Appendix A: Detailed flood risk analysis method

1. Estimating high water levels

1.1 Bass Harbor Mean Higher High Water (MHHW) and Highest Astronomical Tide (HAT) tidal datums

There is no present or historical tide gauge installation in Bass Harbor that provides data for direct calculations of tidal datums; however, there is a NOAA "subordinate station" in Bass Harbor (Station 8413651), where predicted high waters and tidal datums can be estimated based on time and height offsets from NOAA's Bar Harbor tide gauge. The published tidal height offset from Bar Harbor to Bass Harbor is a ratio of 0.93, meaning that Bar Harbor predicted high waters, reported relative to mean lower low water (MLLW), can be multiplied by 0.93 to get an estimated predicted high water height at Bass Harbor relative to local MLLW.[1]

Elevations of structures on land are often measured to the orthometric datum, or land-based "zero," called the North American Vertical Datum of 1988 (NAVD88). The NOAA's VDatum software provides model-based transformations between vertical datums, including NAVD88 and tidal datums (MLLW, MHH, etc.).[2] At Bass Harbor, NAVD88 is 5.71 feet above MLLW. Table A.1 shows the calculations for obtaining Bass Harbor MHHW and HAT relative to NAVD88. We also note that the methods used here are the same as those used to develop the Maine Geological Survey's Highest Astronomical Tide Line.[3]

	Bar Harbor, ft MLLW (from NOAA gauge)[4]	Bass Harbor, ft MLLW (multiply Bar Harbor by 0.93)[1]	Bass Harbor, ft NAVD88 (NAVD88 is 5.71 ft above MLLW)[2]
MHHW	11.37	10.57	4.86
HAT	13.69	12.73	7.02

Table A.1: *High tidal datum calculations for Bass Harbor.*

1.2 Bass Harbor 1% Annual Chance Stillwater Elevation (1% SWEL) and wave height

In participating communities, the FEMA National Flood Insurance Program requires properties to purchase flood insurance if they are located within the area that has a 1% annual chance of being flooded. FEMA publishes county Flood Insurance Studies providing information on the 1% annual chance flood zone. Hancock County's most recent Flood Insurance Study became effective in 2016,[5] and Table 17 of the study provides a breakdown of the 1% SWEL (the prolonged rise in water level from high tide plus storm surge) and 1% Annual Chance significant wave height (the average height of the largest

33% of waves, measured from mean water level to the crest of the wave) along coastal transects. These transects and their associated 1% SWEL and significant wave heights are shown in Figure A.1 below.

Transects 74 through 83 fall within Tremont, and all have a 1% SWEL of 9.2 ft NAVD88. This FEMA 1% SWEL estimate is close to the observation-based 1% SWEL at the Bar Harbor tide gauge of 9.44 ft NAVD88. We do not use the FEMA-estimated wave heights for sites within Bass Harbor because, according to residents, they are overestimates. The largest waves residents have observed in southern Bass Harbor were roughly 2.5 feet in amplitude (or 5 feet from crest to trough), and they have only observed a light chop north of Little Island.[6] Residents also noted that southeasterly winds drive the highest surges, but under these conditions, Bass Harbor is protected from waves. Thus, the combination of a 9.2 ft SWEL plus 2.5-ft waves represents a conservative estimate for the 1% annual chance flood.

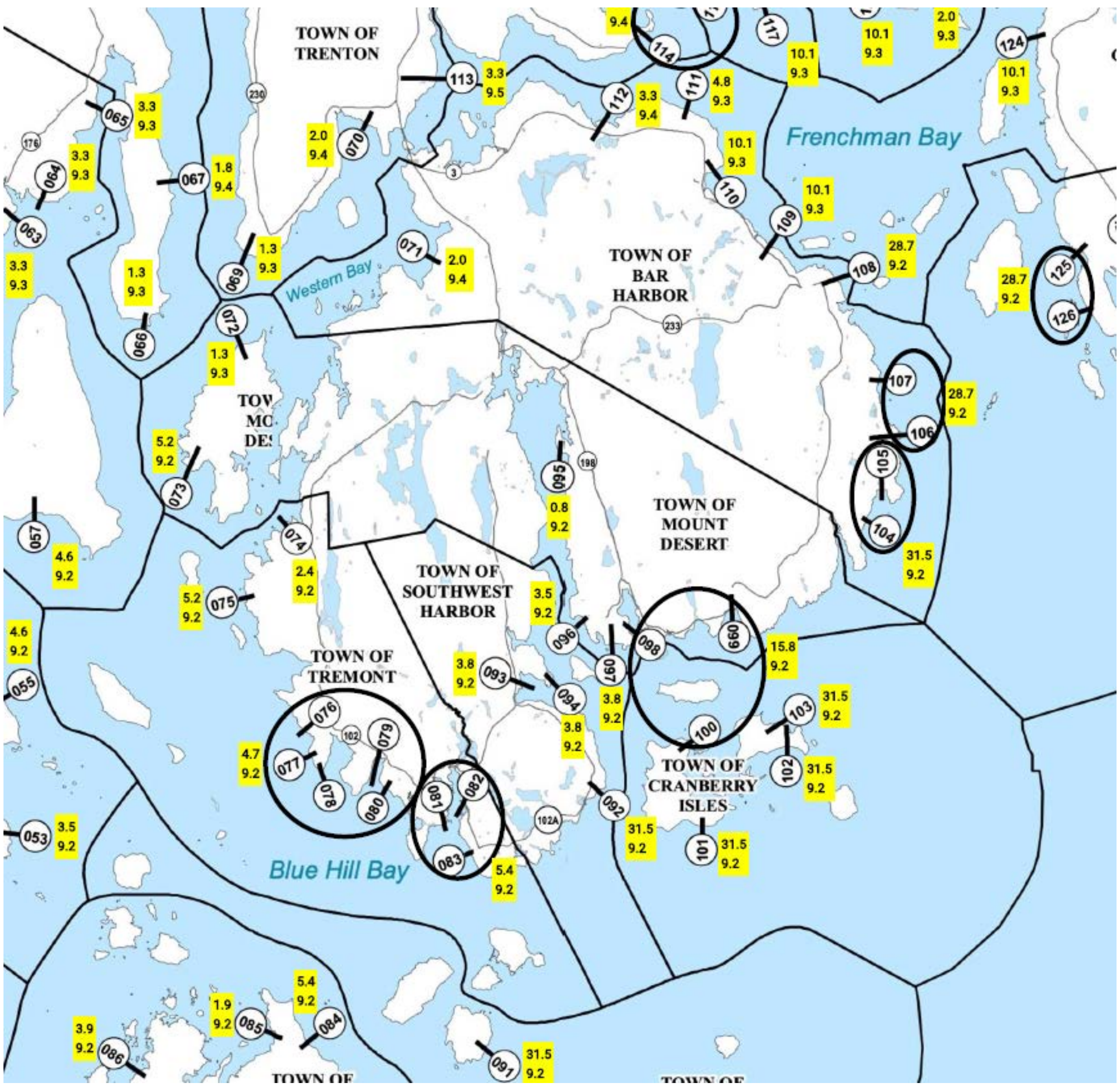

Figure A.1: *Transect map from the 2016 Hancock County FEMA Flood Insurance Study showing transect numbers (3-digit numbers in black circles), 1% SWELs (lower number in each yellow box), and 1% annual chance significant wave heights (upper number in each yellow box). Transects that are circled all have the same water level values.*

1.3 Attenuation of high waters north of Clark Bridge

We estimate that the tidal crossing under Clark Bridge reduces the height of high waters by roughly 1 foot, based on a reduction in elevation of the marsh on either side of the bridge. We measured the elevation of the transition from saltmarsh cordgrass to less salt-tolerant shrubby vegetation on either side of Clark Bridge. This elevation is generally around the height of the highest annual tide. Elevation measurements were taken via real-time network (RTN) surveying using an Emlid RS2+ GNSS receiver and the MaineDOT CORS network for receiving real-time corrections. We found that this vegetation transition was between 20 and 35 cm (0.66 to 1.15 ft) lower on the north side of Clark Bridge (landward of the restriction) than the south side. Our approximation of a 1-foot reduction in high water landward of Clark Bridge compared with the mouth of Bass Harbor is likely less than the actual reduction, given that the shallow water in northern Bass Harbor likely also reduces high water heights.

2. Elevation data

To determine the areas within Tremont that are impacted by high coastal water levels, high water elevations were mapped onto a digital elevation model of Tremont. We used the 1-meter DEM based on the Lidar dataset called *2021-2022 USGS Lidar: Midcoast Maine*, accessed through NOAA's Data Access Viewer. We checked key elevations for bridges, low-lying coastal roadways, and piers using the original point cloud data, also available through the NOAA Data Access Viewer.

To determine elevations of utilities on the town landing and MaineDOT Bass Harbor ferry terminal, we used a tape to measure the distance of each utility above the ground or decking and used the lidar point data to determine the elevation of the ground location we taped up from.

References

1. NOAA (2014). Tide Tables 2015: High and Low Water Predictions; East Coast of North and South America Including Greenland. https://tidesandcurrents.noaa.gov/tidetables/2015/ectt2015book.pdf
2. NOAA [VDatum]. 2023. https://vdatum.noaa.gov/welcome.html
3. Maine Geological Survey, 2021, Highest Astronomical Tide Line. https://www.maine.gov/dacf/mgs/hazards/highest_tide_line/index.shtml. Accessed October 31, 2023.
4. https://tidesandcurrents.noaa.gov/datums.html?id=8413320
5. FEMA (2016). *Flood Insurance Study: Hancock County, Maine. Volume 2 of 2* (Flood Insurance Study Number 23009CV002A, Version Number 2.3.2.1).
6. Chris Eaton, personal communication, August 2023