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RECOMMENDATIONS FOR SEA LEVEL RISE PROJECTIONS

A report for the Governor's Coastal Climate Resiliency Plan

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Sea level rise projections for Virginia planning purposes

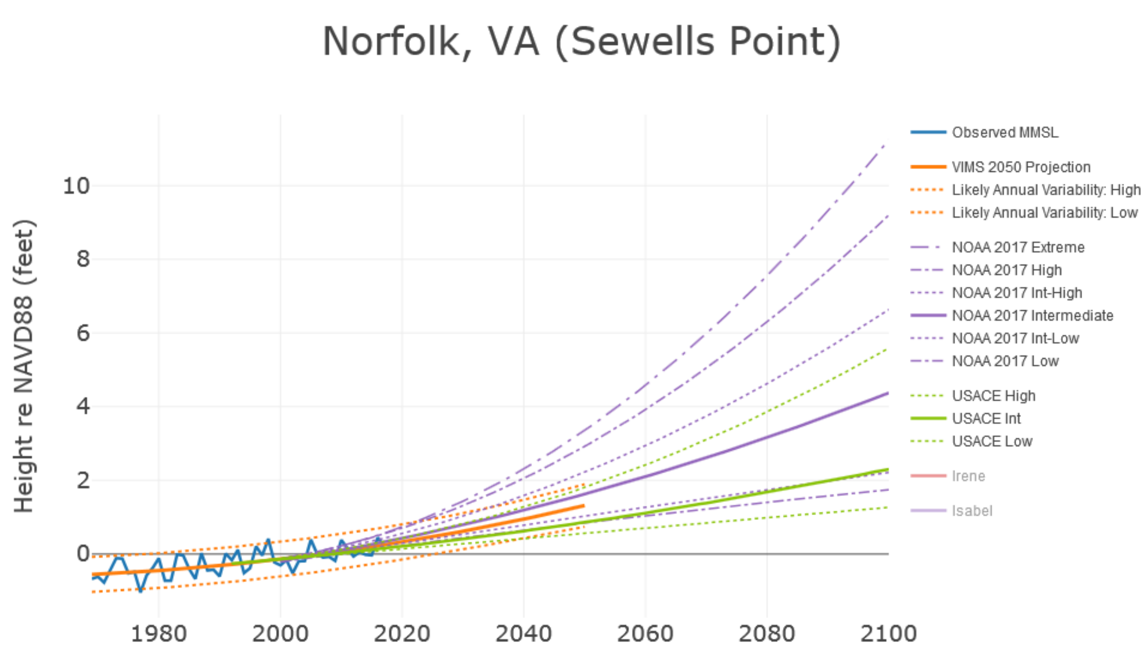
Among long-term tide gauge records, Virginia has the highest rate of change of any station on the East Coast. Sea level rise will significantly increase the flooding threat to low-lying roads, residences and critical infrastructure. Selecting an appropriate sea level projection for planning purposes is a critical step towards promoting resiliency. There are several important considerations in the selection of a sea level projection, which are: climate and oceans dynamics are in a period of active change which affects the inherent uncertainty in the projections, sea level changes can be affected by local conditions and future storm surges will occur on top of sea level rise, increasing the reach of storm surge flooding.

Recommended projection

For a single state-wide projection, we recommend the use of a tide-gauge based analysis for Sewell's Point, Norfolk until 2050 and the use of the NOAA (2017) climate model-based projections for times beyond 2050. Sewell's Point was chosen because it has the longest record of any Virginia tide gauge stations and is located in the Hampton Roads area. This area is among the most vulnerable to flooding due to their high population and low land elevations.

Sea level projections for Norfolk, VA have increased over time, as climate and ocean dynamics have shifted (Boon and Mitchell 2015). Therefore, the state projection should be re-considered annually, and updated if necessary to reflect the best available science. To enable annual re-consideration, AdaptVA.org provides a graph with both tide-gauge (to 2050) and climate model-based (to 2100) projections (http://adaptva.org/info/virginia_sea_level.html). The current graph (2017) is shown below:

Figure 1. Virginia Sea Level Rise Projections



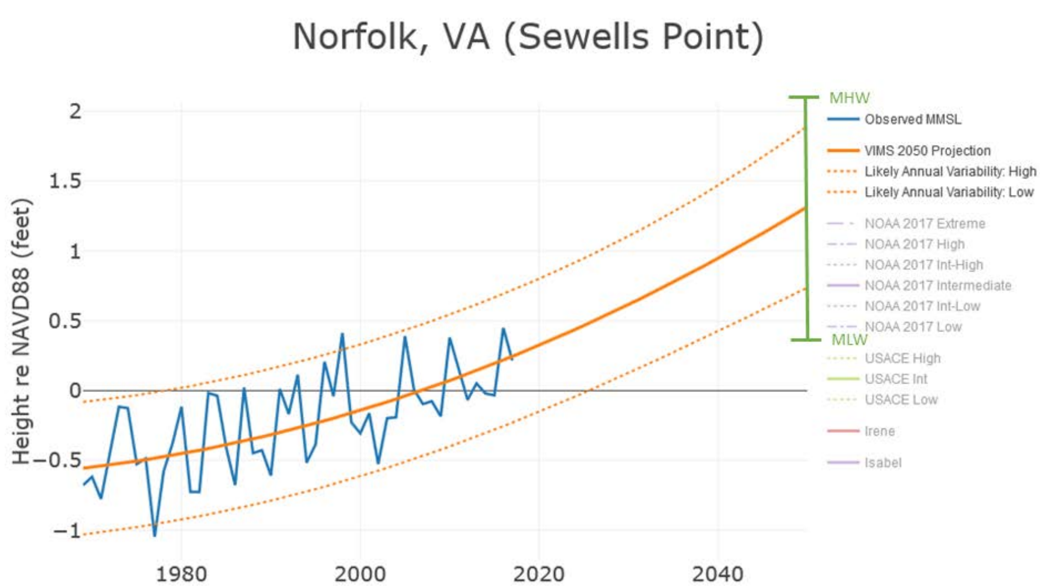
The tide gauge projection (VIMS 2050 Projection) is derived from the Sea Level Rise Report Cards (Boon et al. 2017). This analysis is updated annually and provides a single target sea level for 2050. The climate model-based projections (NOAA 2017 Low-Extreme) provide several climate scenarios and potential target sea levels through 2100. These will be updated with the next NOAA publication. The USACE Low-High projections are also provided for projects which need to be compliant with USACE requirements.

All projections are provided relative to NAVD88. This is a land-based elevation and therefore directly relatable to first-floor elevations and other land-based engineering criteria. For more information on NAVD88 or to see the projection relative to a tidal datum, please see Appendix A.

Using the sea level projections

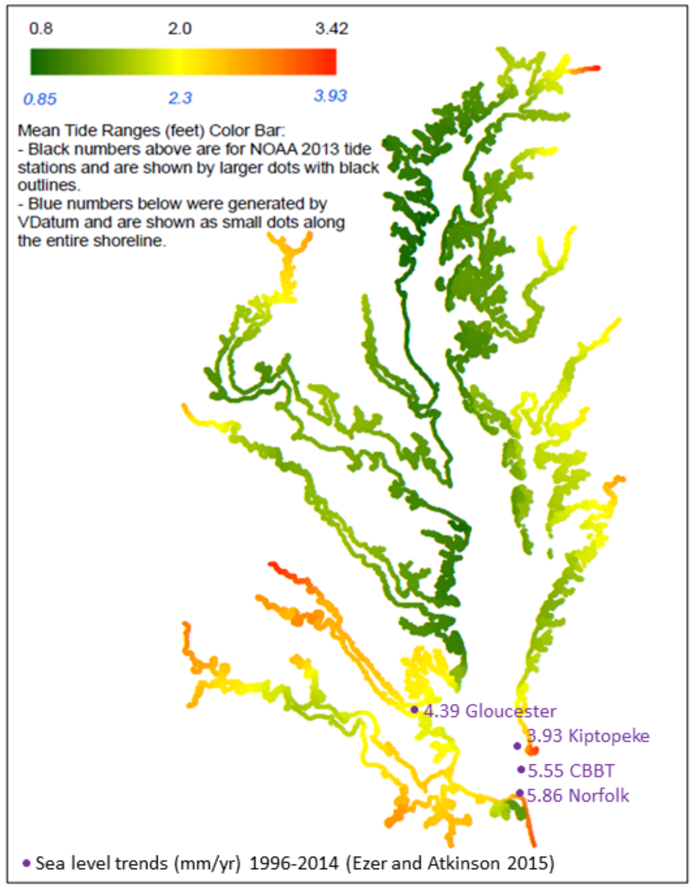
There are three important considerations when using sea level projections for planning purposes. These have been illustrated on the graph below for Norfolk, VA.

- Since all of the projections are for mean sea level, the daily high tide will be above this level and must be accounted for in the planning process. An example is shown on the graph in green. The elevation of the high tide varies along Virginia shorelines and should be adjusted accordingly (see map of tidal heights below). At Sewell's Point, **mean sea level in 2050 is expected to be 1.32 ft NAVD88 and mean high water is expected to be 2.3 ft NAVD88.**
- Annual mean sea level (shown in blue on the graph) is dynamic through time, oscillating around the mean trend line (solid orange). The dotted orange lines show the outer bounds of this oscillation. For a given year, the mean sea level is expected to be between the orange dotted lines, not exactly on the solid orange line. This means that mean sea level in 2050 may be above the trend line. At Sewell's Point, **mean sea level in 2050 could be up to 1.89 ft NADV88 and mean high water would be 2.9 ft NAVD88.**
- Storm surge can be significantly higher than the tide range and occurs on top of mean sea level. The effect will vary by location, storm characteristics and point in the tidal cycle. **An Isabel-like storm could produce surges above 5 ft NAVD88 by 2050.**



Variations around the Bay

Sea level rise rates (purple dots on the map) show small variations around the Virginia portion of the Bay (Ezer and Atkinson 2015). Unfortunately, there are not many gauges with long enough records to confidently detect sea level trends. None of the tide gauges with the necessary length of record are located in the upper reaches of the tributaries. Therefore, it is impossible to justifiably project sea level rise spatially at this time. Until tide gauges in the upper parts of the tributaries have useable records, **we recommend using the Norfolk gauge as the state standard.** Since Norfolk has the highest known rate of rise in Virginia, this approach is conservative and will reduce the likelihood of underestimating future water levels; improving flood resiliency.



Tide range varies from about 0.5 ft to around 3.5 ft along Virginia shorelines. The highest ranges are in the lower part of the Bay and the upper parts of the tributaries. Tide range is lowest on the Bay-front Northern Neck and the Potomac River. Tide range should be considered as part of the planning on a local basis.

Other planning considerations

The incorporation of project lifespan and flood tolerance can assist with selecting a sea level projection.

- For projects with short lifespans (e.g., less than 30 years), the 2050 mean projection (orange curve) is ideal for projects with short life spans.
  - All infrastructure should be constructed at elevations above the projected mean sea level for 2050.
  - Infrastructure that can tolerate moderate flooding (e.g., some roads) can be constructed in elevations between the orange curve and the orange dotted lines.
  - Infrastructure that can tolerate only occasional flooding (due to storm events) should be built at elevations above the upper dotted line.
  - Infrastructure that cannot tolerate flooding should include a consideration of storm surges, by adding 3+ feet to the elevation of the dotted line. Additional flood proofing measures should be considered for this type of critical infrastructure.
- Projects with longer lifespans (30-100 years) should consider the NOAA climate scenarios for the target lifespan.
  - The Intermediate curve is potential target for infrastructure that can tolerate moderate flooding; flood intolerant infrastructure should incorporate higher curves.

References

ADAPTVA website. http://adaptva.org/info/virginia_sea_level.html

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National Oceanographic and Atmospheric Agency. 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. Found online at: https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Sea level rise report cards. https://www.vims.edu/research/products/slrc/

Appendix A. Comparing NAVD88 and the current tidal datum

NAVD88 is a land-based datum and therefore is most relevant to the engineering of buildings, roads and shoreline protection structures. Mean sea level values relative to NAVD88 can be interpreted as the depth of the water over the land. This datum does not change with sea level rise.

The **tidal datum** is a water level datum and is relevant to channels, navigation and other water-based activities. In Virginia, the current tidal datum was calculated using the 19-year period from 1983-2001. This datum does change with sea level rise and is periodically recalculated. It is hard to relate to current conditions, since annual MSL has risen above the current tidal datum MSL. NOAA does provide a station datum, which is a surveyed benchmark that does not change. This can be used to relate MSL between tidal datums after they change.

The VIMS sea level rise projection for Sewell's Point in MSL of the current tidal datum can be found at: https://www.vims.edu/research/products/slrc/localities/nova/index.php

At the Sewell's Point gauge in Norfolk, MSL and NAVD88 are very similar, but not identical. 0 ft NAVD88 is 0.25 ft above 0 ft MSL. Therefore, values in NAVD88 can be converted to MSL by adding 0.25 ft.