Appendix K: Sea Level Rise Technical Appendix

This appendix provides additional detail on the calculations of sea level rise (SLR) and nuisance flooding included in the main report. One challenge with planning for SLR is that tidal waters are dynamic due to natural cycles, storm events, wind and other occurrences that result in varying tidal elevations. The National Oceanic and Atmospheric Administration (NOAA) has developed an approach for making assumptions based on recent historical tidal data to establish a consistent tidal reference, referred to as the datum.[1] In addition to the datum, NOAA calculates regular tide heights based on the same historical data (Table I-1). The current datum and tidal reference heights (Figure I-1) are based on the years 1983 to 2001. Therefore, it is important to note that any SLR since 2001 is not incorporated into the datum or tidal references.

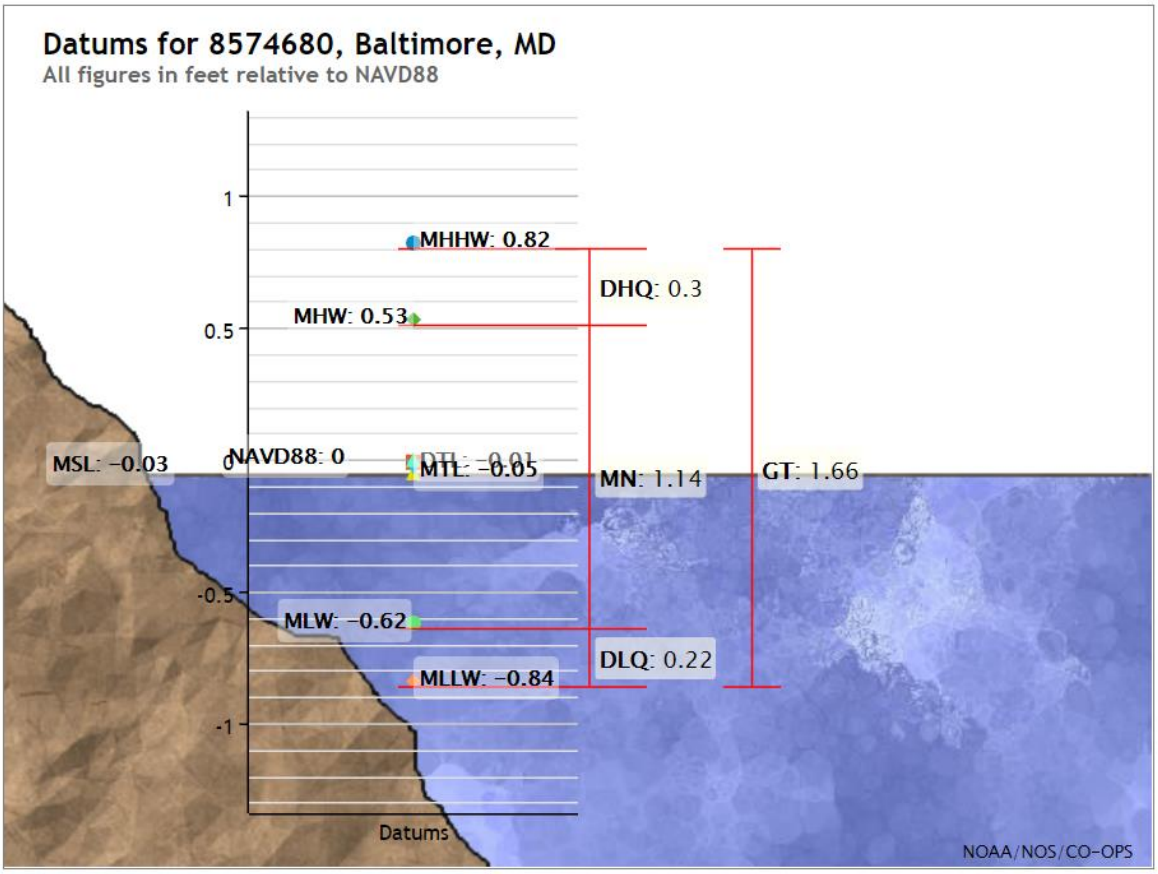

Figure I-1: Tidal Reference Elevations for the Tide Gauge in Baltimore, MD[2]

[1] Tidal datums are developed for each tide gauge and are used as references to measure local water levels and should not be extended into areas having differing oceanographic characteristics without substantiating measurements.

[2] https://tidesandcurrents.noaa.gov/datums.html?id=8574680

It is expected that NOAA will update the epoch at some point, which will cause all of these values to shift. However, the typical datum for land elevation, North American Vertical Datum of 1988 (NAVD88), will not change, so elevations for surface features (buildings, roads, etc.) will remain the same.

Table I-1: Table of Common Tidal Reference Definitions

Tidal Reference	Definition
Mean Sea Level (MSL)	The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.
Mean Higher High Water (MHHW)	The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.
Mean High Water (MHW)	The average of all the high water heights observed over the National Tidal Datum Epoch.
Mean Low Water (MLW)	The average of all the low water heights observed over the National Tidal Datum Epoch.
Mean Lower Low Water (MLLW)	The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Based on the NOAA definitions, the typical tidal range is between the MHHW and MLLW. However, tides can often be higher or lower than these values due to storms, wind, astronomical events or other occurrences that affect the tides. For example, spring tides are generally the highest non-weather-related tides due to the alignment of the moon and sun (Figure I-2).

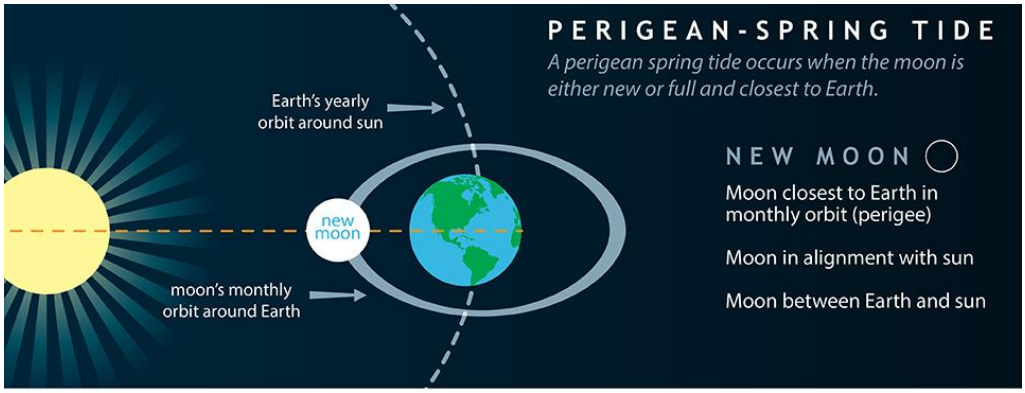

Figure I-2: Diagram of the Astronomical Phenomena that Affect Spring Tides[3]

NOAA does not provide an official reference value for these unusually high tides. Therefore, the MHHW is the typical baseline value for tide height used in SLR assessments.[4] NOAA has analyzed the tidal trends across the U.S. and has identified common patterns for minor, moderate and major tidal flooding.[5] This analysis identified approximately 0.5 meters as a common threshold for minor, nuisance flooding that generally does not result in flood damage beyond the effects of inundation. This value is not an "official"

[3] https://oceanservice.noaa.gov/facts/perigean-spring-tide.html

[4] NOAA. (2012). *Mapping Coastal Inundation Primer*. Accessed at https://coast.noaa.gov/data/digitalcoast/pdf/coastal-inundation-guidebook.pdf

[5] NOAA. (2018). *Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using A Common Impact Threshold*. NOAA Technical Report NOS CO-OPS 086.

flood determination by NOAA but can be a useful approximation where NOAA has not established local flood thresholds. Further, this value (rounded to 1.75 feet) was referenced as a definition for nuisance flooding in the 2018 Maryland SLR report.[6]

For the Baltimore County Climate Action Plan, the estimates for SLR in 2050 and 2080 were used to elevate the tidal reference values for the Baltimore, MD tide gauge Figure I-3. The MHHW elevation (0.82 feet) plus SLR was used to assess the impacts to County facilities and infrastructure. This value was used because the MHHW "typically delineates perennial inundation."[18] For nuisance flooding of roads, an additional 1.75 feet was added to the MHHW plus SLR value to capture the occasional high tides that result in road flooding. It should be emphasized that because the tides are variable, infrastructure located at the lower end of these elevations will be more heavily impacted, and infrastructure at the higher end of the tidal ranges will experience lesser impacts. For simplicity, infrastructure was categorized based on being inside or outside of the tidal ranges and no consideration for inundation depth was included in the analysis.

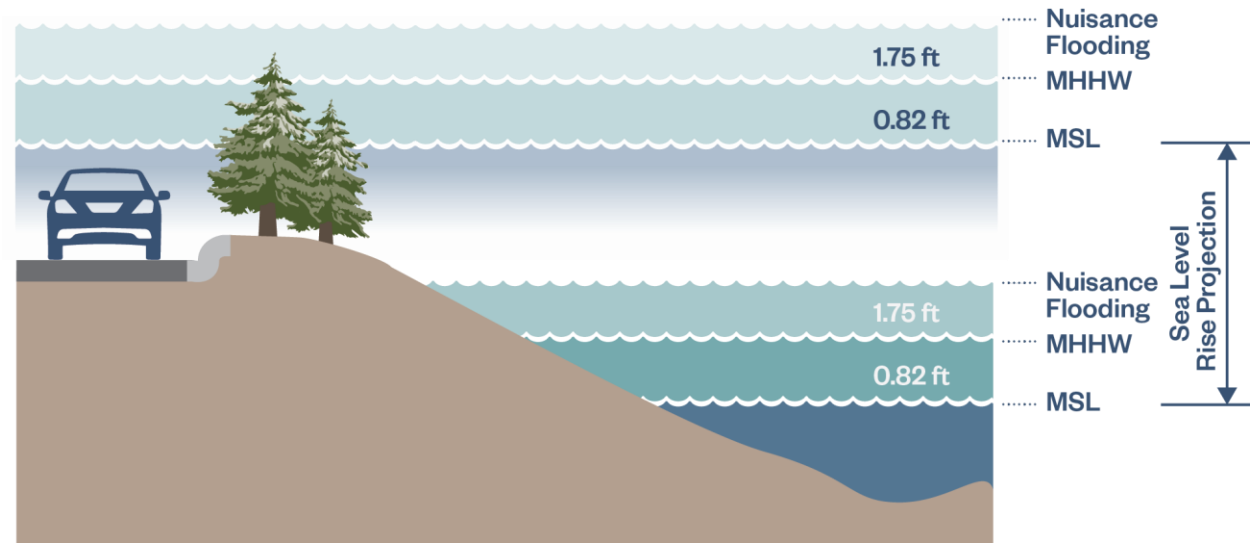

Figure I-3: Graphical Representation of Estimating Change in Tides due to SLR Projections (not to scale)

[6] Boesch, D.F., W.C. Boicourt, R.I. Cullather, T. Ezer, G.E. Galloway, Jr., Z.P. Johnson, K.H. Kilbourne, M.L. Kirwan, R.E. Kopp, S. Land, M. Li, W. Nardin, C.K. Sommerfield, W.V. Sweet. 2018. *Sea-level Rise: Projections for Maryland 2018*, 27 pp. University of Maryland Center for Environmental Science, Cambridge, MD.