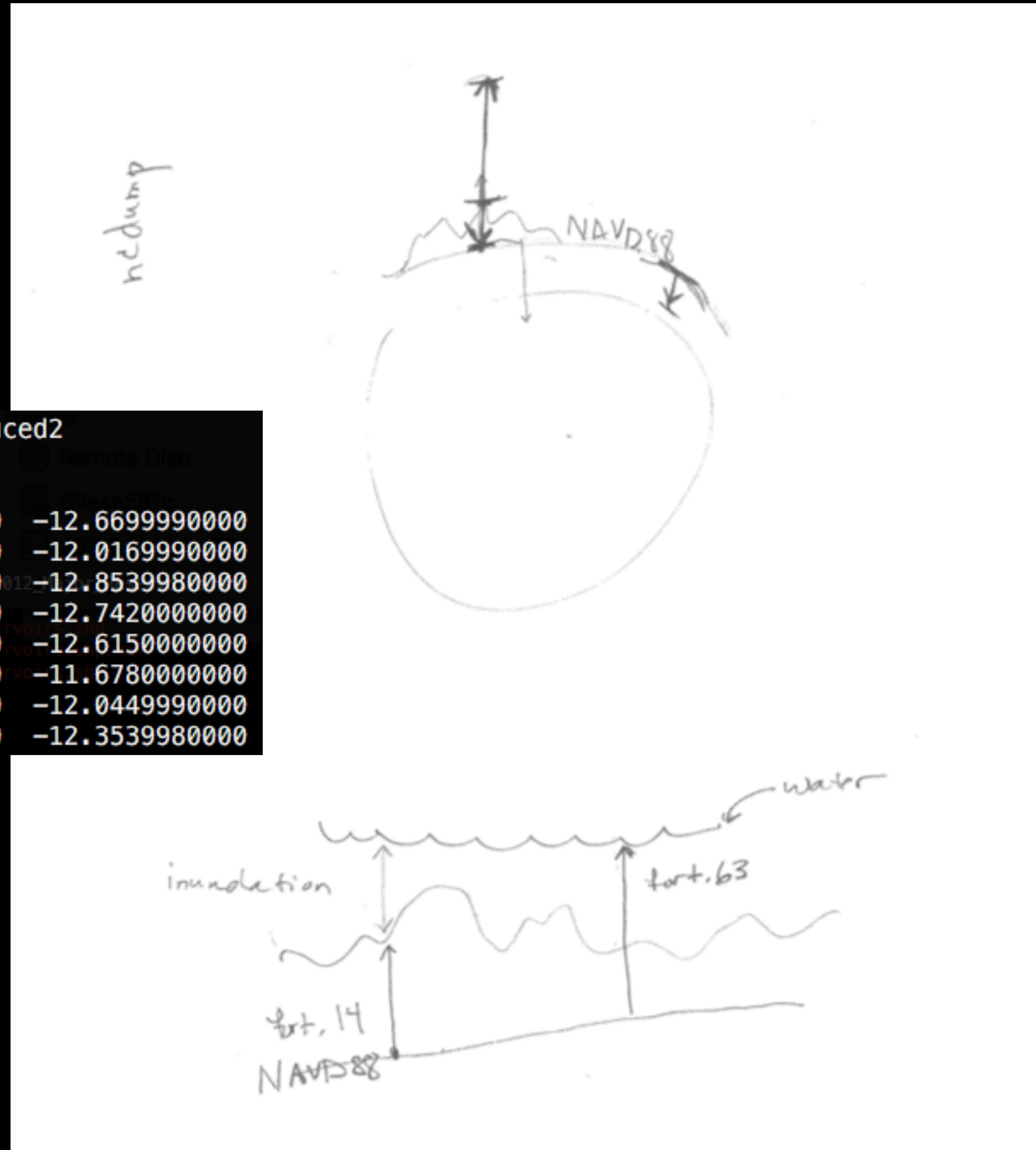


Figure 5.4. The ADCIRC Model Texas Grid.

```
ashaw@iMac-22 ike  $ head -10 fort.14.reduced2
tx2008_r35h
3666307  1846542
        1  -95.2348460000   29.8469070000  -12.6699990000
        2  -95.2344780000   29.8445710000  -12.0169990000
        3  -95.2350320000   29.8485990000  -12.8539980000
        4  -95.2354060000   29.8477430000  -12.7420000000
        5  -95.2356890000   29.8466290000  -12.6150000000
        6  -95.2349510000   29.8436950000  -11.6780000000
        7  -95.2354200000   29.8446890000  -12.0449990000
        8  -95.2347630000   29.8457650000  -12.3539980000
```



Why Isn't Texas Ready for the

https://projects.propublica.org/houston/#hsc

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16 Hours before Landfall | Flood Level | Storm makes landfall

Storm Scenarios: Ike | P7 | P7+15 | 36

Proposed Solutions: Mid-Bay | Spine 1 | Spine 2

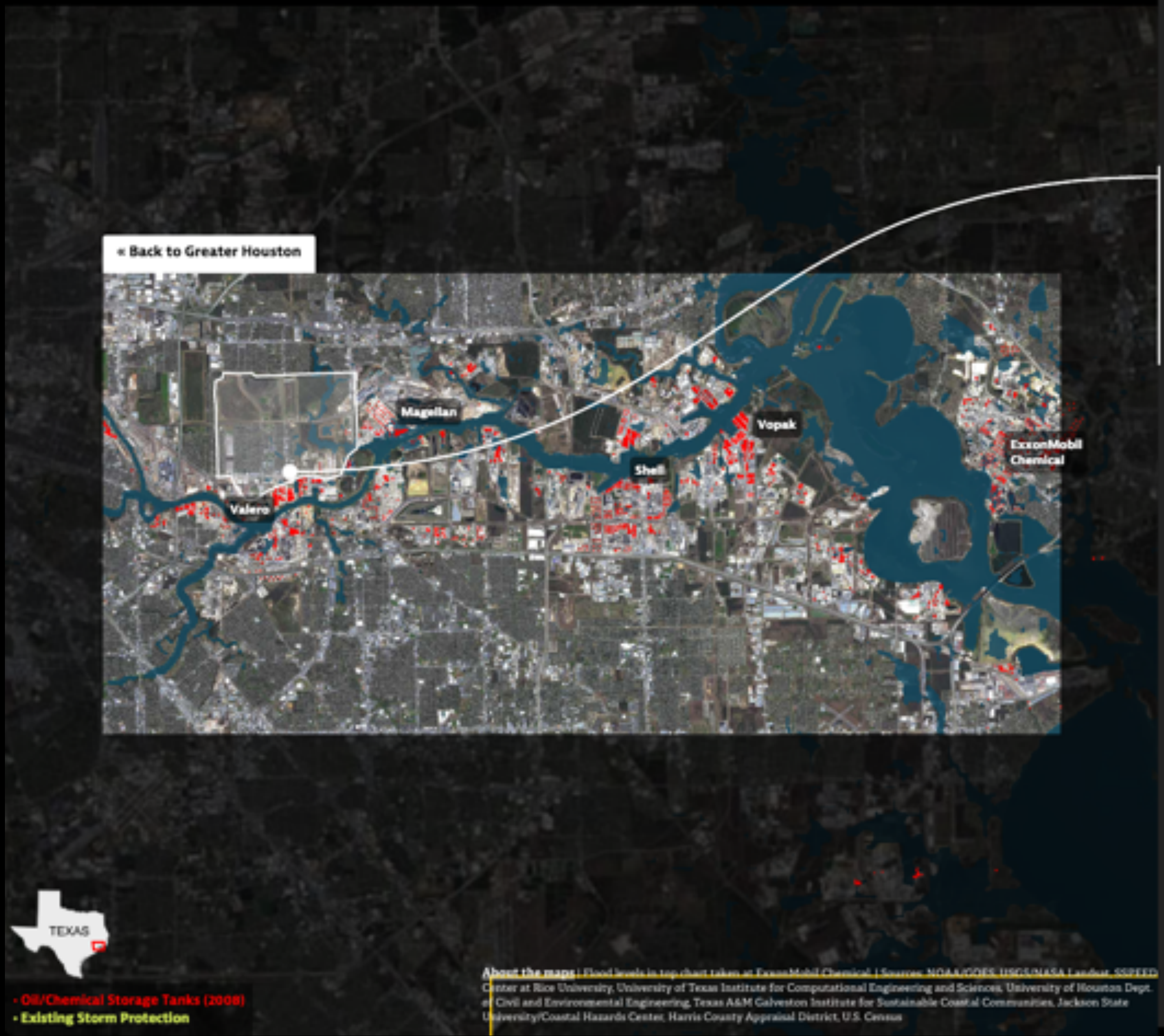
‹ Intro

See flood levels for a location in Houston

Search

Ex: 1000 Tidal Rd, La Porte, TX

« Galveston | Greater Houston | Clear Lake »



About the maps | Flood levels in top chart taken at ExxonMobil Chemical | Sources: NOAA/GOES, USGS/NASA Landsat, SSPEED Center at Rice University, University of Texas Institute for Computational Engineering and Sciences, University of Houston Dept. of Civil and Environmental Engineering, Texas A&M Galveston Institute for Sustainable Coastal Communities, Jackson State University/Coastal Hazards Center, Harris County Appraisal District, U.S. Census

Experts want better protections

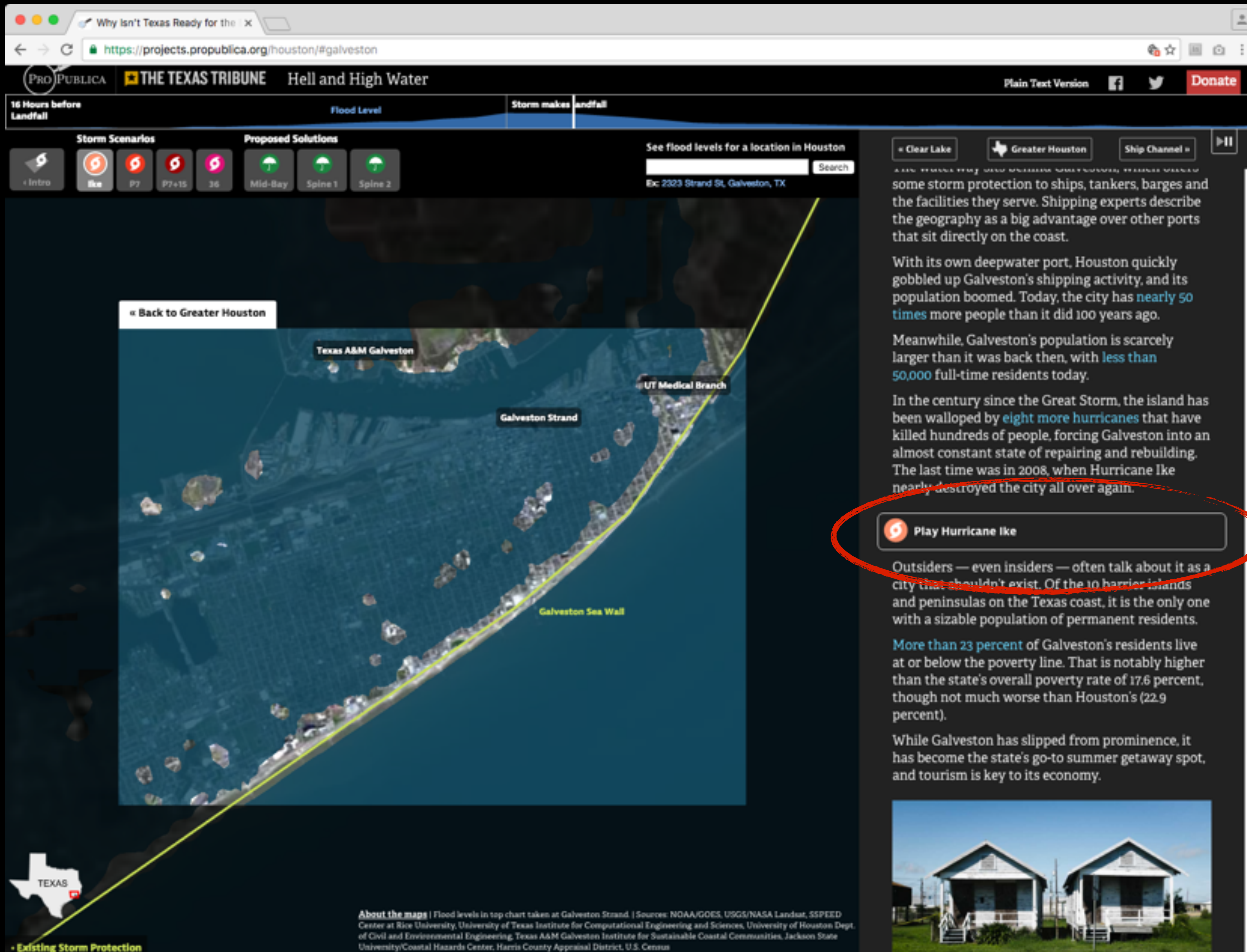
Murphy Oil's tank wasn't the only one to fail in 2005, and it didn't even cause the largest spill; tanks damaged during Hurricanes Katrina and Rita caused more than 8 million gallons of oil to spill in Louisiana, Mississippi and Texas, according to government estimates.

Some tanks on the Houston Ship Channel were even damaged during Hurricane Ike in 2008, though the storm surge was far smaller than originally anticipated. About 15 feet of water covered the eastern part of Magellan Terminals Holdings' oil storage terminal in Galena Park, right on the Ship Channel, the company reported to the Texas Commission on Environmental Quality.

The storm surge and high winds caused damage to several tanks and a spill of nearly 1 million gallons of oil. Some was recovered, but about 300,000 gallons were released into the Ship Channel and "lost at sea," Magellan reported. (The spill didn't appear to impact any homes or businesses in Galena Park.)

"As a community, it would be good if we could come together and have a discussion about" the issue of storage tank safety, said Deer Park resident Jana Pellusch, who has worked at Shell since 2004. *(Edmund D. Fountain/ProPublica/Texas Tribune)*

Asked about its hurricane preparedness, Magellan spokesman Bruce Heine said that the company has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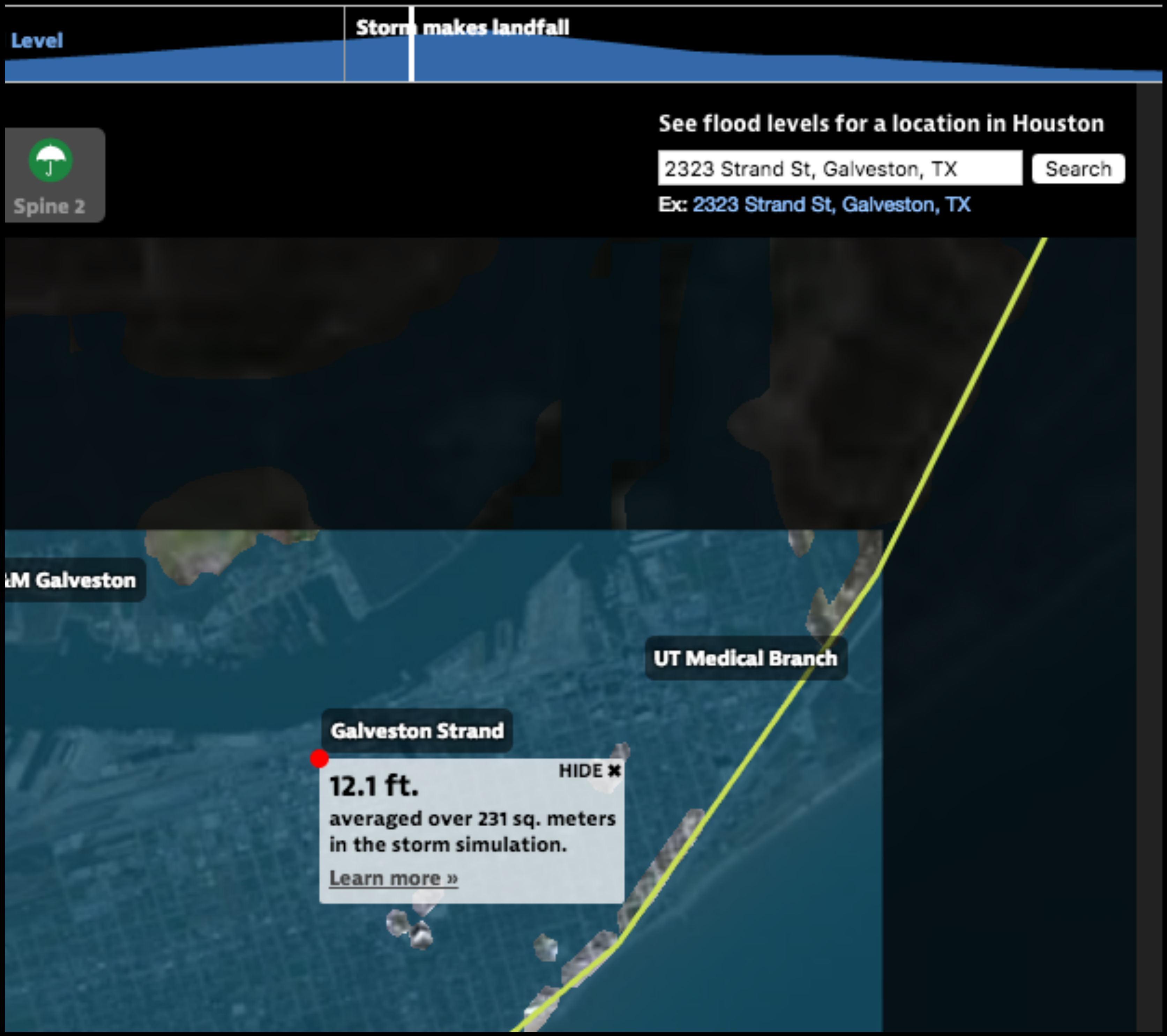
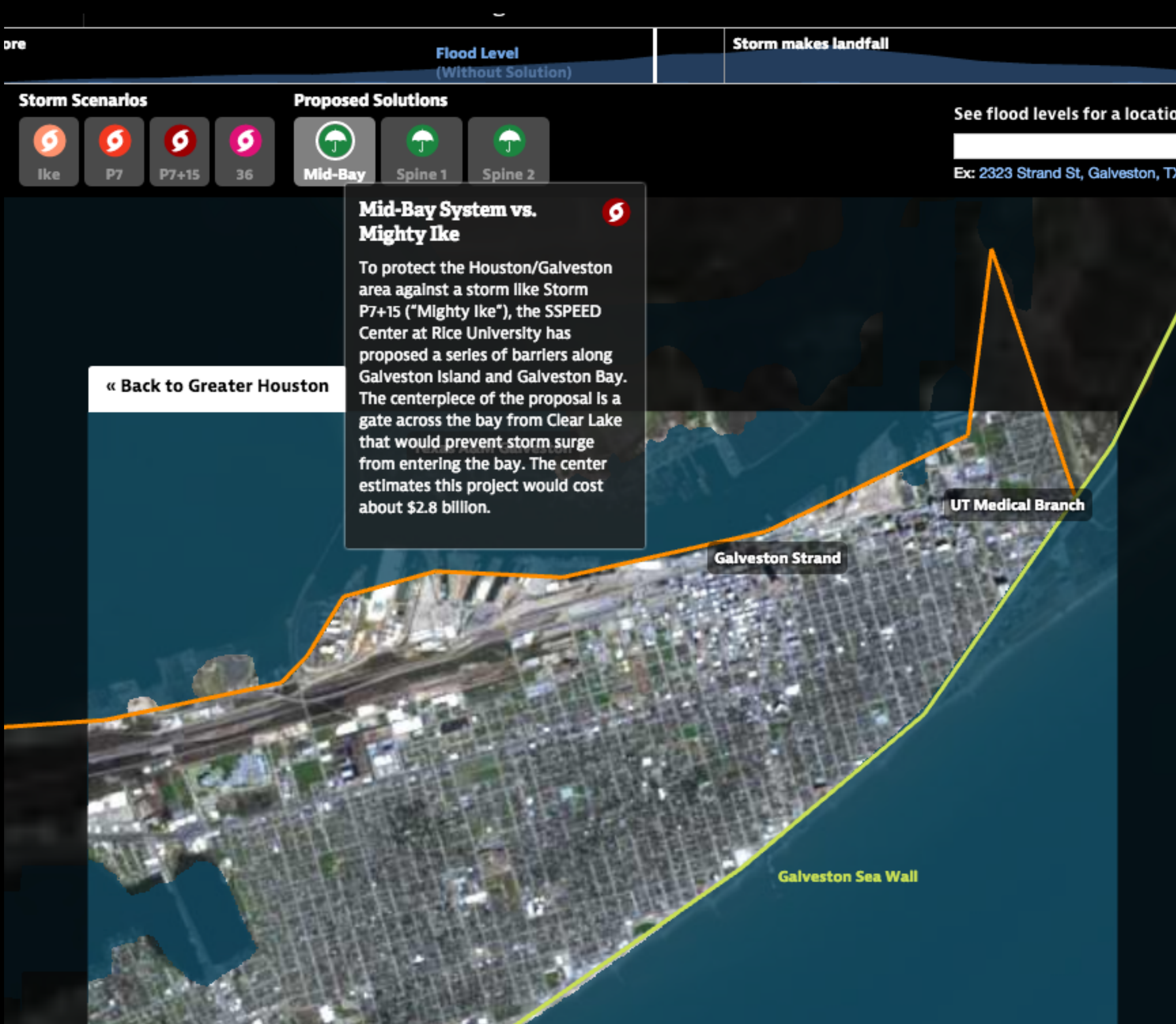
16 Hours before Landfall
Flood Level
Storm makes landfall
Storm Scenarios
Proposed Solutions
Intro
Ike
P7
P7+15
36
Mid-Bay
Spine 1
Spine 2
See flood levels for a location in Houston
Search
Ex: 2323 Strand St, Galveston, TX
« Clear Lake
Greater Houston
Ship Channel »
« Back to Greater Houston
Texas A&M Galveston
UT Medical Branch
Galveston Strand
Galveston Sea Wall
TEXAS
Existing Storm Protection
some storm protection to ships, tankers, barges and the facilities they serve. Shipping experts describe the geography as a big advantage over other ports that sit directly on the coast.
With its own deepwater port, Houston quickly gobbled up Galveston's shipping activity, and its population boomed. Today, the city has nearly 50 times more people than it did 100 years ago.
Meanwhile, Galveston's population is scarcely larger than it was back then, with less than 50,000 full-time residents today.
In the century since the Great Storm, the island has been walloped by eight more hurricanes that have killed hundreds of people, forcing Galveston into an almost constant state of repairing and rebuilding. The last time was in 2008, when Hurricane Ike nearly destroyed the city all over again.
Play Hurricane Ike
Outsiders — even insiders — often talk about it as a city that shouldn't exist. Of the 10 barrier islands and peninsulas on the Texas coast, it is the only one with a sizable population of permanent residents.
More than 23 percent of Galveston's residents live at or below the poverty line. That is notably higher than the state's overall poverty rate of 17.6 percent, though not much worse than Houston's (22.9 percent).
While Galveston has slipped from prominence, it has become the state's go-to summer getaway spot, and tourism is key to its economy.

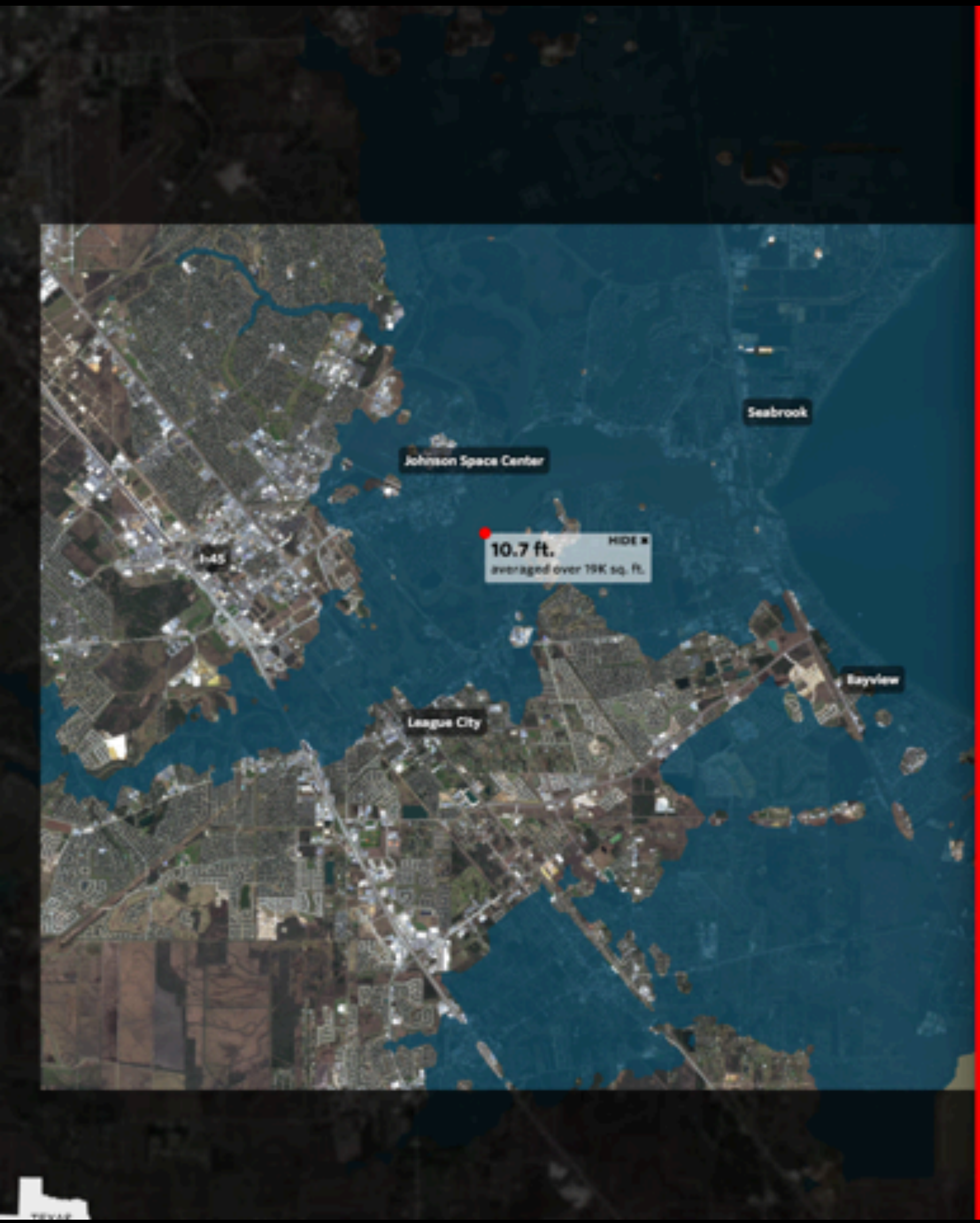
ligh Water

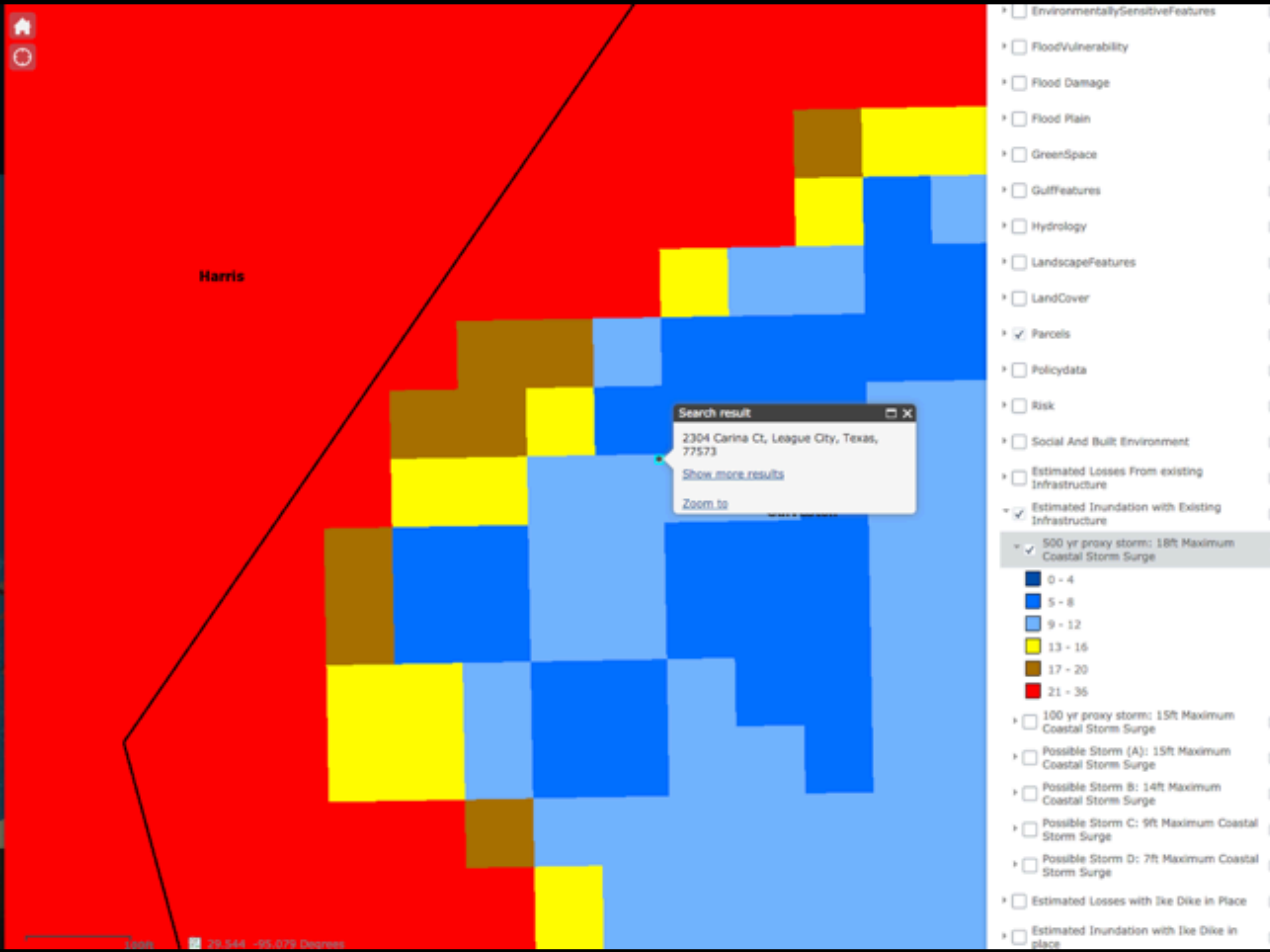


Level
Storm makes landfall
Spine 2
See flood levels for a location in Houston
2323 Strand St, Galveston, TX
Search
Ex: 2323 Strand St, Galveston, TX
&M Galveston
UT Medical Branch
Galveston Strand
HIDE ✖
12.1 ft.
averaged over 231 sq. meters in the storm simulation.
Learn more »



Flood Level
(Without Solution)
Storm makes landfall
Storm Scenarios
Ike
P7
P7+15
36
Proposed Solutions
Mid-Bay
Spine 1
Spine 2
See flood levels for a location
Ex: 2323 Strand St, Galveston, TX
Mid-Bay System vs. Mighty Ike
To protect the Houston/Galveston area against a storm like Storm P7+15 ("Mighty Ike"), the SSPEED Center at Rice University has proposed a series of barriers along Galveston Island and Galveston Bay. The centerpiece of the proposal is a gate across the bay from Clear Lake that would prevent storm surge from entering the bay. The center estimates this project would cost about $2.8 billion.
« Back to Greater Houston
UT Medical Branch
Galveston Strand
Galveston Sea Wall


Seabrook
Johnson Space Center
I-45
10.7 ft.
HIDE ×
averaged over 19K sq. ft.
Bayview
League City

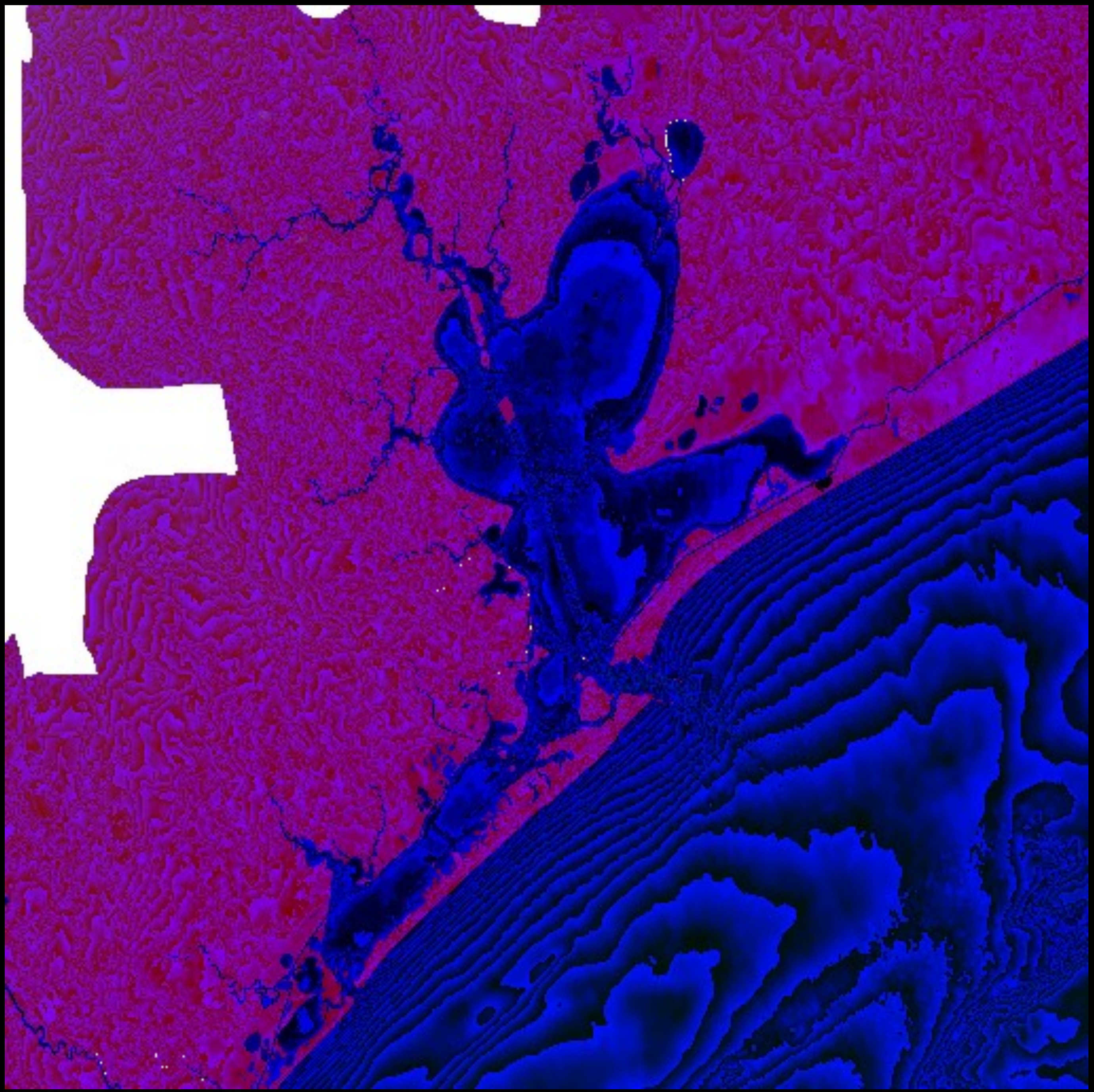

Harris
Search result
2304 Carina Ct, League City, Texas, 77573
Show more results
Zoom to
EnvironmentallySensitiveFeatures
FloodVulnerability
Flood Damage
Flood Plain
GreenSpace
GulfFeatures
Hydrology
LandscapeFeatures
LandCover
Parcels
Policydata
Risk
Social And Built Environment
Estimated Losses From existing Infrastructure
Estimated Inundation with Existing Infrastructure
500 yr proxy storm: 18ft Maximum Coastal Storm Surge
0 - 4
5 - 8
9 - 12
13 - 16
17 - 20
21 - 36
100 yr proxy storm: 15ft Maximum Coastal Storm Surge
Possible Storm (A): 15ft Maximum Coastal Storm Surge
Possible Storm B: 14ft Maximum Coastal Storm Surge
Possible Storm C: 9ft Maximum Coastal Storm Surge
Possible Storm D: 7ft Maximum Coastal Storm Surge
Estimated Losses with Ike Dike in Place
Estimated Inundation with Ike Dike in place

Storms:

- Hurricane Ike (2008)
- Hurricane Ike @ "point 7"
- Hurricane Ike @ "point 7" +15%
- "Storm 36" (another model)
- Ike-p7+15 with Mid-Bay
- Ike-p7+15 with Spine
- "Storm 36" with Spine

```
ashaw@iMac-22 ike  $ ls -lah | grep fort.63
-rw-r-----@  1 ashaw  staff   4.1G Sep 16  2015 fort.63
```

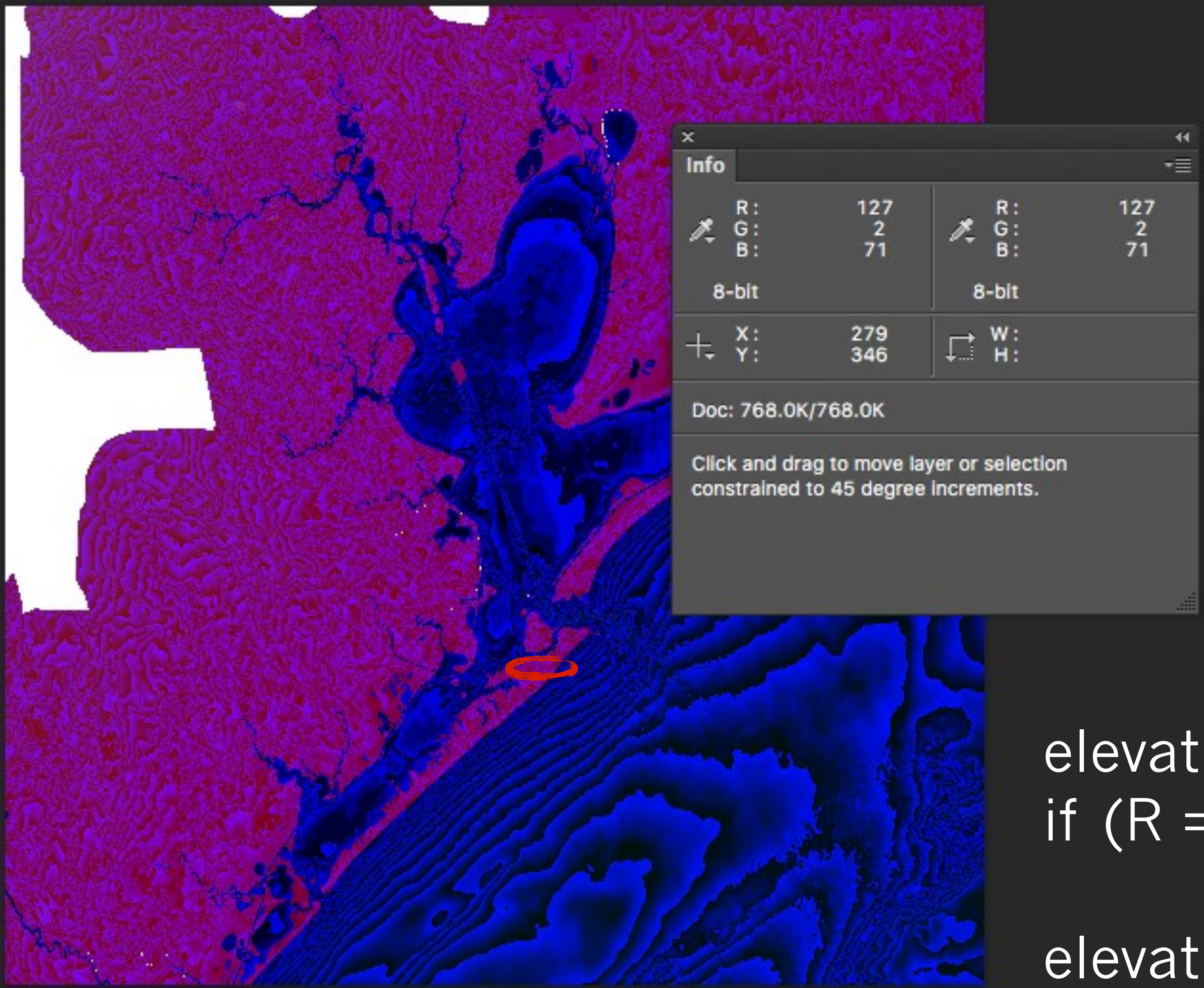
Solution: Images as databases



R = above/below sea level flag
G = depth (before decimal)
B = depth (after decimal)

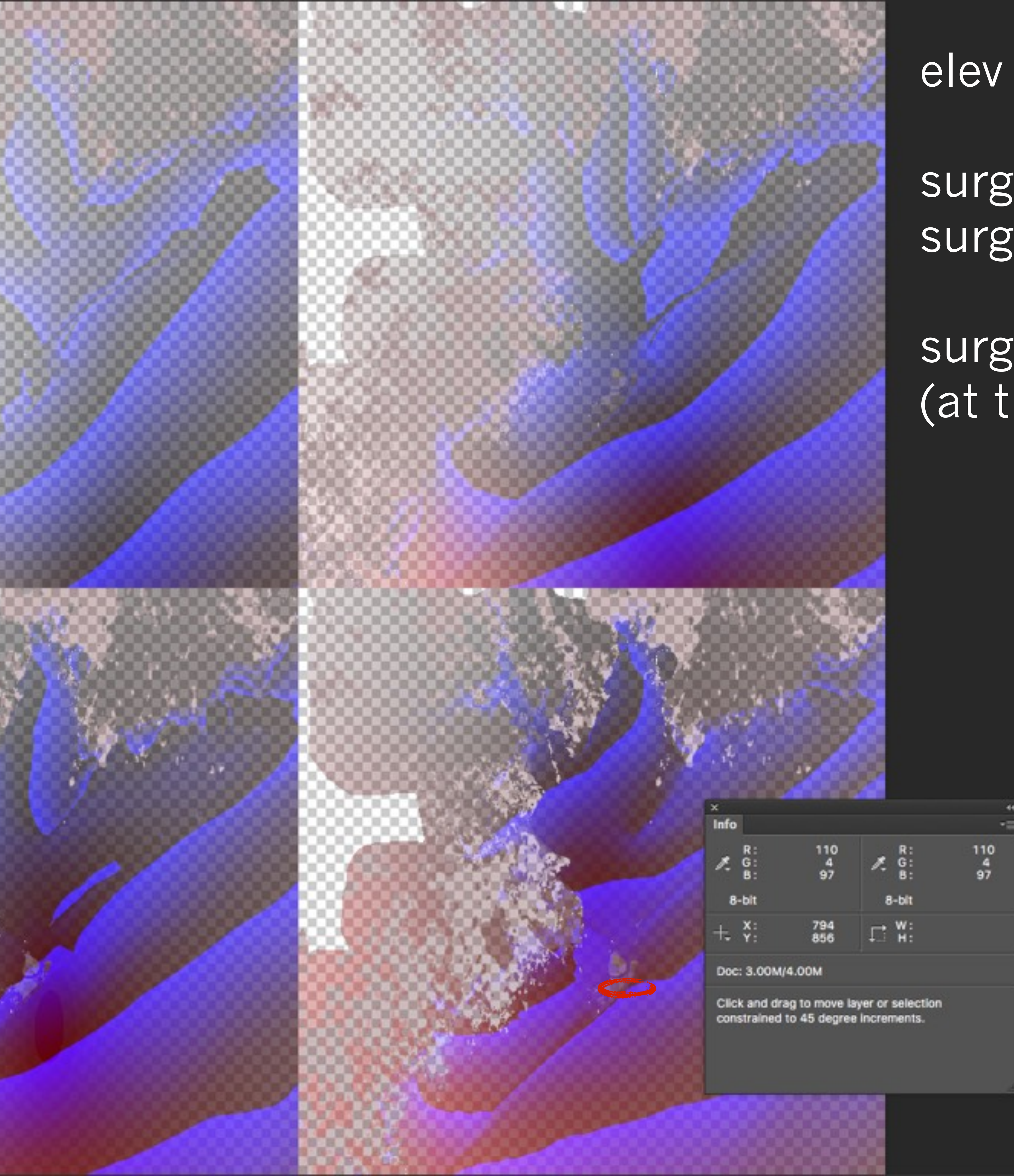
Solution: Images as databases

R = Wind X
A = Wind Y
G = Depth (before decimal)
B = Depth (after decimal)



elevation = G + B / 255
if (R == 0) depth *= -1

elevation = 2.27 meters
above sea level



elev = 2.43 MASL

surge = (G + B / 255) - elev
surge = 4.38 meters

surge = 1.95 MASL
(at this point in the storm)

x 10 (40 hours)
x 7 storms
x 4 AOIs
= 308 images (with grids)

```ruby
VERTEX_SHADER = <<-GLSL
  #version 120

  attribute vec3 position;
  attribute float water_height;
  attribute vec2 wind;
  varying float height;
  varying vec2 w;

  void main() {
    gl_Position = gl_ModelViewProjectionMatrix * vec4(position.xy, 0.0, 1.0);
    height = water_height;
    w = wind;
  }
GLSL

FRAGMENT_SHADER = <<-GLSL
  #version 120
  varying float height;
  varying vec2 w;

  vec4 pack_depth(const float depth, vec2 w) {
    float r, g, b, a;

    r = w.x;
    a = w.y;
    g = floor(abs(depth)) / 255.;
    b = fract(depth);
    return vec4(r, g, b, a);
  }

  void main() {
    gl_FragColor = pack_depth(height, w);
  }
GLSL
```

Pack: Ruby/OpenGL

```glsl
float unpack_depth(const vec4 rgba_depth) {
  float depth = rgba_depth.g * 255.;
  depth = depth + rgba_depth.b;
  if (rgba_depth.r == 0.) {
    depth *= -1.;
  }
  return depth;
}

float unpack_surge(const vec4 data) {
  float depth = data.g * 255.;
  depth = depth + data.b;
  return depth;
}
```

Unpack: JavaScript/WebGL

```
ashaw@iMac-22 ike  $ head -100 fort.63
  BTK NOAA Ike Track - Holland      padcirc 50.71          tx2008_r35h
        72    1846542  0.3600000E+004     7200     1 FileFmtVersion:    1050624
    5.2200000000E+005          1044000
          1    -9.9999000000E+004
          2    -9.9999000000E+004
          3    -9.9999000000E+004
          4    -9.9999000000E+004
          5    -9.9999000000E+004
          6    -9.9999000000E+004
          7    -9.9999000000E+004
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         10    -9.9999000000E+004
         11    -9.9999000000E+004
```

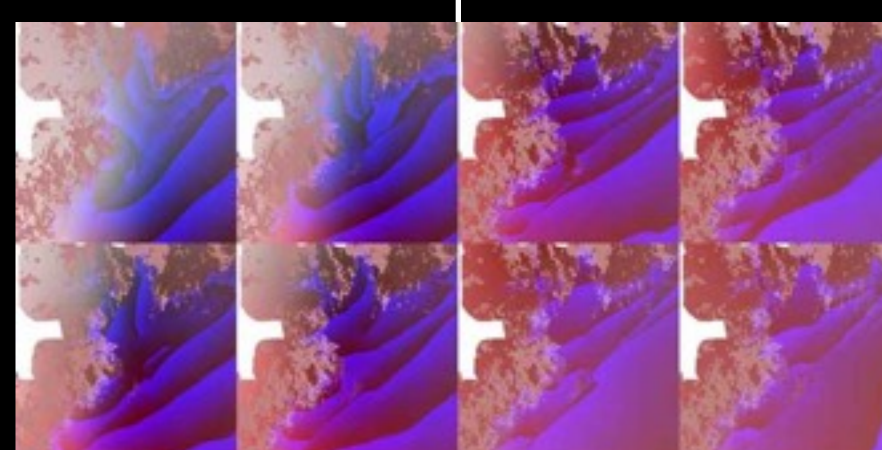

Why Isn't Texas Ready for the

https://projects.propublica.org/houston/

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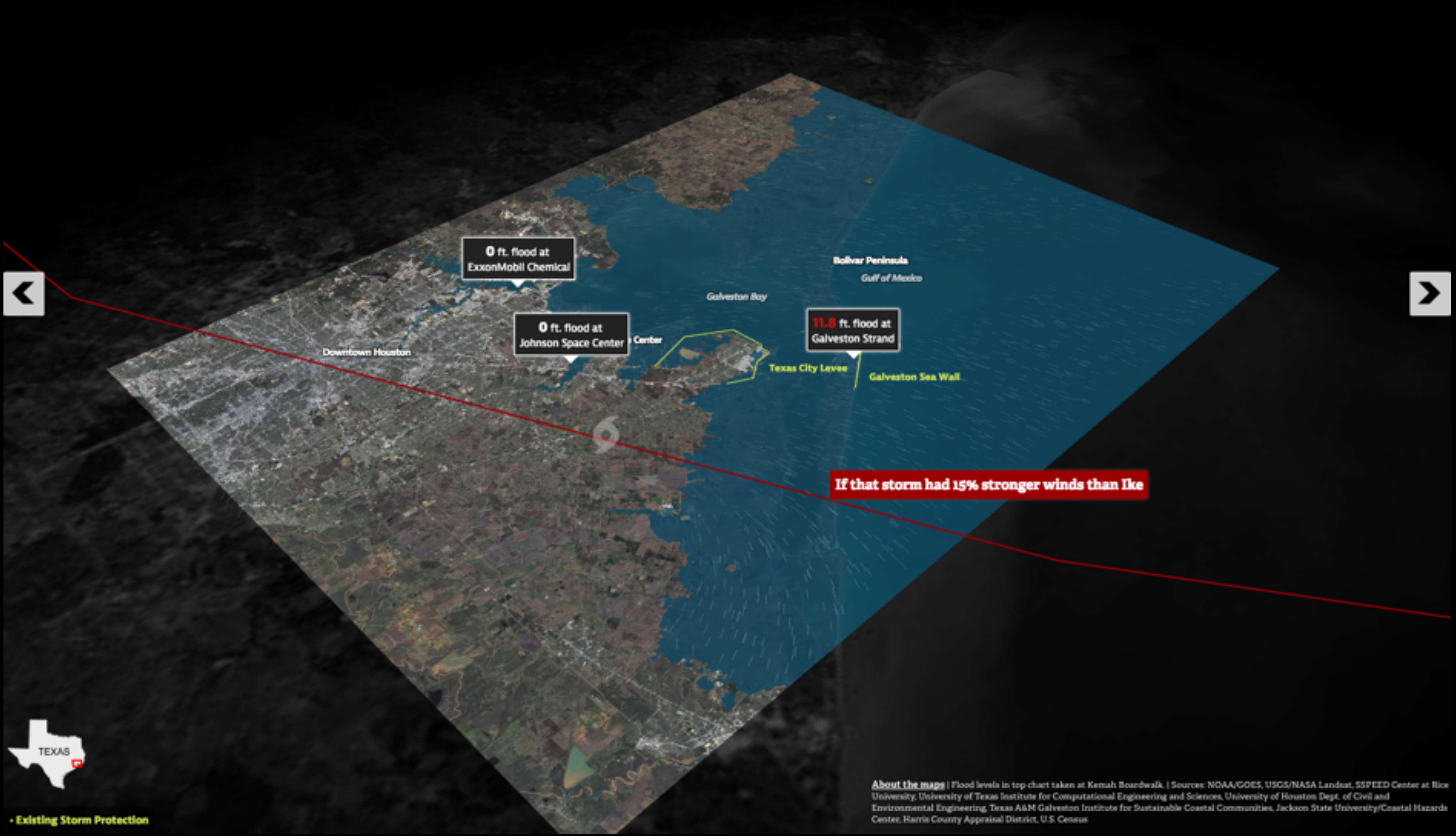
16 Hours before Landfall | Flood Level | Storm makes landfall

...if that storm had been stronger, it would have devastated the Ship Channel, killed thousands, and crippled the economy.



• Existing Storm Protection

About the maps | Flood levels in top chart taken at Kemah Boardwalk. | Sources: NOAA/GOES, USGS/NASA Landsat, SSPEED Center at Rice University, University of Texas Institute for Computational Engineering and Sciences, University of Houston Dept. of Civil and Environmental Engineering, Texas A&M Galveston Institute for Sustainable Coastal Communities, Jackson State University/Coastal Hazards Center, Harris County Appraisal District, U.S. Census

HELL AND HIGH WATER

Sen. Cornyn Files Bill to Speed Texas Hurricane Study

The Texas senator has proposed a bill to speed up the process of protecting Houston from a devastating hurricane.

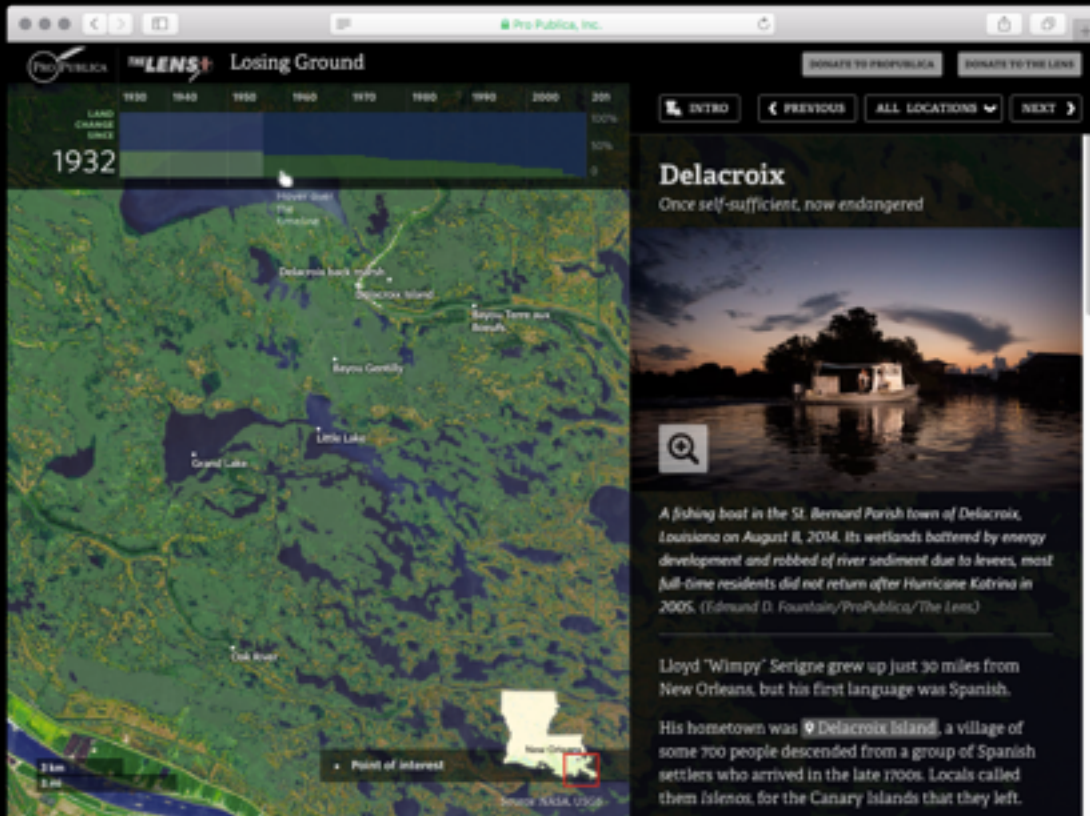
by **ProPublica**, April 28, 2016, 2:30 p.m. EDT

HELL AND HIGH WATER

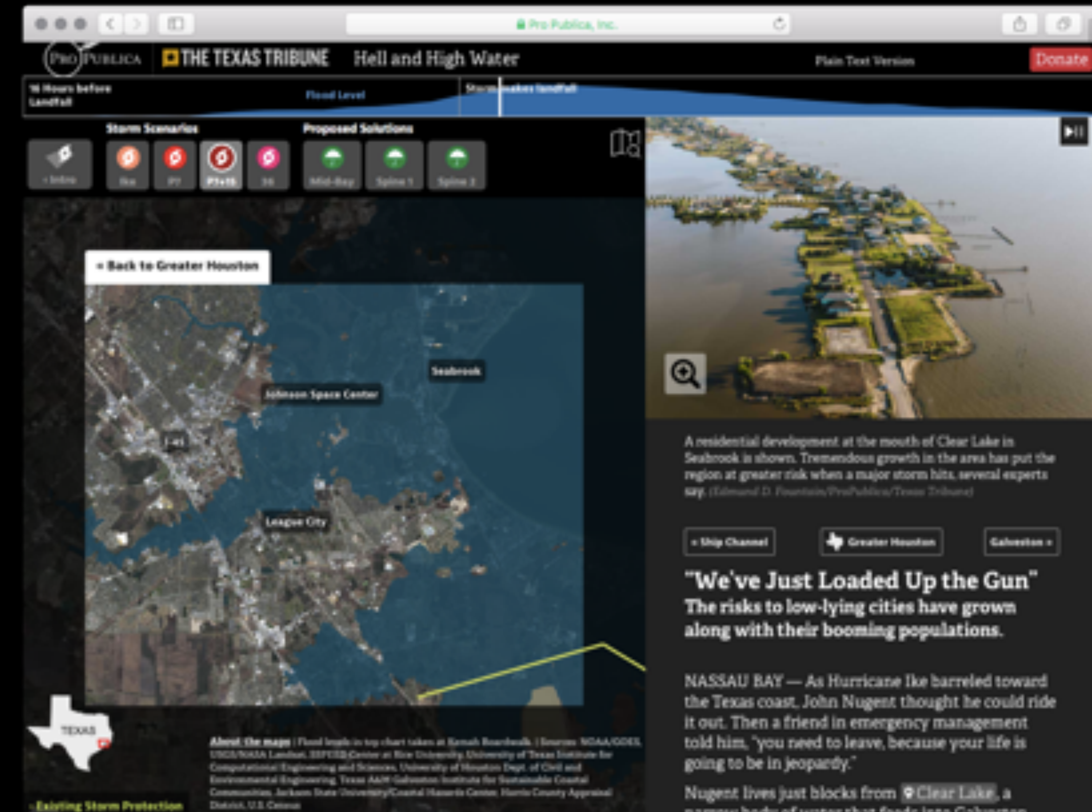
U.S. Rep. Weber Says He'll Work on Bill to Speed Hurricane Protection Plan

The Texas Republican will introduce a companion to a Senate bill filed this week seeking to expedite a hurricane protection plan for Houston.

by **ProPublica**, April 29, 2016, 4:20 p.m. EDT



2014



2016

- National newsroom's interactive chops
- Local newsroom's domain knowledge
- Relationships with researchers

Thank you!

Al Shaw
al.shaw@propublica.org @A_L