

Compound Flooding Buffalo Bayou GSSHA Model Example

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Port Arthur TX Buffalo Bayou GSSHA Model



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Model/Project Background

- Linking levee performance reliability assessment with the outputs of models that simulate flood events in coastal zones.
- Applied to a levee system at Port Arthur, TX to investigate the performance of that levee system during Hurricane Ike, a Category 2 storm that occurred on September 11, 2008.
- The hydraulic loading on Port Arthur levee during the event is simulated by integrating the outputs of two hydraulic models, the Advanced CIRCulation (ADCIRC) model and the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model.



Model/Project Background

- The ADCIRC and GSSHA hydrographs were used as inputs to geotechnical simulation models that simulate the performance of the levee system at selected levee cross sections and estimate the probability of unsatisfactory performance (PUP) over a six day period encompassing the storm event.
- Levee performance is evaluated with respect to four levee modes of failure: 1) underseepage, 2) through-seepage, 3) uplift and 4) slope stability



Site map of Port Arthur Levee system



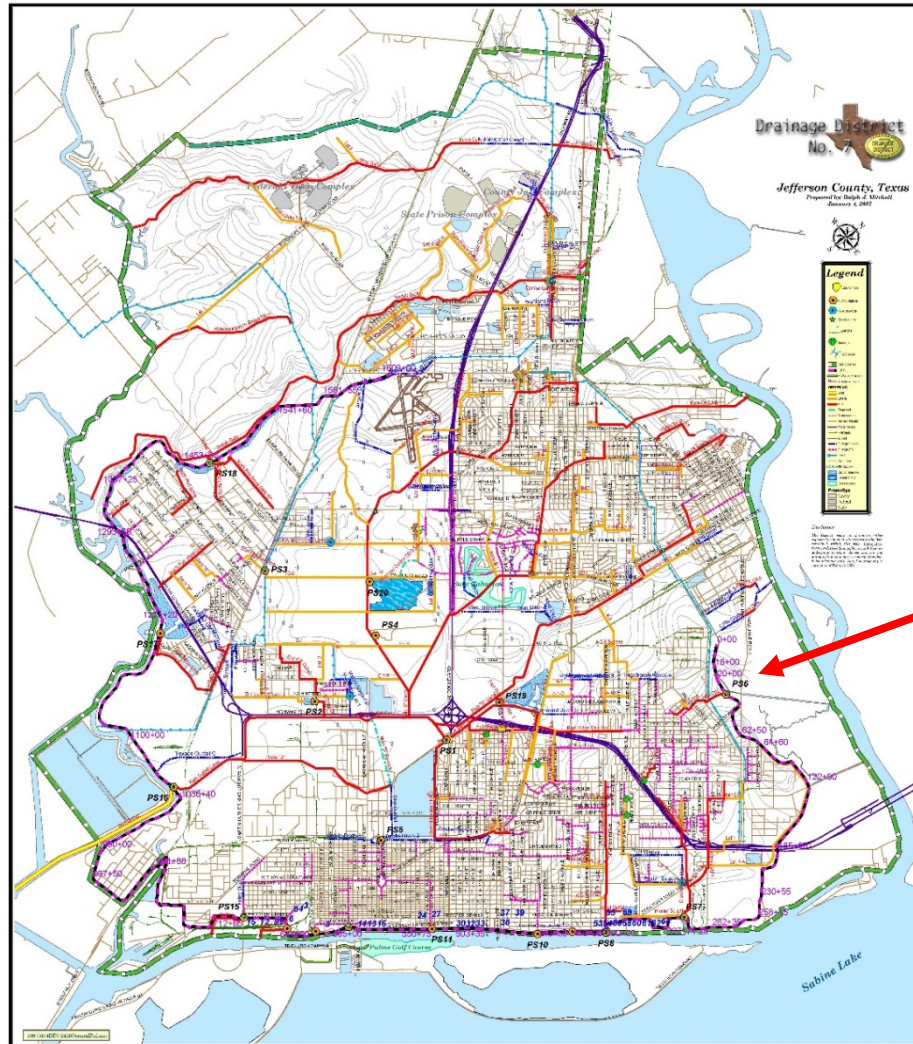
8 points of evaluation on the levee shown



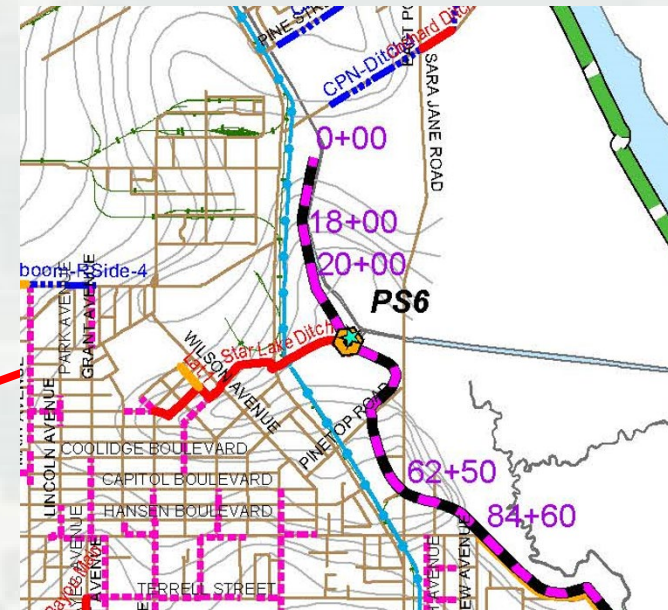
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Pumping Stations for Inland Flow resulting from landside rainfall



Detailed
information
available



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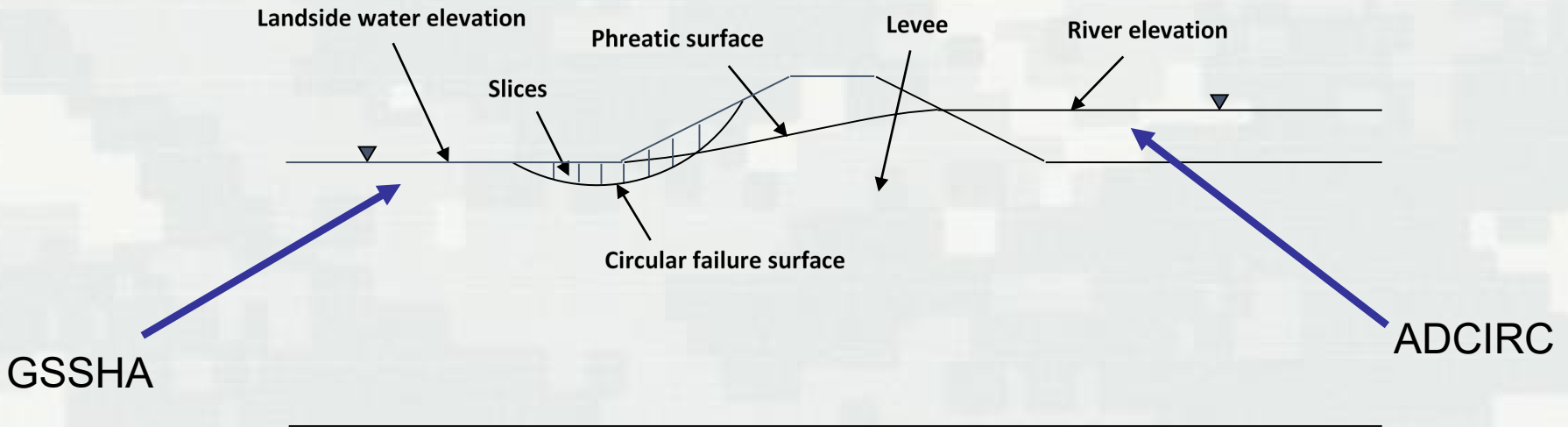
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Pumping Station Rate Used from Maximums Provided

PORT ARTHUR PUMP REFERENCE SHEET									
No	Station #	STATION NAME	Size inch	PUMPS	Rated Capacity (gpm)	m3/sec pumping	Rated Capacity (cfs)	Actual	
								ON	OFF
								*DATUM UNKNOWN	*DATUM UNKNOWN
1 S	1	Memorial	6	ELECTRIC 25 HP	2000		4.46	-13.65	-14.31
2 S	1	Memorial	6	ELECTRIC 25 HP	2000		4.46	-13.48	-13.98
3 E	1	Memorial	36	ELECTRIC 100 HP	20000		44.57	-8.00	-9.00
4 E	1	Memorial	36	ELECTRIC 100 HP	20000		44.57	-7.00	-8.50
5 E	1	Memorial	48	ELECTRIC 250 HP	65000		144.84	-4.00	-5.00
6 E	1	Memorial	48	ELECTRIC 250 HP	65000		144.84	-4.50	-5.50
7 D	1	Memorial	72	CUMMINS 780 HP	158,400		352.97	-5.00	-6.00
8 D	1	Memorial	72	CUMMINS 780 HP	158,400		352.97	-5.50	-6.50
9 D	1	Memorial	48	CUMMINS 185 HP	76,000		169.35	-6.00	-7.00
1 S	1	Memorial	6	ELECTRIC 25 HP	2,000		4.46	-12.00	-14.00
TOTAL					568,800	35.89	1,267		
1 D	2	El Vista	48	DETROIT 515 HP	77,700		173.14	-5.00	-8.50
2 E	2	El Vista	36	ELECTRIC 150 HP	20000		44.57	-11.50	-13.50
3 D	2	El Vista	48	DETROIT 515 HP	77,700		173.14	-5.00	-8.50
4 E	2	El Vista	6	ELECTRIC 25 HP	1,000		2.23	-13.50	-14.50
TOTAL					176,400	11.13	393		
1 D	3	West Port Arthur Road	36	CUMMINS 206 HP	37000		82.45	-3.00	-6.50
2 D	3	West Port Arthur Road	36	CUMMINS 206 HP	37000		82.45	-3.50	-7.00
2 E	3	West Port Arthur Road	36	ELECTRIC 125 HP	35000		77.99	-3.50	-7.00
3 D	3	West Port Arthur Road	36	CUMMINS 206 HP	37000		82.45	-4.00	-7.50
3 E	3	West Port Arthur Road	36	ELECTRIC 125 HP	35000		77.99	-4.00	-7.50
4 E	3	West Port Arthur Road	20	ELECTRIC 60 HP	13000		28.97	-6.50	-10.50
5 E	3	West Port Arthur Road	6	ELECTRIC 25 HP	2000		4.46	-13.00	-14.00



Levee Slope Stability – Method of Slices



- Evaluates failure of the levee as a result of river and landside water elevations calculated by GSSHA.
- Analysis uses river elevations provided by GSSHA and ADCIRC, soil properties of the levee, and trial failure surfaces.
- Programs are SEEP2D (HPC version).
- Uses the method of slices.



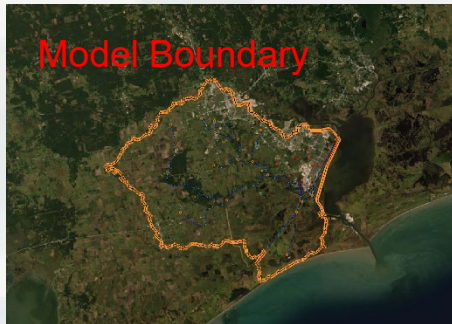
Model Boundary



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Port Arthur GSSHA Model for Compound Flooding

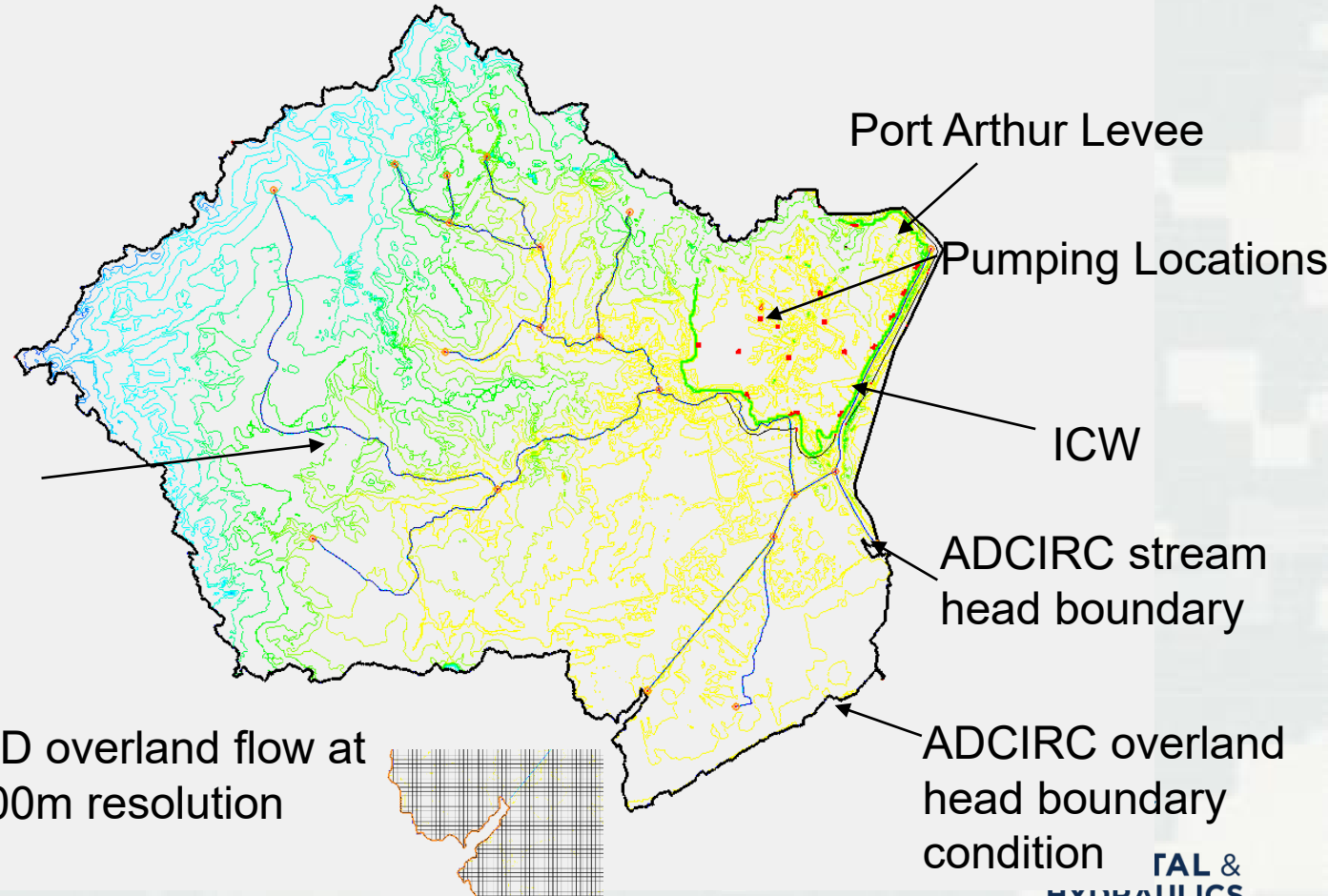
Location



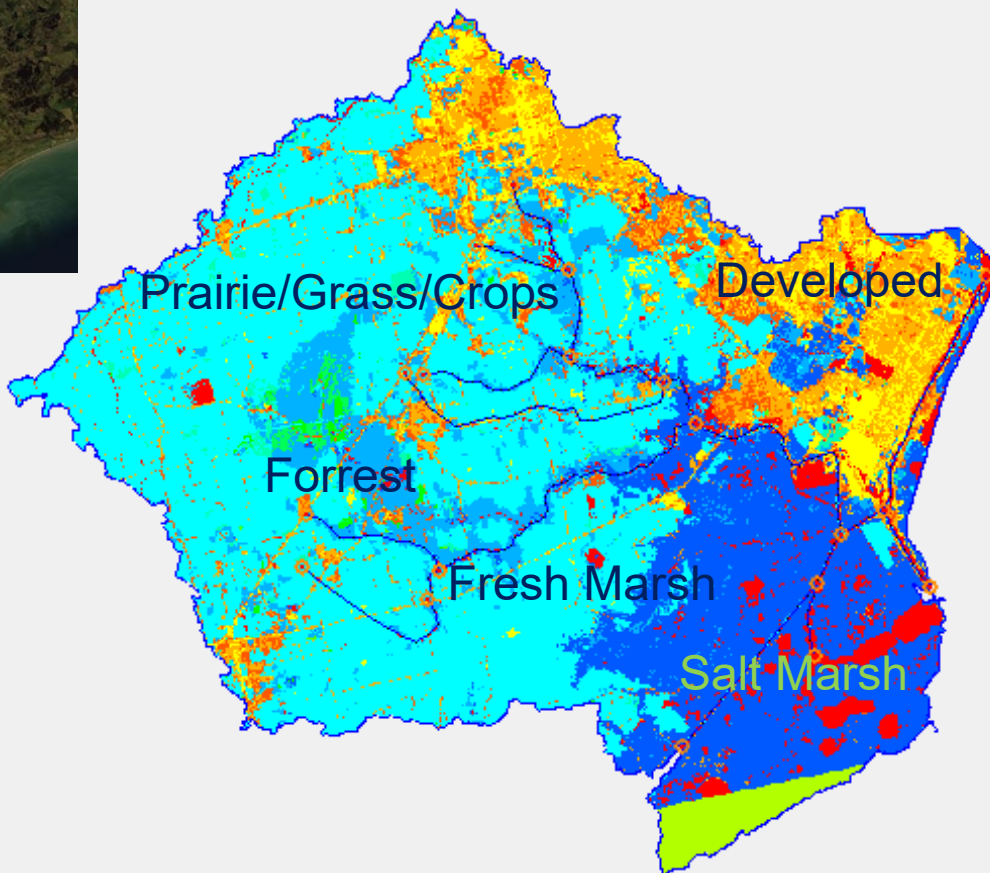
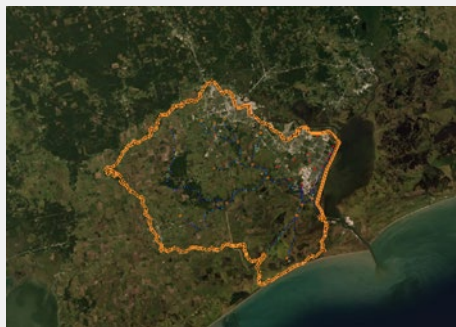
1-D Stream
Network with 2
way flow

2-D overland flow at
100m resolution

Features

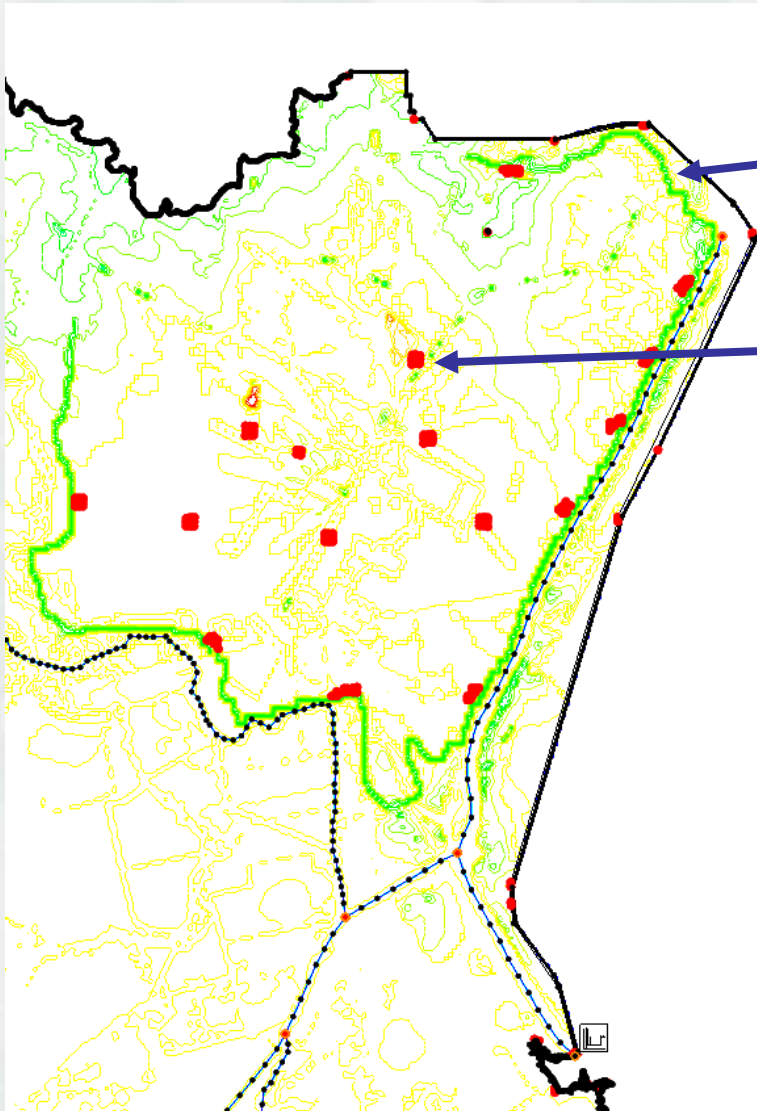


Land Use



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GSSHA Model Details



Levee is in the
DEM

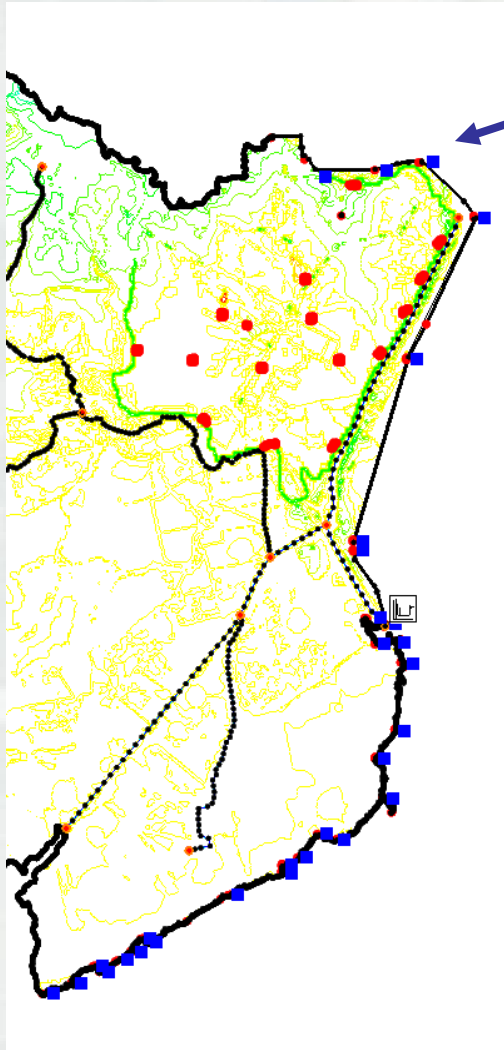
Pumping
stations are
wells with (-)
flow values
on the
overland
flow plane



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ADCIRC Boundary Conditions

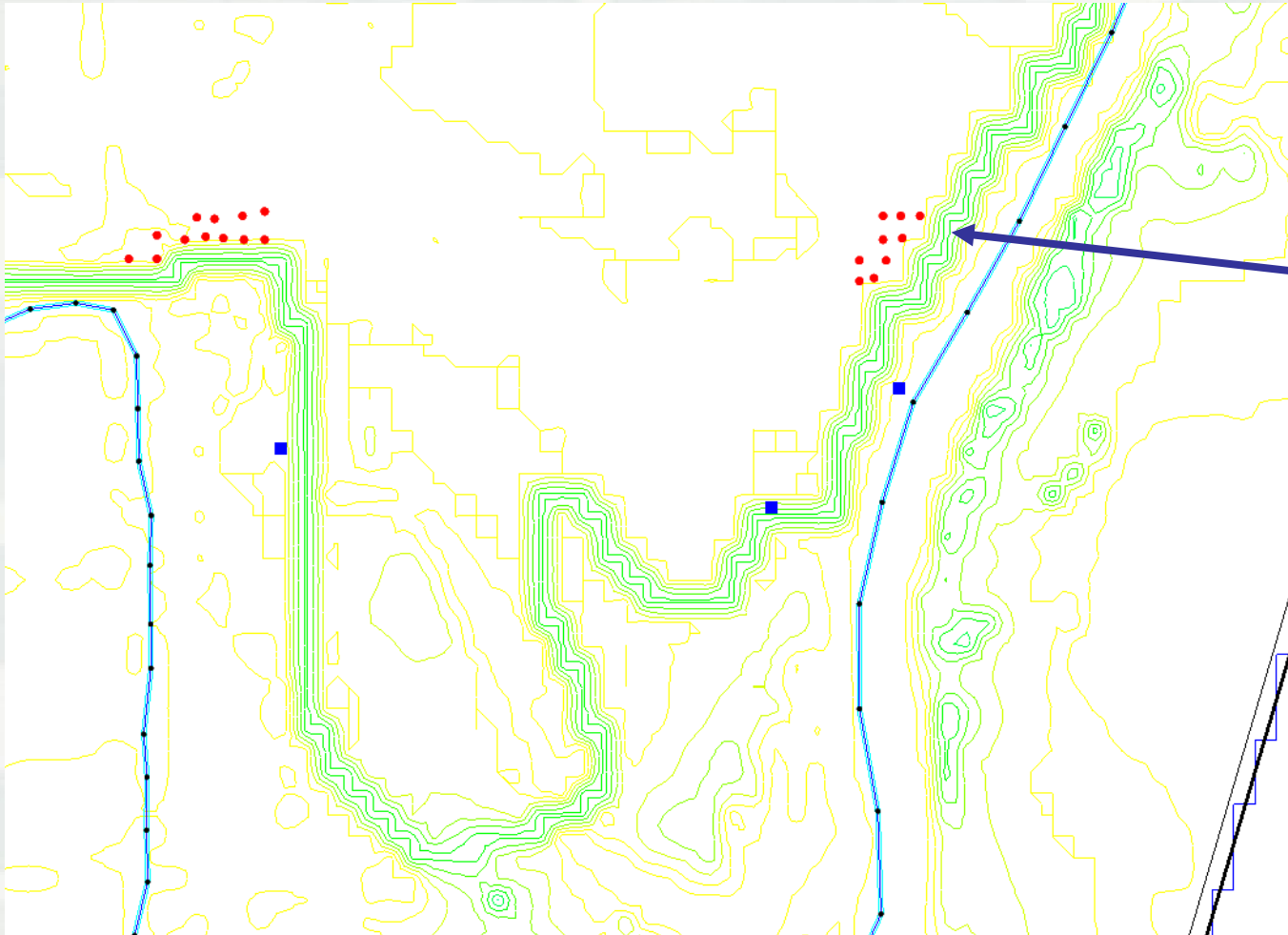


ADCIRC ocean storm surge is provided at these blue points as a boundary condition on the GSSHA model

XY_OV_DEPTH_INTERP									
26									
X					389356.57				390727.04
Y					3280746.01				3280936.34
2008	9	5	18	30	0.84055627				0.61144793
2008	9	5	19	0	0.84055627				0.61144793
2008	9	5	19	30	0.84055627				0.61144793
2008	9	5	20	0	0.84055627				0.61144793
2008	9	5	20	30	0.84055627				0.61144793
2008	9	5	21	0	0.84055627				0.61144793
2008	9	5	21	30	0.84055627				0.61144793
2008	9	5	22	0	0.84055627				0.61144793
2008	9	5	22	30	0.84055627				0.61144793
2008	9	5	23	0	0.84055627				0.61144793
2008	9	5	23	30	0.84055627				0.61144793
2008	9	6	0	0	0.84055627				0.61144793
2008	9	6	0	30	0.84055627				0.61144793
2008	9	6	1	0	0.84055627				0.61144793
2008	9	6	1	30	0.84055627				0.61144793
2008	9	6	2	0	0.84055627				0.61144793
2008	9	6	2	30	0.84055627				0.61144793
2008	9	6	3	0	0.84055627				0.61144793
2008	9	6	3	30	0.84055627				0.61144793
2008	9	6	4	0	0.84055627				0.61144793
2008	9	6	4	30	0.84055627				0.61144793
2008	9	6	5	0	0.84055627				0.61144793
2008	9	6	5	30	0.84055627				0.61144793
2008	9	6	6	0	0.84055627				0.61144793
2008	9	6	6	30	0.84055627				0.61144793
2008	9	6	7	0	0.84055627				0.61144793
2008	9	6	7	30	0.84055627				0.61144793
2008	9	6	8	0	0.84055627				0.61144793
2008	9	6	8	30	0.84055627				0.61144793
2008	9	6	9	0	0.84055627				0.61144793
2008	9	6	9	30	0.84055627				0.61144793
2008	9	6	10	0	0.84055627				0.61144793



Pumping Wells

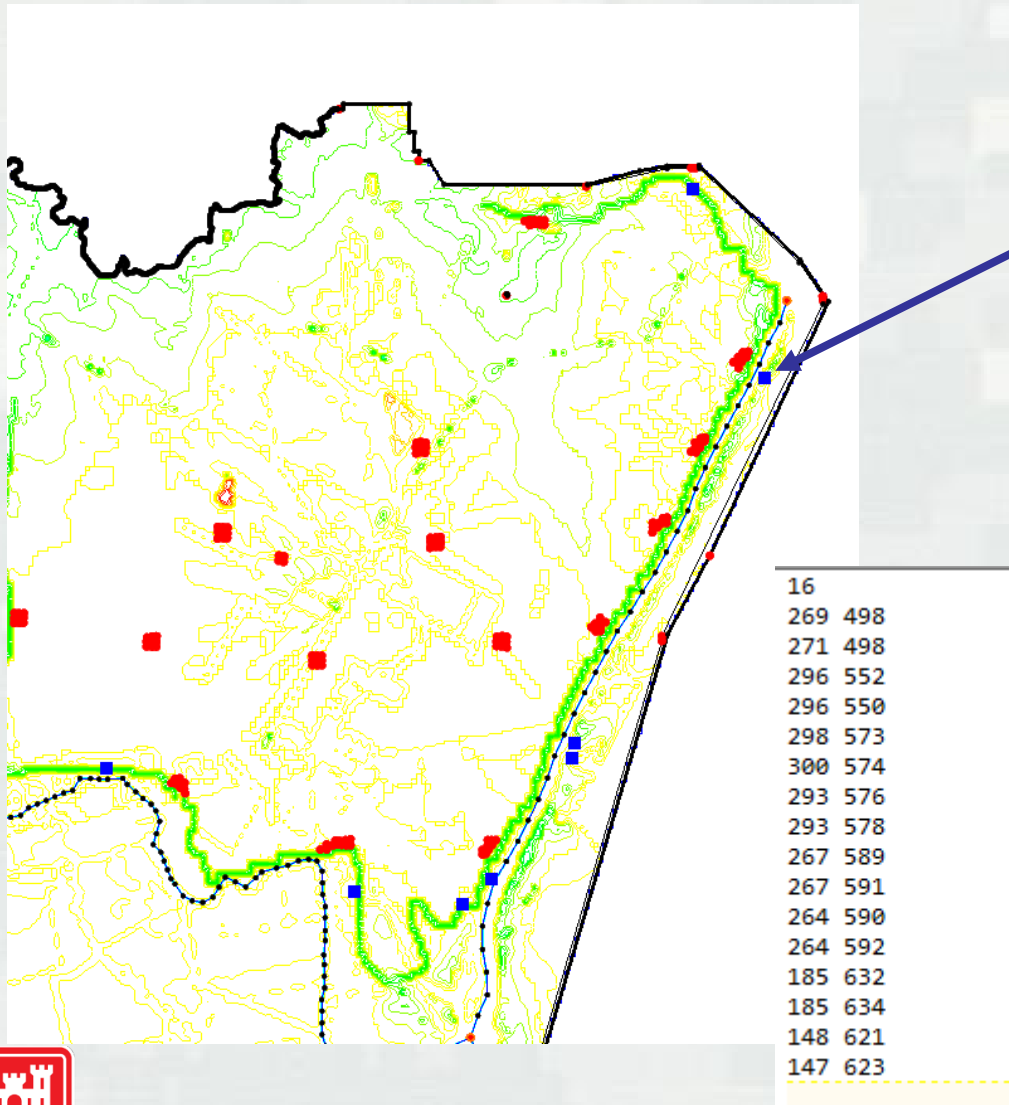


Pumping wells are distributed on the overland flow plane with (-) pumping values removing water.



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Hydrograph Points on the Levee



- 8 locations with one point on each side of the levee (coordinate are I and J in GSSHA).
- SEEP2D model run at these 8 cross sections
- GSSHA provides hydrographs at these 16 points.



Hurricane Ike Details

- Hurricane Ike made landfall at Galveston Island on September 13, 2008 as a Category 2 Storm, which extensive storm surge flooding, wind damage and rainfall flooding.
- Maximum sustained winds – 110 mph
- Rainfall
 - Initially 6-10 inches in Harris County
 - An additional 3 – 8 inches occurred the next day
- Storm Surge
 - 12-15 ft across Harris County
 - 15-17 ft across Bolivar County
 - 14.24 ft at Sabine Pass (highest on record)

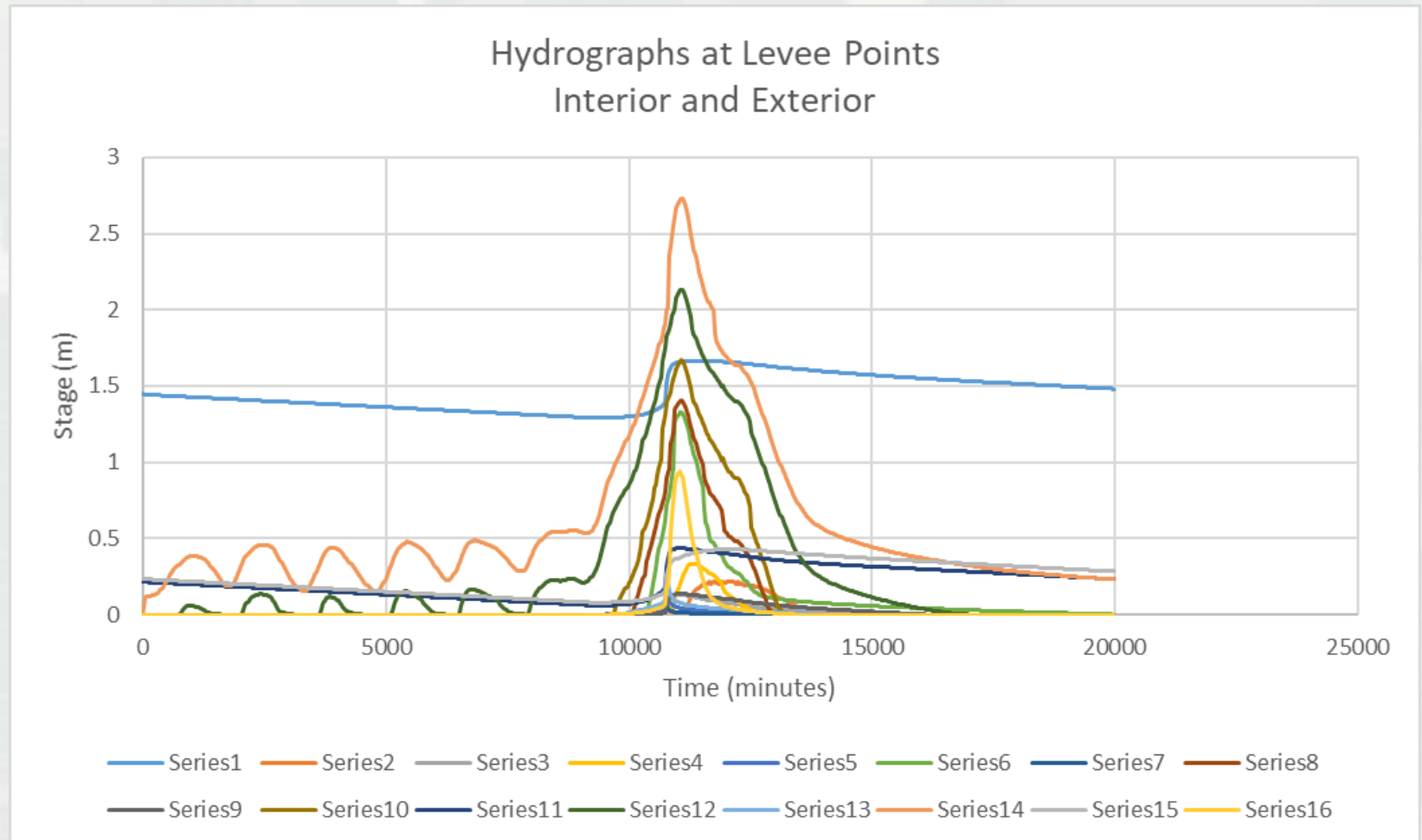


Flooding

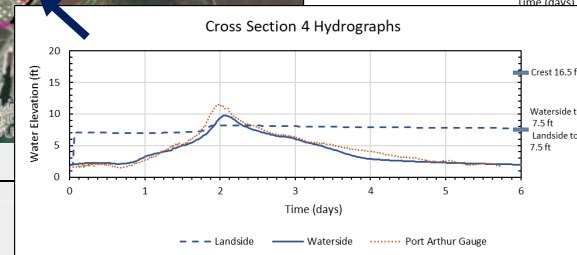
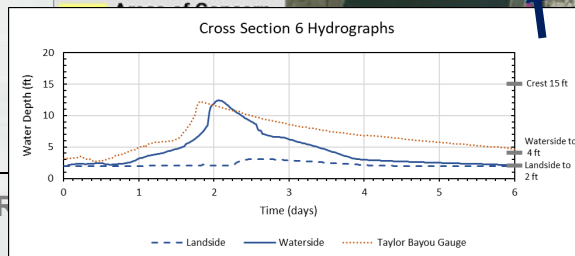
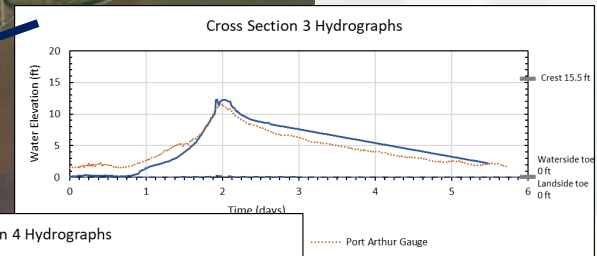
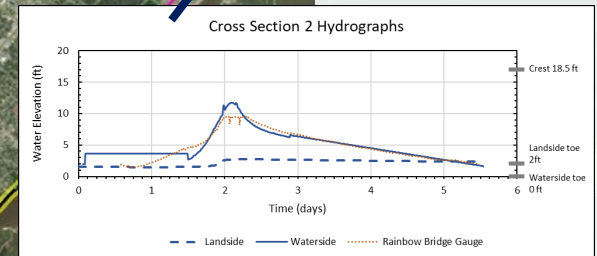
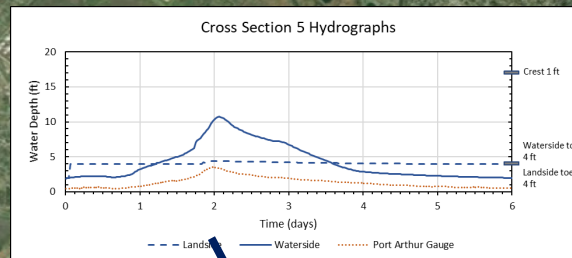
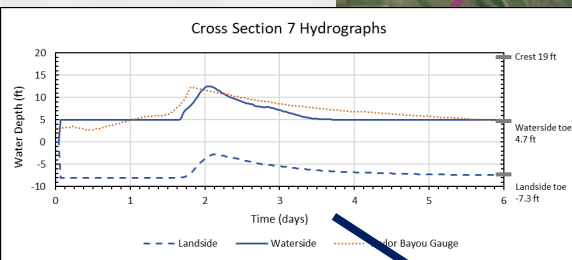
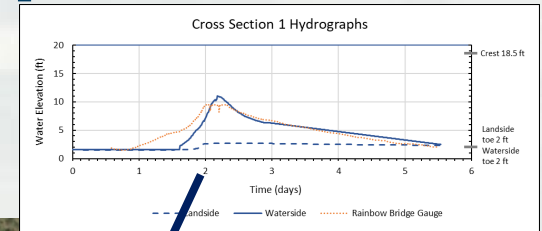
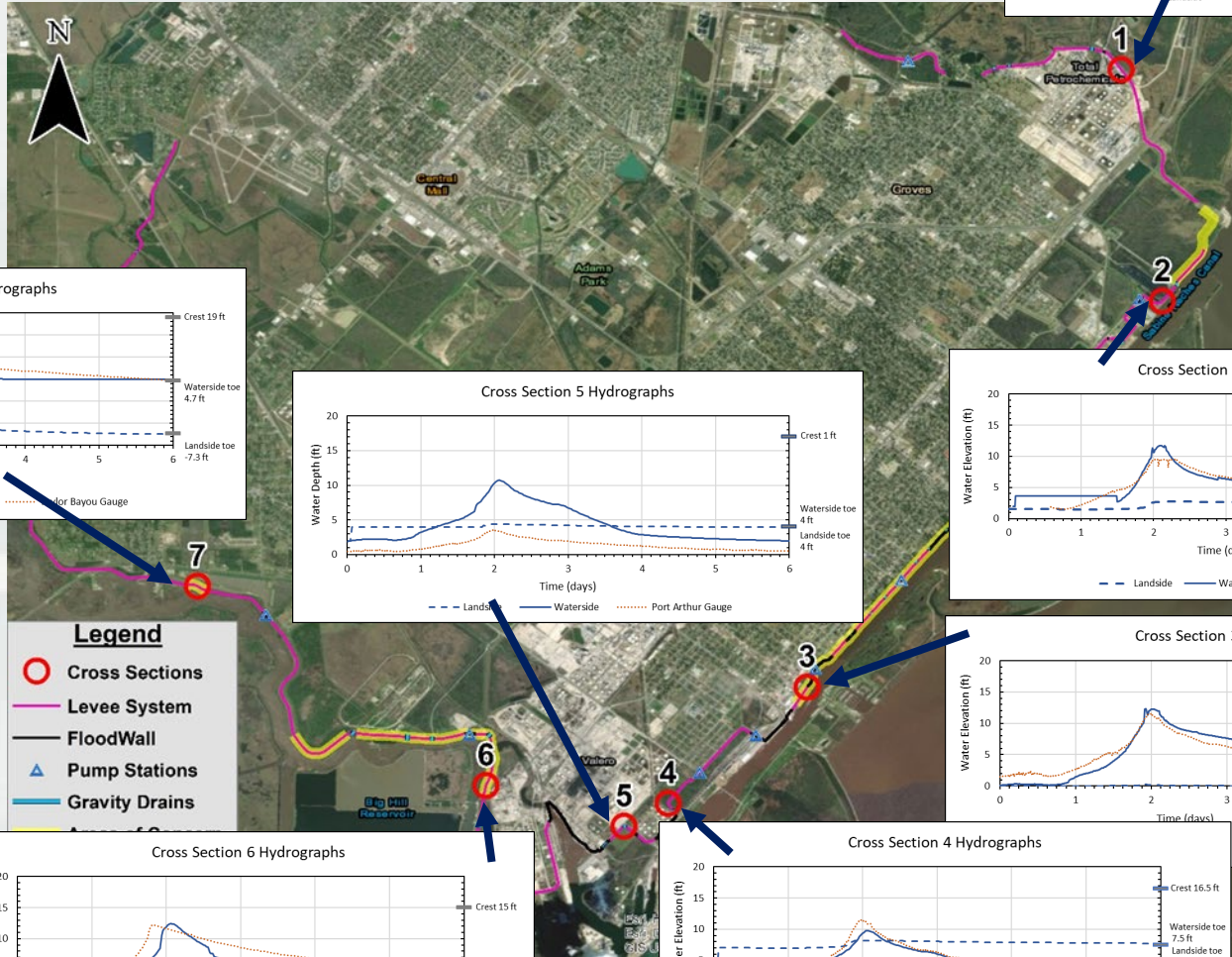
- Storm Surge
 - 2550 homes flooded in Harris County
 - Storm Surge extended almost 20 miles into Chambers County
- Rainfall
 - Major street flooding during second event
 - Exacerbated by clogged drains
 - 1300 homes flooded by rainfall
- River/Stream
 - Major flooding along Hunting, Little White Oak, Halls, lower White Oak, and lower Brays Bayous



Simulated 10 Day Levee Hydrographs



5 Day Levee Point Hydrographs

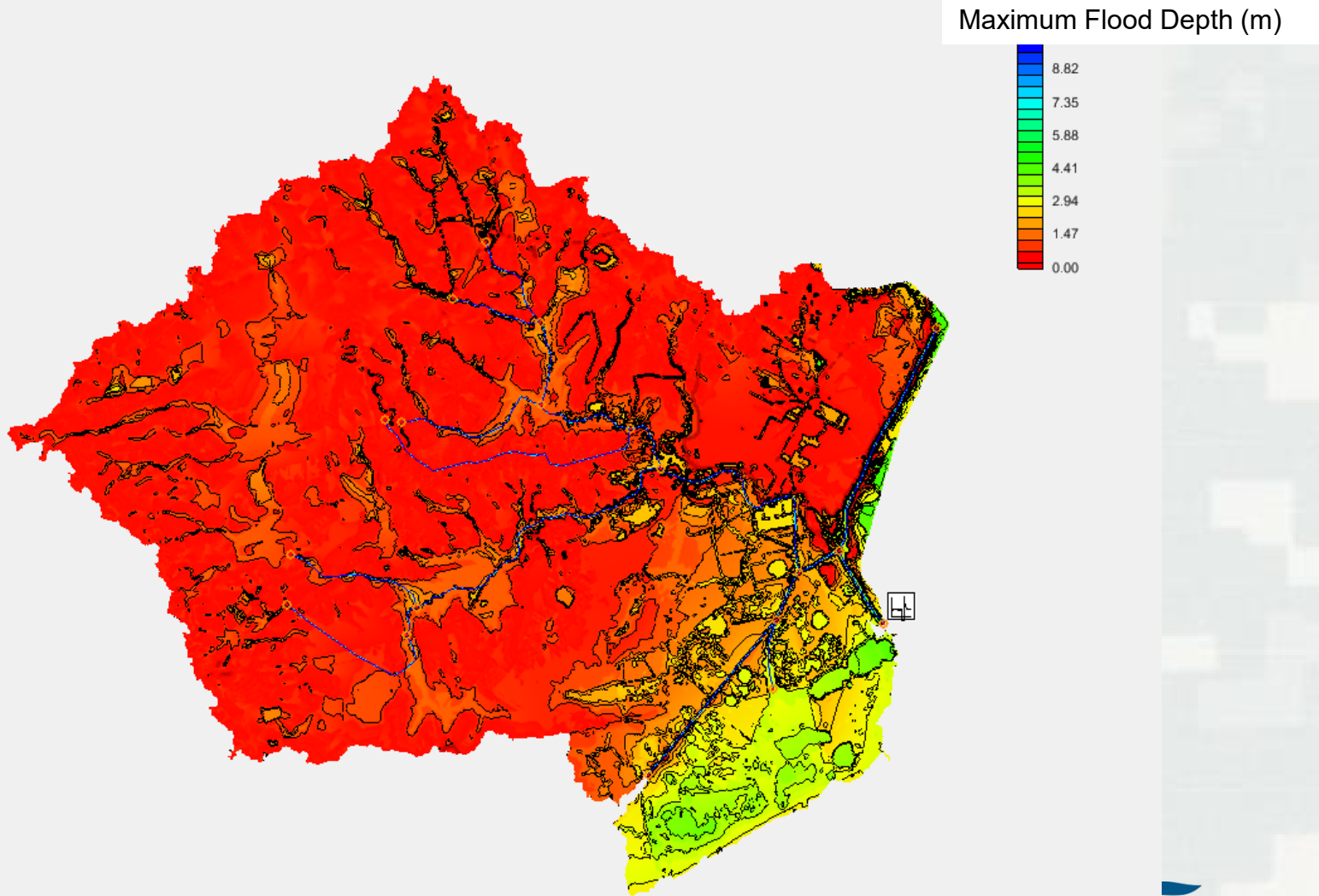


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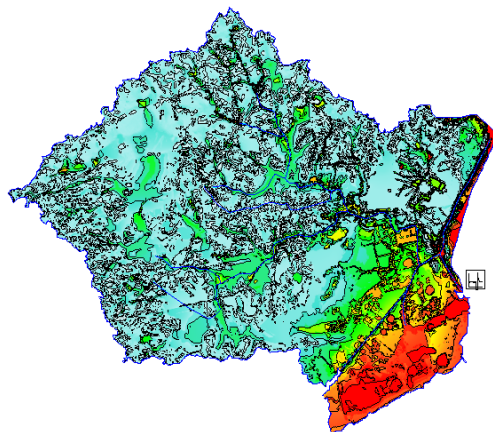
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Maximum Flood Depth



flood_grid



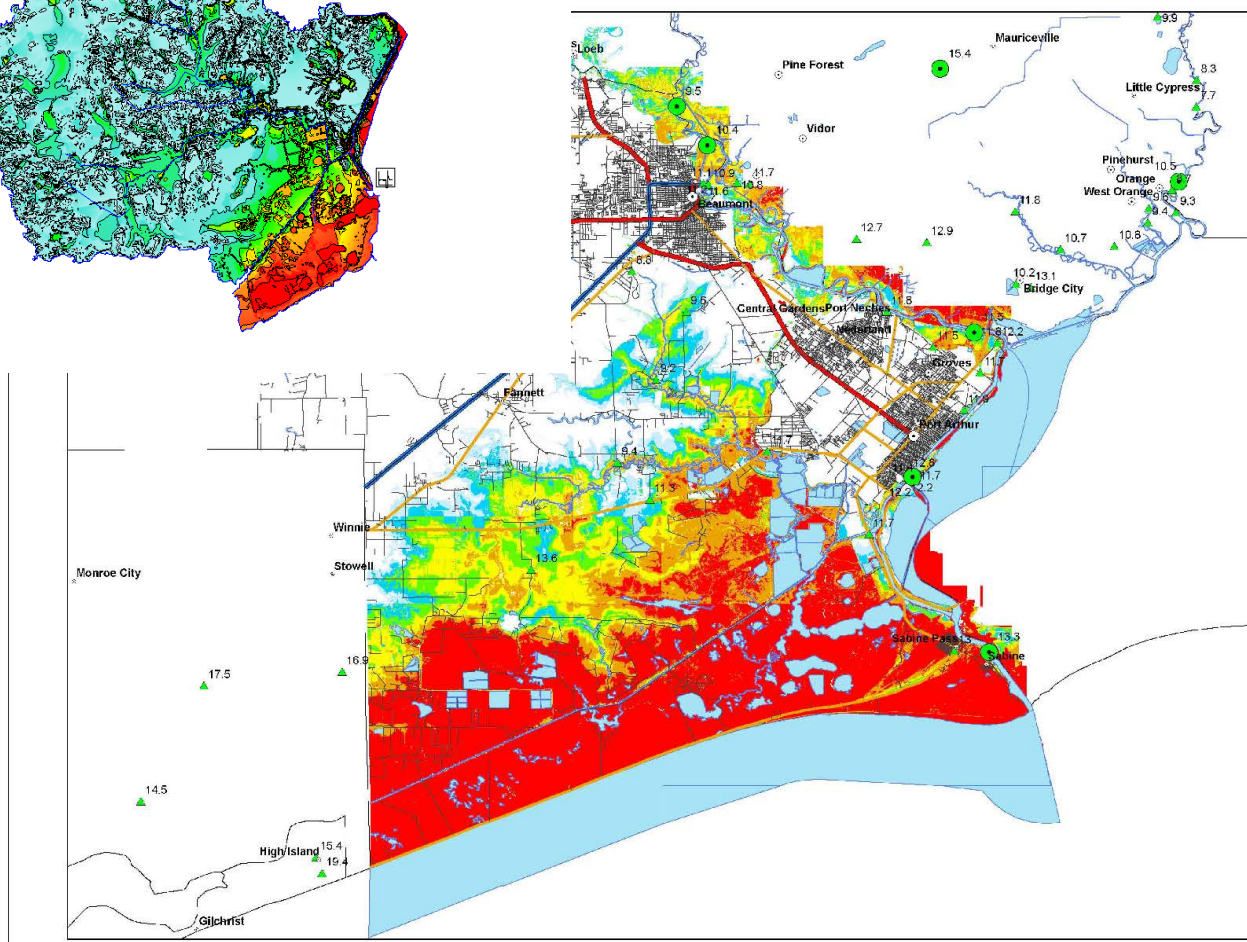
Flood Inundation Estimate for Jefferson County

Legend

Legend

- >10 Feet
- 8-10 Feet
- 6-8 Feet
- 4-6 Feet
- 2-4 Feet
- < 2 Feet
- No Inundation
- Measured Water Level
- FEMA High Water Marks

Note: This is the best estimate of storm tide at the time the map was made on November 4th. This map should be considered preliminary and will be updated as new information becomes available. Use map with caution. All elevation data is in NAVD88.



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