Coastal Road Flooding in Connecticut

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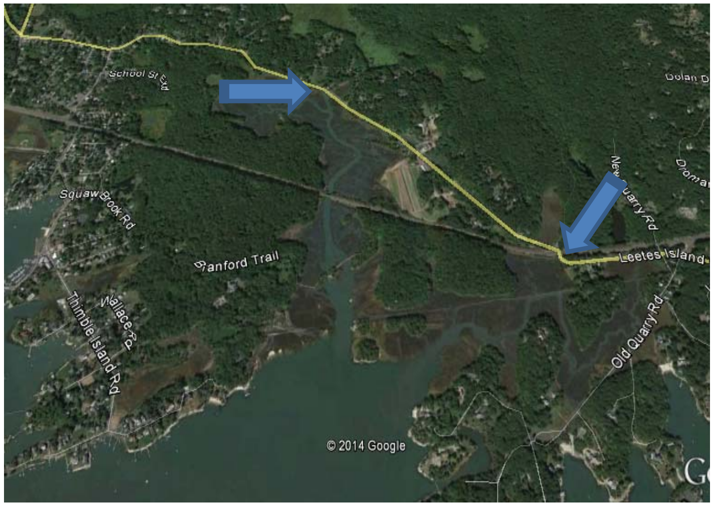

3. **Indian Neck Avenue and RT146, Branford**

4. **Linden and Sybil Avenues, Branford**

5. **Limewood Avenue (RT 146) and Waverly Road, Branford**

6. **RT 146 at Jarvis Creek, Branford**

Flooding on Route 146
November 24, 2014

Photos by Bill Horne

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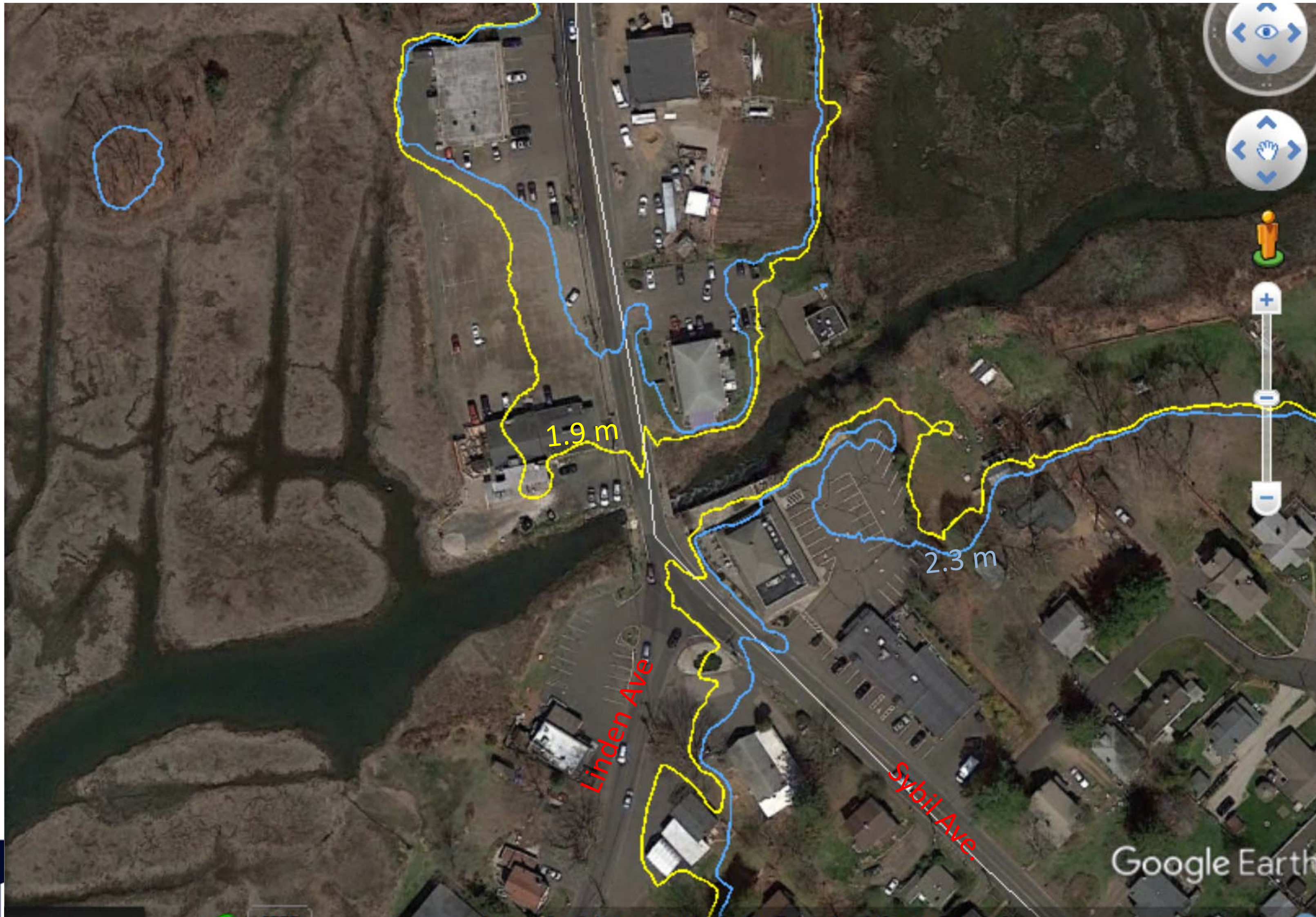
4. Linden and Sybil Avenues, Branford


1.9 m
2.3 m
Linden Ave
Sybil Ave
Google Earth

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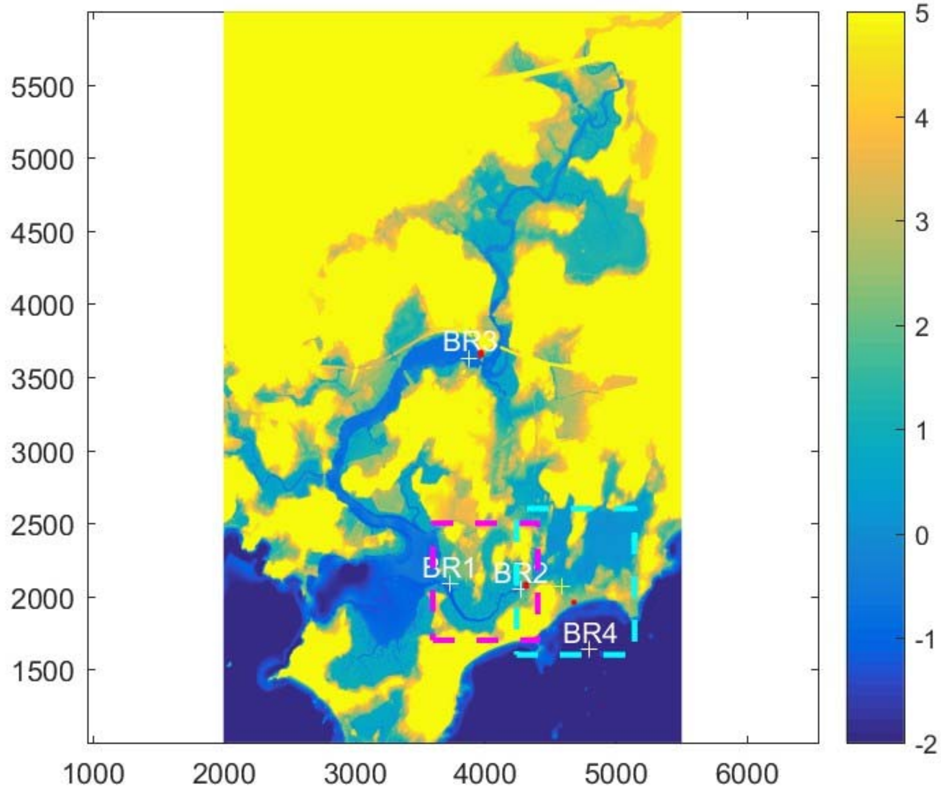

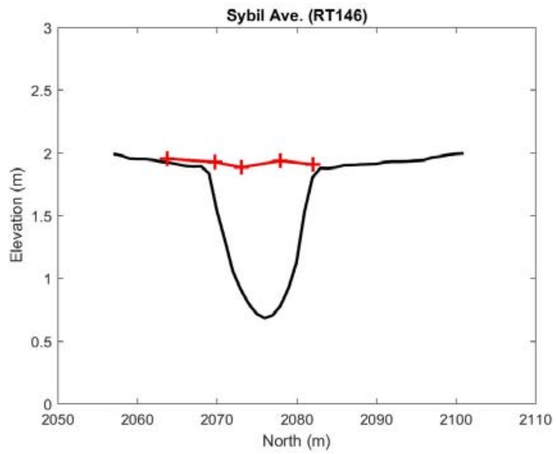

Figure 46. The black line shows elevation estimates along Sybil Avenue from the LIDAR shown in Figure 45, and the red + symbols and line shows measurements by RTK GPS at the locations shown by the red points in Figure 45.

Figure 44. The topography and bathymetry of Branford, CT. The color codes are shown on the right. The square defined by the dashed magenta line surrounds the junction of Sybil and Linden Avenue and defines the area shown in higher resolution in Figure 45. The white + symbols show the location of moored instruments. The area surrounded by the cyan square is discussed in the next section.

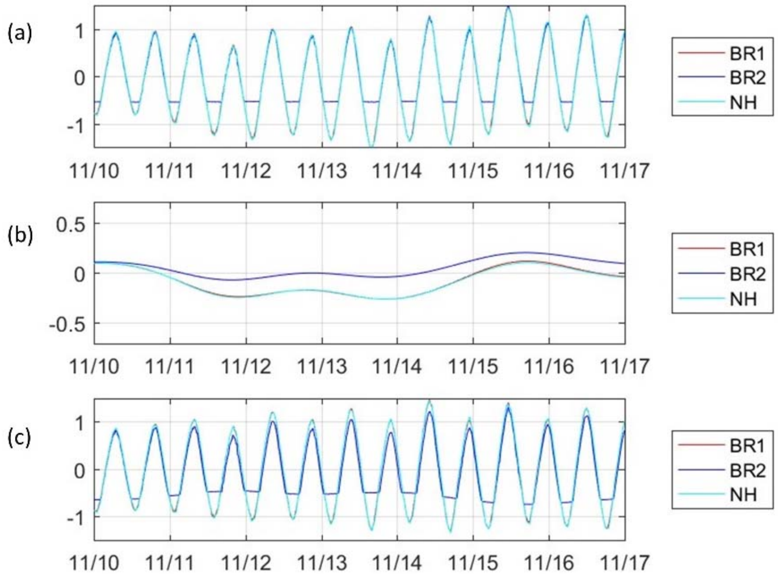

Figure 48. The same data as in Figure 4 but for a 7 day interval in November 2016.

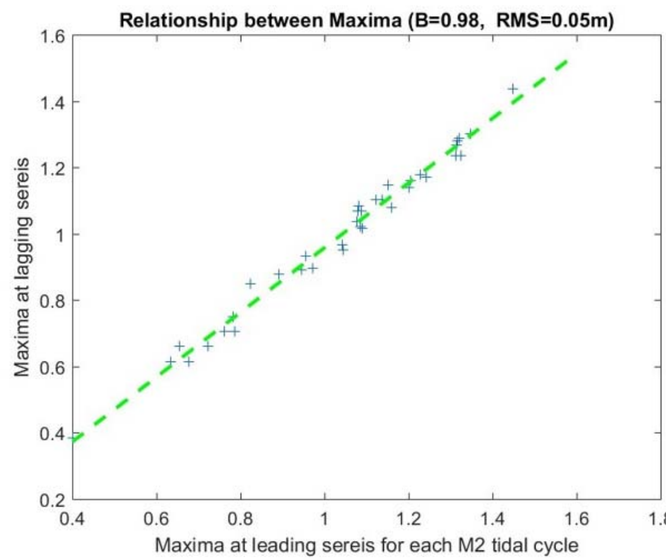

Figure 49. The correlation between the magnitude of the peaks observed in the New Haven (horizontal axis) and BR2 (vertical axis) series shown in Figure 4 (a).

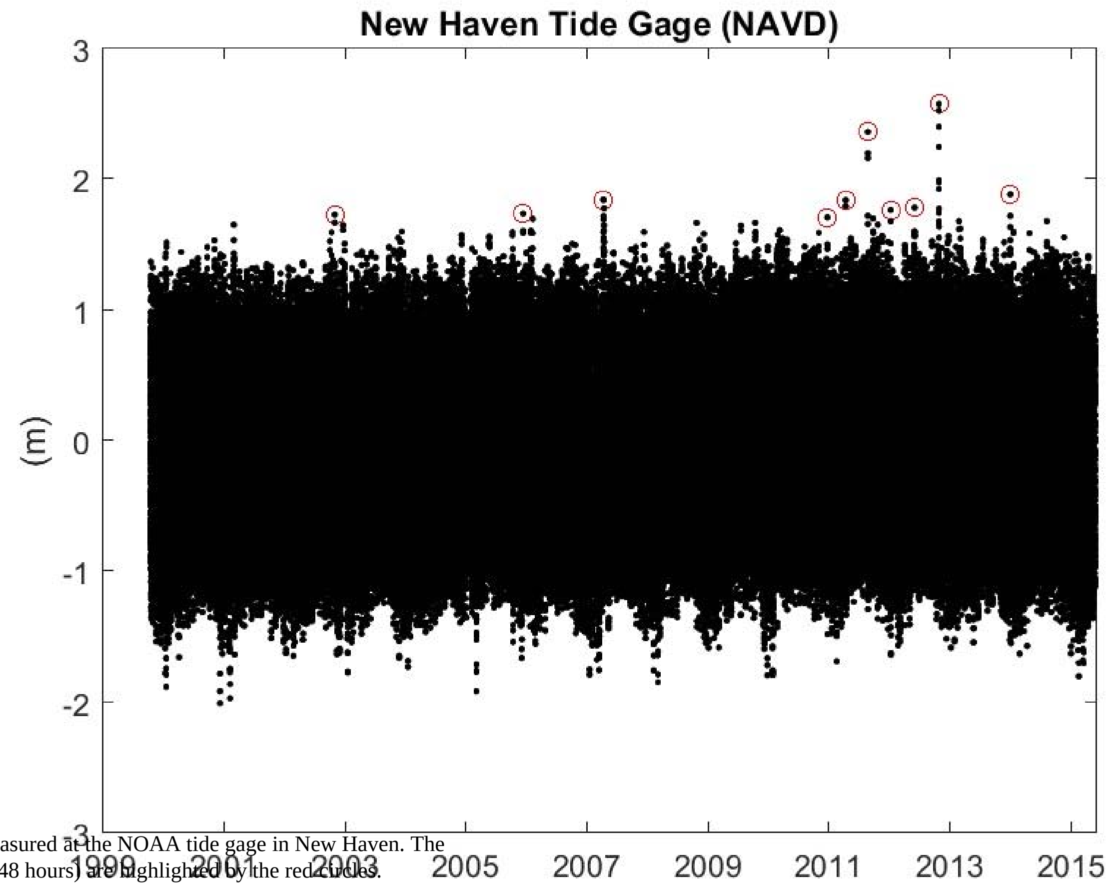

Figure 14. The time series of sea level measured at the NOAA tide gage in New Haven. The largest 10 values (separated by more than 48 hours) are highlighted by the red circles.

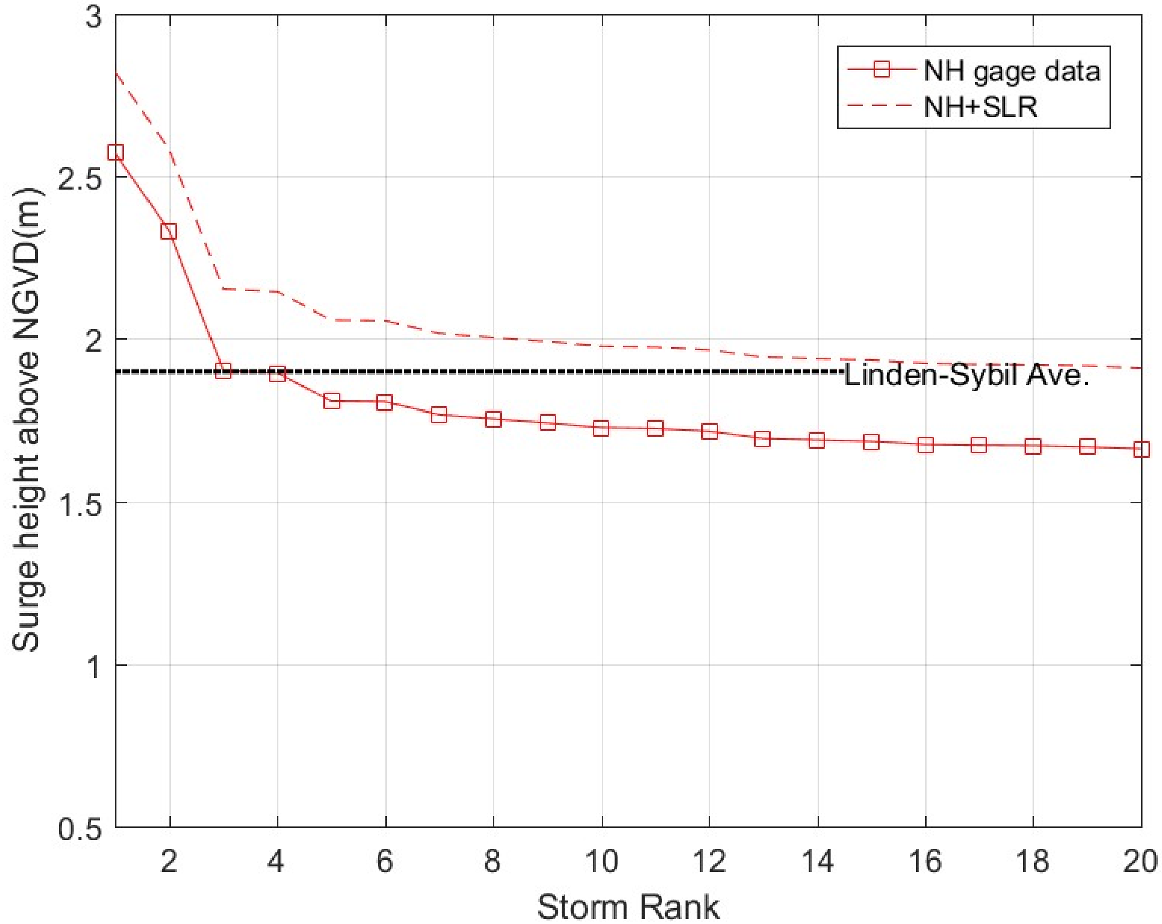

Figure 50. The red squares show the levels of the 20 highest water levels observed at New Haven since January 1999. The dashed black line shows the level 1.9 m, which is the elevation of the road surface at the bridge across Sybil Creek. The dashed line is the levels that the water levels would have reached of the means sea level was 0.25 m higher.

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Pine Orchard Rd
Main St
Maple St
Harbor St
Indian Neck Ave
Foote Memorial Park
Ecology Park
3
2
1
Google

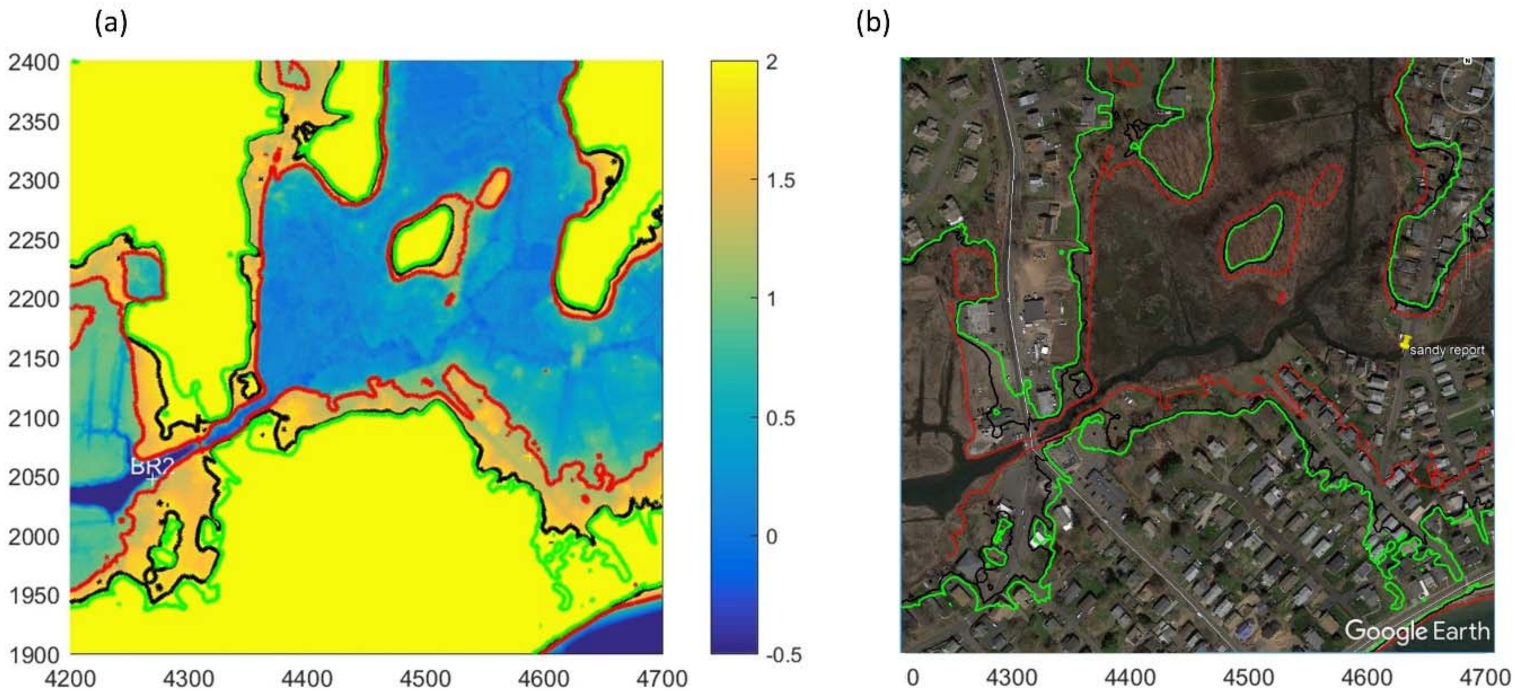

Figure 51 (a) Topography of the study area shown by the colors using the key on the right. The black line shows the 1.9 m contour and the green line shows the 2.15 m contour. (b) GoogleEarth display of the 1.9 m (black) and 2.15 m (green) contours in the study area overlaid on aerial photography. The red line shows the 1.1 m contour which was the maximum level reported during super storm Sandy at the location shown by the yellow pin

Linden and Sybil Avenues in Branford

We made elevation measurements that show the bridge and low areas of the Road are at 1.9 m NAVD88.

We also made water level measurements that show the levels at Sybil Avenue vary in line with the measurements are the New Haven tide gage.

Analysis of the highest water levels in New Haven show that the 1.9 m level was reached or exceeded 4 times since 1999.

An increase of mean sea level of 0.25 m would cause the road level to be exceed by 20 storms.

When the road level is exceeded, water can flow over the road and into the marsh surrounding Sybil Creek and cause flooding in the adjacent neighborhoods.


Waverly
Sybil Ave.
Linnewood
Google Earth
Tour Guide
1992
Imagery Date: 4/20/2016 41°15'45.97" N 72°48'03.26" W elev 0 m eye alt 451 m
Connecticut Institute for Resilience and Climate Adaptation

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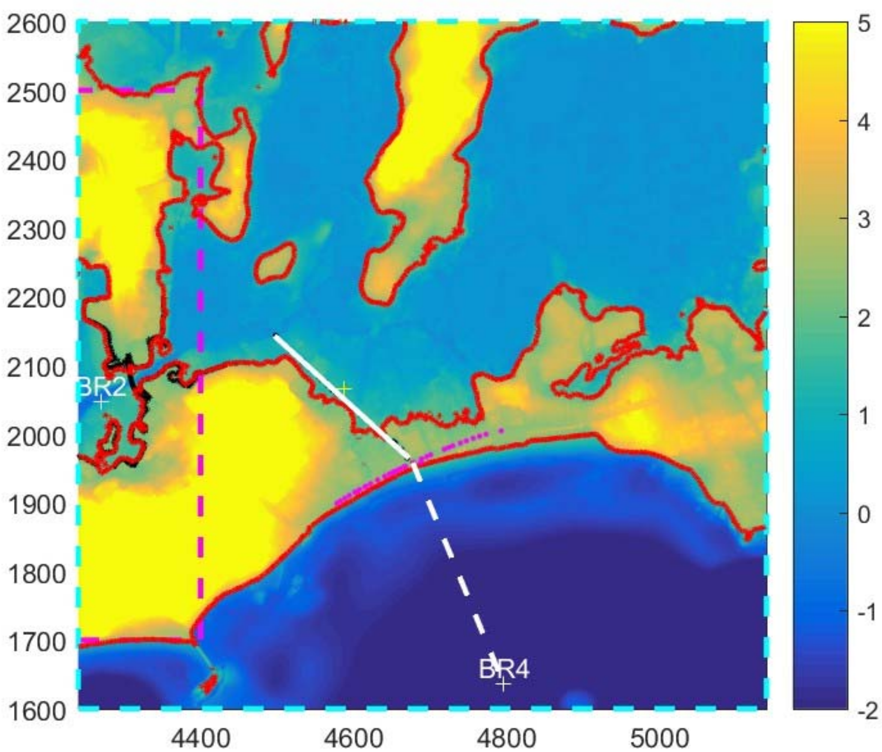


Figure 52. Topography of the Limewood Avenue –Waverly Road area. The color scale show the elevation in the range -2 to 5 m using the color scale on the right. The location of the water level and wave sensors at BR 4 is shown by the white + symbol. The magenta points lie on Limewood Avenue and the solid white line shows Waverly Road.

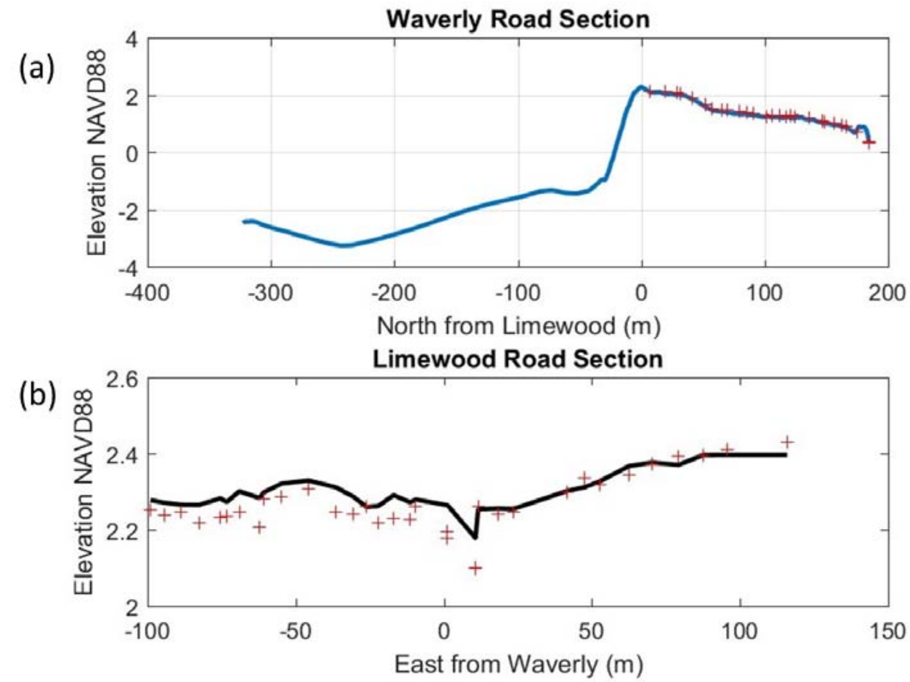


Figure 53. (a) The variation of water depth and land elevation along the dashed white line from BR4 to Limewood Avenue, and along the solid while line that shows Waverly Road in Figure 52. (b) The variation of elevation along Limewood Avenue. The zero of both graphs is at the junction of Limewood and Waverly. The red + symbols show measurements by RTKGPS

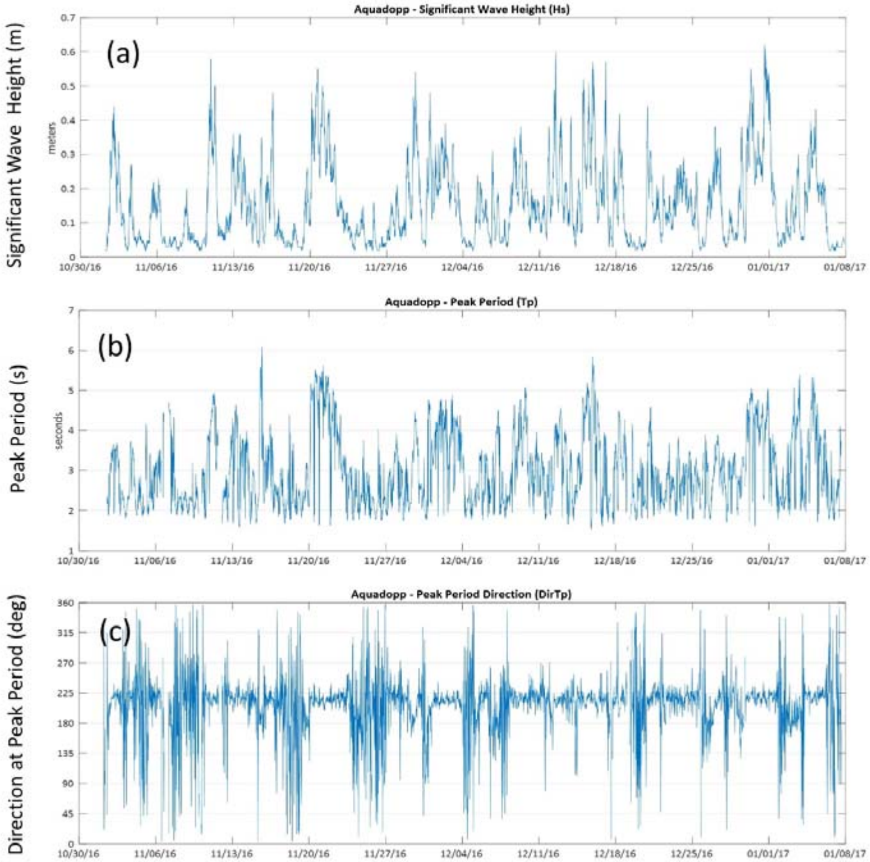


Figure 54. Wave observations at BR4 from October 30, 2016 to January 8th, 2017. (a) shows the significant wave height (m), (b) the peak wave periods (s) and (c) shows the direction (degs.) the waves at the peak period were traveling from.

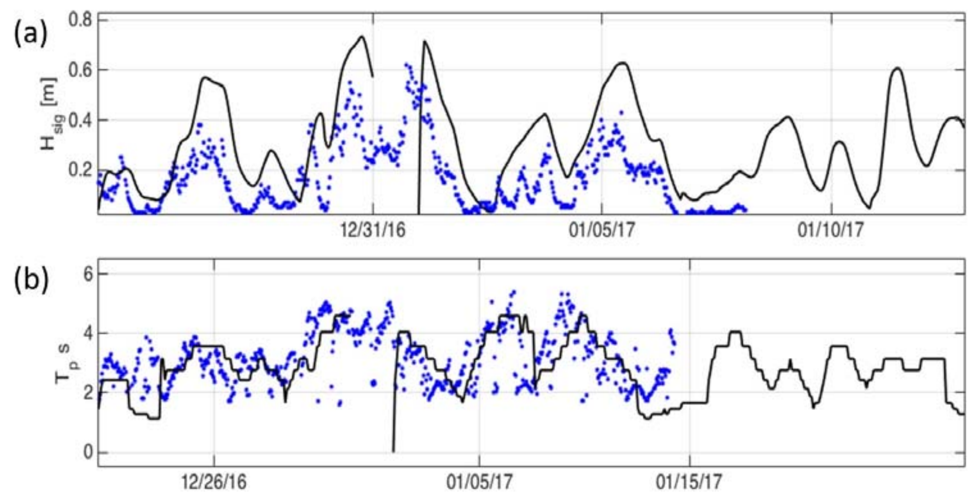


Figure 55. Results of the simulation of the (a) significant wave height at BR4 and (b) the peak wave period.

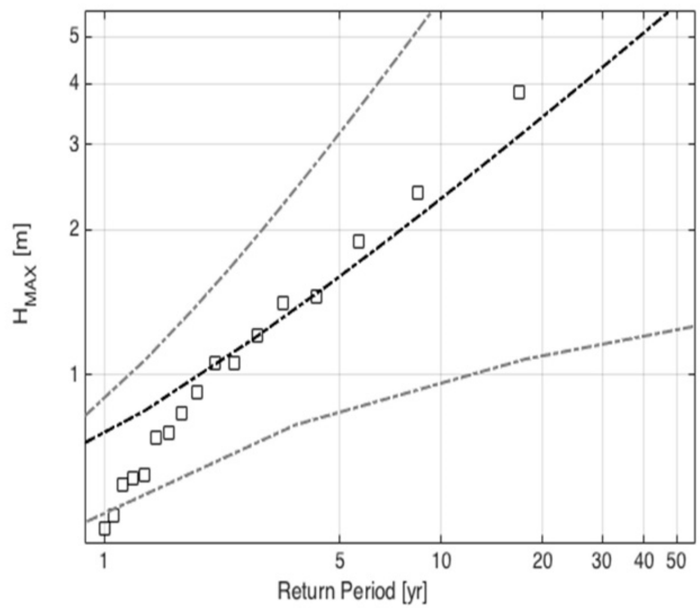
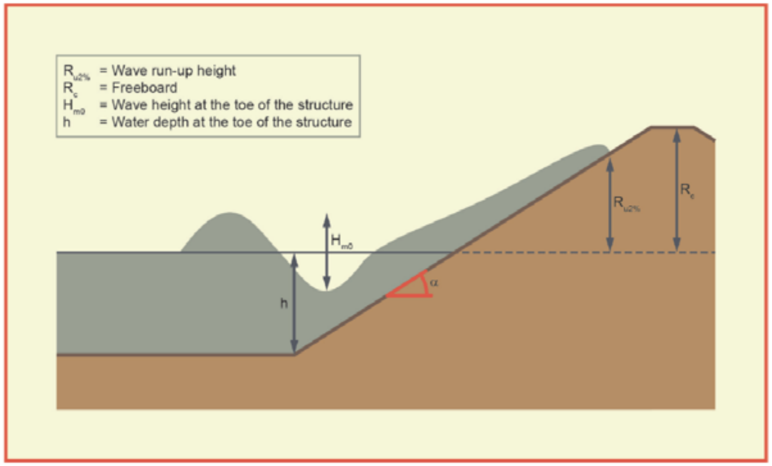


Figure 56. Return period of significant wave heights Branford, CT. The dashed black line corresponds to the best-fit GEV function and the grey dashed lines mark the 95% confidence interval. The black squares show the maximum significant wave height (m) in the simulations at the site.

Table 2. Results of the simulations of significant wave height, H_s and dominant period T_p near Branford, CT.

Year	[m]	T_p [s]
1985	3.84	8.83
1954	2.38	9.67
2012	1.89	7.37
2011	1.45	6.73
2017	1.41	6.75
2008	1.31	4.68
2014	1.21	5.92
2006	1.06	5.12
1991	0.93	4.61
2015	0.76	5.61
1978	0.75	5.61
2013	0.62	4.27
2007	0.61	4.05
2005	0.59	4.05
2016	0.51	2.26
2003	0.48	4.05
2009	0.41	3.56
2011	0.37	4.68



$$Q_{SO} = \sqrt{gH_0^3}\, a\, exp\left\{-\left\{b\,\frac{R_c}{H_0}\right\}^c\right\}$$

Figure 57. Schematic of an idealized coastal dyke or embankment defined in the EurOtop II report (Van der Meer et al., 2016). The

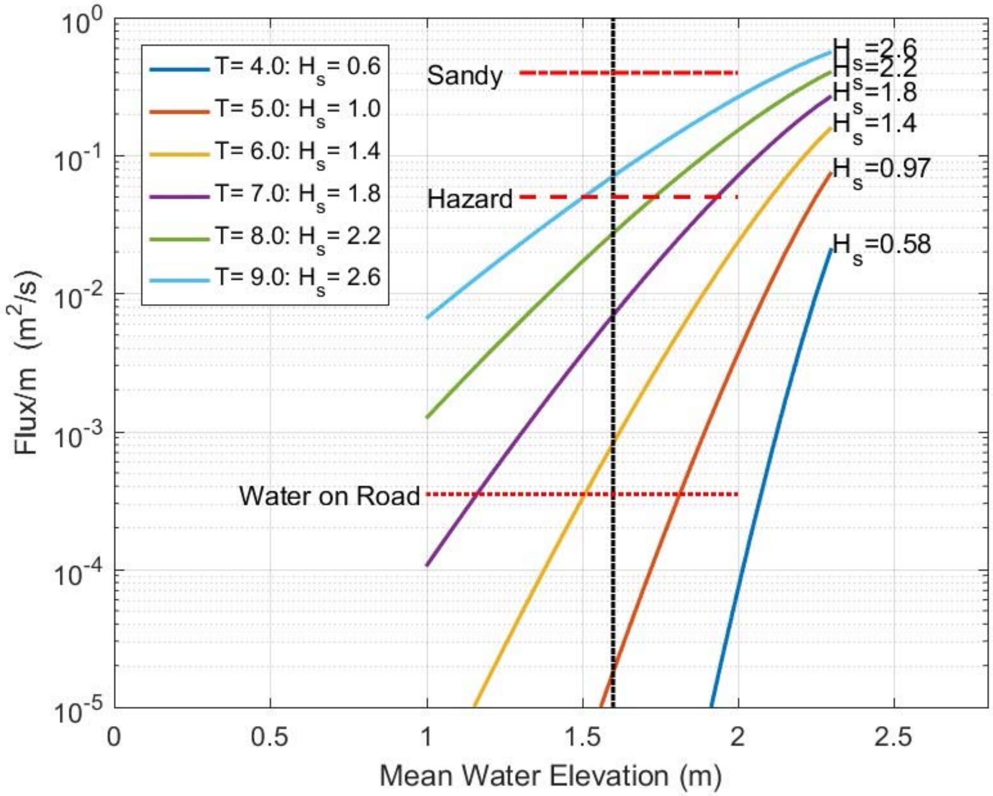


Figure 60. The over-topping flux predicted at Limewood Road as a function on water elevation for 6 different wave conditions that span the range predicted in Figure 7. The red horizontal lines show values that result in significant impacts. The red dotted line is the rate that would be equivalent to equivalent to a 10 inch/hour rainfall rate on a 5 m wide road. The red dashed line shows 0.05 m^2/s which would pose difficulty for vehicles according to Van der Meer et al. (2010), and the red dot-dash line show the level that is estimated during super storm Sandy.

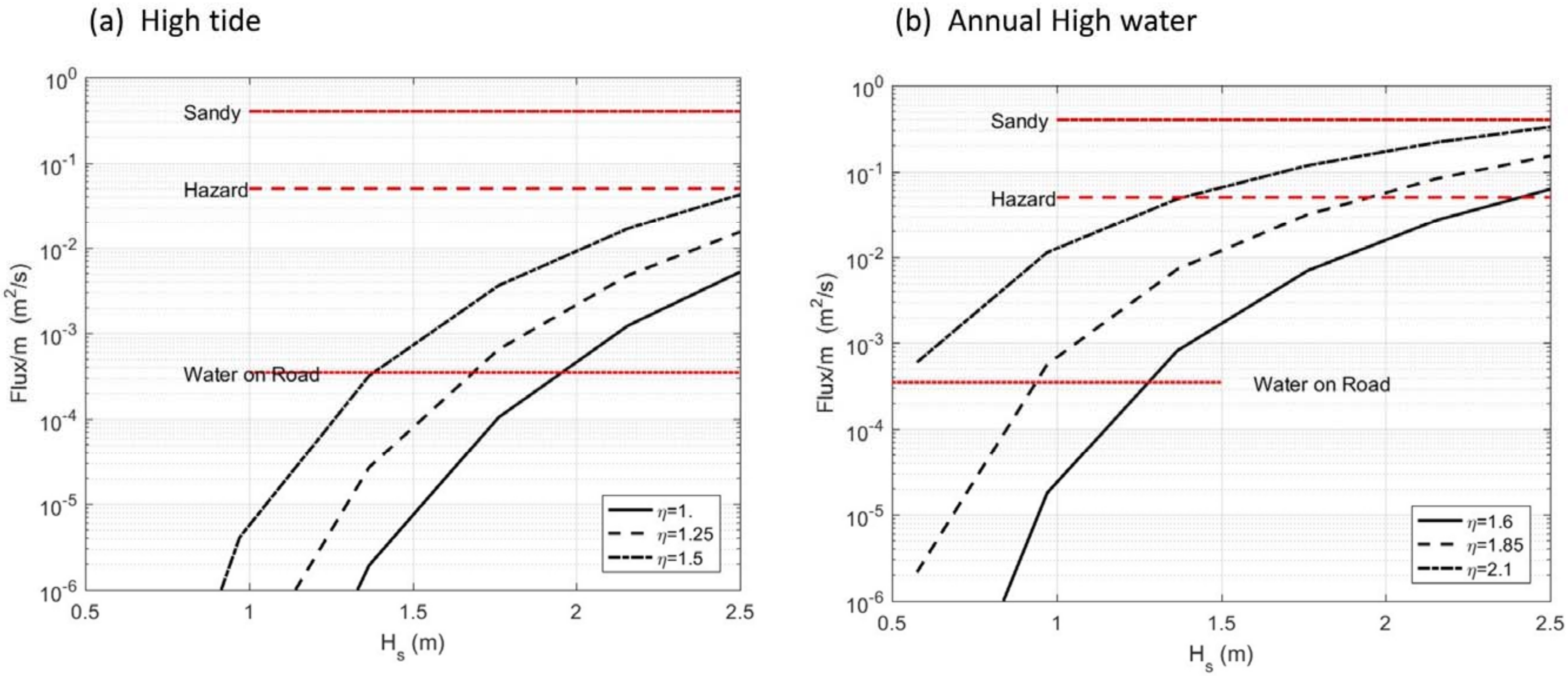


Figure 61. (a) The dependence of the over-topping flux on the significant wave height (and period) at a typical high tide ($\eta=1$ m) is shown by the solid black line. The variation at .25 and 0.5 m higher levels are shown by the dashed and dot-dashed lines respectively. The variation during high tide in a storm ($\eta=1.6$) is shown in (b), where again the 0.25 and 0.5 m higher levels are shown by the dashed lines.

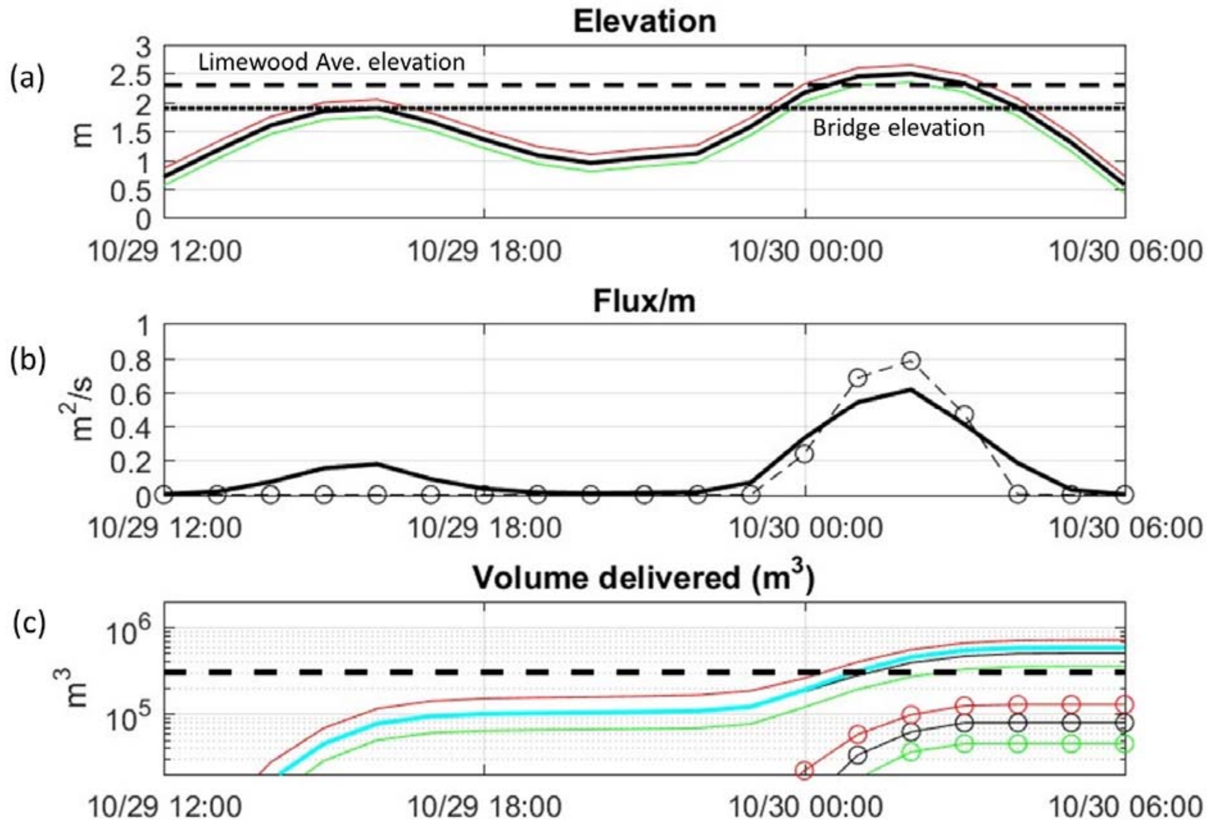


Figure 58. (a) The evolution of the water level at New Haven during super storm Sandy is shown by the solid black line and the level of Limewood Avenue is shown by the thick black dashed line. The red and green lines show the 0.3 m interval surrounding the measured value to represent the uncertainty interval. The dotted black line show the level of the top of the bridge at Sybil Avenue. (b) The thick black line show the estimate of the water flux per meter of shore front (m^2/s) due to both splash over and over-bank flow at Limewood Avenue. The dashed line with circles shows the estimate of the flow over the road at Sybil Avenue. (c) The thin black line and the line with black circles show the accumulated volume (m^3) of seawater delivered into the marsh surrounding Sybil Creek by the flow over Limewood Avenue and Sybil Avenue respectively. The red and green lines show the volumes computed with the higher and lower water level bounds. The thick cyan lines shows the sum of the volume from both sources. The thick dashed line shows our estimate of the volume accumulated in the marsh based on the USGS water level report.

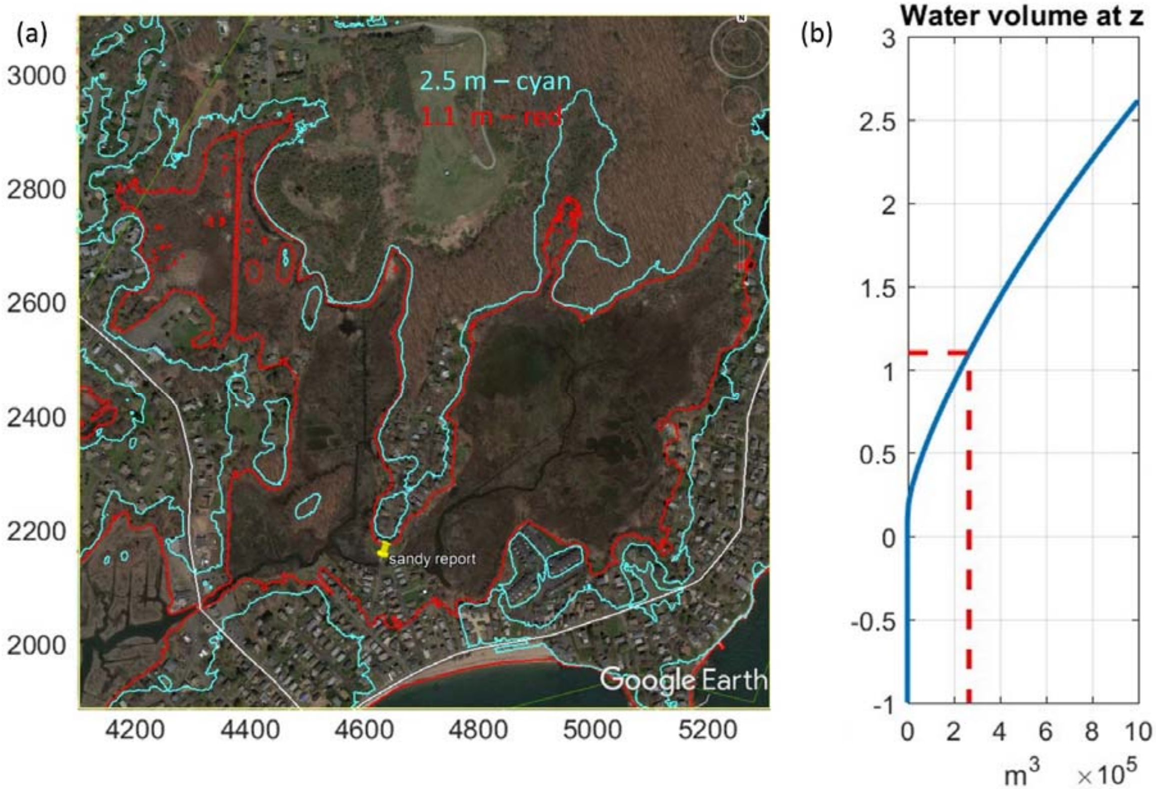


Figure 59. (a) A GoogleEarth map with the location of the USGS high water mark (site CTNEW19322) shown by the yellow push pin. The 1.1 and 2.5 m elevation contours are shown by the red and cyan lines respectively. The volume required to fill the basin to the 1.1 m elevation is shown in (b).

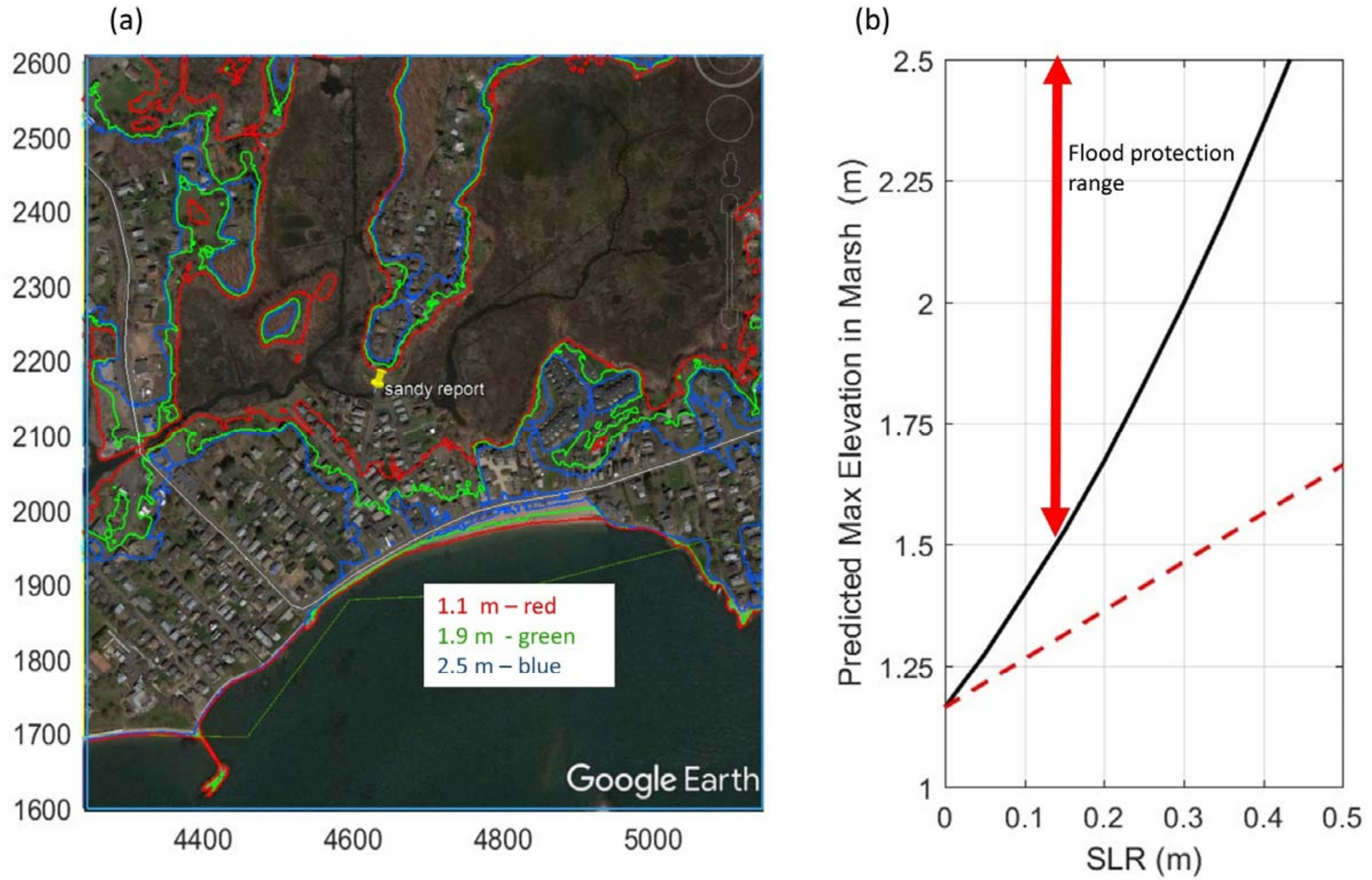


Figure 62. (a) A GoogleEarth map of the coastal area near Limewood Avenue. The white line show the location of RT 146 and the red, green and blue lines show the 1.1 m 1.9, and 2.5 m elevation contours. (b) The black solid line shows the elevation in the marsh that corresponds to the maximum predicted volume transported into the marsh. The red dashed line shows the change in sea level in the marsh if it was just do to sea level rise.

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 made elevation measurements to characterize the topography of the coastal area, and wave and water elevation measurements to evaluate the skill of models.

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.