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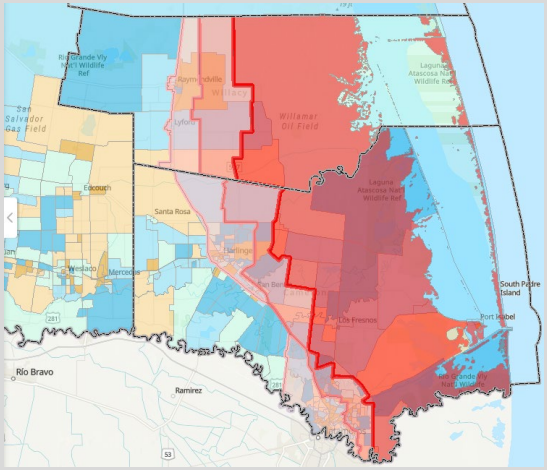
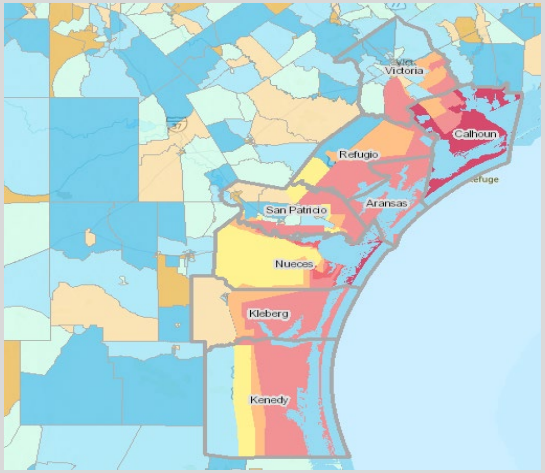
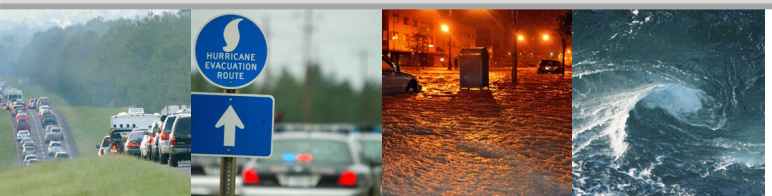
Hurricane Evacuation Studies

Risk-based evacuation zone planning for the Texas Gulf Coast



Douglas Wunneburger – HRRC
Walt Peacock – HRRC
Alexander Abuabara – HRRC
David Bierling – TTI
Darrell Borchardt – TTI





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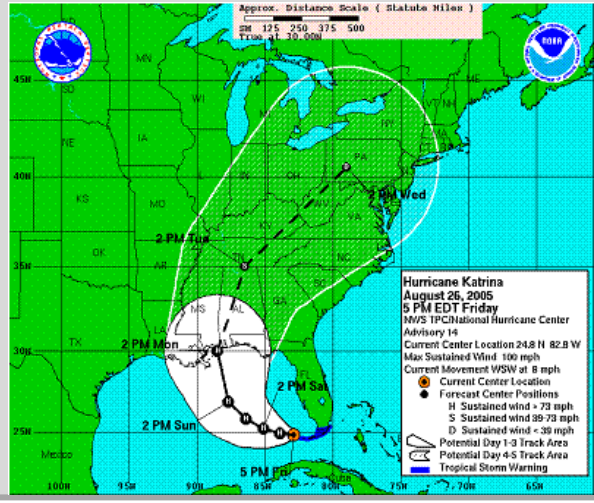
FEMA

Hurricane Katrina (8/23/2005)

- Massive storm surge
- 1800 fatalities
- Evacuation orders late
- Flooding due to levee breeches
- 100,000 remained in New Orleans
- Notable issues with:
  - infrastructure,
  - emergency response,
  - disaster preparedness


Paul Morse/The White House



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Hurricane Rita (9/24/2005)

Ashish/Houston, TX

- Evacuation called early
- 9/20 – Galveston Island
- 9/21 – First watch
- 9/24 – Landfall
- 66% evacuees from safe areas
- Long travel times (12 – 36 hrs)
- Shortages of fuel, water, food, medical attention
- Temperature near 100˚F
- 107 perished during evacuation

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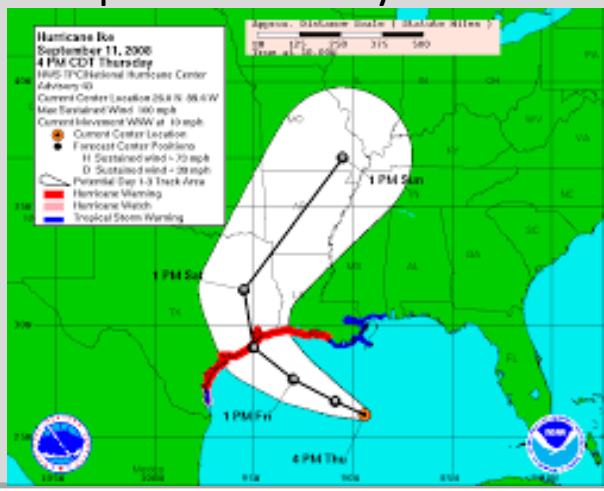
Hurricane Ike (9/13/2008)

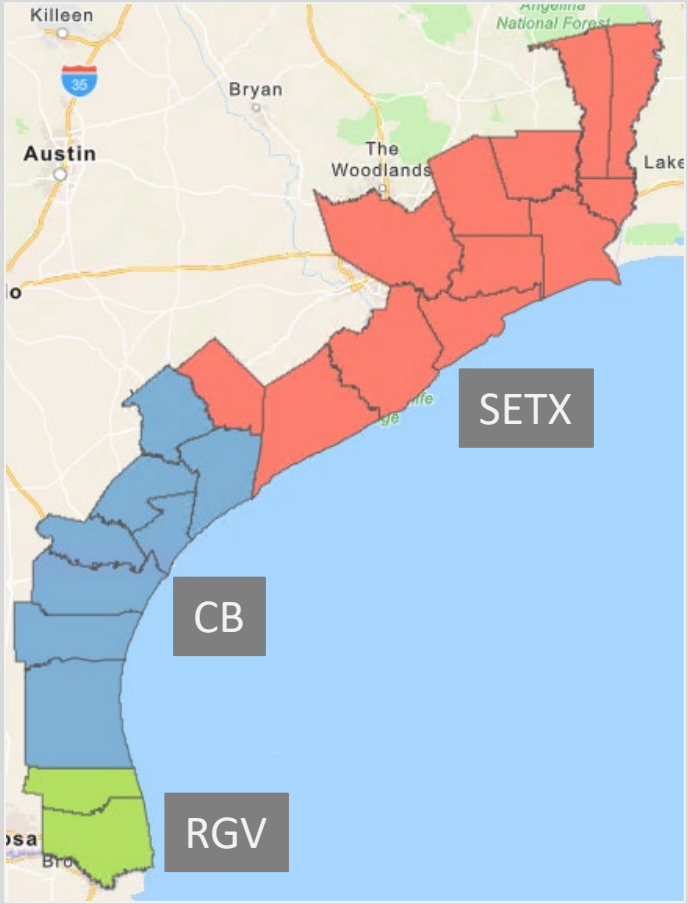
Jocelyn Augusitno/FEMA

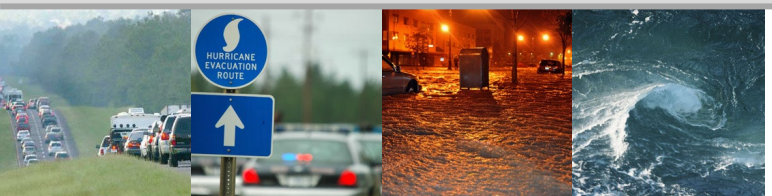
- Massive size/uncharacteristic surge
- 100+ fatalities
- 2.2 million evacuees
- Many chose to remain w/ concerns:
  - Traffic, looting, protect property
- Prompted changes in:
  - Forecasting focus separated
    - Surge
    - Wind
- Evacuation procedures key



Hurricane Evacuation Studies

- Assemble, integrate, clean, and generate data
- Develop GIS layers and build web-based GIS platform
  - Southeast Texas – 2025
  - Coastal Bend – 2018
  - Rio Grande Valley – 2015
- Conduct vulnerability analysis
  - Physical risk
  - Socio-demographic factors
  - Critical facilities
  - Transportation infrastructure





Set Criteria for General Guidelines and Principles in Evacuation Planning

Life safety

Storm surge is key hazard driving zone development

- Although the generally high flooding potential should be considered and wind issues, particularly for mobile homes

Facilitate risk/warning communication

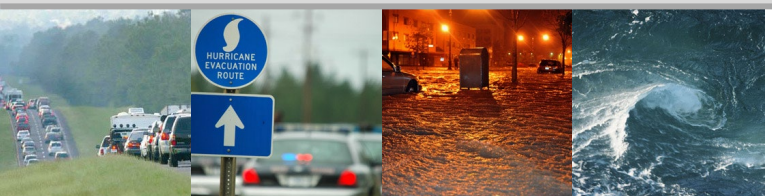
- Boundaries should be easily communicable and interpretable and make sense for EM decisions

Rejection of using storm categories (Cat. 1-5)

Previous HES zone IDs:

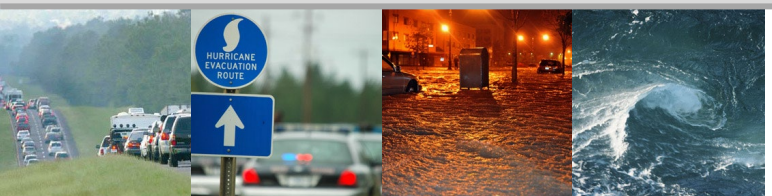
- 2013 – Three zones: A, B, C
- 2015 – A, A1, A2, B, C
- 2023 – Coastal, A, B, C

Strive for consensus decision making



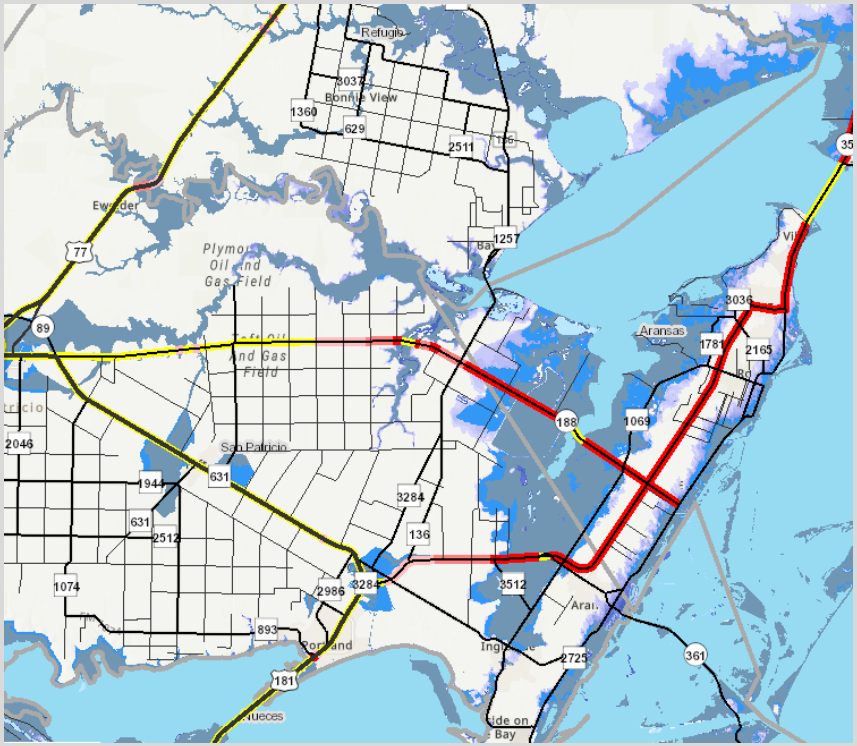
Principle data sources

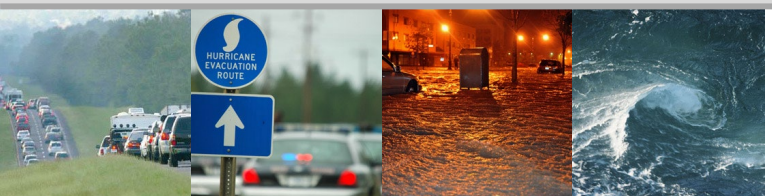
- The USACE's new hurricane risk surge data
- HRRC "generalized" USACE surge data
- Topographical / imagery information
- Road network layers
- Geospatial imagery data
- *Landscan* population data
- U.S. Census American Community Survey



Vulnerability Assessment

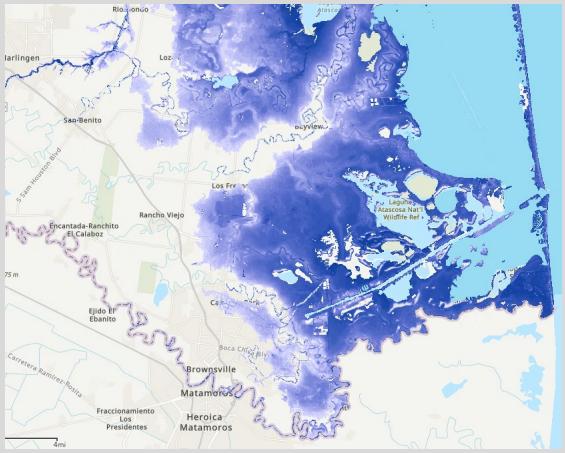
- Physical risk
  - Storm surge models
  - Flood risk maps
- Socio-demographic risk
  - Vulnerable populations and household estimates
  - Total vehicles to evacuate
  - Mobile homes, RVs
  - Job locations and employee residences
  - Social vulnerability tool set
- Critical facilities
  - Health, schools, police, fire
  - Hotels, seasonal rentals
- Evacuation zones
  - Recognizable geography
- Transportation infrastructure
  - Evacuation routes

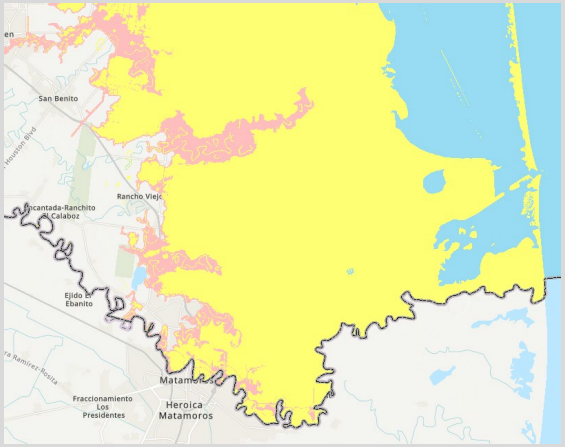




From Precise Surge Model to Evacuation Zone

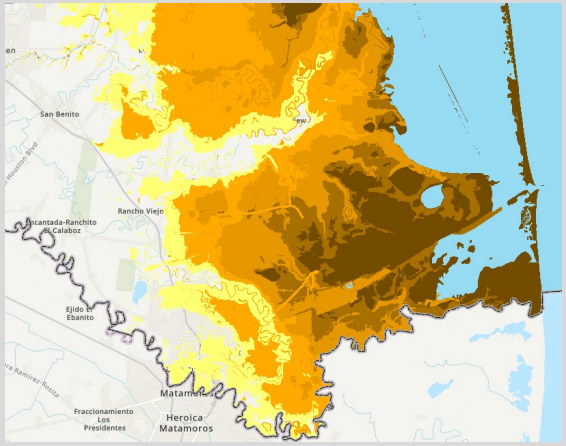
Precise Category 5 Surge

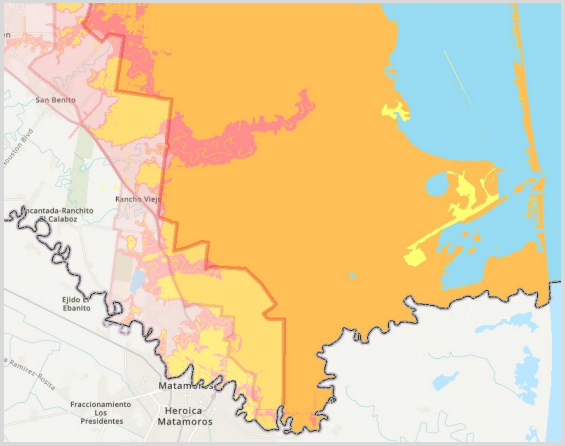




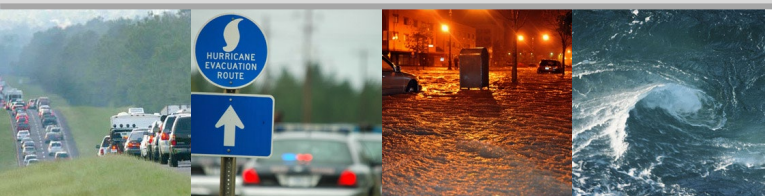
Aggregated Category 5 Surge

Smoothed Category 5 Surge





Smoothed Category 5 Surge with Evacuation Zones



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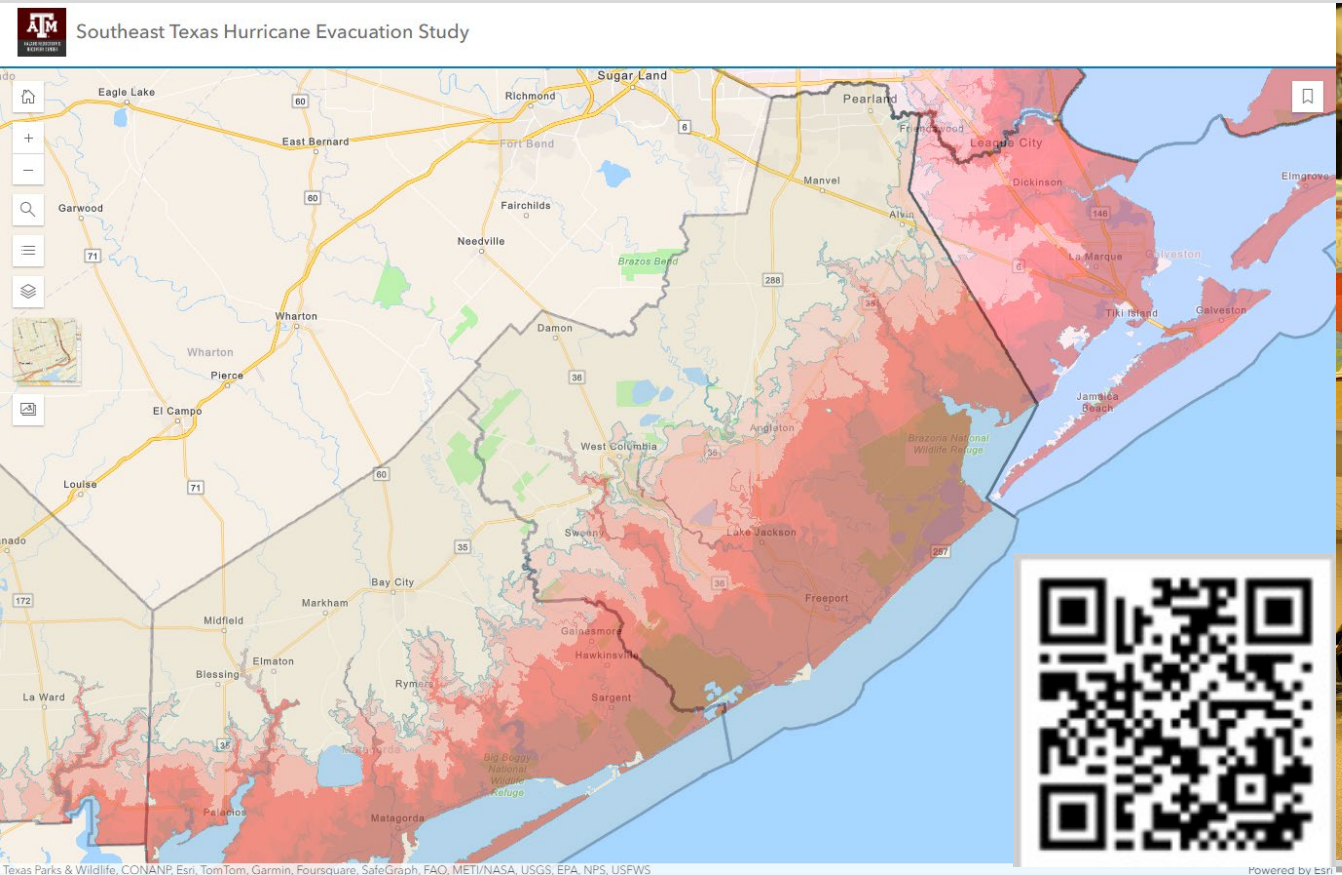
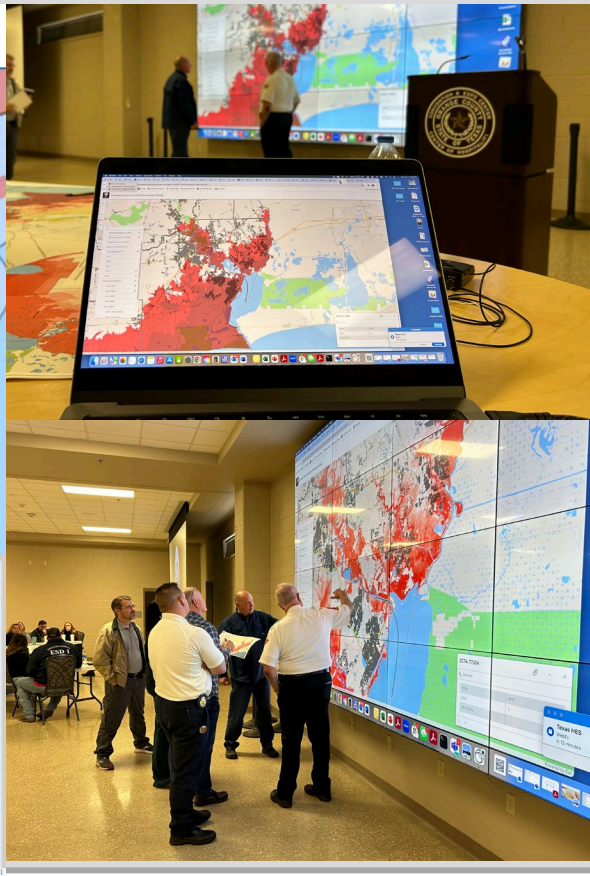
Web GIS Application





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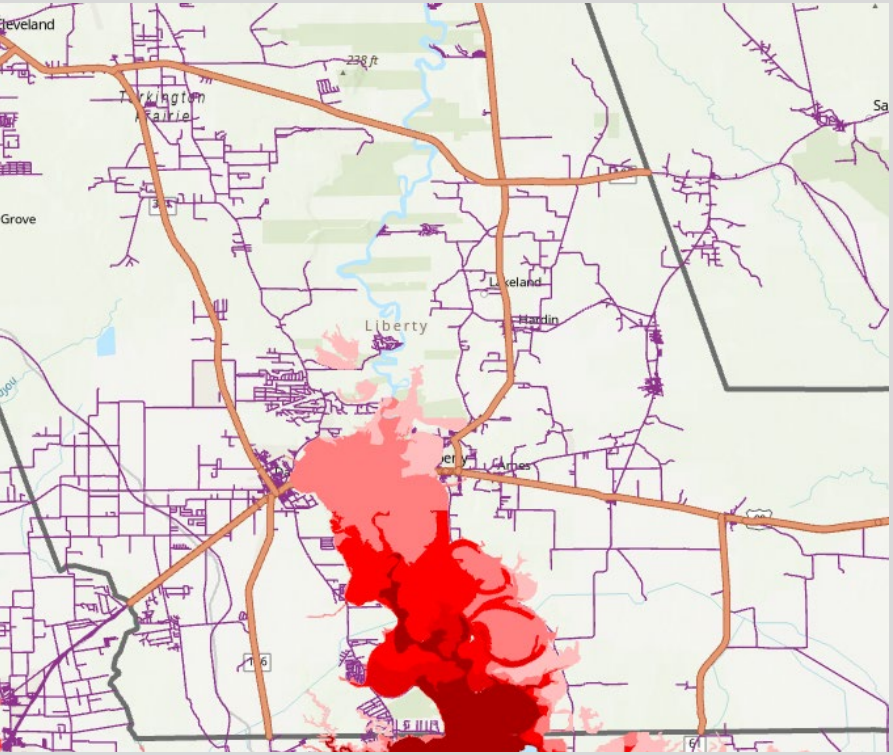
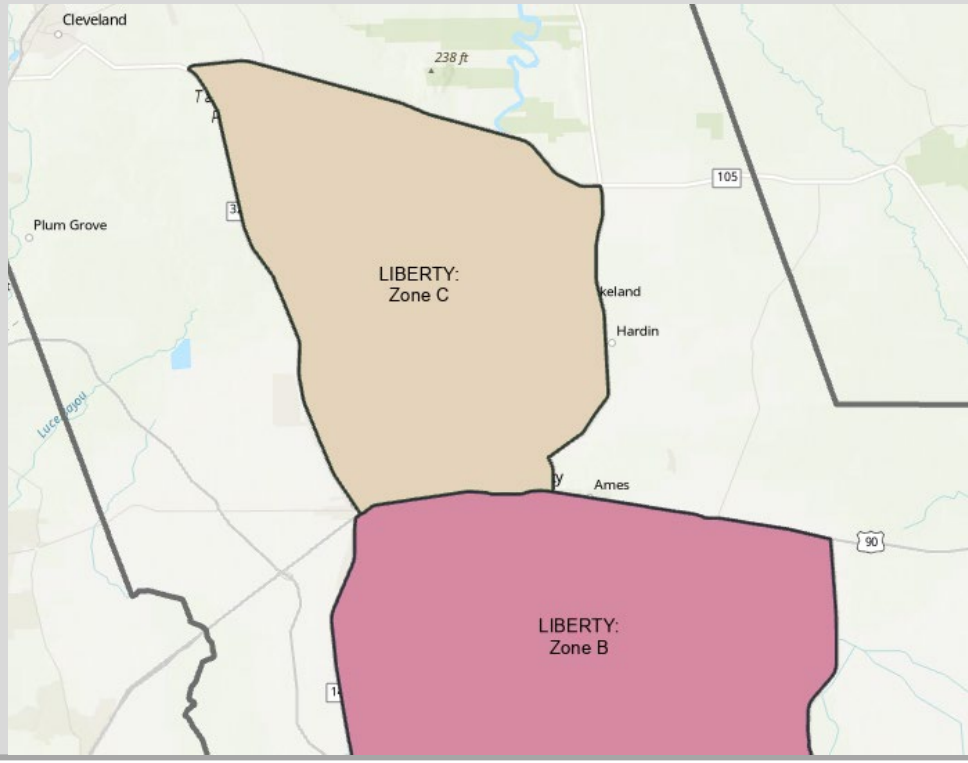
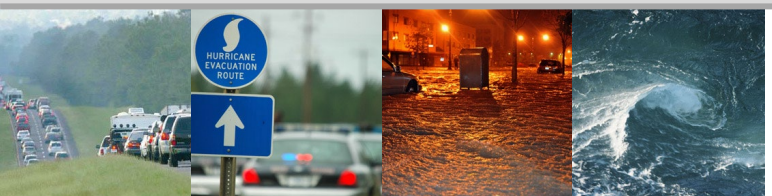
Physical Risk Assessment

Determine surge inundation limits



Identify well-known geography for first draft zone boundaries





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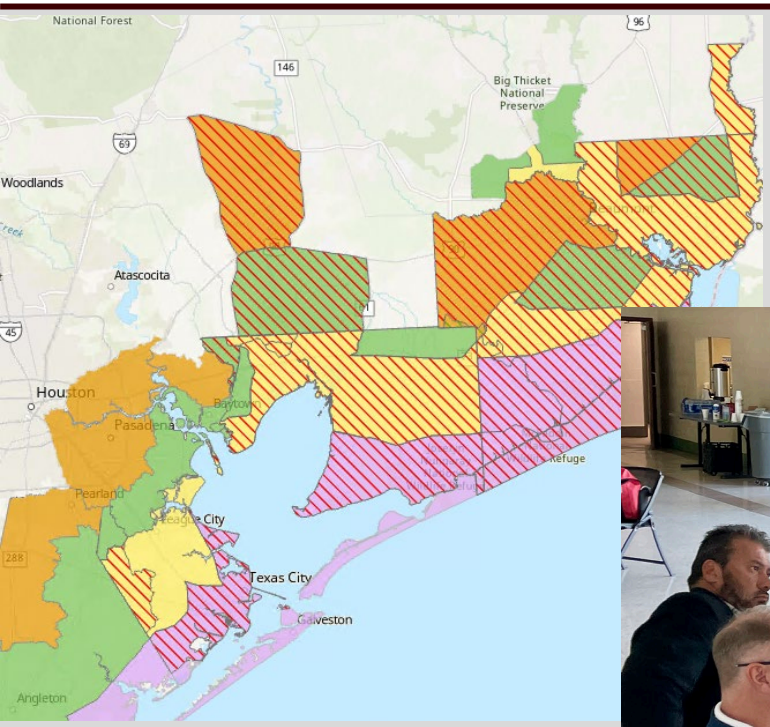
Present Draft Zones to Community Stakeholders and EOC Leaders for Comment



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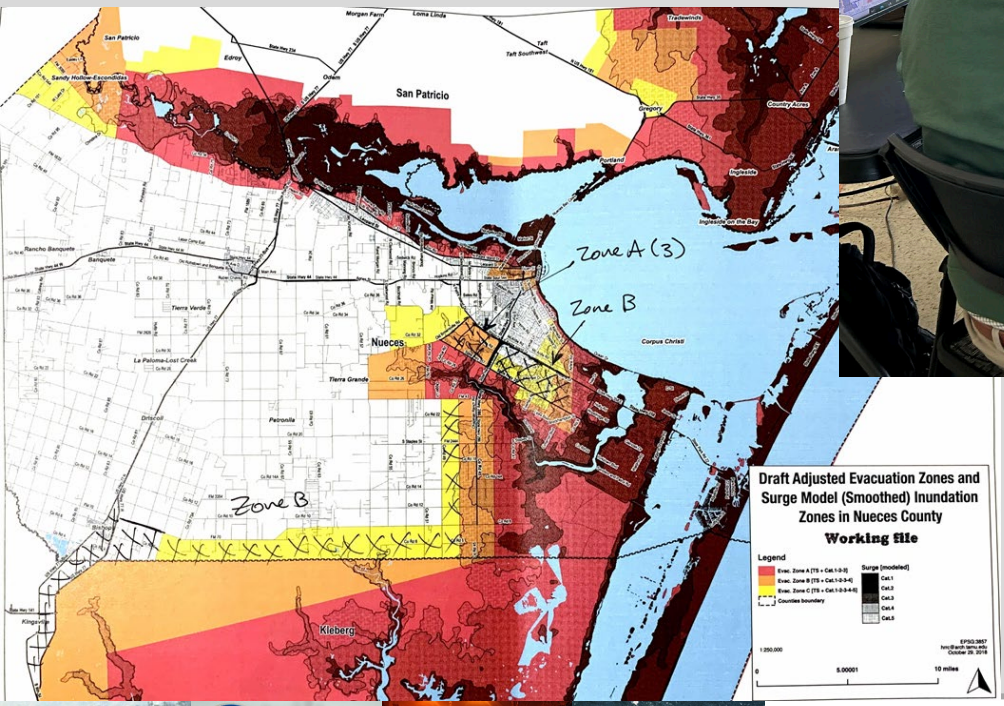
Draft Zone Markup



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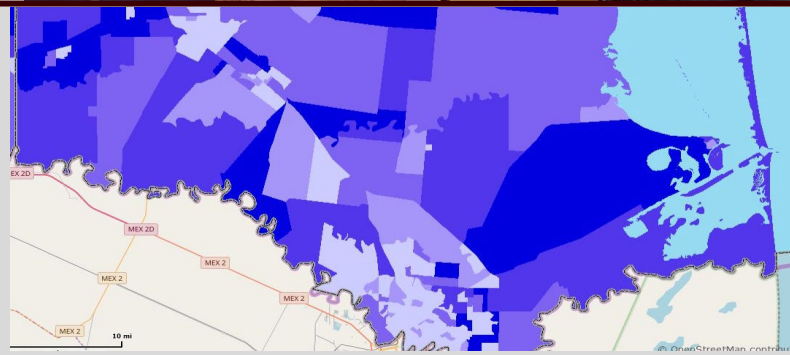
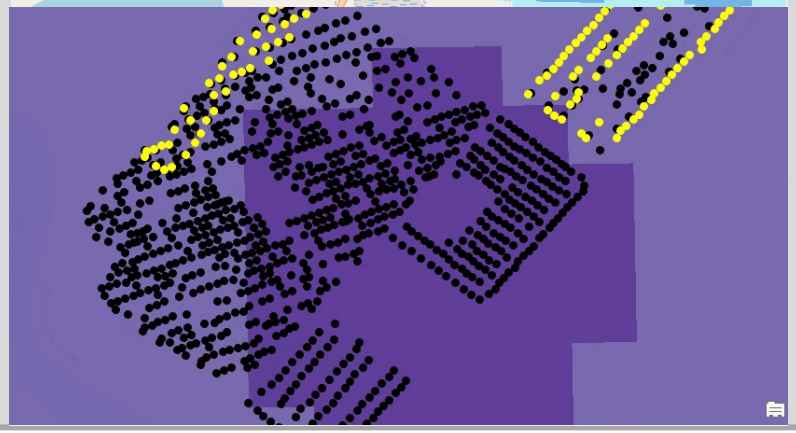
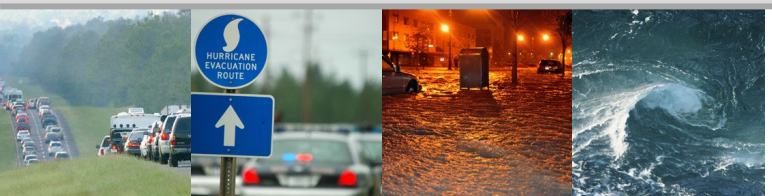
Social Risk Assessment

- Indices refined by fine granularity of Landscan 90M population estimates
- Mobile home layer physical example of methods applied to all indices
- Kernel density heatmap
- Digitized mobile homes in black
- LandScan structures in yellow

Source	Estimate
MOBILe	601 HU
MOBILEi	95.6%
LS Population	867 Pop
Digitized (blk)	978 HU
LS Structures	120 HU







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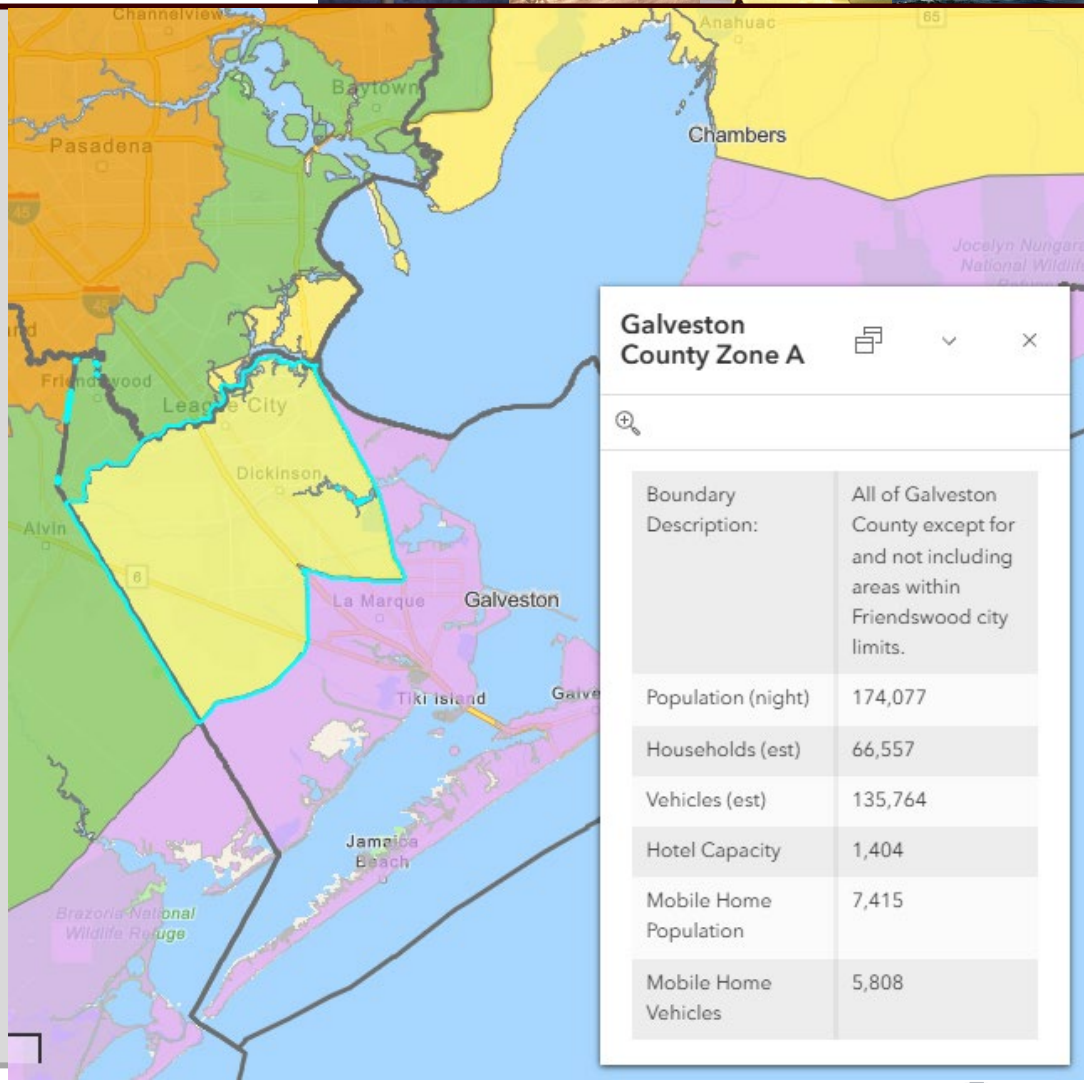
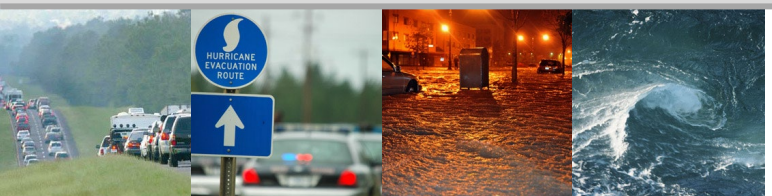
Population Characteristics by Evacuation Zone

- Sociodemographic impacts on evacuations
  - Population
  - Households
  - Vehicles
  - Seasonal population
- Boundary description
  - Identifiable geographic features
  - Zip codes
    - Not applicable in many cases
    - Harris County is exception because of population density





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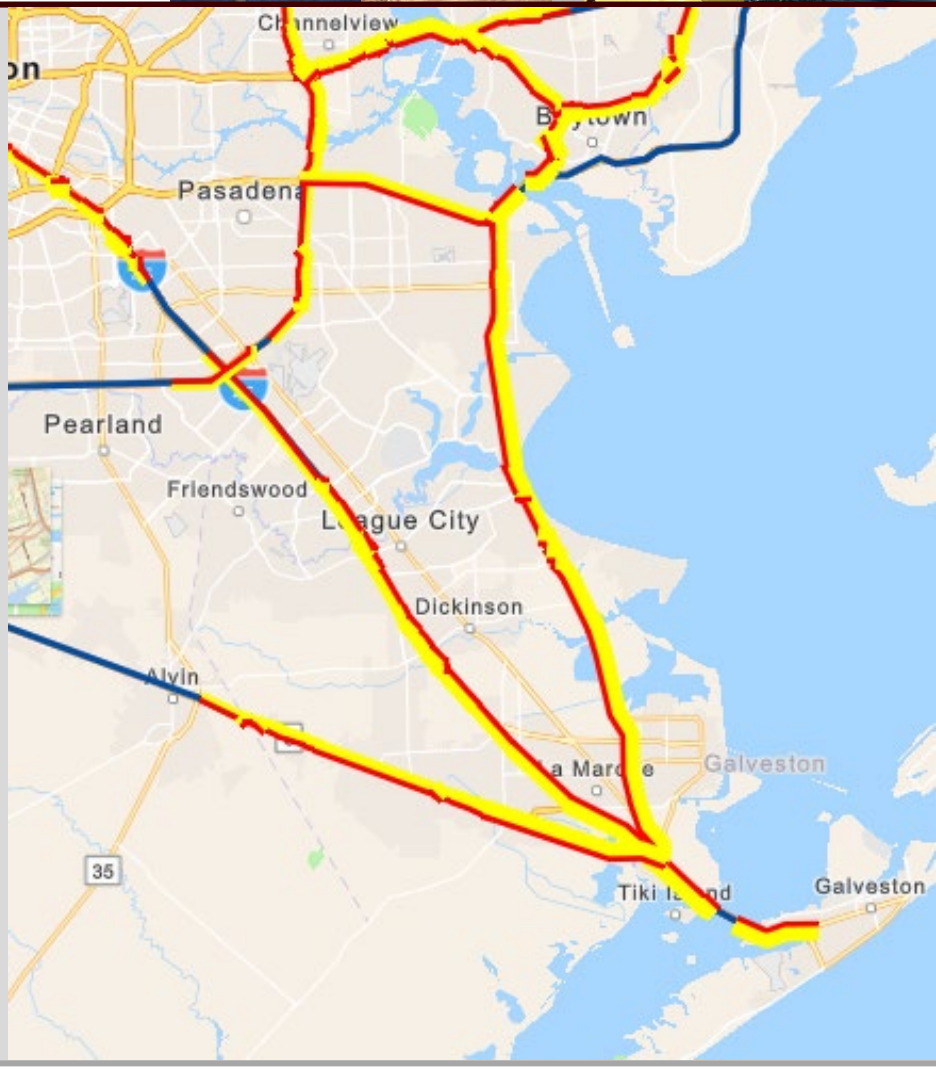
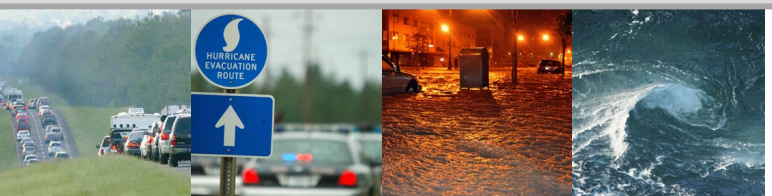
Evacuation Route Assessment

- Evacuation routes set by TXDOT
- Segments identified for special reconfiguration
  - Evaculanes
  - Contra-flow
  - Shadow evacuation





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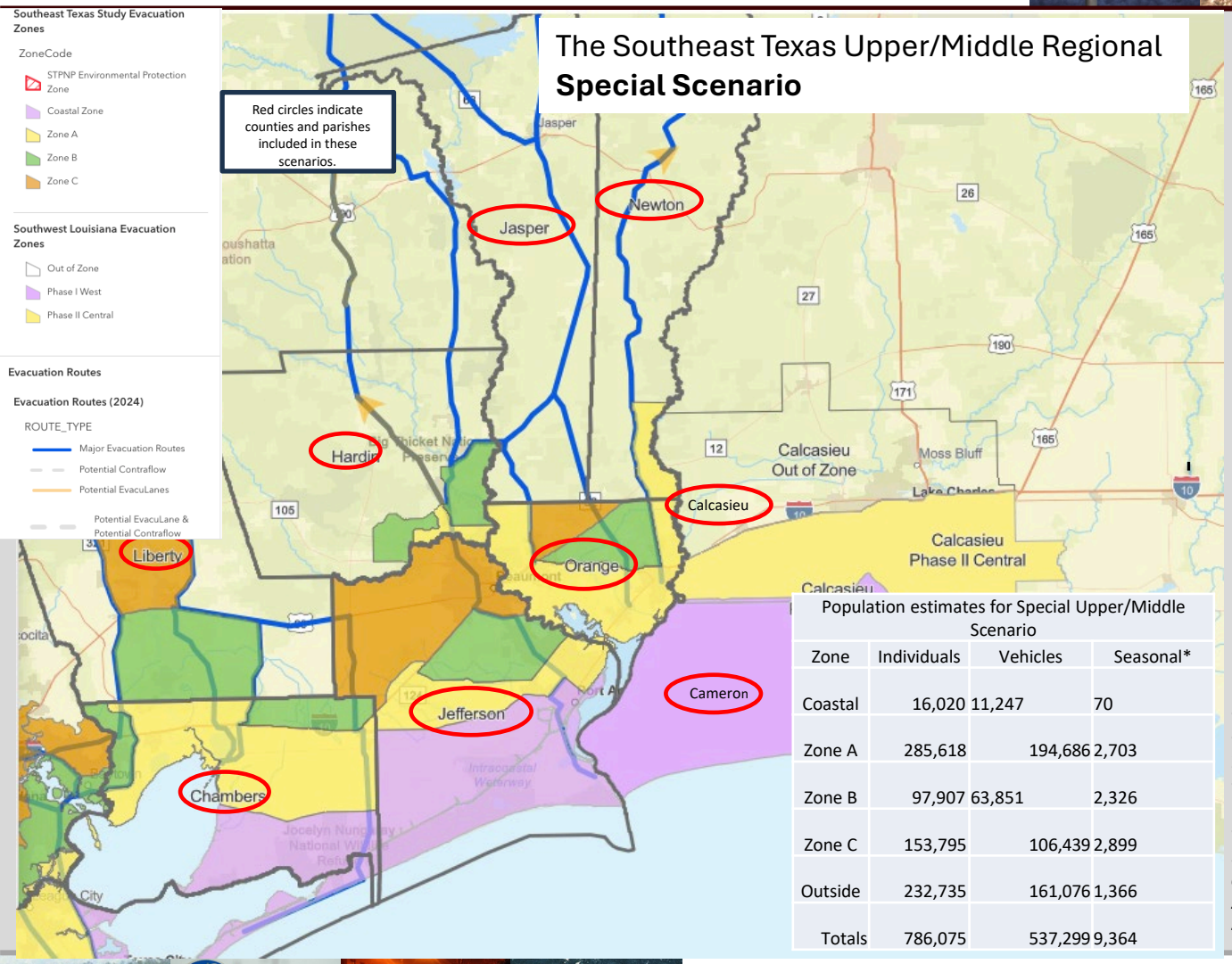
The Southeast Texas Upper/Middle Regional **Special Scenario**



Population estimates for Special Upper/Middle Scenario

Zone	Individuals	Vehicles	Seasonal*
Coastal	16,020	11,247	70
Zone A	285,618	194,686	2,703
Zone B	97,907	63,851	2,326
Zone C	153,795	106,439	2,899
Outside	232,735	161,076	1,366
Totals	786,075	537,299	9,364

1. *Significant* surge event

Significant Surge sett: Coastal, A, & B Zones (40%, 70%, & 100%);shadow evac. for Zone C at 30% & 20% for outside zones; & 8-hour and 2-days (70/30) response times. (6-runs)

25% for assumed participation rates for LA zones, moving west into Texas

Coastal Zone
Zone A
Zone B
Zone C
40, 70, & 100%
30 %

20% for out of zone areas

2. *Major* surge event

Major Surge Scenario: Coastal, A, B, & C Zones at 70% & 100% with 30% shadow evacuation rate outside zones; 8-hour and 2-days (70/30) response times. (4-runs)

25% of assumed participation rates LA zones, all moving west into Texas

Coastal Zone
Zone A
Zone B
Zone C
70% & 100%

30% for out of zone areas

1. Each scenario set will be run for two response times
   - - 8-hour Response time
   - - 2-day response time (70% day 1 & 30% day 2)
2. All Scenarios will assume
   - - Seasonal population included at full occupancy for each zone
   - - Background traffic and traffic incidents not adjusted
3. *Evacuation from Louisianna will be constrained to 25% of assumed participation rates moving west from the two zones and shadow.*
4. *Total of **10** runs*

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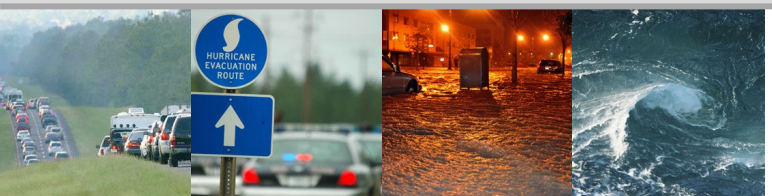
Evacuation Timing Assessment

Real-time evacuation Planning Model (RtePM)

- Scenarios seeded by zone data
  - Population
  - Households
  - Vehicles
  - Seasonal Population
- Determines timing necessary to clear evacuation areas

County	Zone	Population [Night]	Households [est]	Vehicles [est]	Hotel Pop
Newton	A	2,030	791	1,567	
	Out of Zone	11,398	4,615	8,062	
	TOTAL	***13,428***	***5,406***	***9,629***	***0***
Jasper	Out of Zone	34,692	14,210	25,671	
	TOTAL	***34,692***	***14,210***	***25,671***	***0***
Hardin	A	3,636	1,198	2,956	2
	B	11,108	4,039	7,924	33
	Out of Zone	43,539	16,516	32,384	
	TOTAL	***58,283***	***21,753***	***43,264***	***35***
Orange	A	57,235	22,563	41,005	516
	B	15,606	5,683	12,512	387
	C	10,024	3,737	7,949	
	TOTAL	***82,865***	***31,983***	***61,466***	***903***
Jefferson	**Coastal**	**10,442**	**4,213**	**6,304**	**58**
	A	71,084	25,999	46,331	1,685
	B	47,347	14,159	26,497	1,397
	C	121,119	48,955	82,521	
	TOTAL	***249,992***	***93,326***	***161,653***	***3,140***
Upper Totals	***In Zones***	***349,631***	***131,337***	***235,566***	***4,078***
	Out of Zone	***89,629***	***35,341***	***66,117***	***0***
	TOTAL	***439,260***	***166,678***	***301,683***	***4,078***



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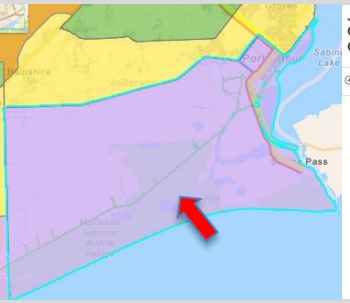
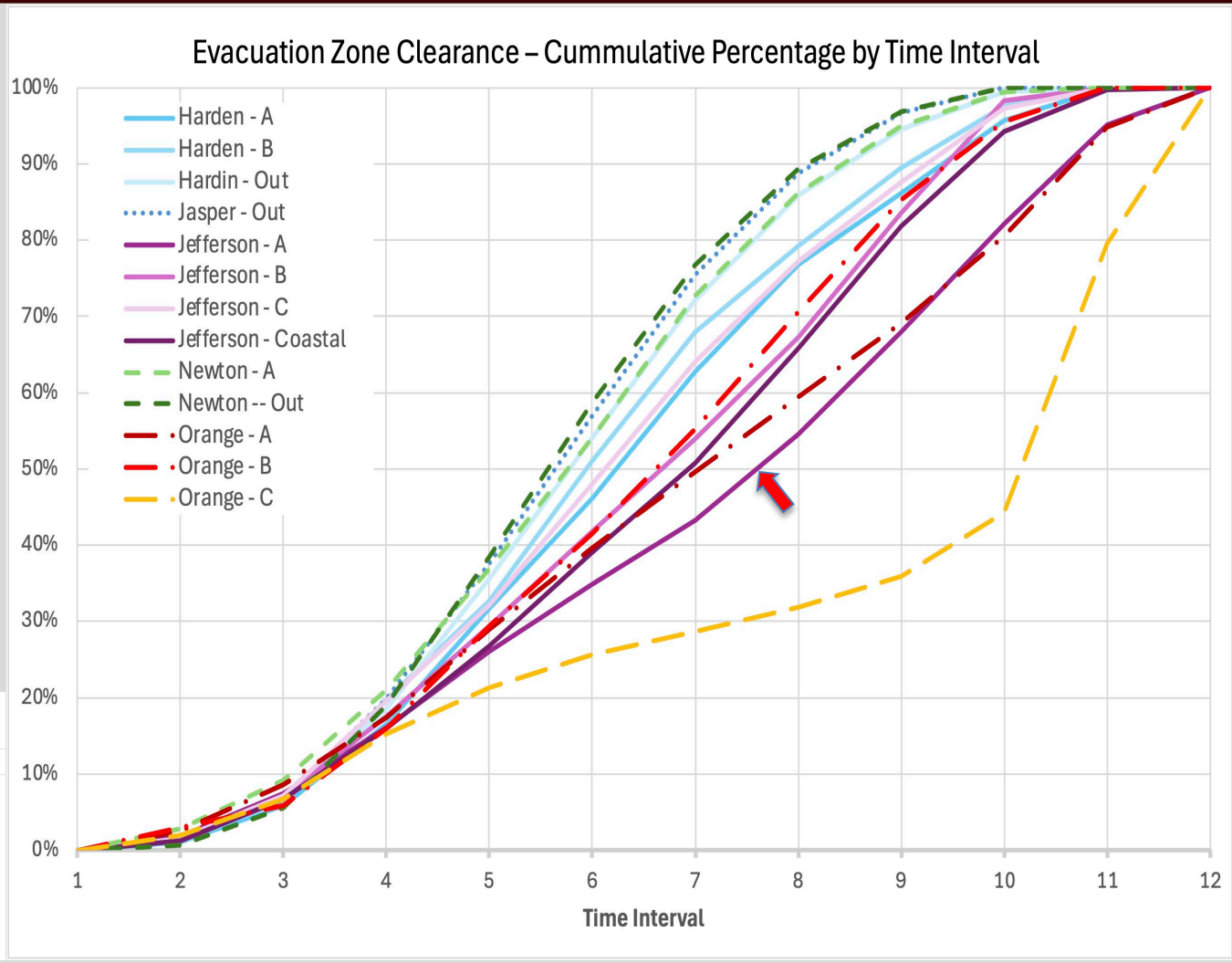
Evacuation Zone Clearance Scenarios

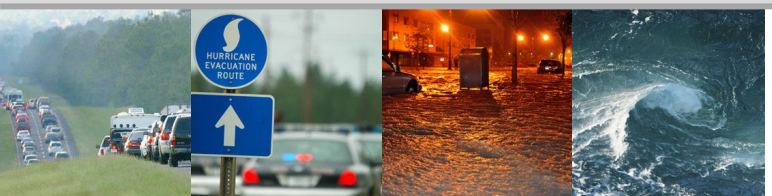
- Results of RtePM model
- Clearance time estimates
- Example (12 hr evac):
  - Jefferson Coastal Zone 50% clear at ~7.6 hrs



Jefferson County Coastal Zone

Boundary Description:	All areas south of SH 73 from western county boundary to US 69 (Memorial Blvd).
Population (night)	10,442
Households (est)	4,213
Vehicles (est)	6,304
Hotel Capacity	58





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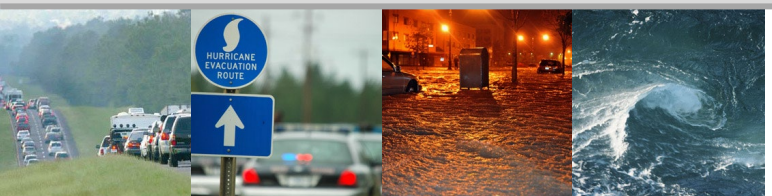
Thank You



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