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Modeling time-varying surge barriers: the impact of closure time and duration on flood protection

Mary Cialone, Greg Slusarczyk, and Robert Hampson

The research presented in this paper focuses on numerical modeling and analysis of the effects of Storm Surge Barriers (SSBs) or gates, on water levels for a set of 10 hypothetical storm events representative of the range of storm conditions in the study region, as well as 3 specific historical storm events. In particular, analysis of the sensitivity of back-bay water levels to SSB operational decisions such as how far in advance of the storm to close a barrier to mitigate back-bay flooding induced by the storm surge and when to reopen the barrier to release water from the bay is investigated in an optimization process.

The study area selected for this analysis was a set of hydraulically connected bays in New Jersey, United States: Barnegat Bay, Manahawkin Bay, and Little Egg Harbor. These bays form the largest bay system in New Jersey (over 326 km^2). A SSB was numerically implemented across Barnegat Inlet, which connects the bay system with the Atlantic Ocean. Several closure combinations with respect to the timing of closing/re-opening the gate were investigated and the results were compared with a Base Condition (the inlet fully open) and a static gate condition (the inlet closed for the entire simulation time). The storm events were numerically simulated for all inlet closure conditions utilizing the ADvanced CIRCulation hydrodynamic model (Luettich et al. 1992). In addition to the fully open and fully closed conditions, a short duration and long duration gate closure condition was simulated. For the short gate closure the inlet was closed 2 hours before the 50% of the annual exceedance probability (AEP) water level was reached and re-opened after the storm passed on the falling tide when the head difference at the gate was less than 0.33 m. The long closure scenario implements the closed gate at low tide 6 to 12 hours before the storm arrived and reopened it about 12 hours after the short closure.

The importance of the timing and duration of implementing surge barriers examined in this paper has implications on reduction in back bay flooding due to: 1) the reduction in peak water levels in the bay, 2) the volume of water prevented from entering the bay, 3) the volume of water not being trapped behind a static, closed gate, and 4) the reduction in the height of seiche with a smaller volume of water in the bay. Not examined, but also of importance, is the potential reduction in environmental impacts by using a dynamic rather than a static closure gate. These findings have potential application to closure timing from impending storms at other locations world-wide, including the Netherlands and Italy. As SSBs become more commonly considered to reduce back bay flooding and to manage coastal storm flood risk, the importance of increased understanding of SSB operations presented in this paper will become increasingly beneficial to the international coastal community.

Luettich, R.A., Westerink, J.J. and Scheffner, N.W., 1992. ADCIRC: an advanced three-dimensional circulation model for shelves, coasts, and estuaries. Report 1, Theory and methodology of ADCIRC-2DD1 and ADCIRC-3DL.