

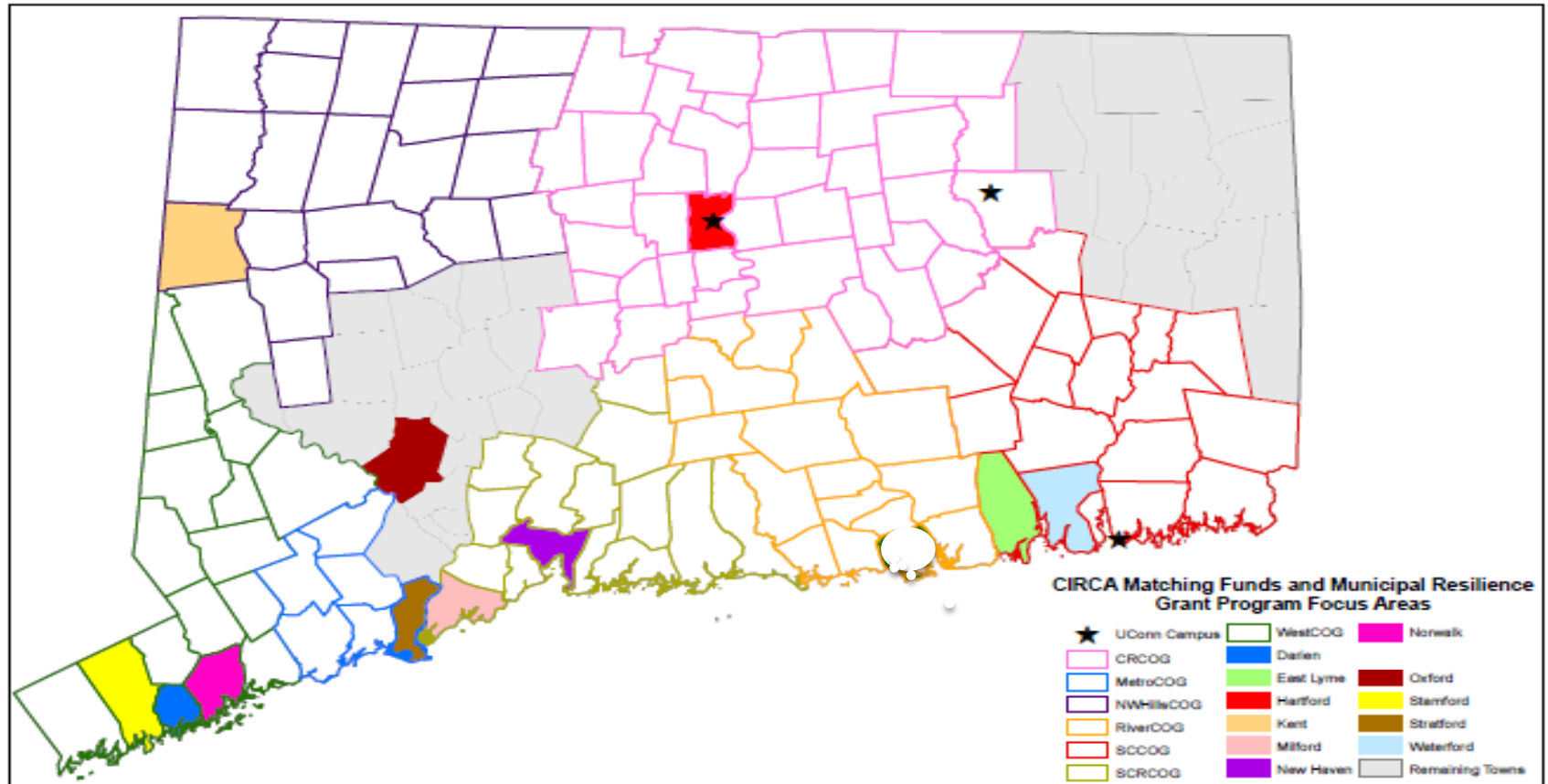
Sea level rise impacts on Connecticut: Increased frequency of coastal flooding along roads crossing marshes

Dr. Rebecca A. French

CAFM 2017

October 25, 2017

CIRCA Matching Funds and Municipal Resilience Grant Program Focus Areas



New Municipal Resilience Project Awards

- **Connecticut Metropolitan Council of Government: Beardsley Zoo Green Infrastructure Project**
 - A highly visible green infrastructure retrofit project with installation and outreach components at the zoo located along the Pequonnock River in Bridgeport.
- **New Haven: Assessing Impacts of Tides and Precipitation on Downtown Storm Sewer System**
 - Creates a low-cost, stormwater sensor network for data on the hydrology of New Haven's urban core (rainfall, tides, green stormwater infrastructure, and sewer conveyance systems).

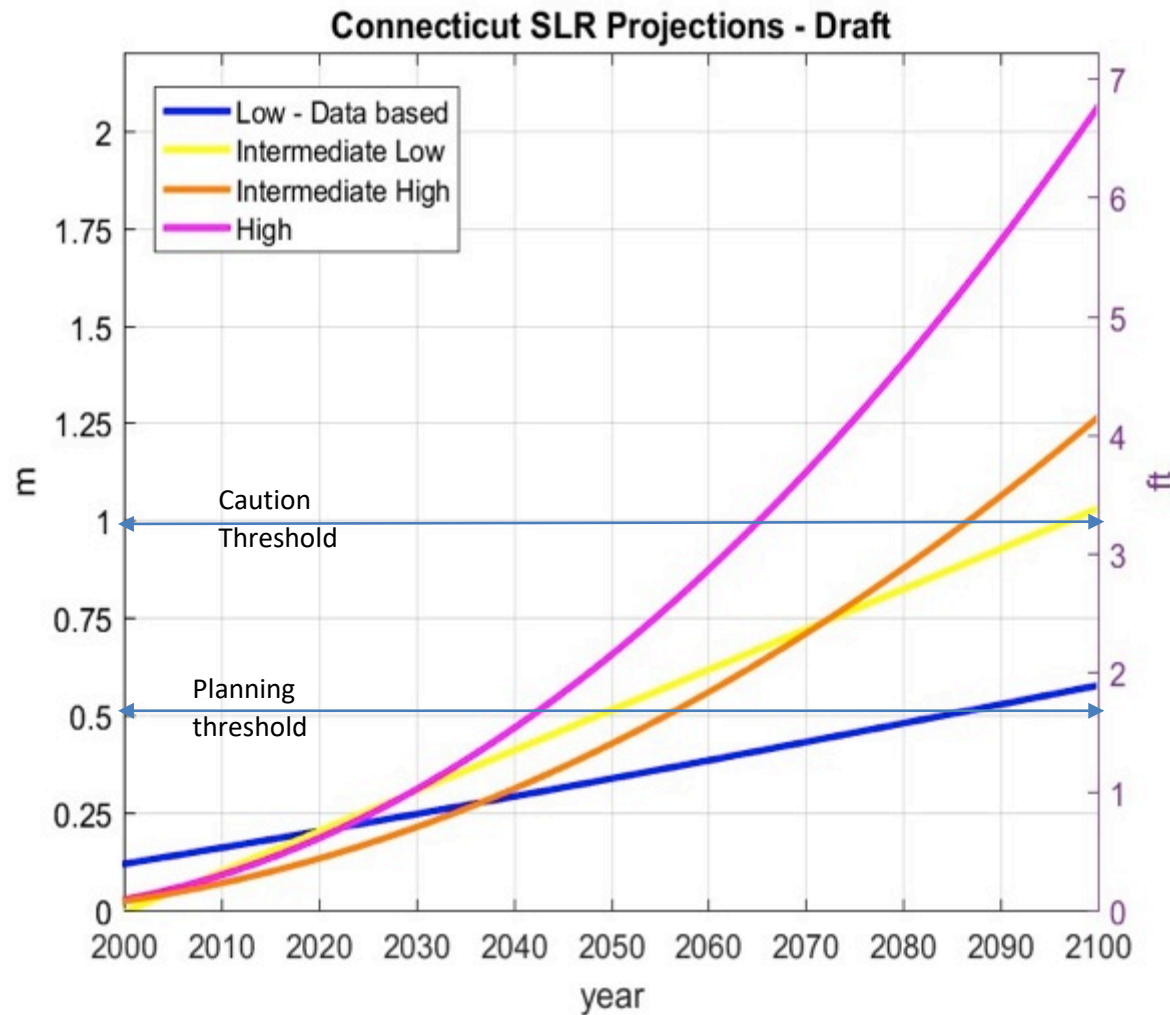


New Municipal Resilience Project Awards

- **Northwest Hills Council of Government: Enhancing Rural Resiliency: A Vision and Adaptation Toolkit**
 - Crafts a vision for *A Resilient Northwest Hills* and produces a web-hosted climate change adaptation toolkit for the region's 21 municipalities and a transferable product for other CT towns.
- **Stamford: Resilience Opportunity Assessment**
 - A pilot project to review the potential vulnerability to climate change hazards and mitigation approaches at Stamford's Government Center and High School, which is an emergency shelter.



Figure 1. Sea level rise projections for Connecticut based on local tide gage observations (blue), the IPCC (2013) RCP 4.5 model simulations near Long Island Sound (yellow line), the semi-empirical model predictions are in orange and the magenta shows the ice mass balance projections.

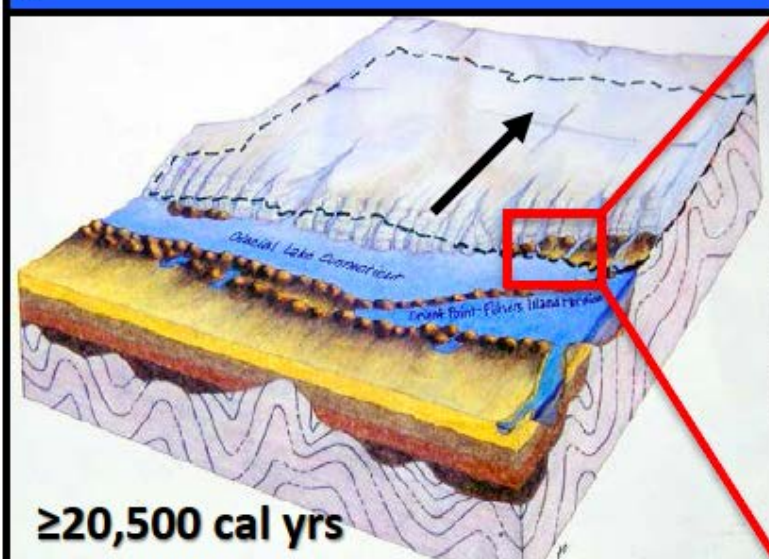
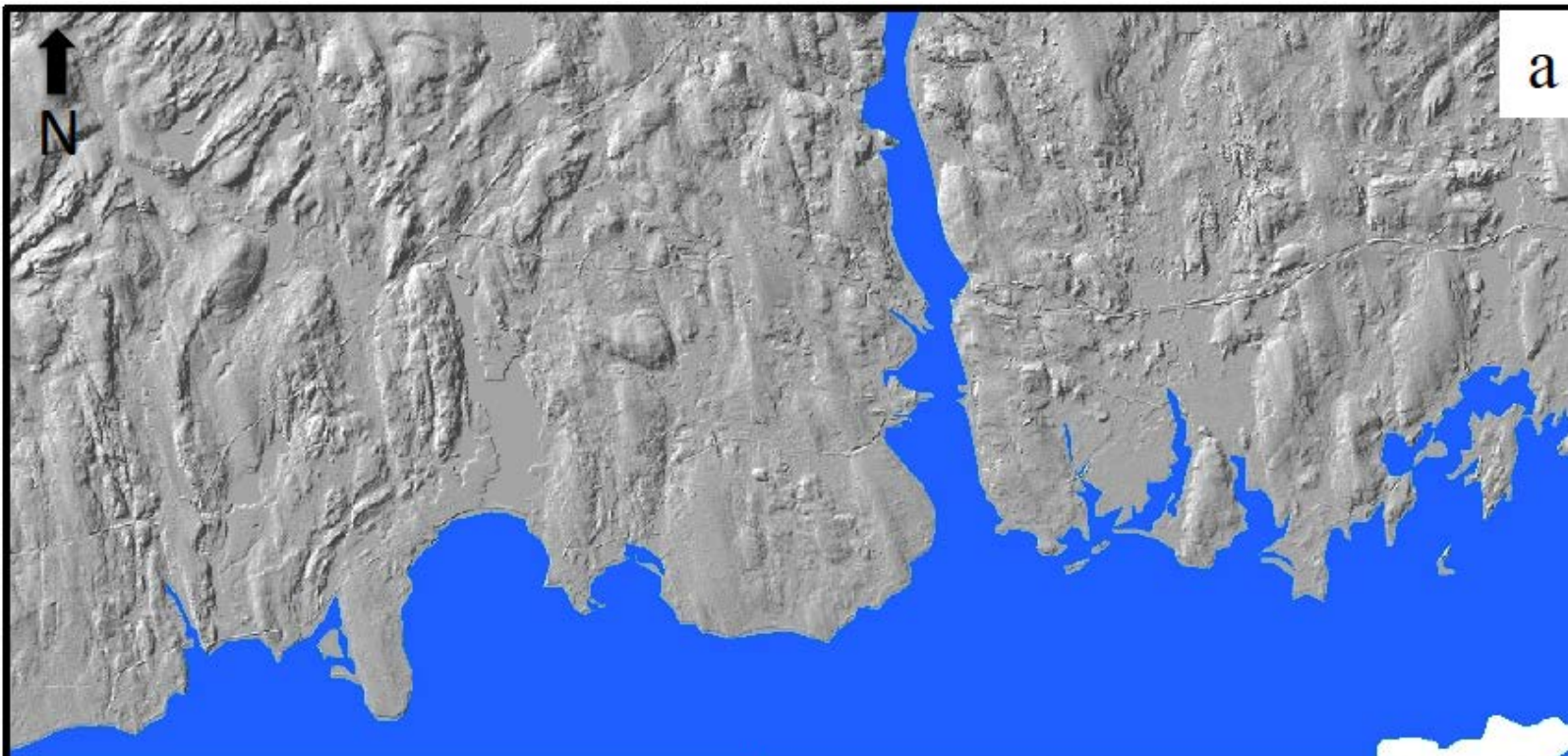


O'Donnell, 2017

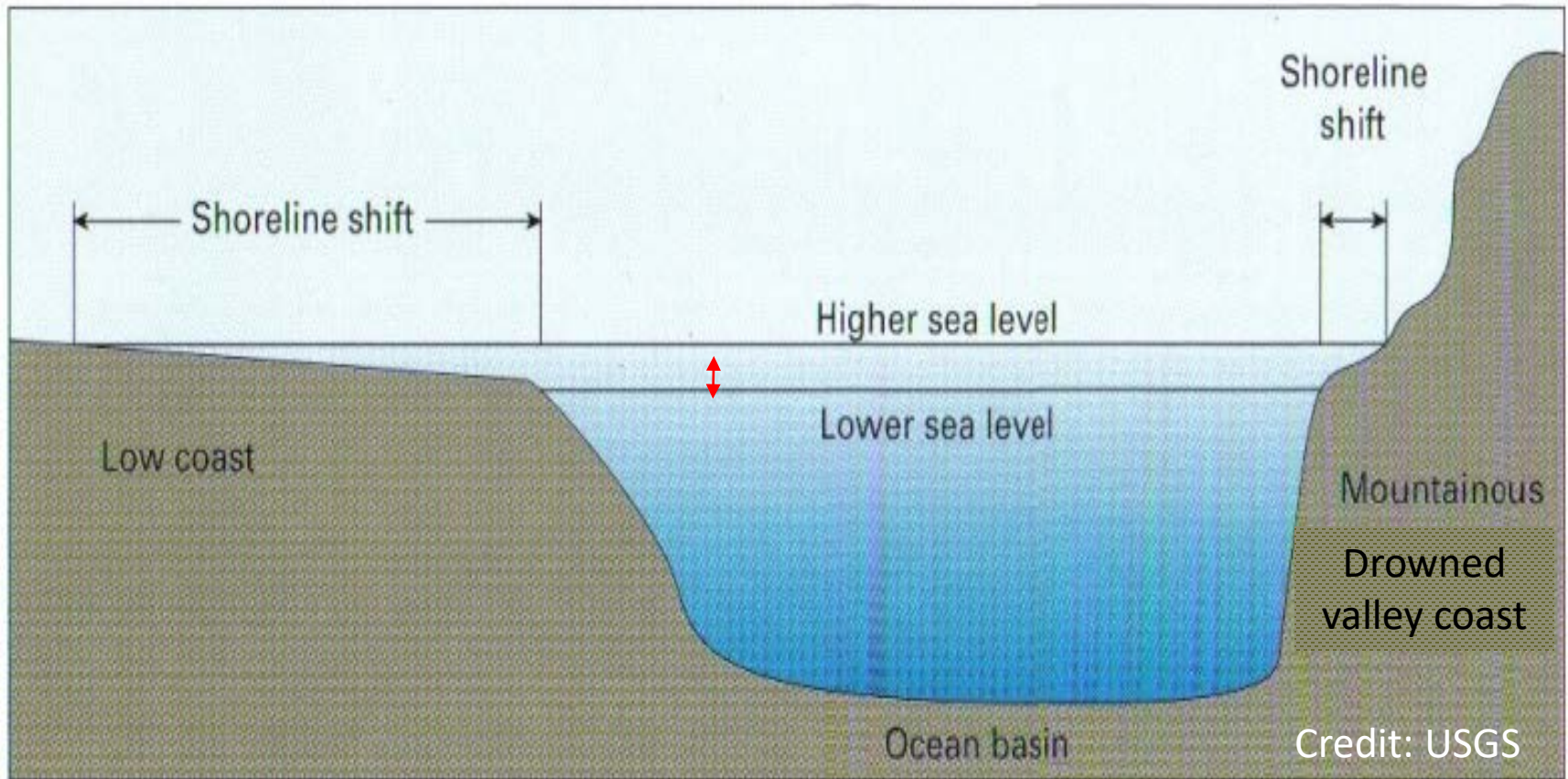
Connecticut's coastline:
Glacially-modified landscape characterized by
erodible deltas and rocky headlands

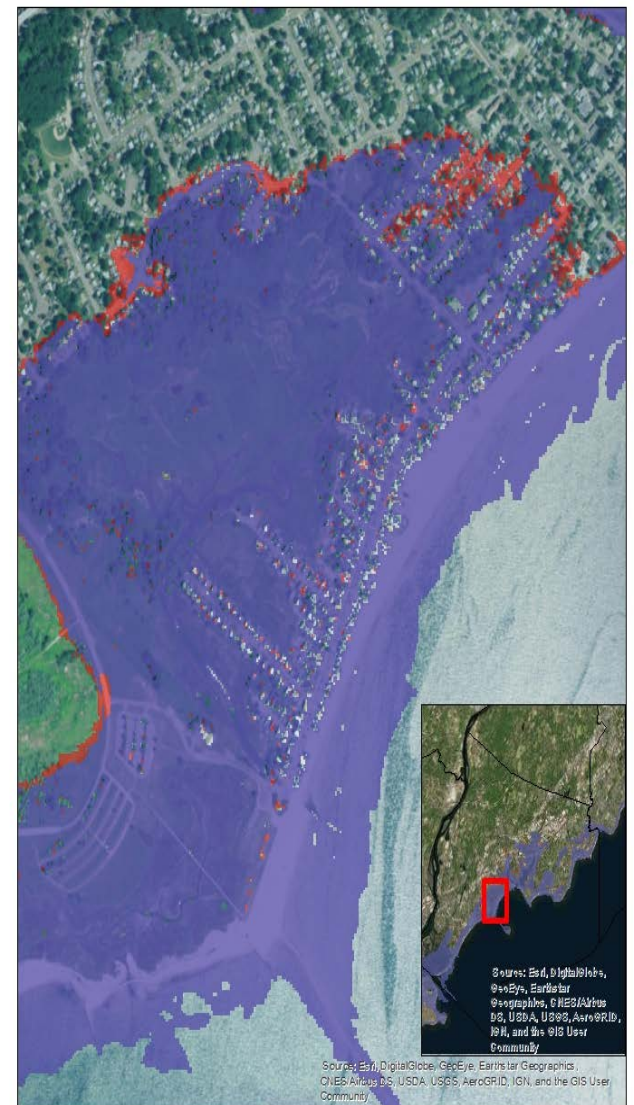


Lewis, 2015, CT GS

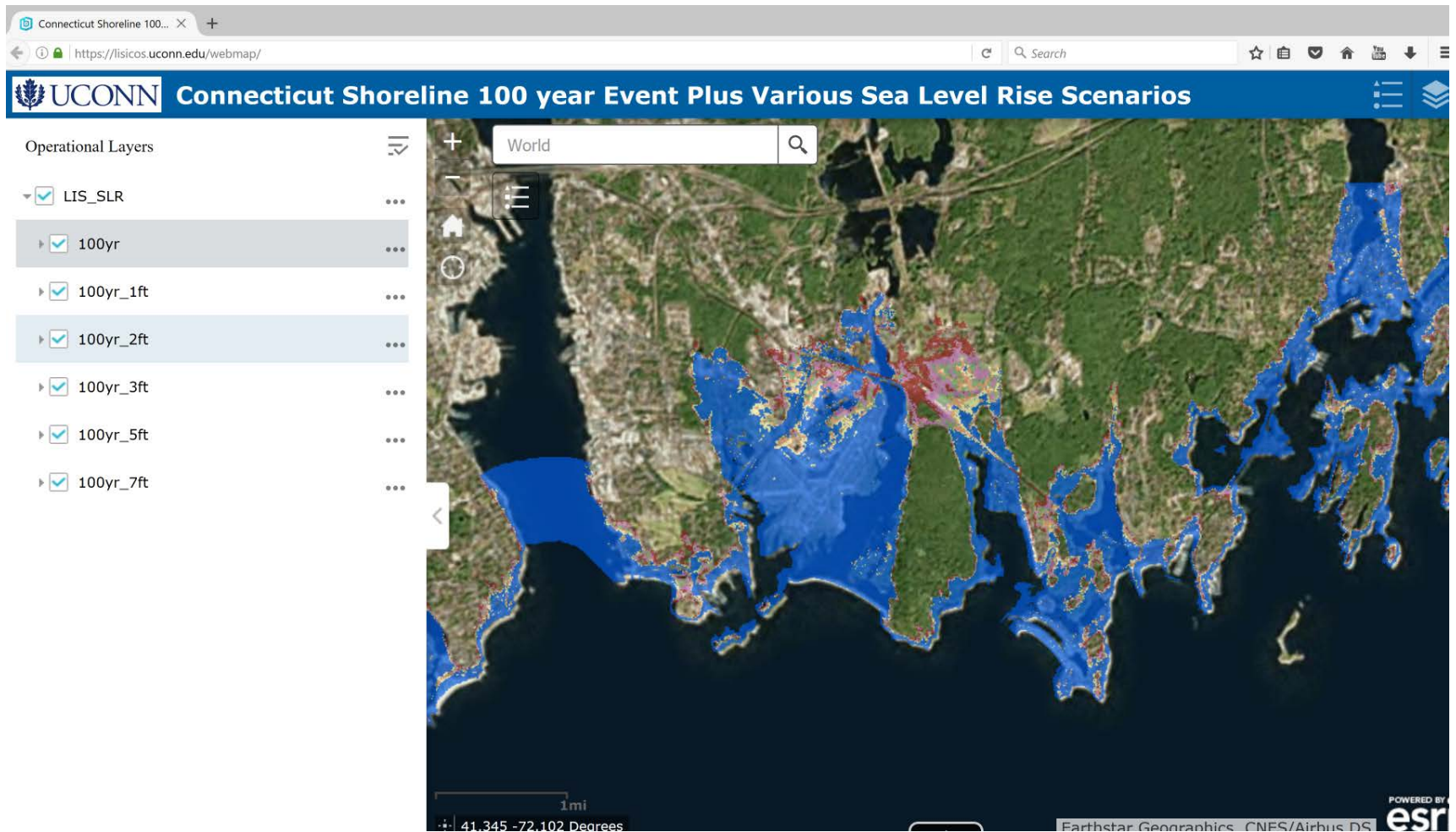


SLR on Coastal Plain vs. Drowned Valley Coast





O'Donnell and Fake, 2017



O'Donnell and Fake, 2017

James O'Donnell,^{1,2} Kay Howard Strobel,² Michael Whitney² and Todd Fake²

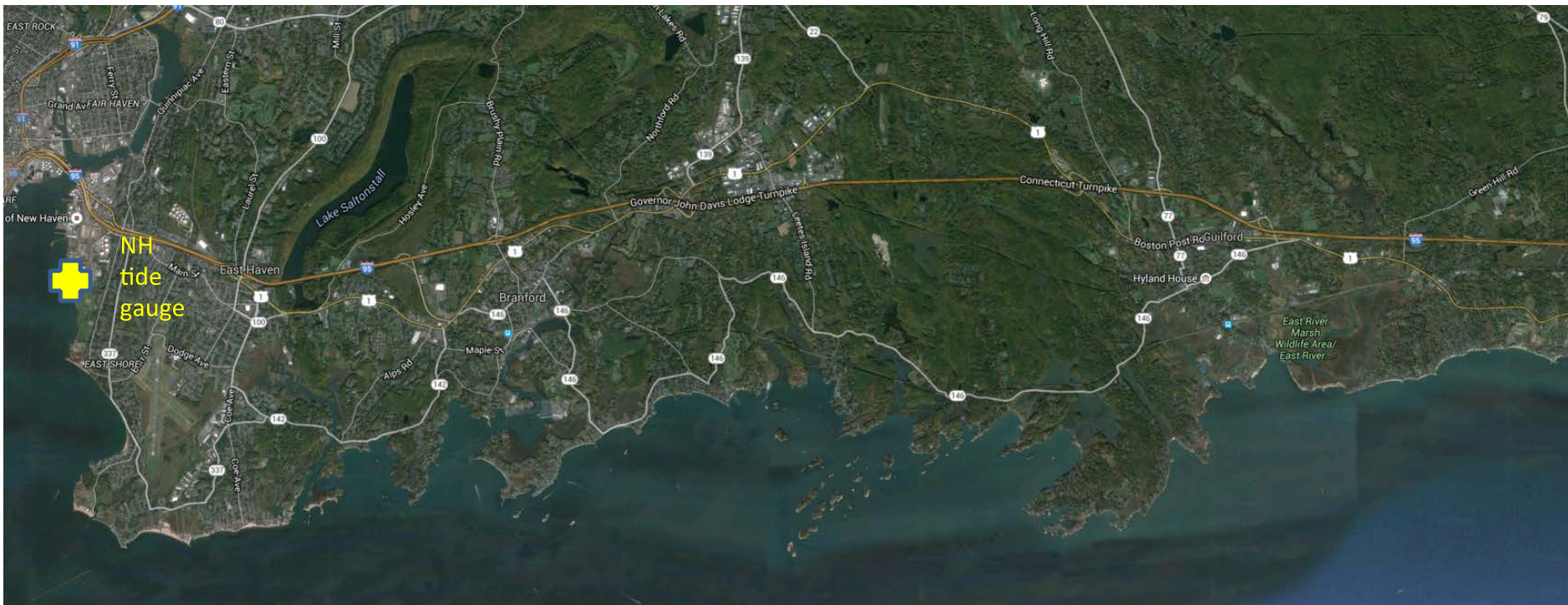
¹Connecticut Institute for Resilience and Climate Adaptation

²Department of Marine Sciences

The University of Connecticut

ROAD FLOODING IN COASTAL CONNECTICUT: FINAL REPORT TO SOUTH CENTRAL REGIONAL COUNCIL OF GOVERNMENTS (JULY 2017)

Study Area



Guilford Study Areas

- Area 1: Sachems Head Road (RT 146)
- Area 2: Leetes Island Road (RT 146)



Branford Study Areas



- Area 3: Indian Neck Avenue and RT146
- Area 4: Linden and Sybil Avenues
- Area 5: Limewood Avenue (RT 146) and Waverly Road
- Area 6: RT 146 at Jarvis Creek

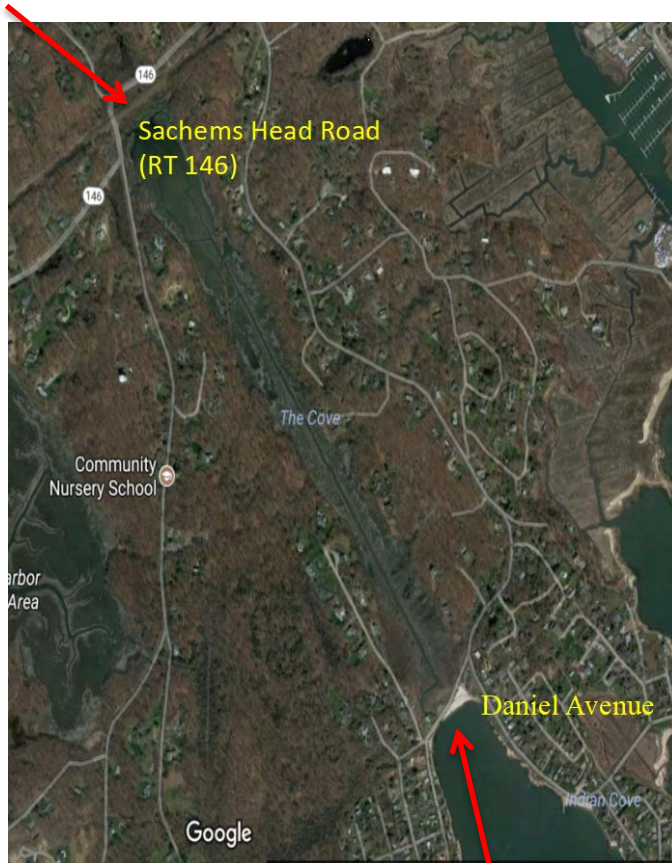


Study Approach

- Past work showed that flooding on roads in these areas determined by marsh basin and flow control structures, not just water level in Long Island Sound.
- Develop relationships between the long term observations of sea level fluctuations at the NOAA tide gages in Long Island Sound and water levels at the study sites using a combination of observations and mathematical models that represent the flow of water through the channels and flow control structures that connect the sites and Long Island Sound.

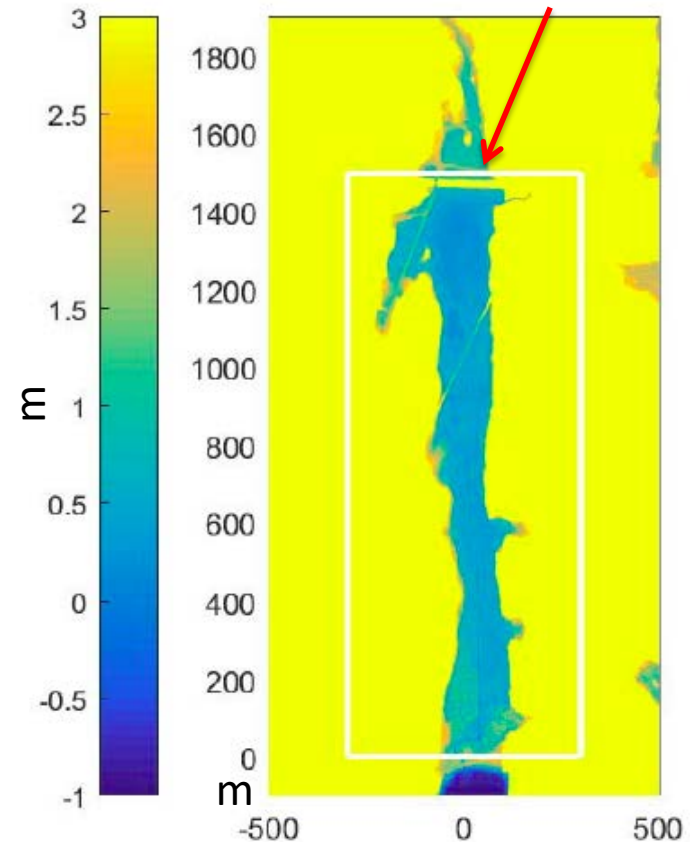
Sachems Head Road (RT 146), Guilford

Rail line



culvert

Rail line



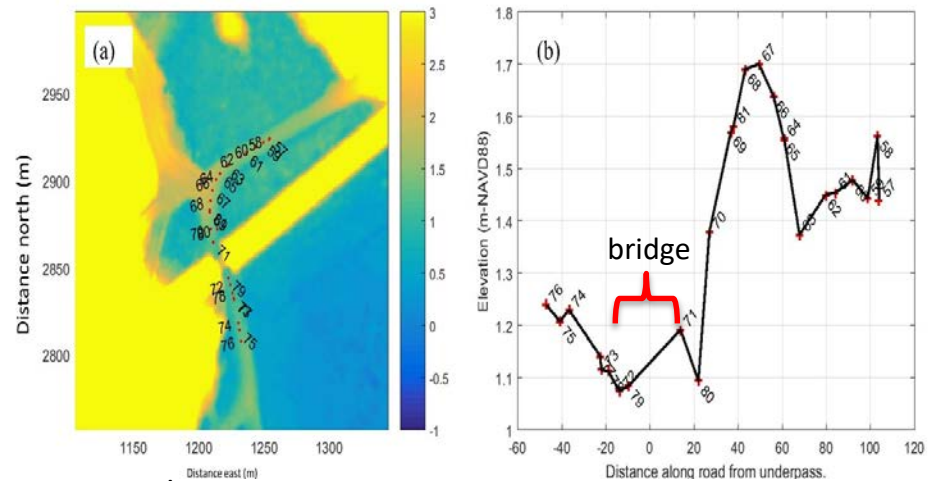
Cove area elevation and bathymetry relative to NAVD88 using 2017 USGS DEM from LIDAR.

Sachems Head Road (RT 146), Guilford



Rt. 146 survey using an RTK GPS system

Sachems Head Road (RT 146)

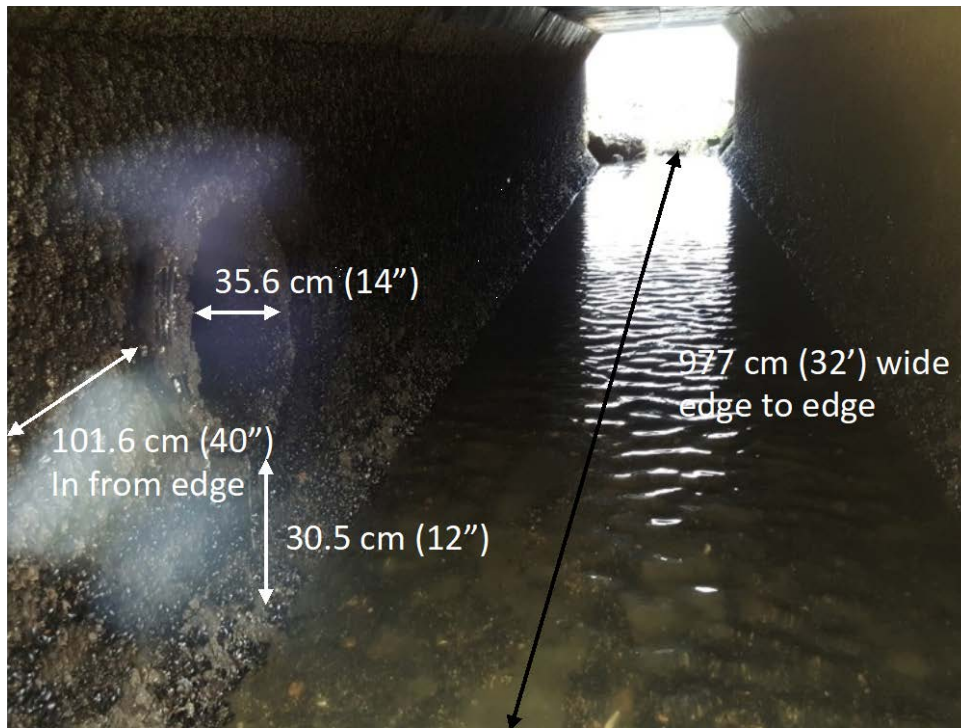


South side – Daniel Avenue Beach culvert

- Culvert restricts amount of water exchanged with LIS
- Model for predicting water level inside Cove depends on cross-sectional area and length of the flow restriction



East side of north end culvert



West side of north end culvert

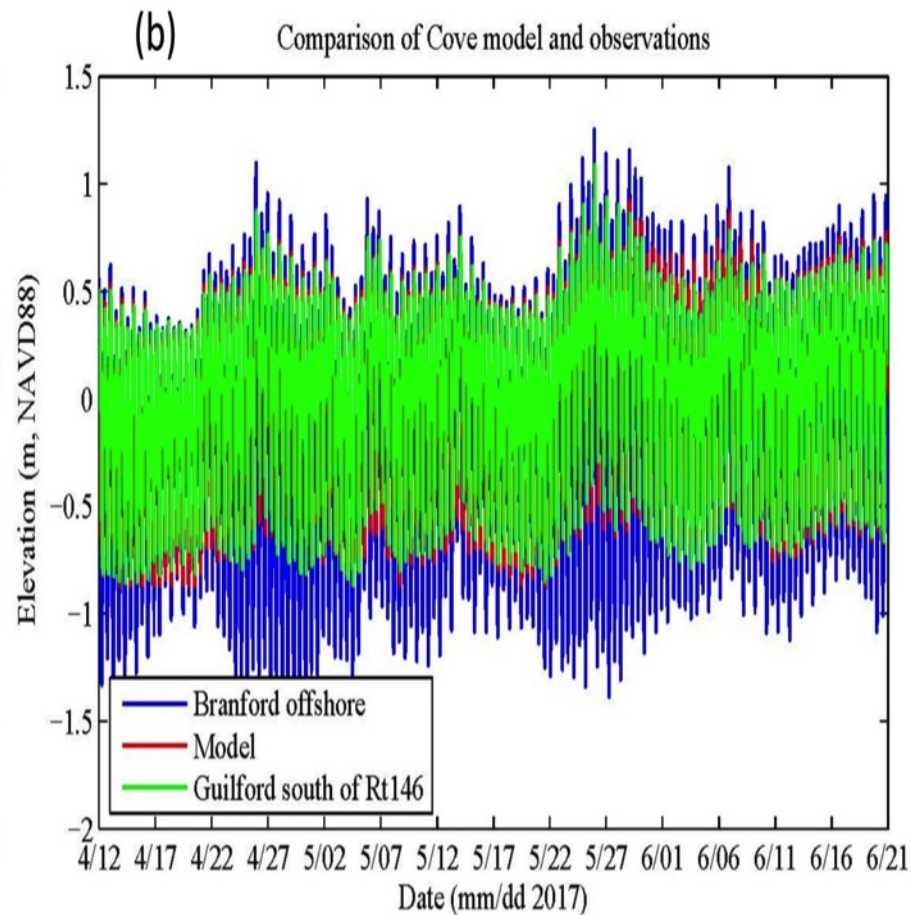
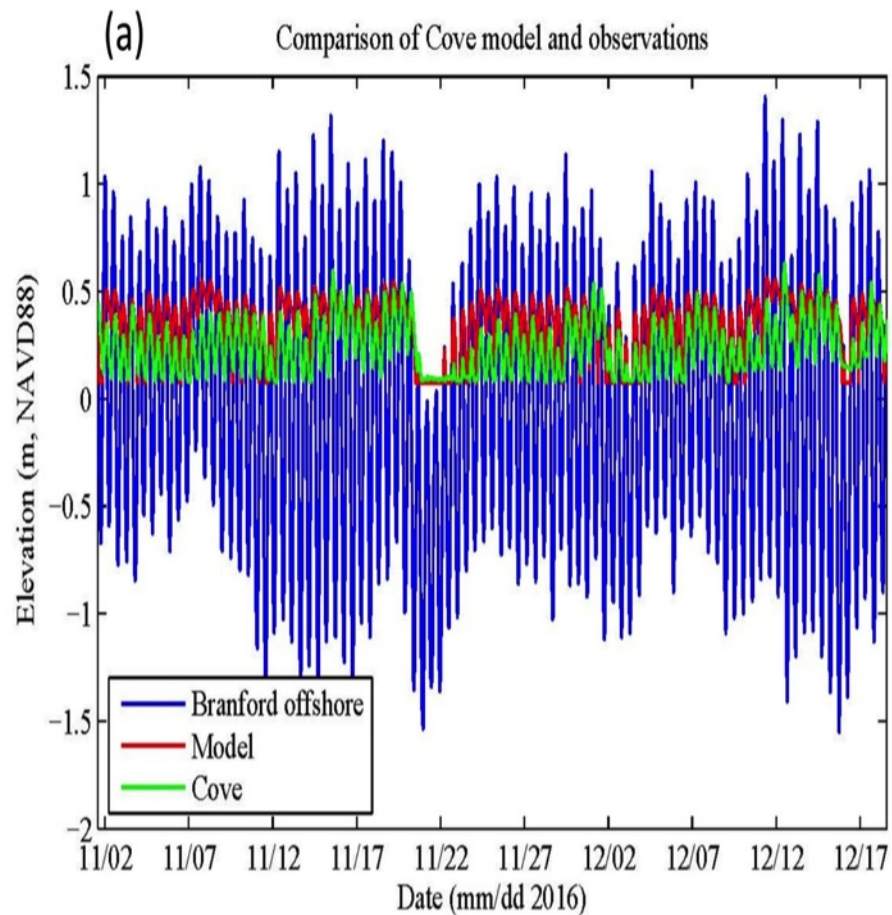


Figure 12. The blue line shows the time series of elevation measurements in Long Island Sound at the yellow * symbol in Figure 2 during the two instrument deployments in (a) Nov., 2016 and April, 2017. The green line shows the measurements in The Cove and the red line shows the simulation.

Comparing storm impacts

Figure 14. The time series of sea level measured at the NOAA tide gage in New Haven. The largest 10 values (separated by more than 48 hours) are highlighted by the red circles.

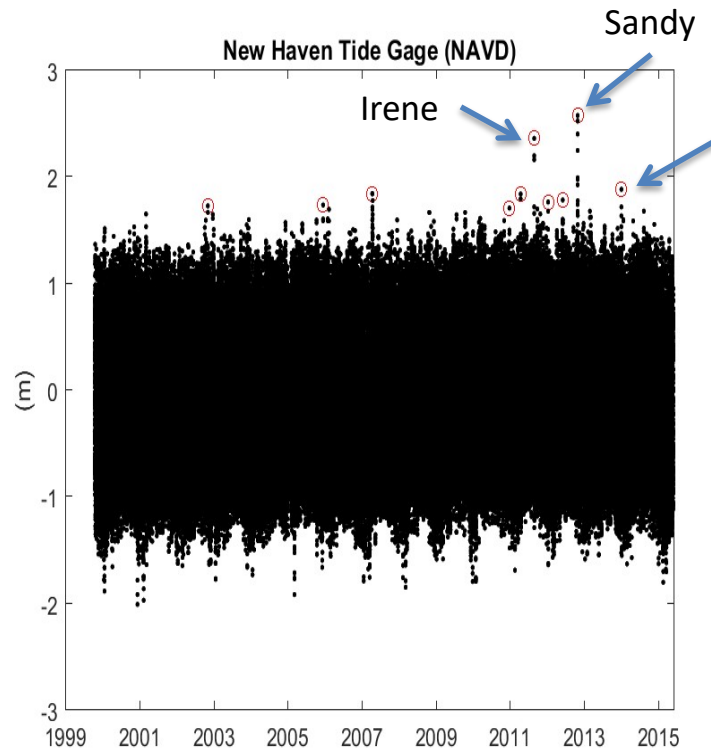
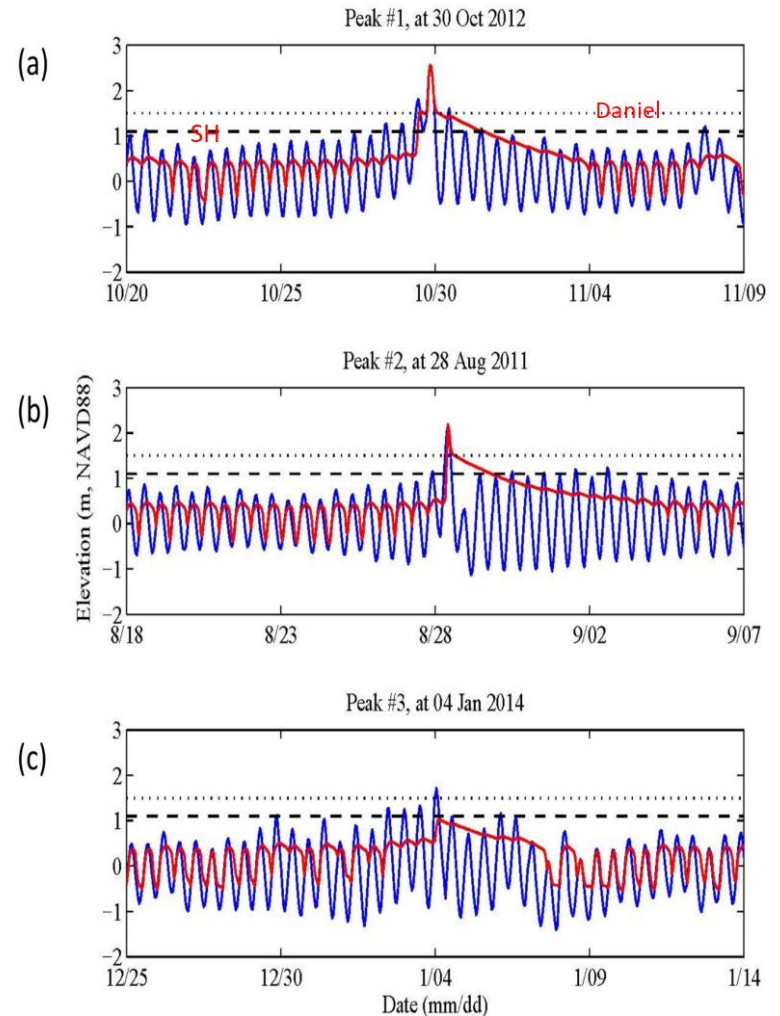


Figure 15. The sea level at New Haven is shown by the blue line in each frame and the simulated sea level in The Cove is shown by the red lines. The dotted black lines show the level of Daniel Avenue and the dashed black lines show the level of Sachems Head Road (RT 146).



Cove levels below Sachems Head in smaller storms (c).

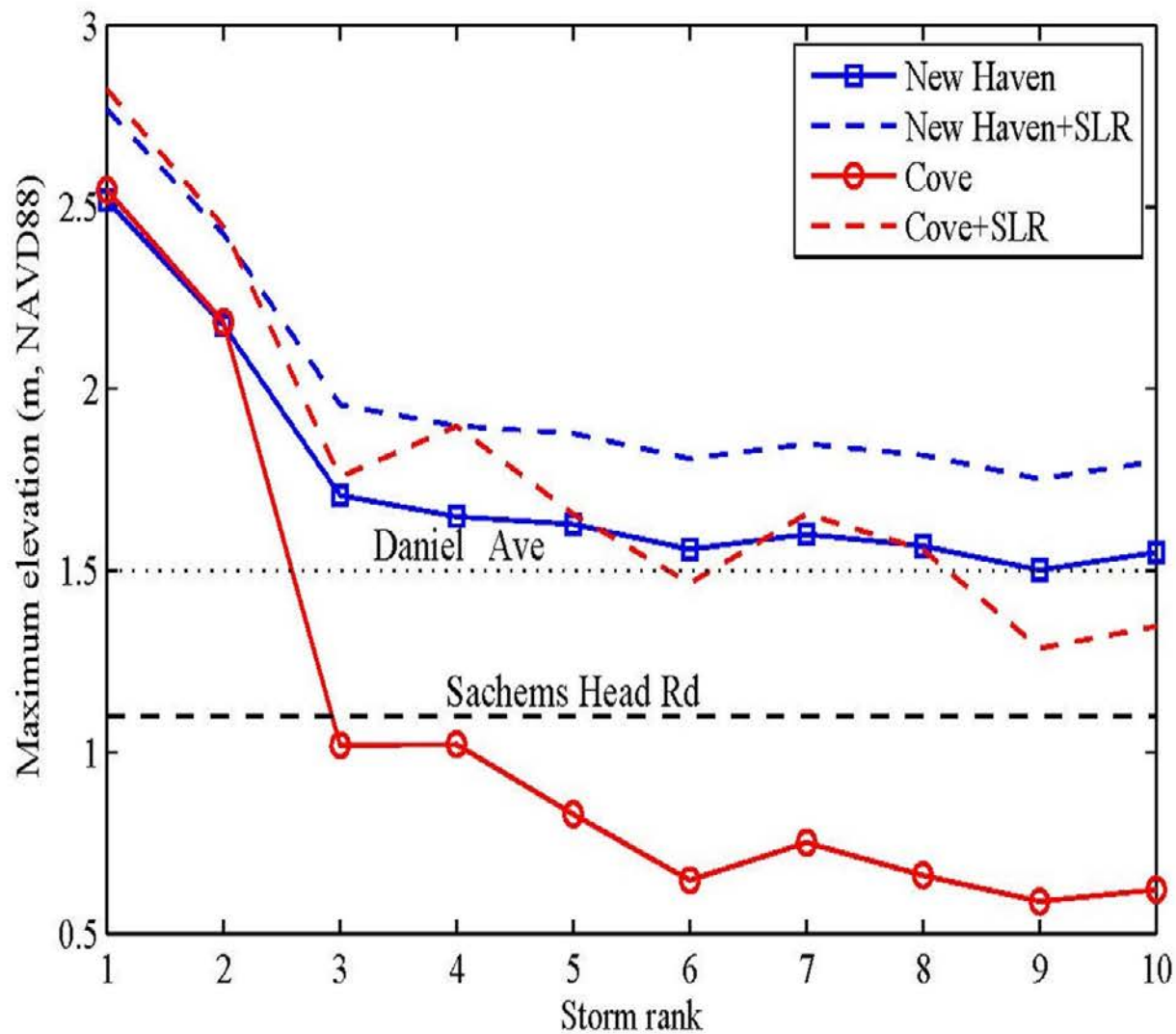


Figure 16. A summary of the simulations of the 10 largest water level events in New Haven. The red line and squares show the maximum water levels observed at New Haven and the blue line and + symbols show the predicted level in The Cove. The dotted black line shows the level of Daniel Avenue and the dashed line shows the level of Sachems Head Road. The dashed red line and the magenta line with circles show results if 0.25 m of meal sea level was added to the levels at New Haven.

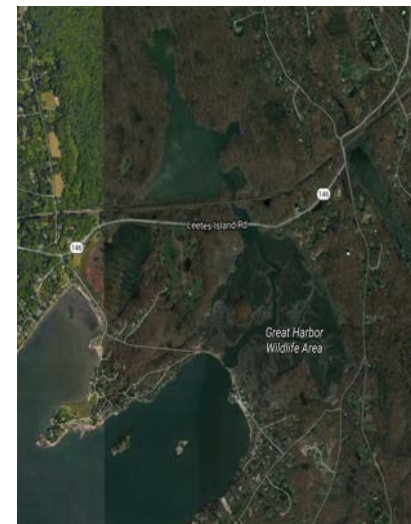
Sachems Head Road (RT 146) in Guilford

- Floods when the water in The Cove exceeds 1.1 m (NAVD88).
- The frequency of flooding is effectively controlled at the moment by the presence of the berm that carries Daniel Avenue and the flow restriction to the marsh imposed by the size of the culvert.
- Since the elevation of Daniel Avenue is only 1.5 m (NAVD 88) severe storms can lead to flow over the road which reduces the flood protection value substantially.
- This has occurred twice since 1999. An increase in mean sea level of 0.25m will lead to overtopping more frequently. Yearly flooding is likely.
- One possible solution: To avoid the predicted flooding for storms 3-10 with a 0.25 m increase in sea level, Sachems Head Road would have to be raised by 0.5 m. Alternatively, Daniel Avenue could be raised by 0.25 m.

Leetes Island Road (RT 146) in Guilford

East

- Simulations showed that the constriction in the width of the entrance to the marsh at Trolley Road substantially reduces the water level fluctuation at Leetes Island Road though flooding still occurs each year.
- Severe storms, like Hurricane Irene and super storm Sandy, cause flow over Trolley Road and extensive flooding at Leetes Island Road. **A 0.25m increase in mean sea level will increase the frequency of flooding substantially.**

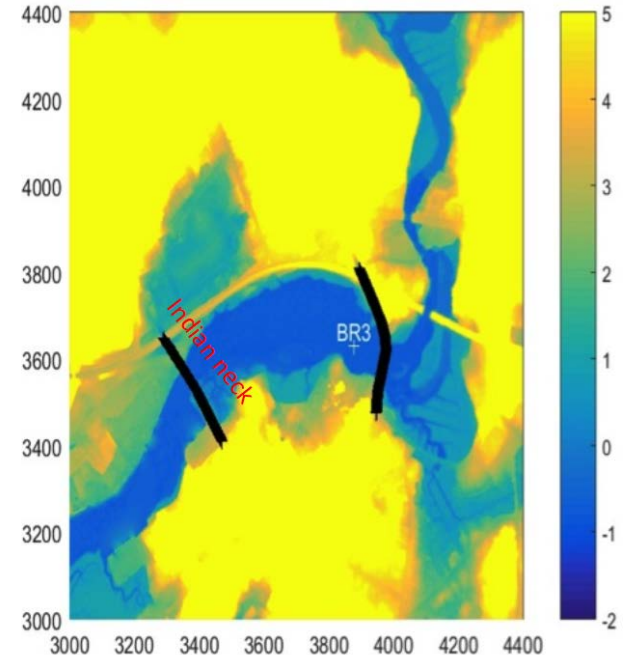


West

- The water level in the western basin fluctuates independently and determines the flooding risk in the western section. It is controlled by flow into the western basin at Shell Beach Road. Flooding is unlikely there unless severe storms drive water over the road.
- **Sea level rise will not increase the flooding risk in western section of Leetes Island Road.**

Indian Neck Avenue and RT146 in Branford

- The RT 146 underpass will flood when the level exceeds 1.6 m, which we expect to occur every year.
- The Indian Neck Avenue underpass floods when the water level exceeds 1.75 m which has a 25% probability per year.
- **A 0.25 m increase in mean sea level will lead flooding multiple times per year in both locations.**



Limewood Avenue (RT 146) and Waverly Road, Branford

- During super storm Sandy wave over-topping was reported to have caused extensive flooding of Limewood Avenue, and the water then drained down Waverly Road to the Jarvis Creek marsh.
- We estimate the over-topping flux from Limewood Avenue and the flow over Sybil Creek Avenue into the marsh and find that the predicted high water level in the marsh was similar to that observed by the USGS survey.
- Most of the water was a consequence of the wave driven flux.
- *Even though the fluxes were high, the large area of the marsh was able to contain the volume below 1.1 m and flooding was avoided in many residences.*
- **At a 0.25 m higher mean sea level, simulation show that the flood protection value is much reduced and Sandy would cause flooding around the marsh to 1.9m.**
- At current sea levels overtopping at Limewood is infrequent, however, risk estimation will require the development of a joint probability distribution of wave and water levels.

RT 146 at Jarvis Creek, Branford

- Flooding occurs at two locations in this area, near the bridge over the creek, and to the east, at the underpass at the AMTRAK line.
- Measurement of the road elevation showed that both areas were at 1.1m.
- The underpass is near an area of the marsh where the flow is unrestricted and water levels are essentially the same as at New Haven. Water level fluctuations at the bridge are reduced by a tide gate and berm in the marsh.
- **If tidal fluctuations alone are considered then the underpass should be expected to flood 5 days per yr and 0.1m increase in the mean sea level would double that.**
- The roadway would have to be elevated to 1.4m to reduce the risk of flooding at the bridge to be less than 1/year.
- To reduce the flooding to once a decade a 2m level would have to be achieved

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Sign up for the Resilience Roundup and CIRCA Announcements

Credit: Bill Horne, Nov. 2014