



Hurricane Storm Surge Vulnerability

Bob Humple

Assistant Director

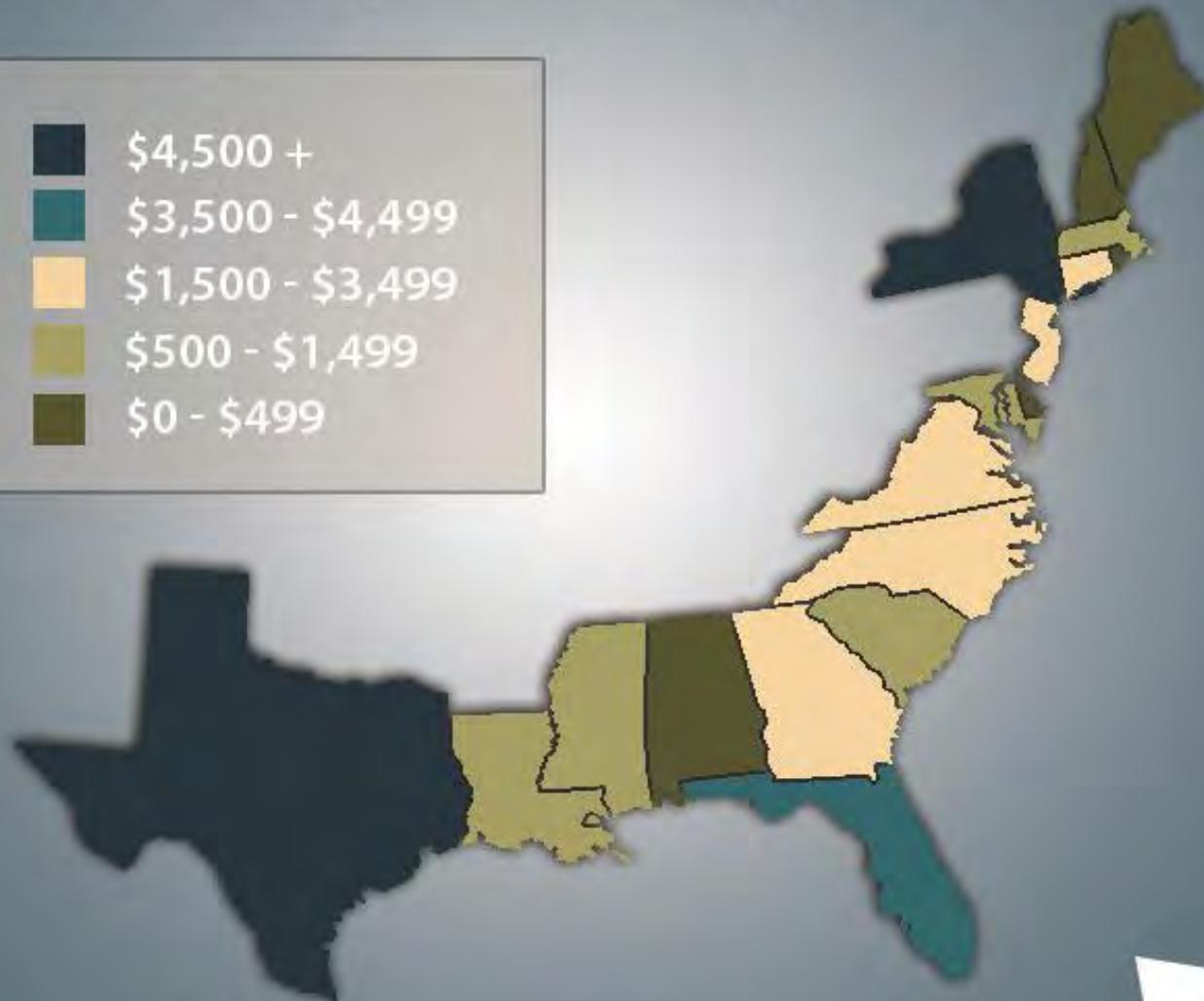
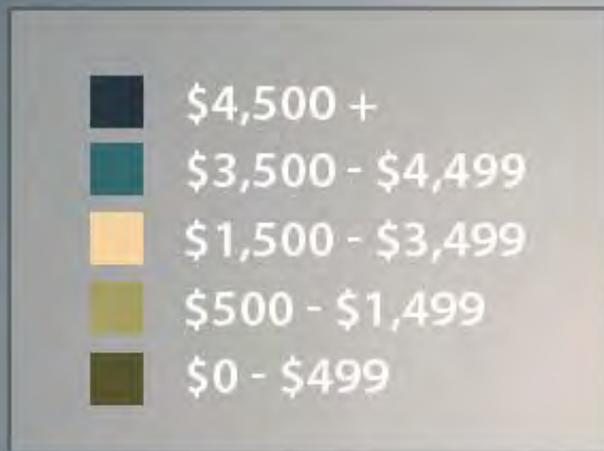
**Broward County
Emergency Management Division**

The Hazards of a Hurricane

- 1. Wind**
- 2. Rainfall and Flooding**
- 3. Storm Surge***
- 4. Tornadoes**

** Storm Surge kills more people than any other hurricane peril*

Estimated 2012 Insured Value of Coastal Properties by State (\$B)



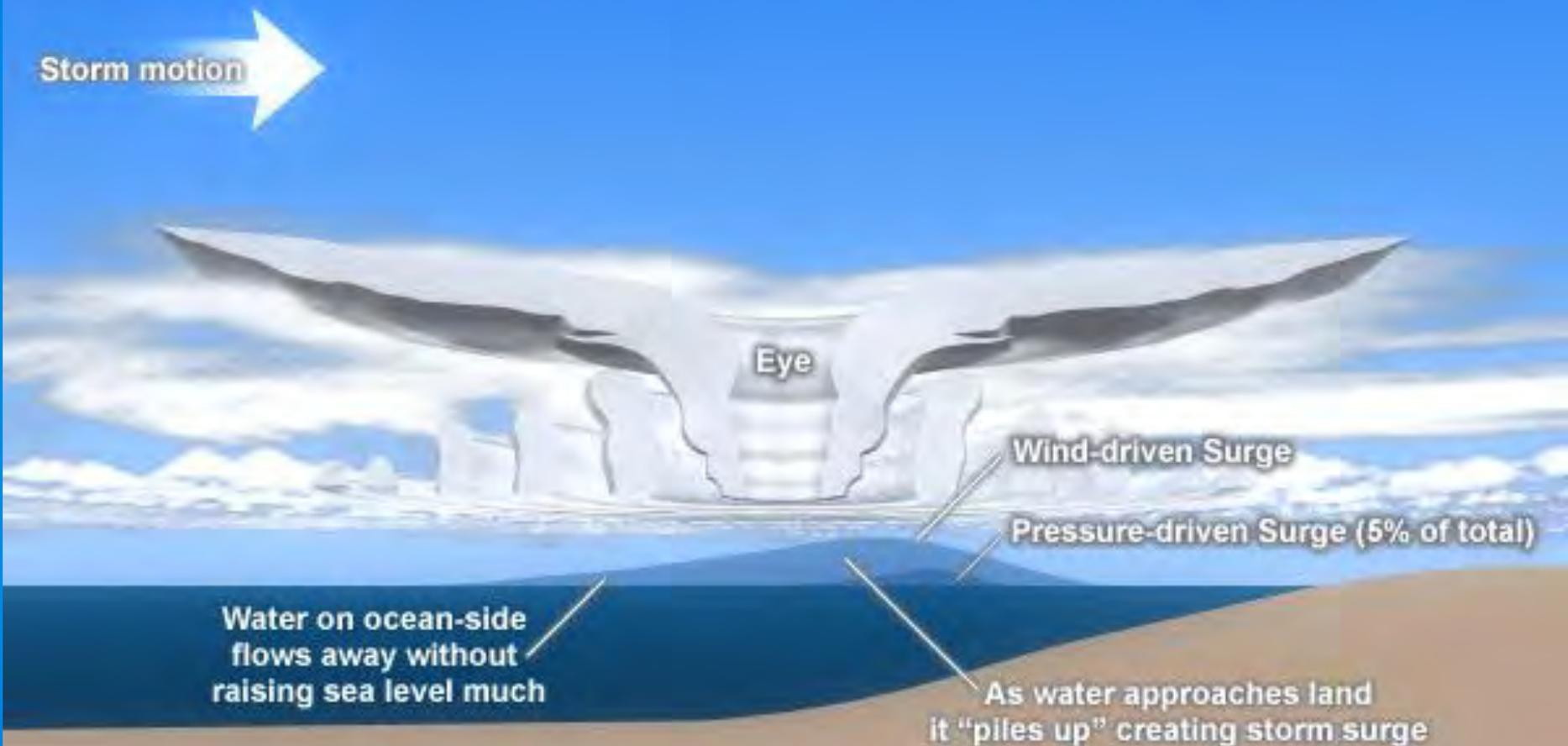
Source: AIR Worldwide

Factors Affecting Storm Surge

- Intensity
- Central pressure
- Forward speed
- Size
- Angle of approach
- Width and slope of continental shelf
- Local coastal features

Wind and Pressure Components of Hurricane Storm Surge

Storm motion



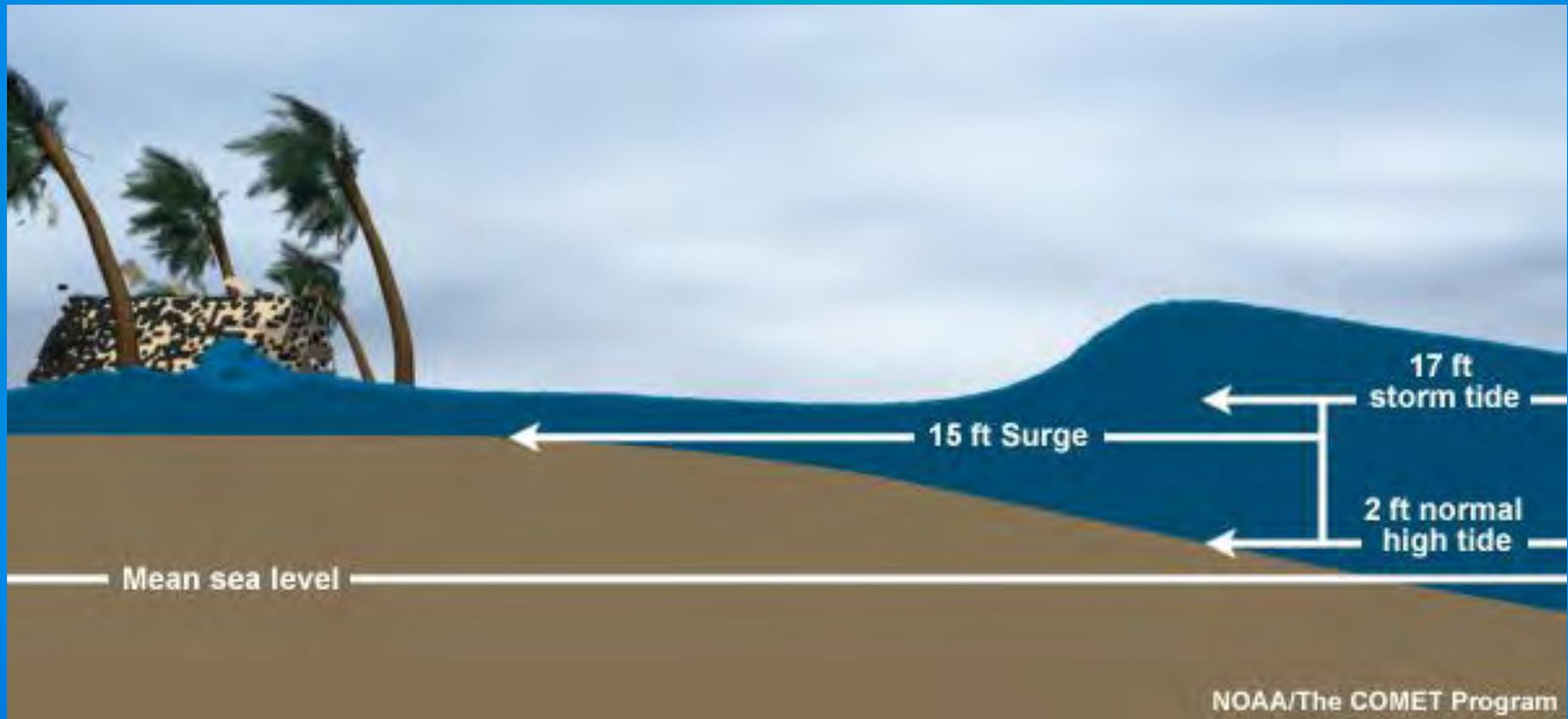
Water on ocean-side
flows away without
raising sea level much

Wind-driven Surge

Pressure-driven Surge (5% of total)

As water approaches land
it "piles up" creating storm surge

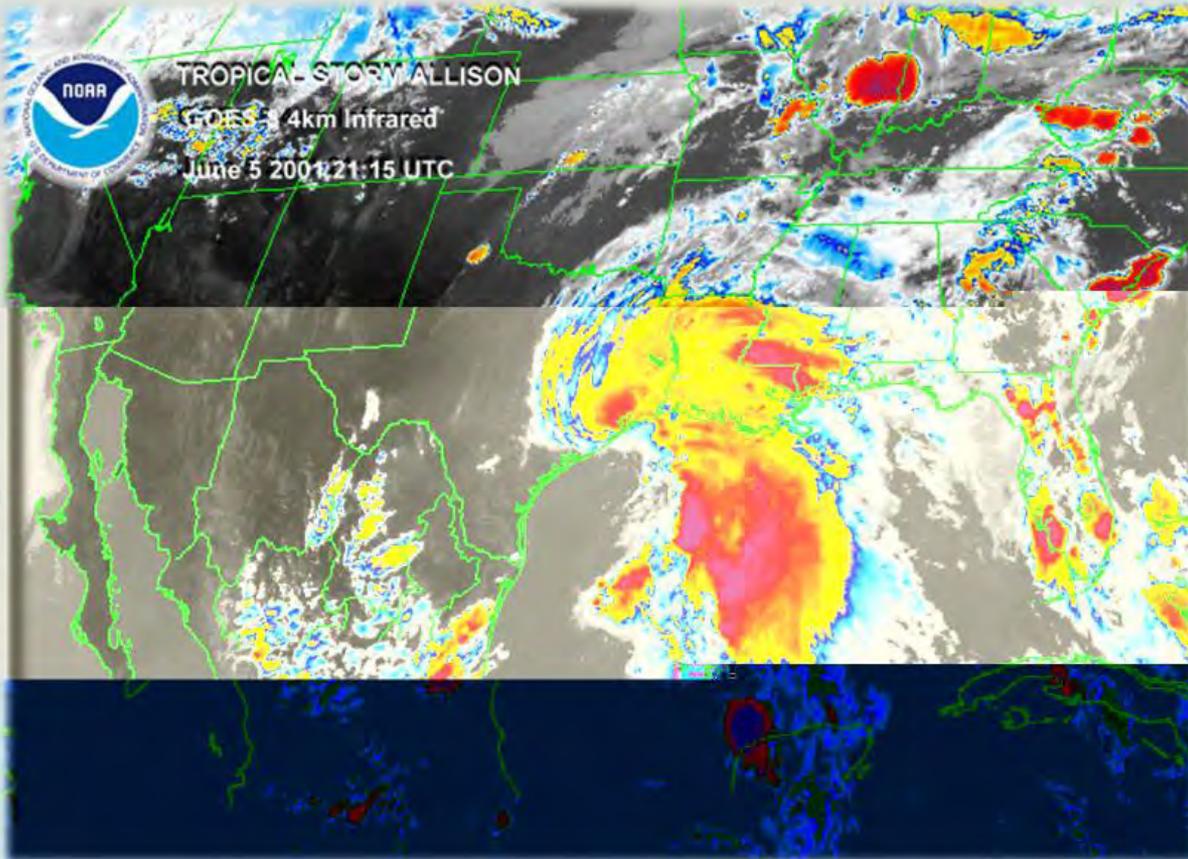
Storm Surge vs Storm Tide



Top 5 Most Vulnerable U.S. Cities

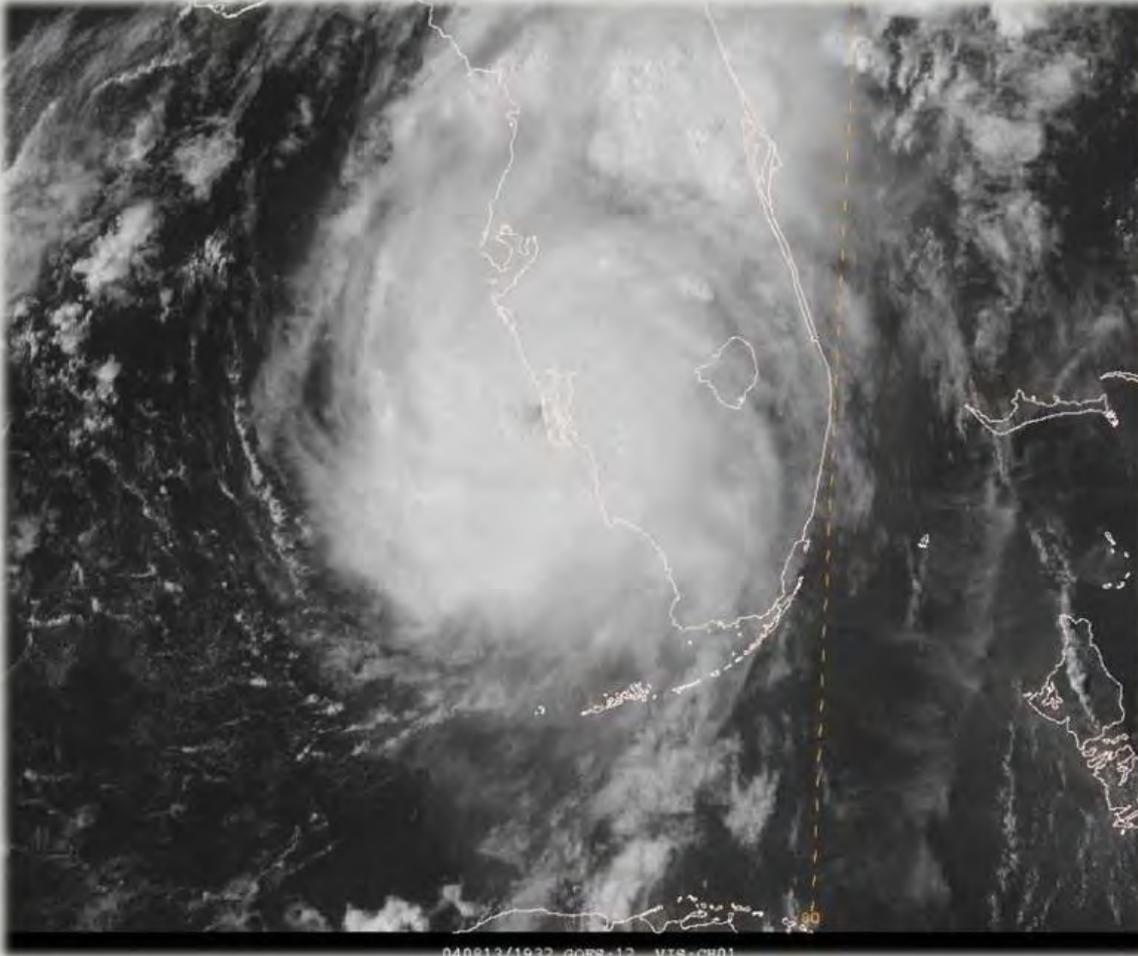
- Tampa/St. Petersburg
- Miami
- New Orleans
- Norfolk/ Virginia Beach
- Houston/Galveston

Allison 2001



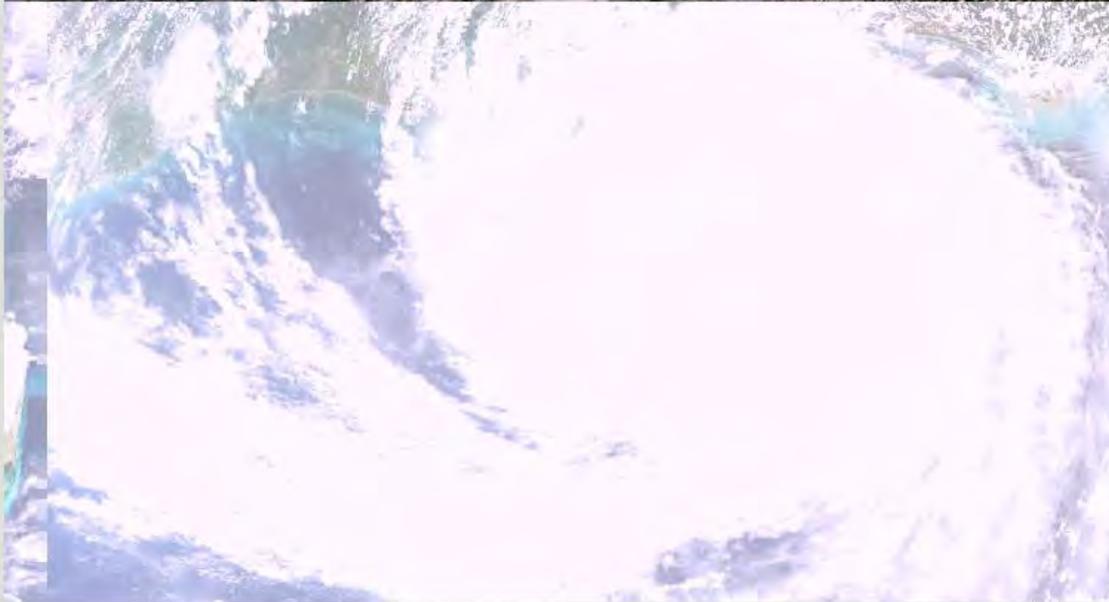
Minimal tropical storm, but slow moving =
copious amounts of rain

Charley 2004



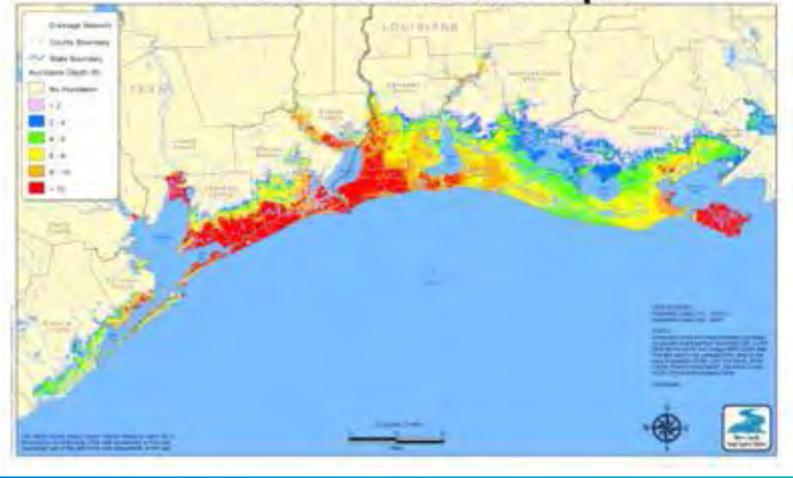
Compact category 4 hurricane =
Incredible wind damage, but little surge

Isaac 2012

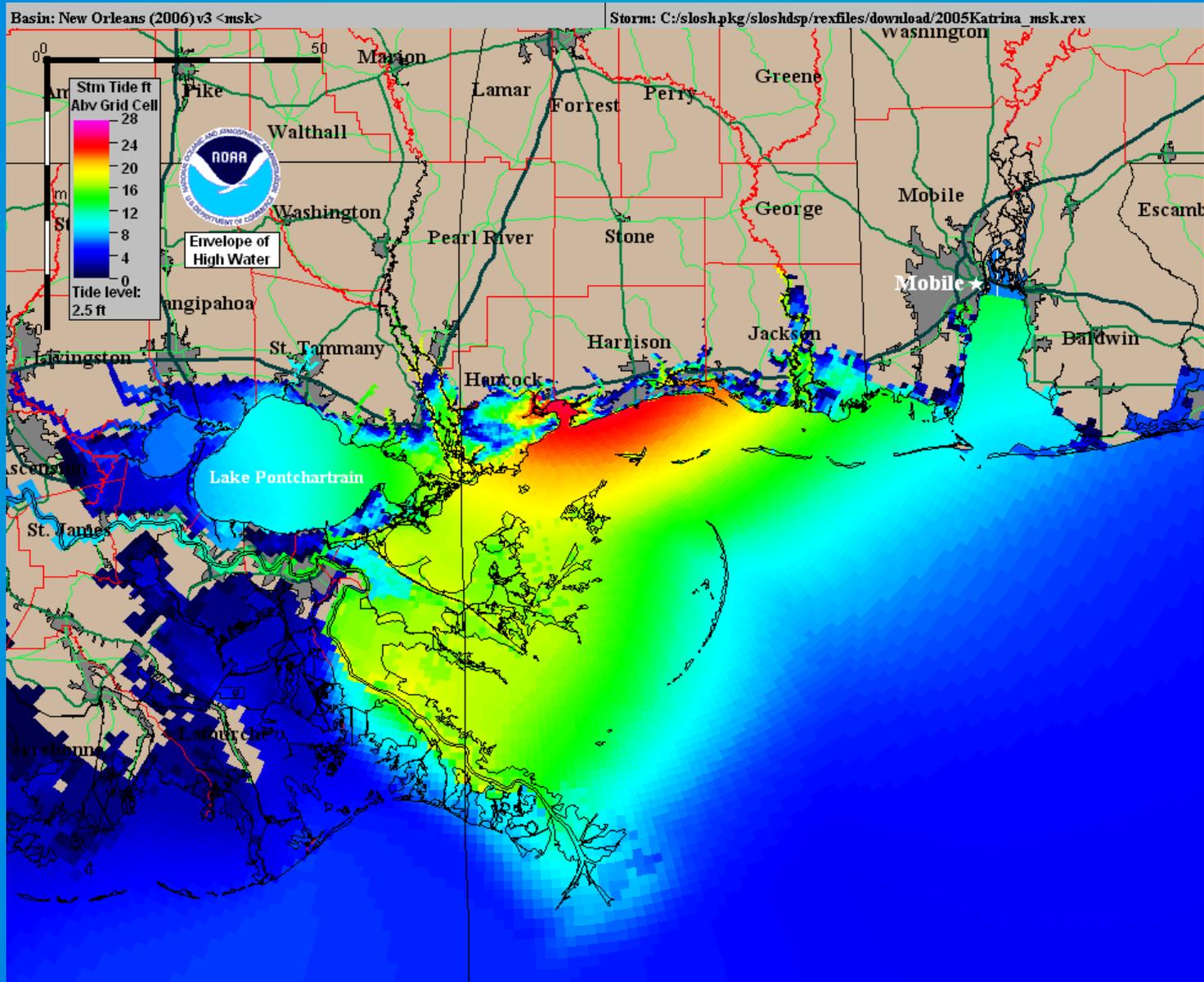


Large, slow moving category 1 hurricane =
Extensive storm surge in portions of SE Louisiana

Hurricane Ike Inundation Depth



Katrina 2005



September 1998



August 31, 2005



September 1998



August 31, 2005



September 1998



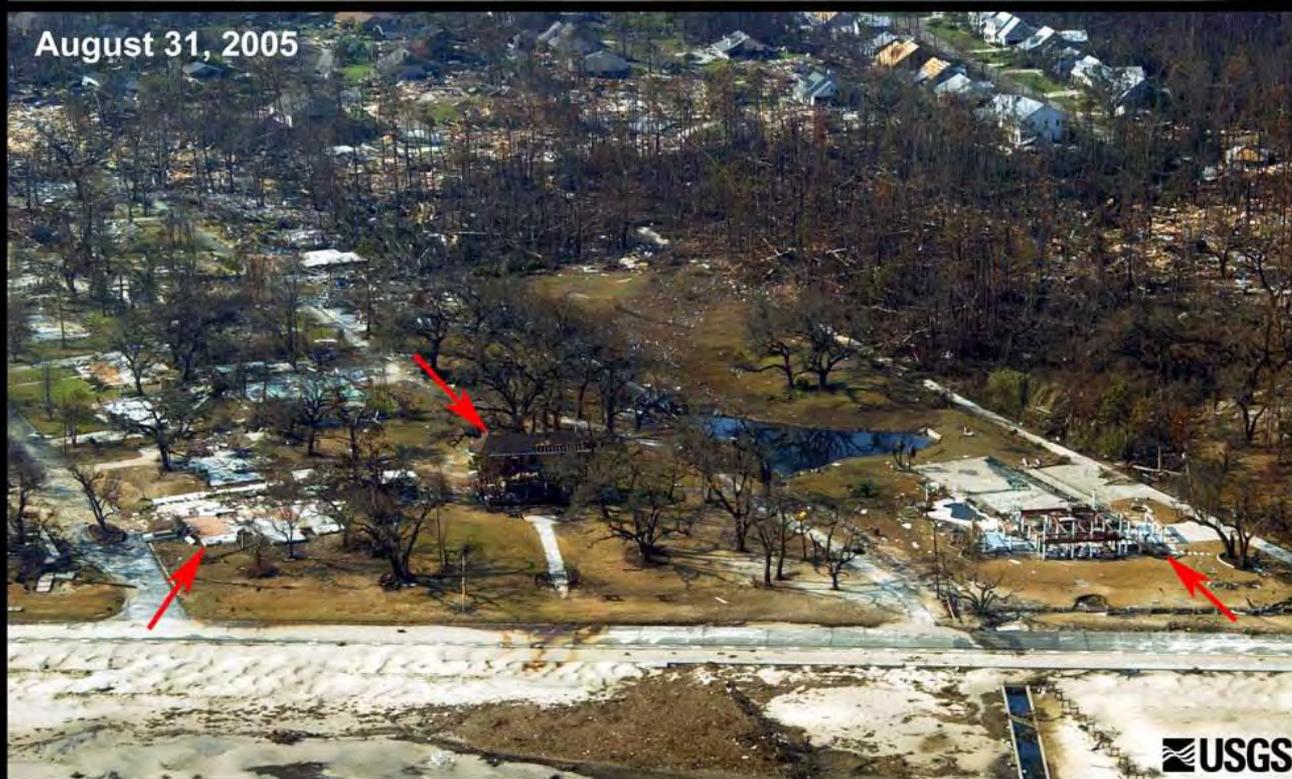
August 31, 2005



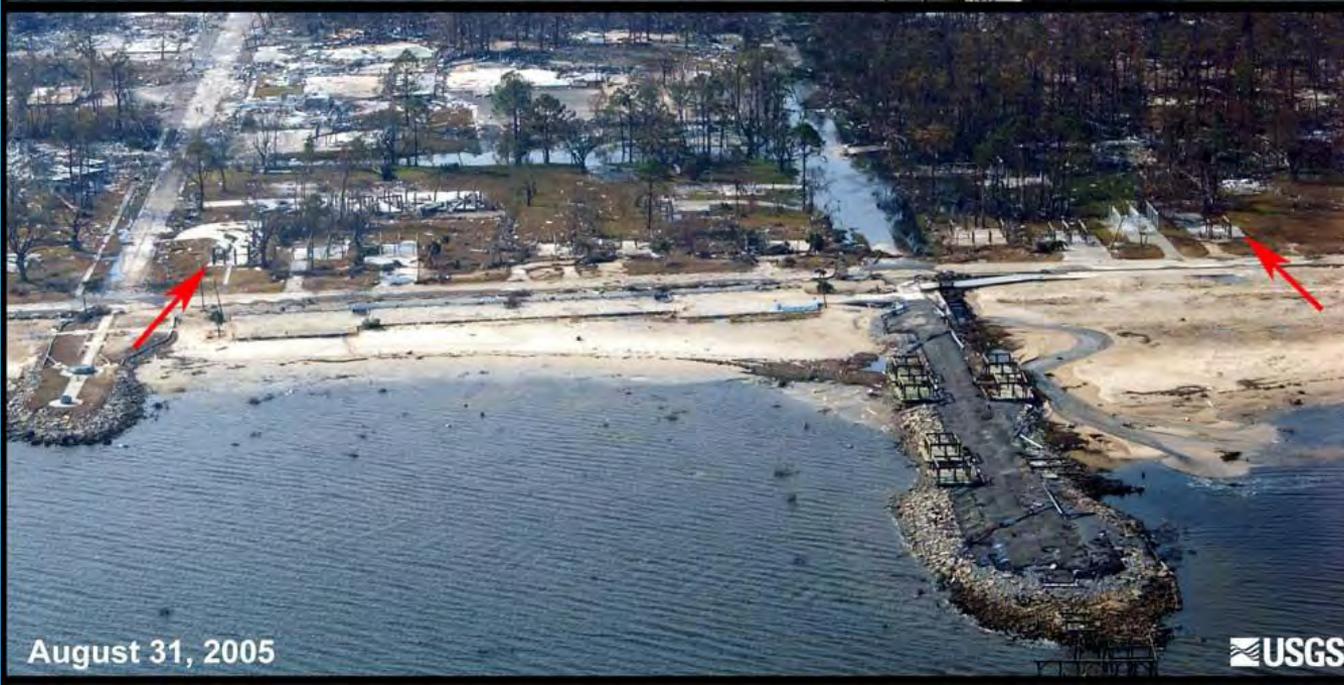
September 1998



August 31, 2005















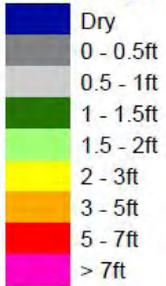


OF MEXICO

SLOSH
Model

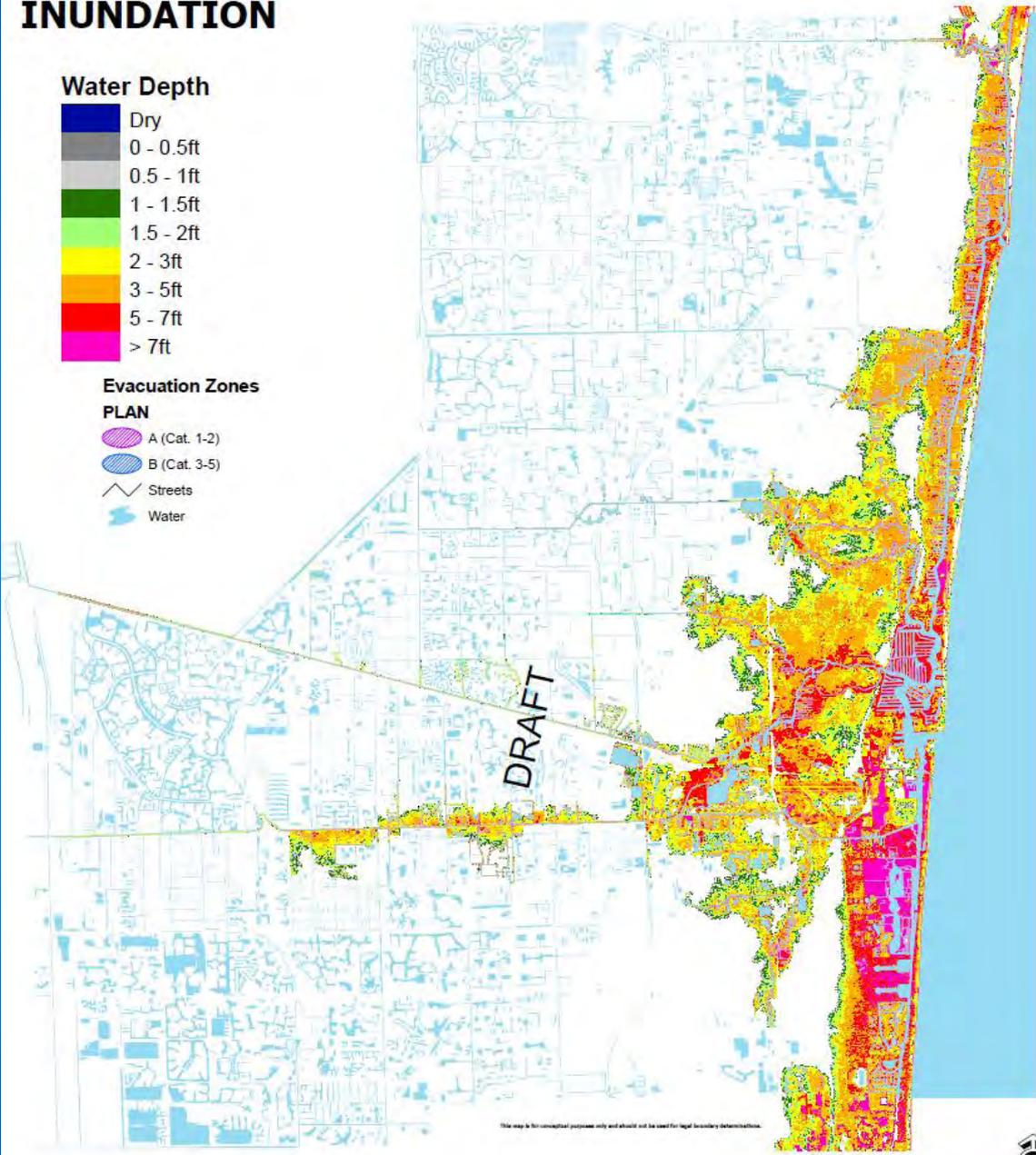
CATEGORY 5 INUNDATION

Water Depth



Evacuation Zones

PLAN

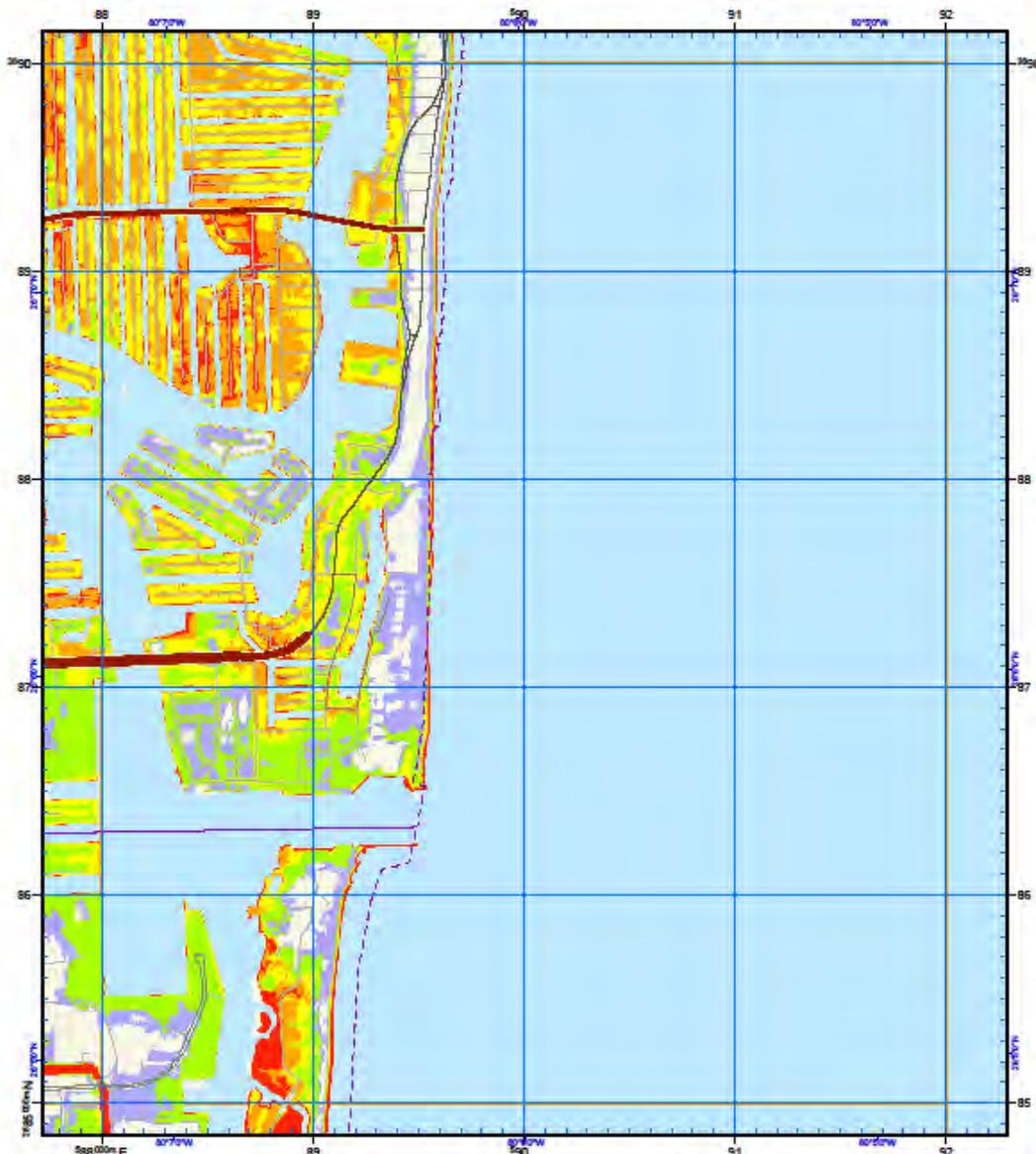


This map is for conceptual purposes only and should not be used for legal boundary determinations.



State-Wide Regional Evacuation Study

State-Wide Regional Evacuation Study



US National Grid
100,000-m Square ID
NJ
Grid Zone Designation
17R
Datum = NAD 1983, 1,000-m USNG

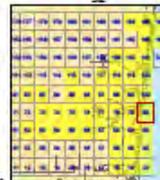


Notes:
1. Elevation data are based on 1-foot contours along the right-of-way elevation above MSL (Mean Sea Level) at high tide with no wave action.
2. Total Storm Tide data were derived from a storm surge model using a 100-year storm surge duration.
3. The Point of Reference locations identified in this report are subject to emergency meeting needs.

ATLAS LEGEND

	HOSPITAL		1
	Points of Reference		2
	Evacuation Route		3
	City Limits		4
	NHD Lakes		5
	NHD Major Water		5

Storm Tide Zones
Broward County, 2010
Scale - 1:24,000
0 2,000 Feet
USNG Page 17R NJ 88 85
Map Plate 80



This map is for reference & planning purposes only.
Hurricane evacuation decision-making and growth management implementation are local responsibilities.
Please consult with local authorities.

Evacuation Zones

PLAN

	A
	B



The map is for conceptual purposes only and should not be used for legal boundary determinations.

Prepared By: Emergency Management Division
Environmental Protection and Growth Management Department

8/16/12 4/19/2012

Path: \\f:\apps\EMD\GIS\EvacuationZones.mxd

Evacuation Zones

Base Scenarios

	Scenario 1 Level A	Scenario 2 Level B	Scenario 3 Level C	Scenario 4 Level D	Scenario 5 Level E
Demographic Data	2010	2010	2010	2010	2010
Highway Network	2010	2010	2010	2010	2010
One-Way Operations	None	None	None	None	None
University Population	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring	Fall/Spring
Tourist Rate	Default	Default	Default	Default	Default
Shelters Open	Primary	Primary	Primary	Primary	Primary
Response Curve	12-hour	12-hour	12-hour	12-hour	12-hour
Evacuation Phasing	None	None	None	None	None
Behavioral Response	100%	100%	100%	100%	100%
Evacuation Zone	A	B	C	D	E
Counties Evacuating	Broward Miami-Dade Monroe Palm Beach Collier				

Clearance Times

	Evacuation Level A Base Scenario 1	Evacuation Level B Base Scenario 2	Evacuation Level C Base Scenario 3	Evacuation Level D Base Scenario 4	Evacuation Level E Base Scenario 5
Clearance Time to Shelter					
Key West	4.0	3.5	N/A	N/A	N/A
Lower Keys	0.5	0.5	N/A	N/A	N/A
Middle Keys	0.5	0.5	N/A	N/A	N/A
Upper Keys	0.5	0.5	N/A	N/A	N/A
Monroe County	4.0	3.5	N/A	N/A	N/A
Miami-Dade County	13.0	13.0	13.0	32.0	51.0
Broward County	12.5	13.0	29.0	29.5	56.0
In-County Clearance Time					
Key West	12.5	12.5	13.0	13.0	13.0
Lower Keys	16.0	17.0	20.0	20.0	20.0
Middle Keys	20.0	21.0	24.0	24.0	24.0
Upper Keys	22.5	24.0	27.5	27.0	27.5
Monroe County	22.5	24.0	27.5	27.0	27.5
Miami-Dade County	23.0	24.0	27.5	32.0	51.5
Broward County	12.5	13.0	30.5	33.5	57.5
Out-of-County Clearance Time					
Key West	12.5	12.5	13.0	13.0	13.0
Lower Keys	16.0	17.0	20.0	20.0	20.0
Middle Keys	20.0	21.0	24.0	24.0	24.0
Upper Keys	22.5	24.0	27.5	27.0	27.5
Monroe County	22.5	24.0	27.5	27.0	27.5
Miami-Dade County	23.0	24.5	28.0	33.5	52.0
Broward County	24.0	25.0	30.5	35.0	57.5
Regional Clearance Time					
South Florida Region	24.0	25.0	30.5	35.0	57.5

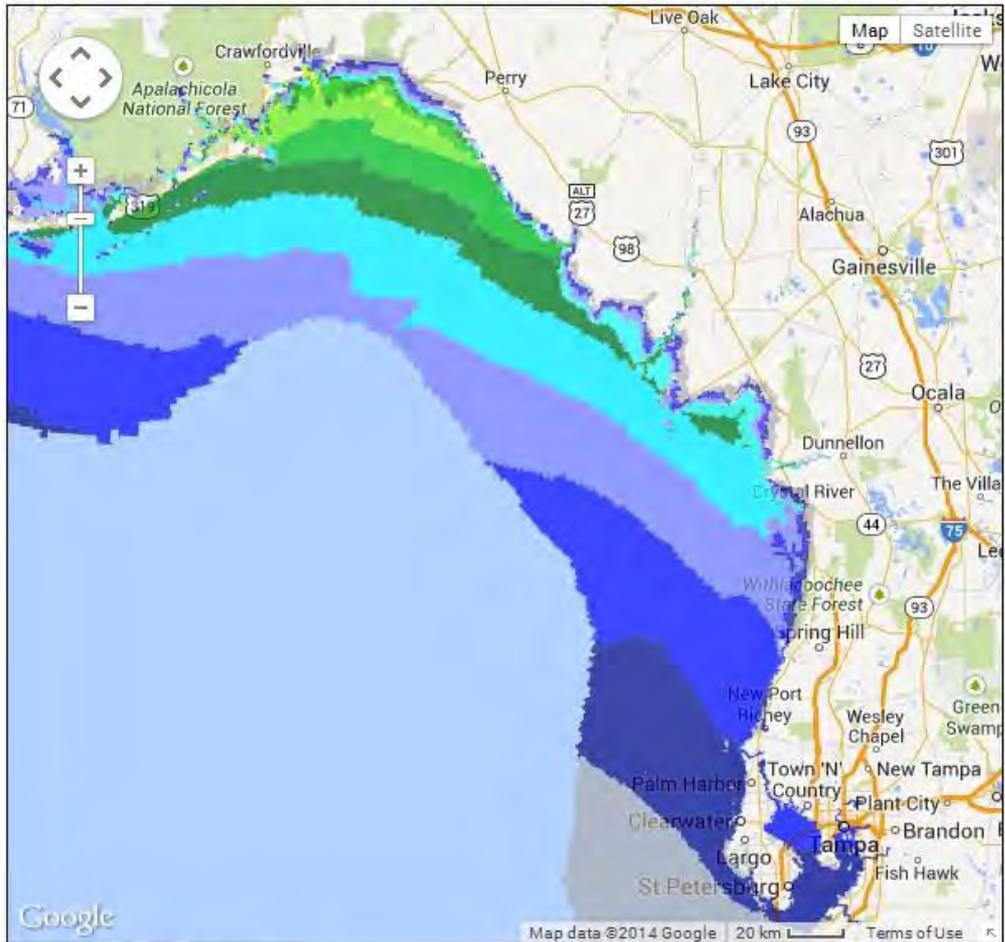
Watches and Warnings

- Tropical Storm Watch – Tropical Storm conditions are possible within 48 hours.
- Tropical Storm Warning – Tropical Storm conditions are expected within 36 hours.
- Hurricane Watch – Hurricane Conditions are possible and the watch is issued 48 hours in advance of the anticipated onset of tropical storm-force winds.
- Hurricane Warning – Hurricane Conditions are expected and the warning is issued 36 hours in advance of the anticipated onset of tropical storm-force winds.

**Tropical Cyclone Storm Surge (with tide) Heights
That Have a 1 in 10 Chance of Being Exceeded
Hurricane Al84psurge1test (2014) Advisory 1
For the 77 hours from 11 AM EDT Wed May 07 to 04 PM EDT Sat May 10**

Select Level: 10% Chance of Being Exceeded ▾

[View in Google Earth \(Active KML\)](#)



Lat 30.3551 Lon: -82.0679

[Larger](#)

Legend

Height above ground (feet)		
0 to < 2	11 to < 13	23 to < 25
2 to < 3	13 to < 15	25 to < 27
3 to < 5	15 to < 17	27 to < 29
5 to < 7	17 to < 19	29 to < 36
7 to < 9	19 to < 21	
9 to < 11	21 to < 23	

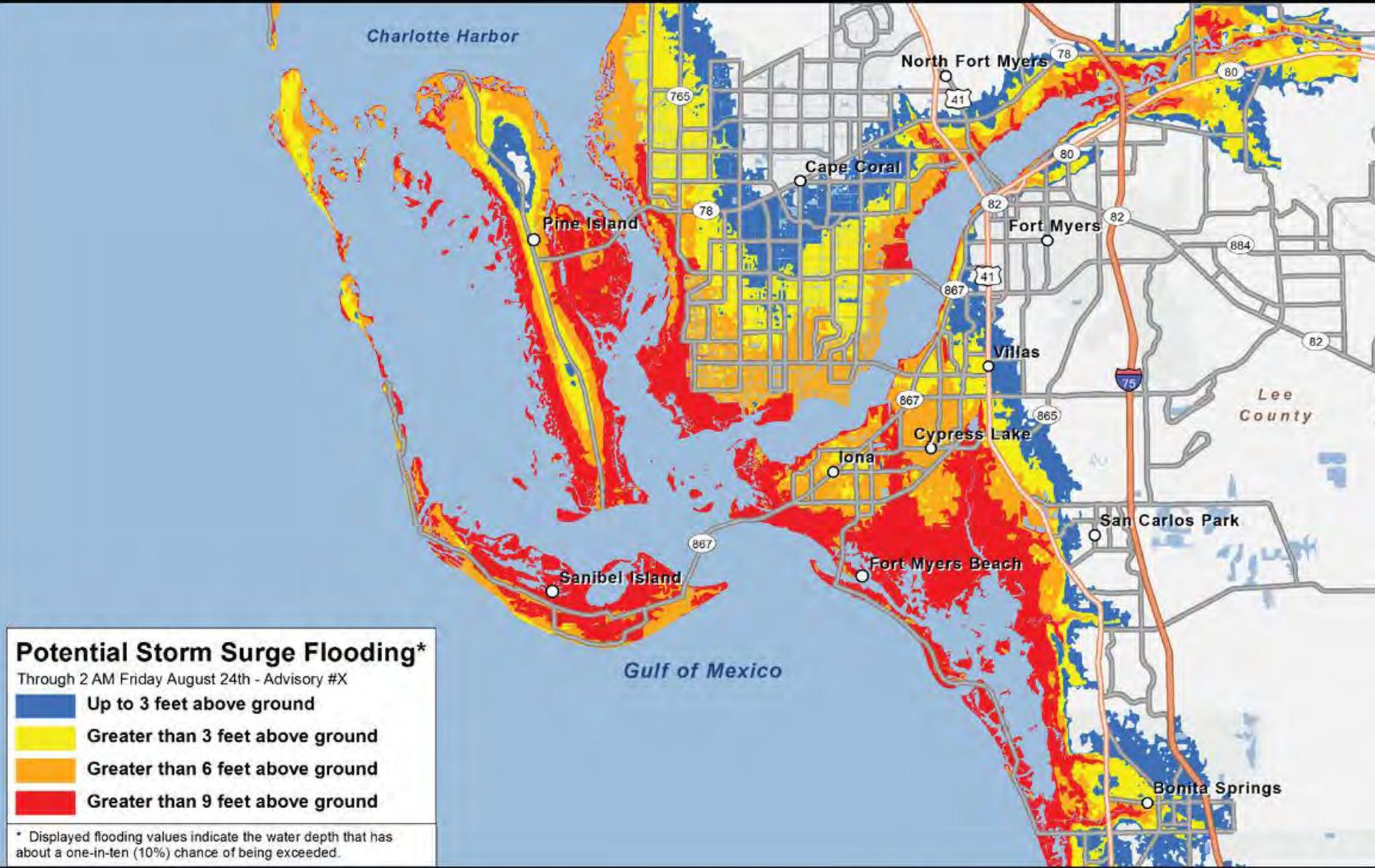
Disclaimer



Historical Data:
NHC this storm
NHC all storms
MDL

P-Surge
(probabilistic)

Hurricane X



Potential Storm Surge Flooding*

Through 2 AM Friday August 24th - Advisory #X

-  Up to 3 feet above ground
-  Greater than 3 feet above ground
-  Greater than 6 feet above ground
-  Greater than 9 feet above ground

* Displayed flooding values indicate the water depth that has about a one-in-ten (10%) chance of being exceeded.



 National Hurricane Center Storm Surge Unit

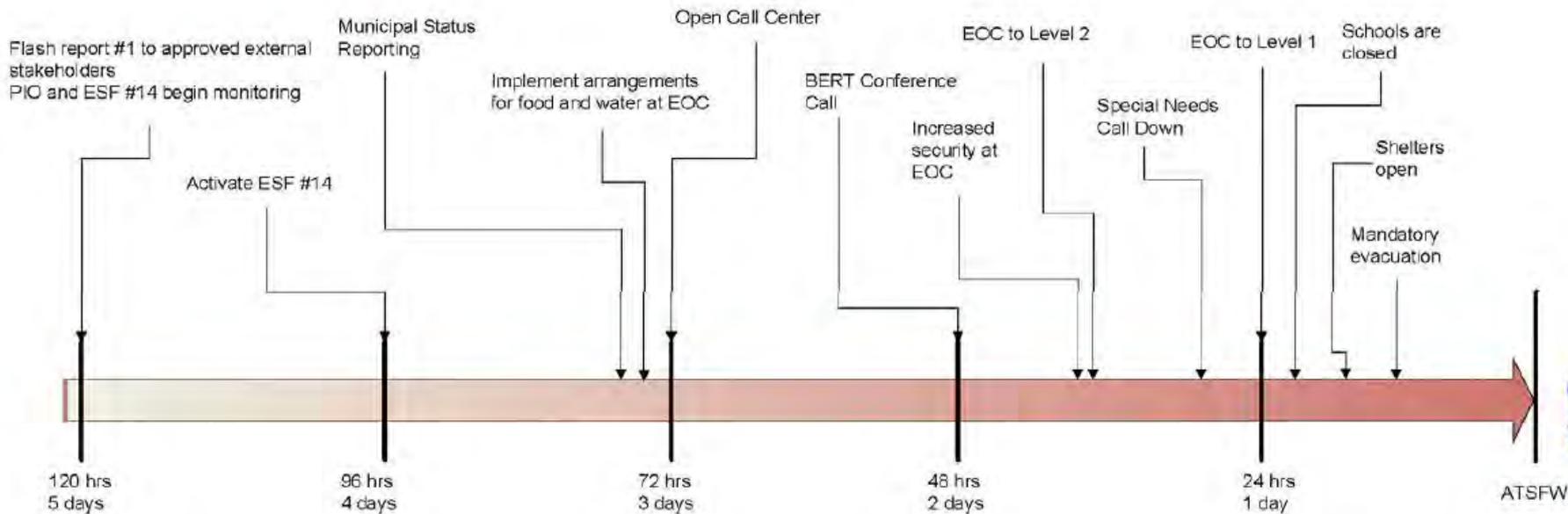
Storm Action Lead Time (Salt)



Storm Action Lead Time

8/1/2008

Plan # 1 Category 1-2 Storm (12-hour evacuation time)





Storm Action Lead Time

Last calculated on: May 27, 2014 @ 1:54 PM

Tasks Print

Storm Name:

Arrival of TSWF:

Evacuation Zone:

NHC ADV Num:

Time of ADV:

Storm Heading:

Forward Speed:

Max. Sust. Wind:

Storm Diameter:

Calculate S.A.L.T.

Saved.

Pre-Arrival During Post-Departure

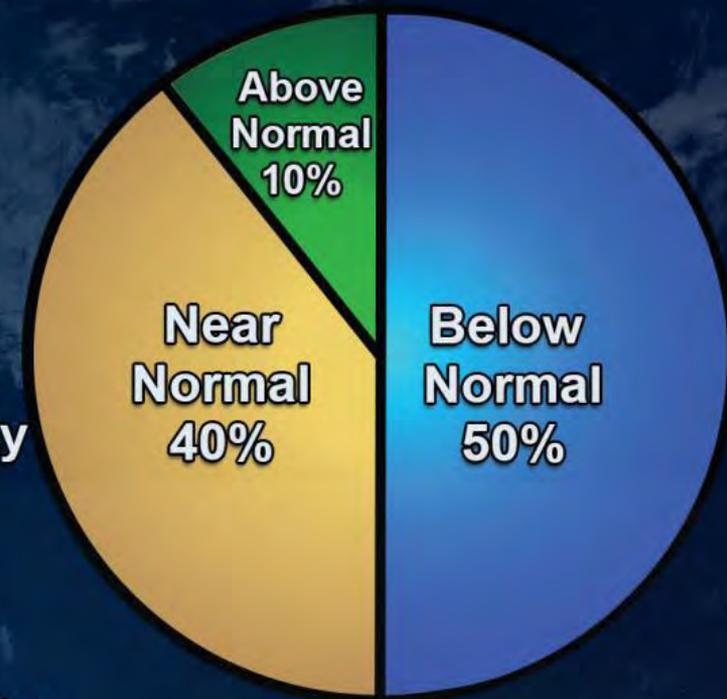
Lead Time	Date & Time to Perform Task	Task	Hours From Now
-120	Tuesday, May 27 2014 7:00 PM	** Flash report #1 to approved external stakeholders	5
-120	Tuesday, May 27 2014 7:00 PM	PIO and ESF-14 begin monitoring	5
-72	Thursday, May 29 2014 7:00 PM	Implement arrangements for food and water at EOC	53
-72	Thursday, May 29 2014 7:00 PM	Notify State Logistics of potential POD openings	53
-72	Thursday, May 29 2014 7:00 PM	Municipal status reporting	53
-68	Thursday, May 29 2014 11:00 PM	Notify security of possible activation	57
-62	Friday, May 30 2014 5:00 AM	Determine operational period and reporting schedule	63
-61	Friday, May 30 2014 6:00 AM	Develop EOC Staffing Schedule	64
-59	Friday, May 30 2014 8:00 AM	EMD staff activation brief	66
-56	Friday, May 30 2014 11:00 AM	** BERT Conference Call	69
-56	Friday, May 30 2014 11:00 AM	Distribute passwords and conf call phone numbers	69
-55	Friday, May 30 2014 12:00 PM	** Municipal EOC conference call	70
-51	Friday, May 30 2014 4:00 PM	Clear RIA database and check RIA application	74
-50	Friday, May 30 2014 5:00 PM	Prepare and test all EOC equipment	75
-50	Friday, May 30 2014 5:00 PM	** Activate ESF-14	75
-50	Friday, May 30 2014 5:00 PM	Prepare electronic and hard copy incident file folders	75
-49	Friday, May 30 2014 6:00 PM	Configure WebEOC for storm	76
-49	Friday, May 30 2014 6:00 PM	Implement increased EOC security measures	76
-48	Friday, May 30 2014 7:00 PM	** Open Call Center	77



2014 Atlantic Hurricane Outlook

Named Storms: 8 - 13
Hurricanes: 3 - 6
Major Hurricanes: 1 - 2

Outlook
Probability



Be prepared: Visit hurricanes.gov
and follow @NWS and @NHC_Atlantic on Twitter

Questions?

**Broward County
Emergency Management Division
(954) 831-3900**

**Bob Humple
rhumple@broward.org
(954) 831-3919**

**www.broward.org/emergency
www.broward.org/hurricane**