Hydrologic Feasibility of Storm Surge Barriers

Malcolm J. Bowman, School of Marine and
Atmospheric Sciences
State University of New York, Stony Brook, NY.

Presented at “Against the Deluge: Storm Surge Barriers to Protect New York City”

Polytechnic Institute of New York University
Brooklyn, New York
30 March 2009

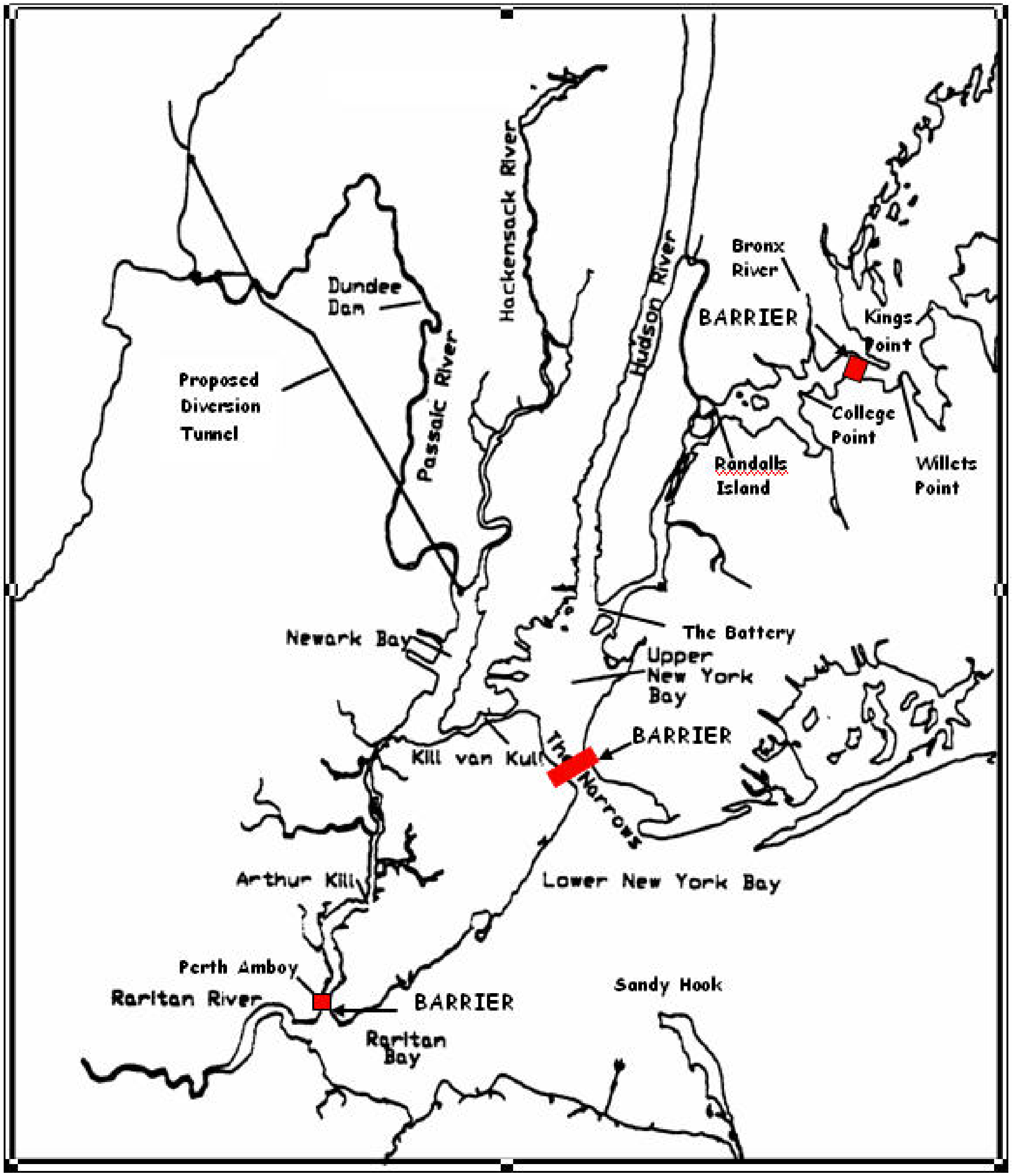


Fig. 2: Locator diagram for New York Harbor and environs (upper panel) and Long Island Sound (lower panel).

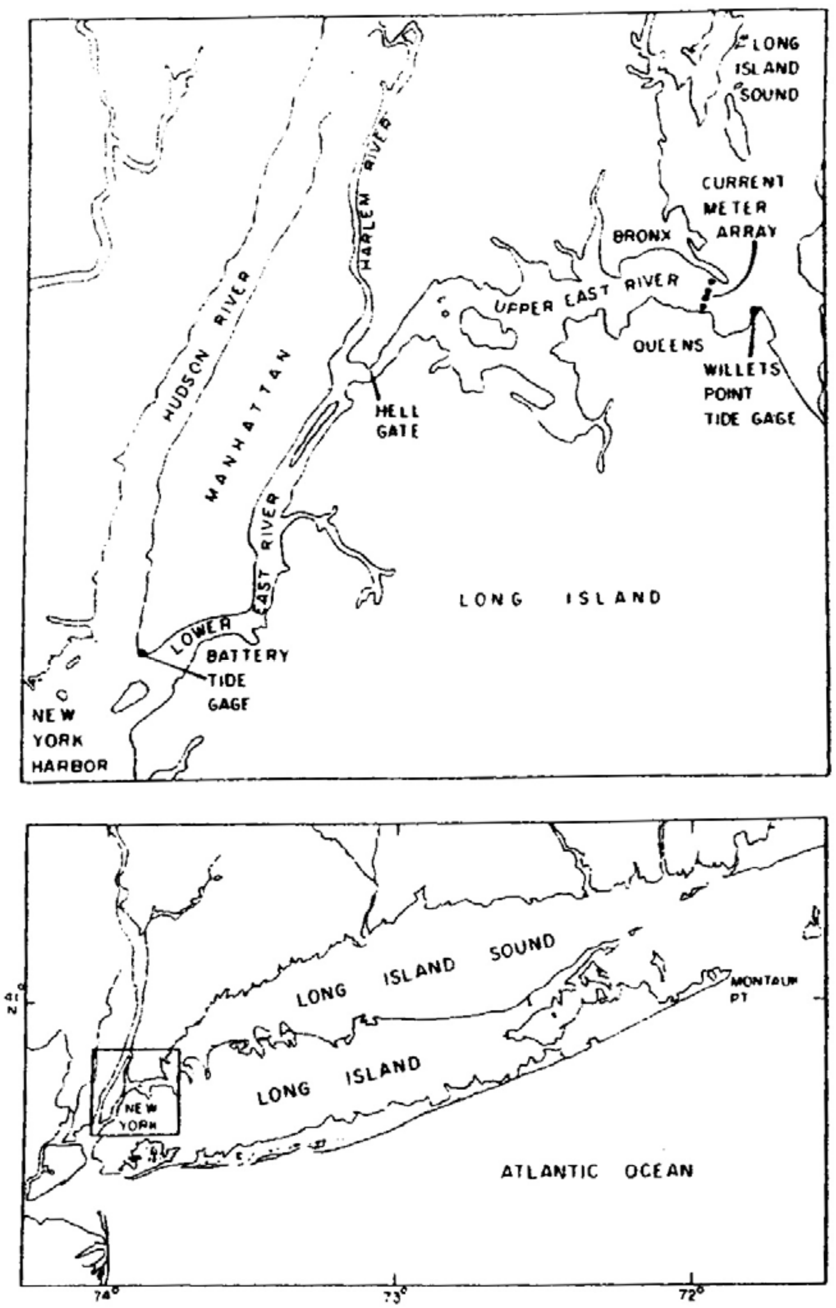
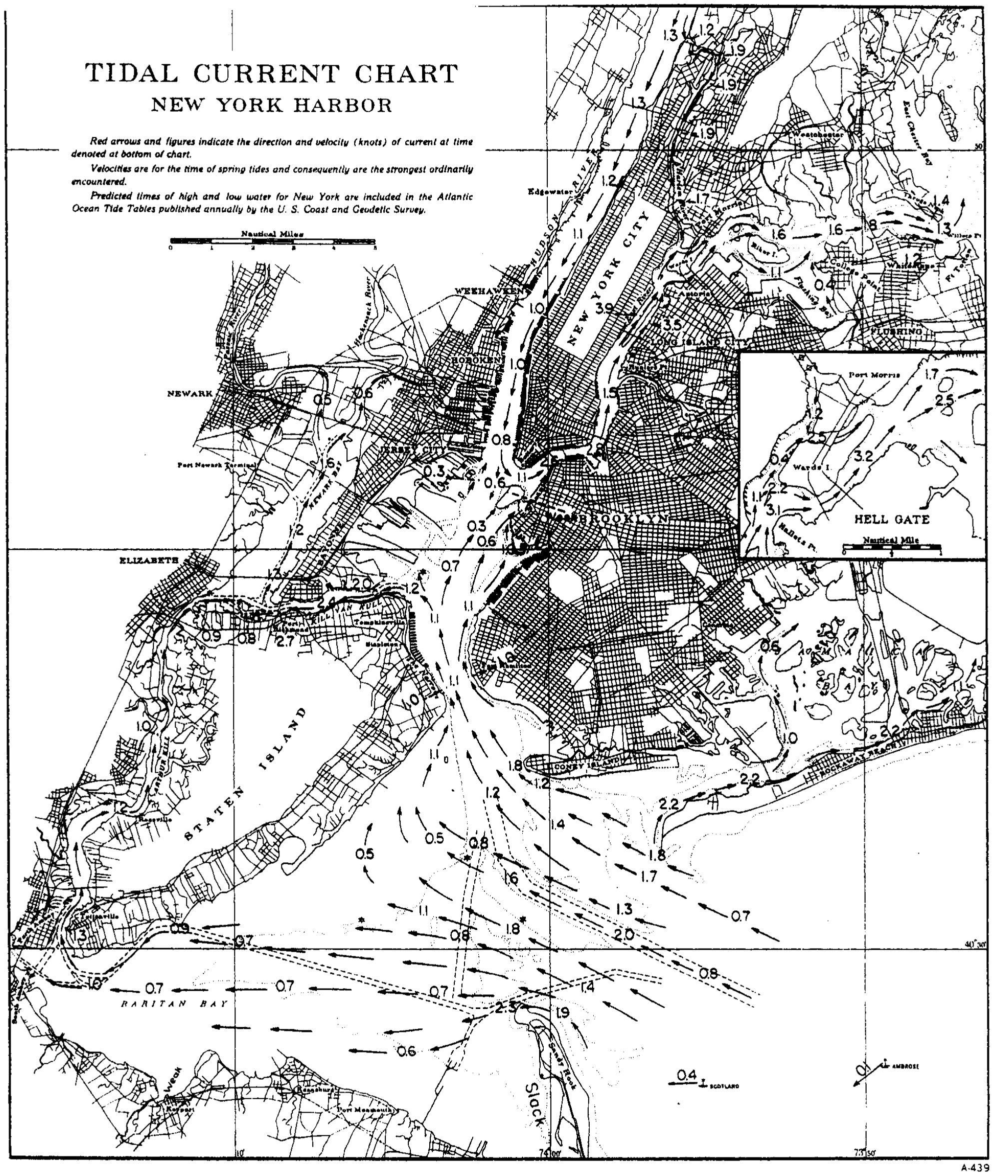


Fig. 2: Locator diagram for New York Harbor and environs (upper panel) and Long Island Sound (lower panel).



THREE HOURS AFTER LOW WATER AT NEW YORK

Fig. 3: Surface tidal currents three hr after low water at the Battery during spring tides (US Coast and Geodetic Survey, 1959).

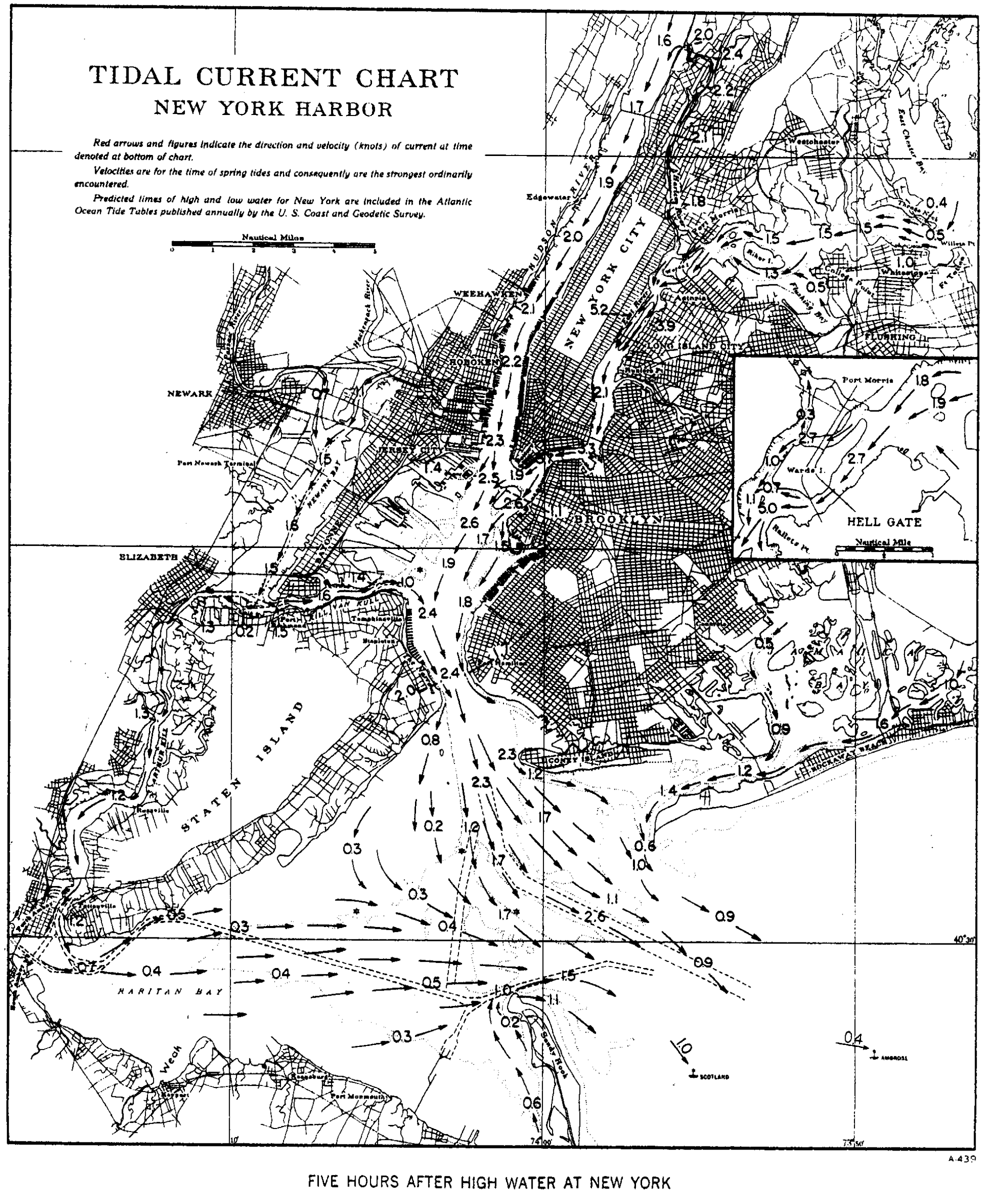
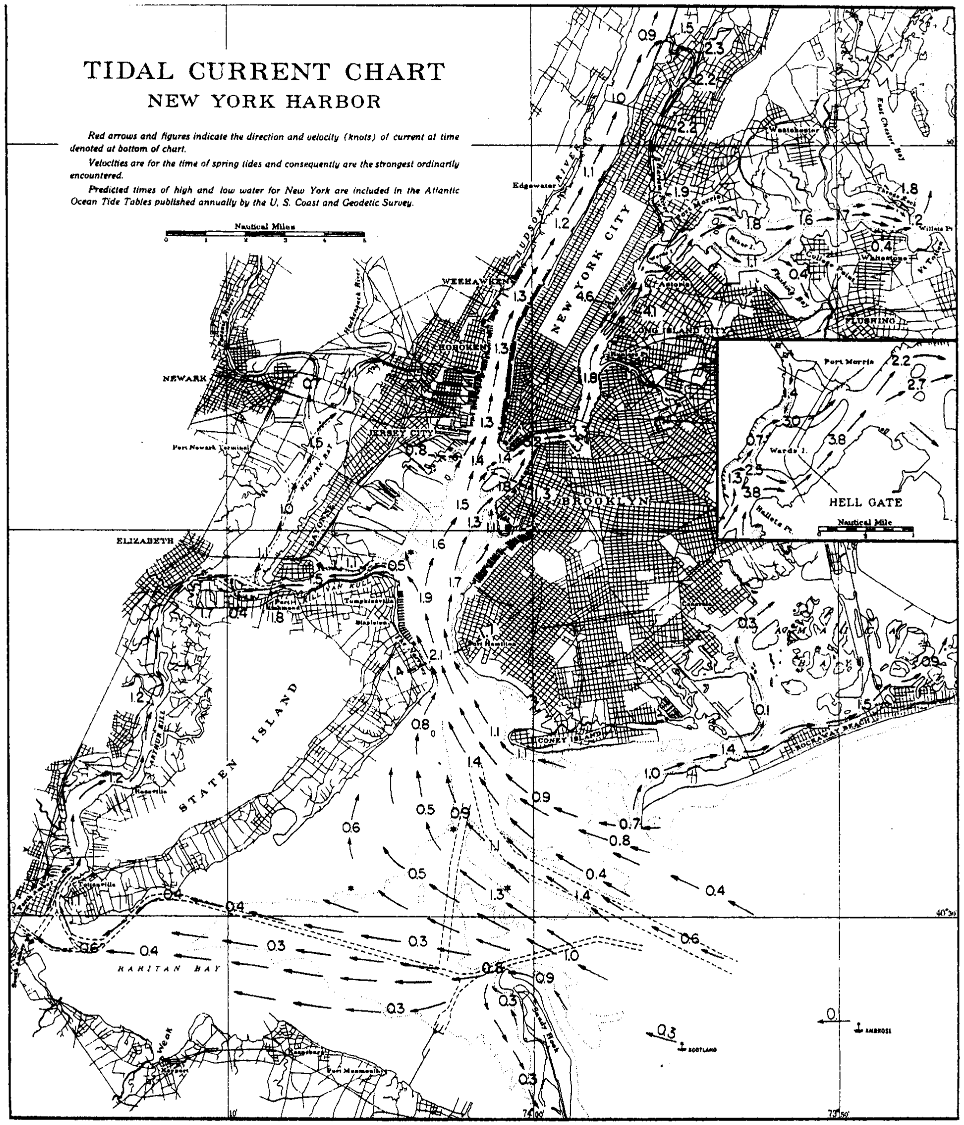


Fig. 4: Surface tidal currents five hr after high water at the Battery during spring tides (US Coast and Geodetic Survey, 1959).



FIVE HOURS AFTER LOW WATER AT NEW YORK

Fig. 5: Surface tidal currents five hr after low water at the Battery during spring tides (US Coast and Geodetic Survey, 1959).

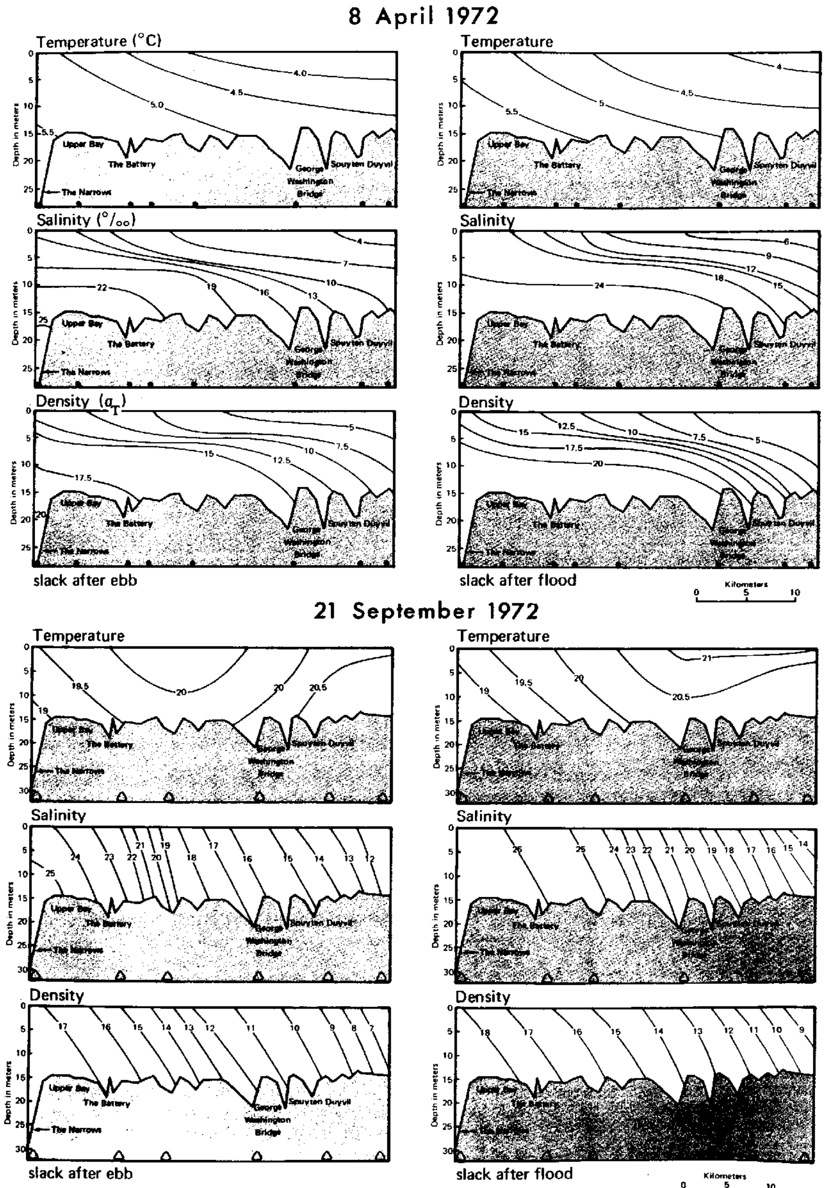


Figure 3. Temperature, salinity, and density contours in lower Hudson River

Fig. 6: Hydrographic properties in the lower Hudson estuary during high runoff conditions (upper 6 panels) and:

low runoff conditions (lower 6 panels). After Bowman, 197x).

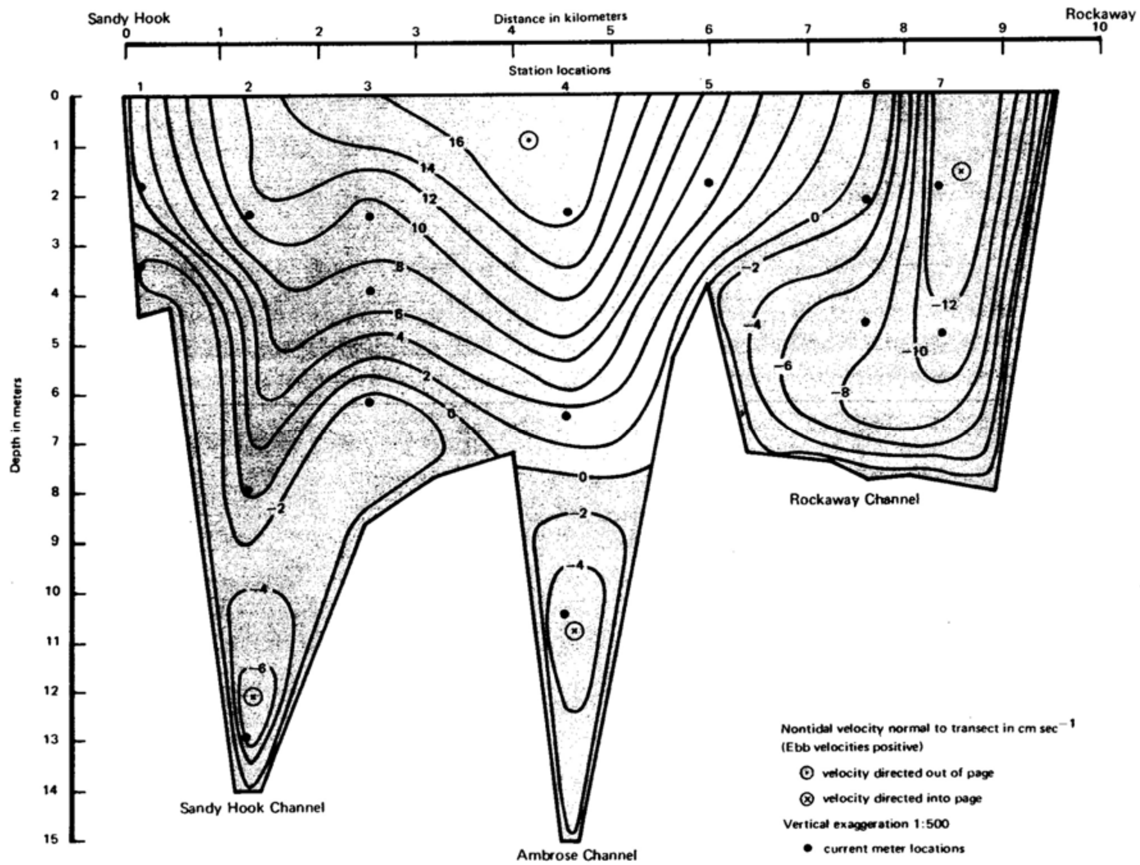


Fig. 7: Tidally-averaged velocities cm s^{-1} across the Sandy Hook – Rockaway transect, looking upstream (from Kao, 1975).

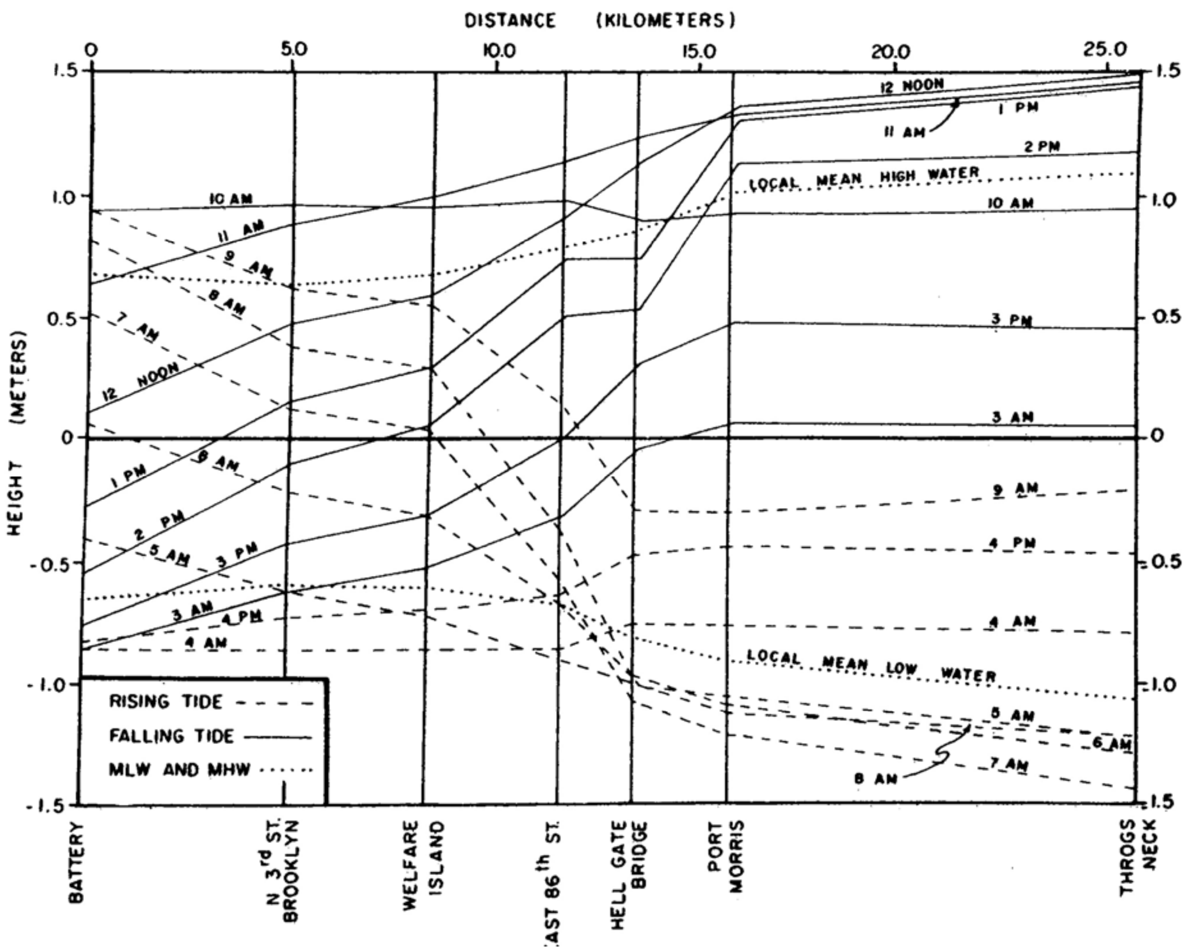


Fig. 8: Slope line diagram for the East River. Lines join observed tidal heights at various locations along the river at each lunar hour (1 lunar hour = 12.42/12.00 solar hours).

The envelope of the bundle gives the tidal range at each location. From Bowman, 1976).

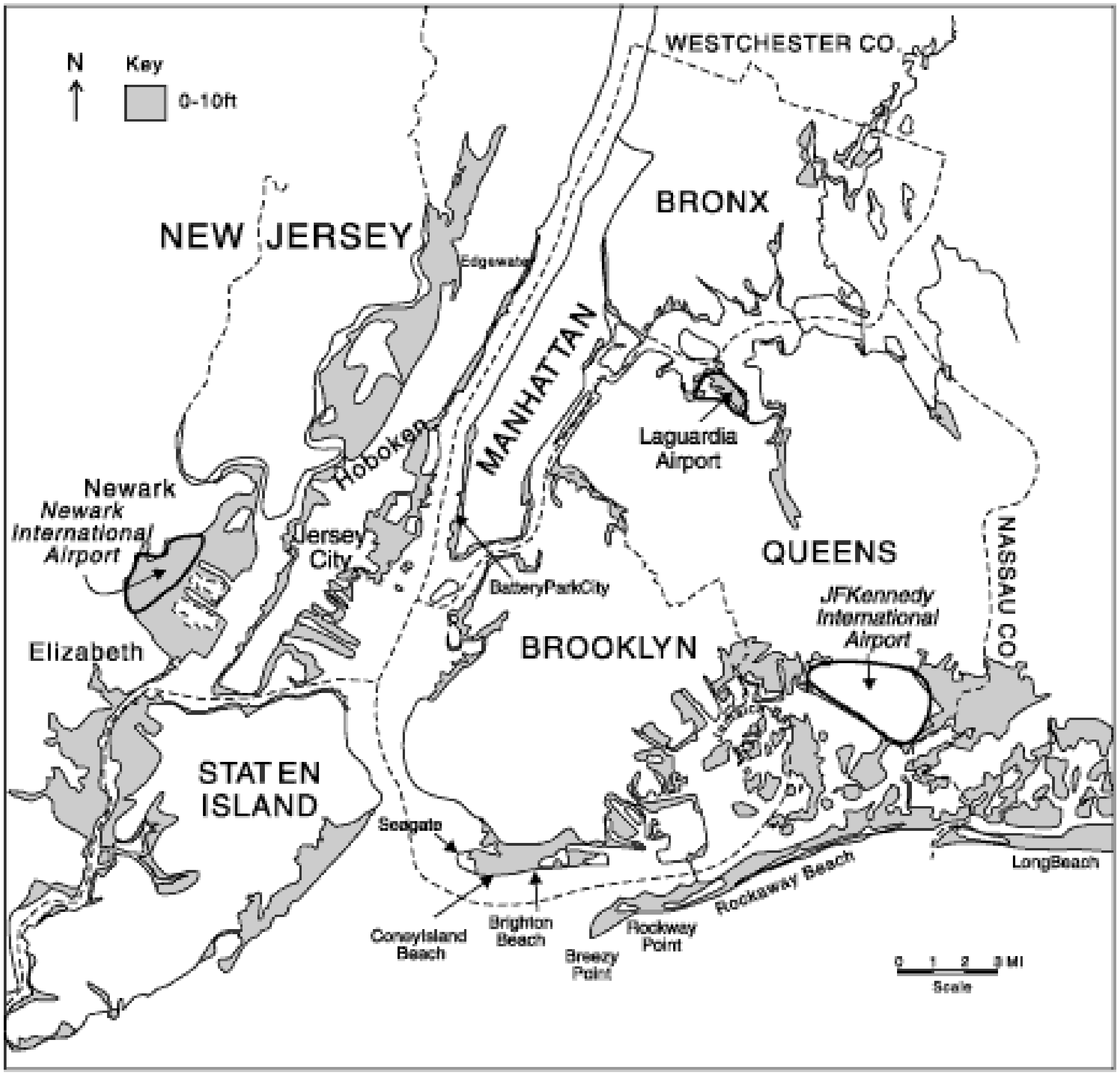


Fig. 9: The 100-year flood, shown shaded, covers ~ 260 km^2 in the metropolitan region, about half of which could be protected with storm surge barriers (after Gornitz et al., 2001).

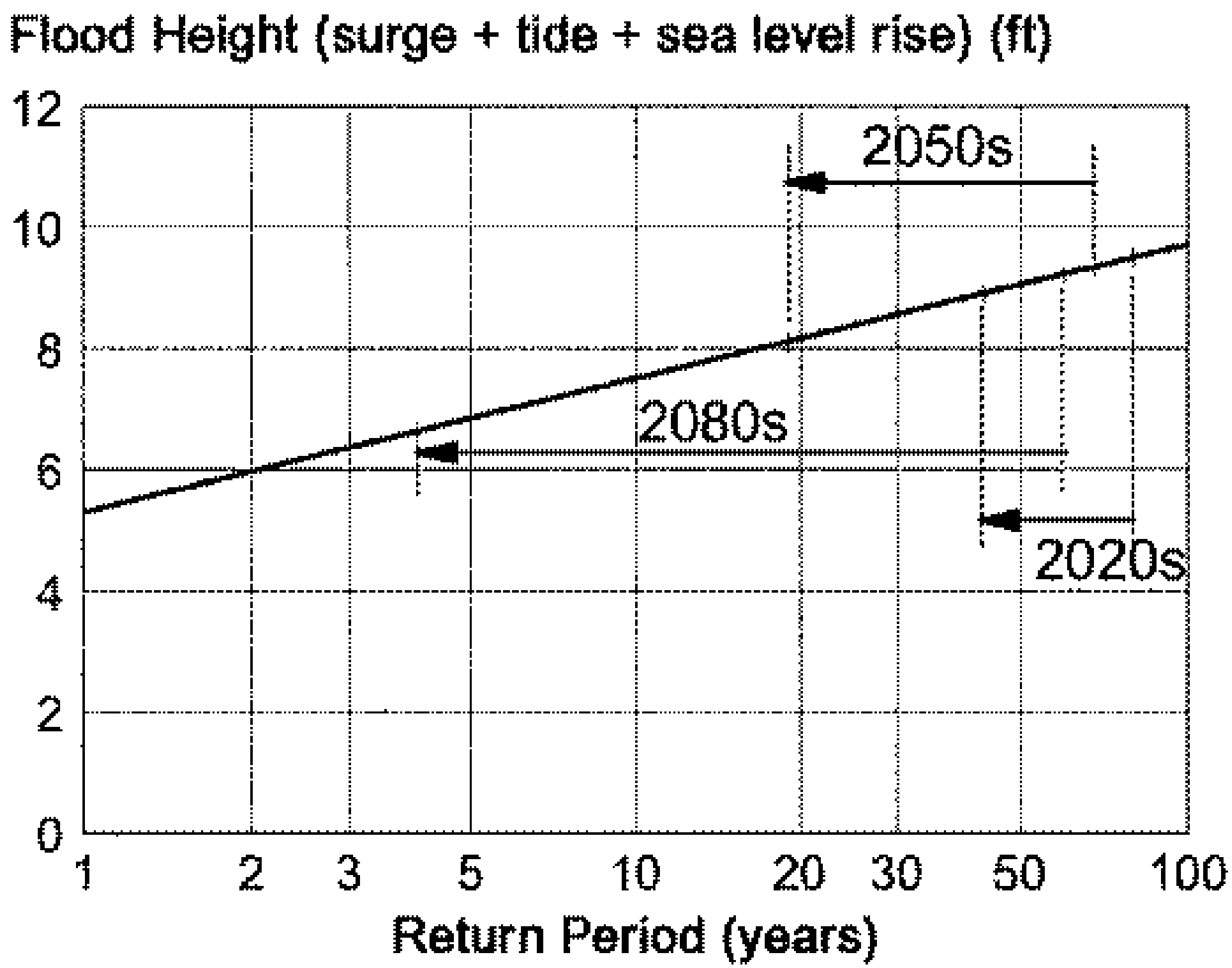


Fig. 10: The rise in sea level due to climate warming is expected to increase the frequency of flooding, shown here by the reduction in the return period of a “100-year flood” of 0.3 ms (~10 ft) surge elevation.

After Gornitz et al., 2001.

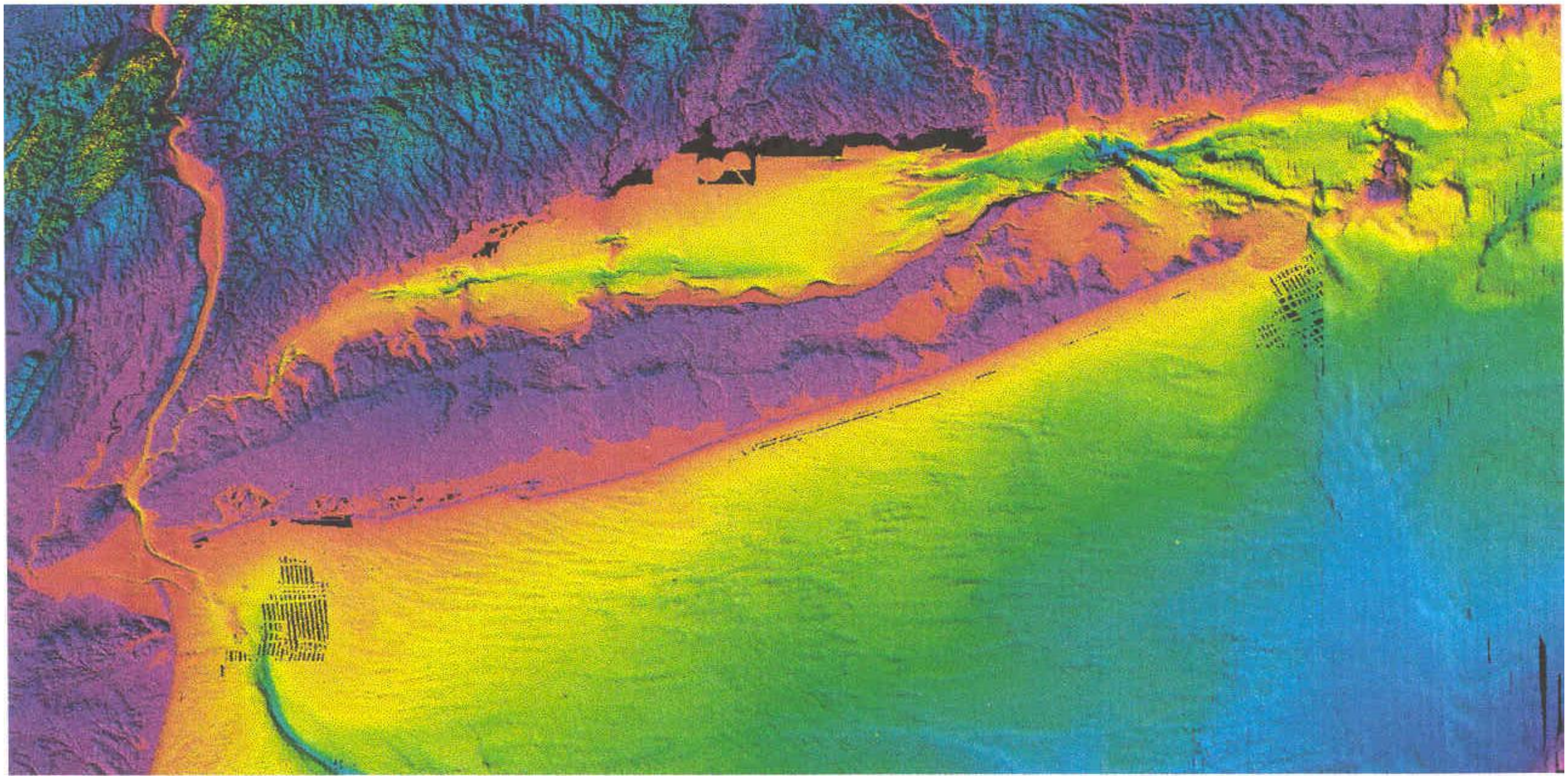


Fig. 11: SBS³ bathymetric and topographic elevation map of Metropolitan New York and Long Island (bathymetry based on various sources, topography based on USGS 10 m x 10 m surveys). Data are normalized to the North American Datum of 1983 (NAD 83). Courtesy R. Flood.

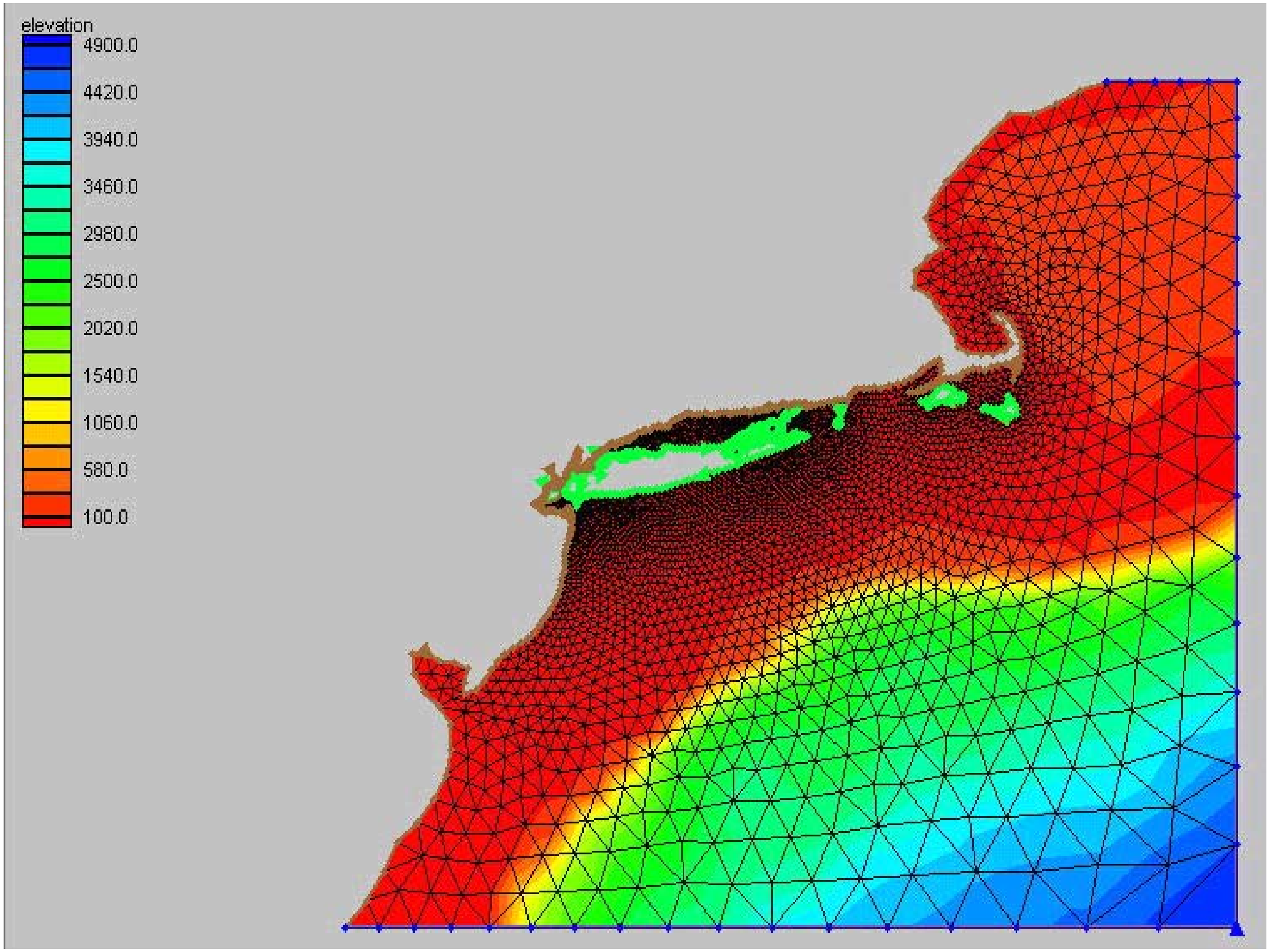


Fig. 12: Partial domain of the ADCIRC ocean circulation model illustrating some of the varying size of the triangular grids according to the detail required to accurately describe the simulate the oceanic, coastal and estuarine hydrodynamics.

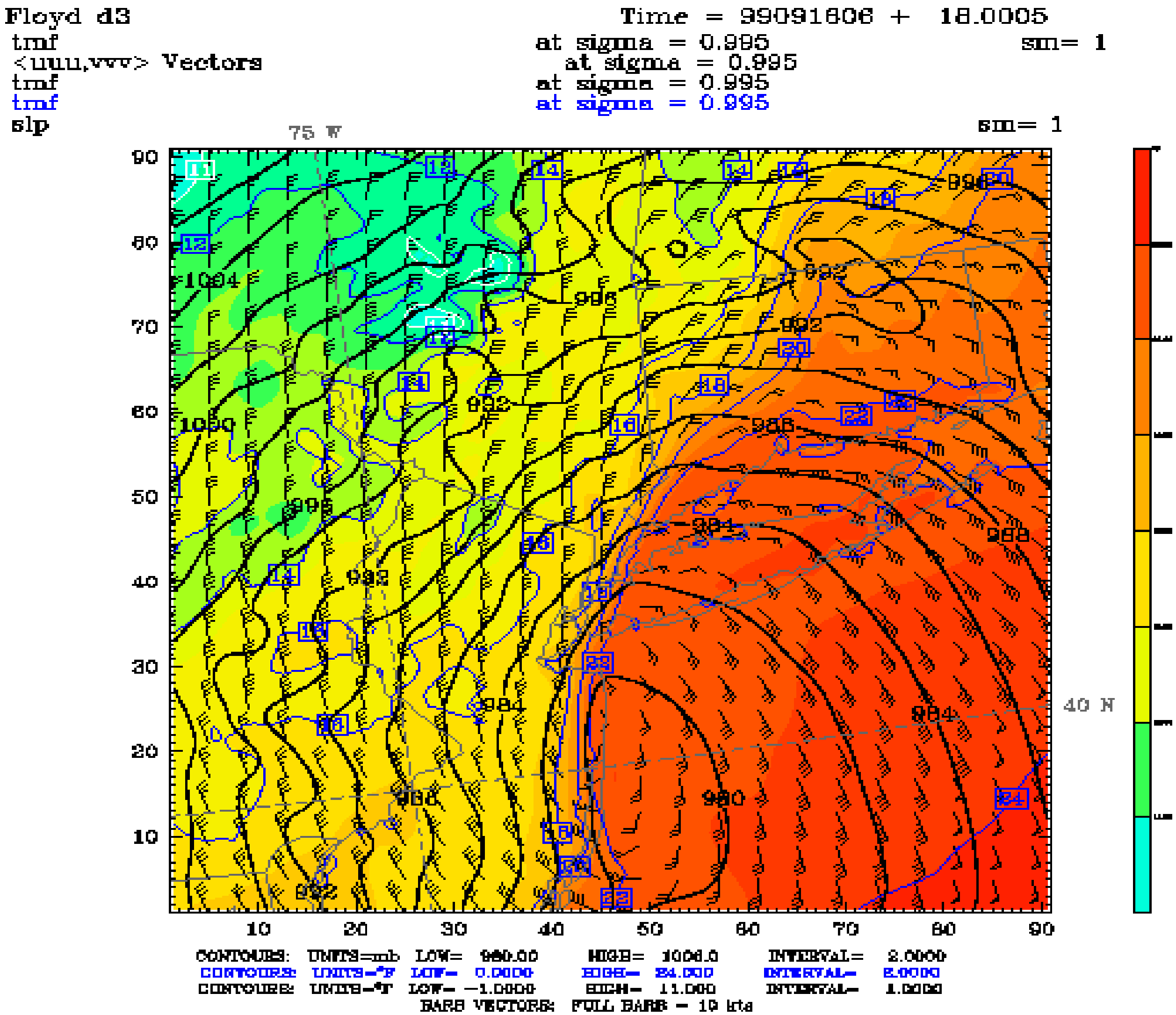


Fig. 13. MM5 simulation of extra-tropical storm Floyd approaching the metropolitan region: wind speeds (10 knot barbs), sea level (10 m) pressure and 10 m temperature. From Bowman et al., 2005).

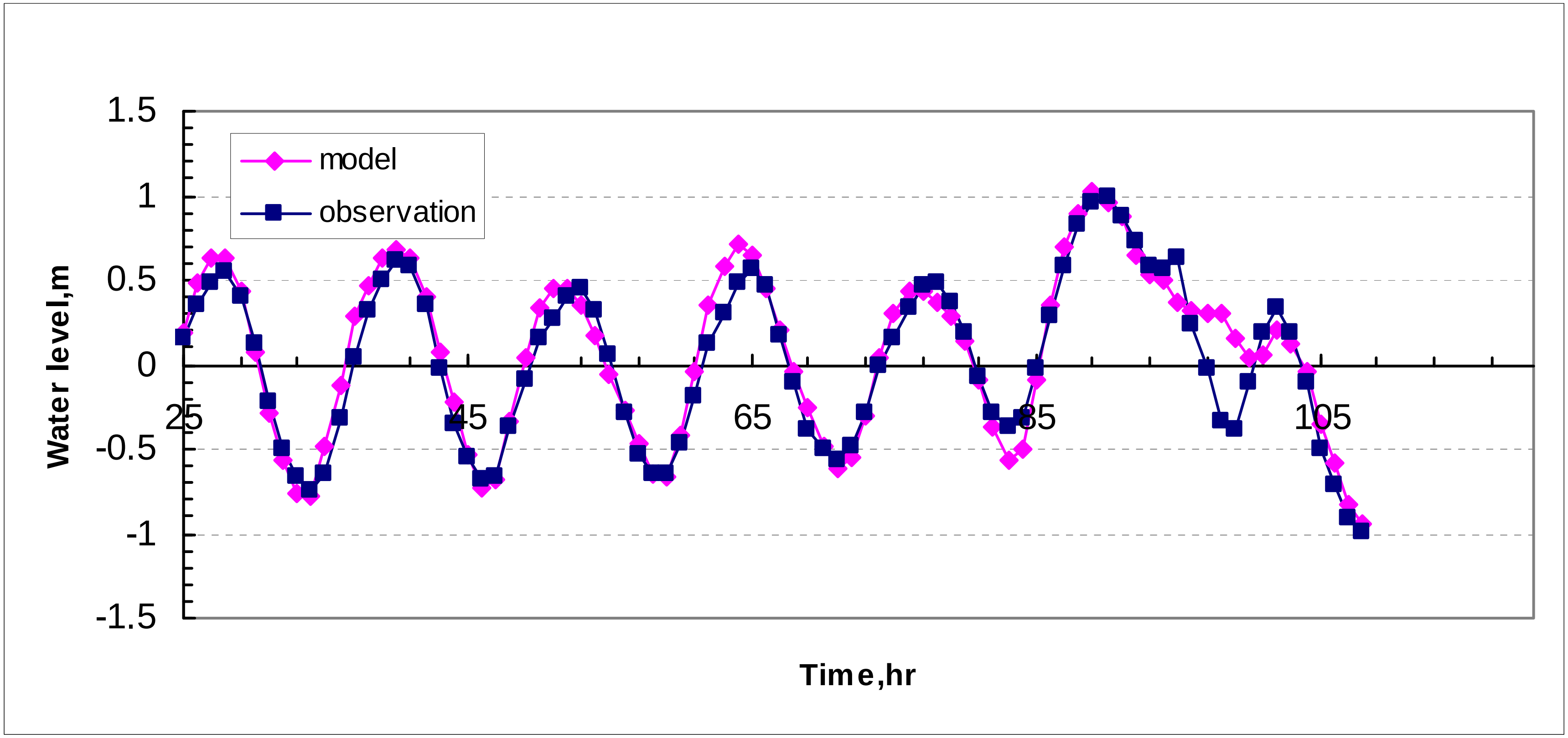


Fig. 14. NOAA-observed and SBS^3-simulated water levels at the Battery during the Floyd 1999 extra-tropical storm, 16-19 Sept.

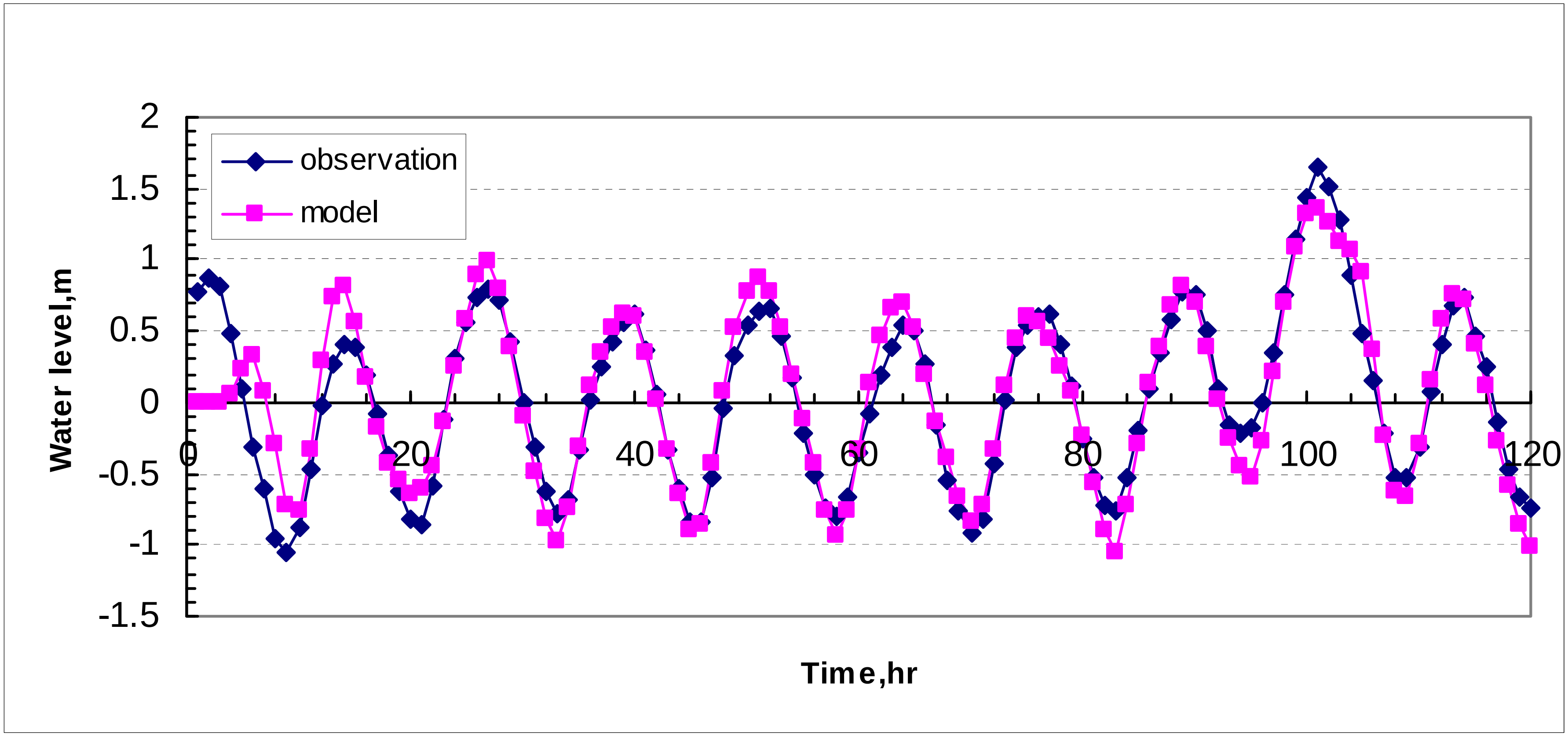


Fig. 15: NOAA-observed and SBS^3-simulated water levels at the Battery during the Christmas 2002 extra-tropical storm.

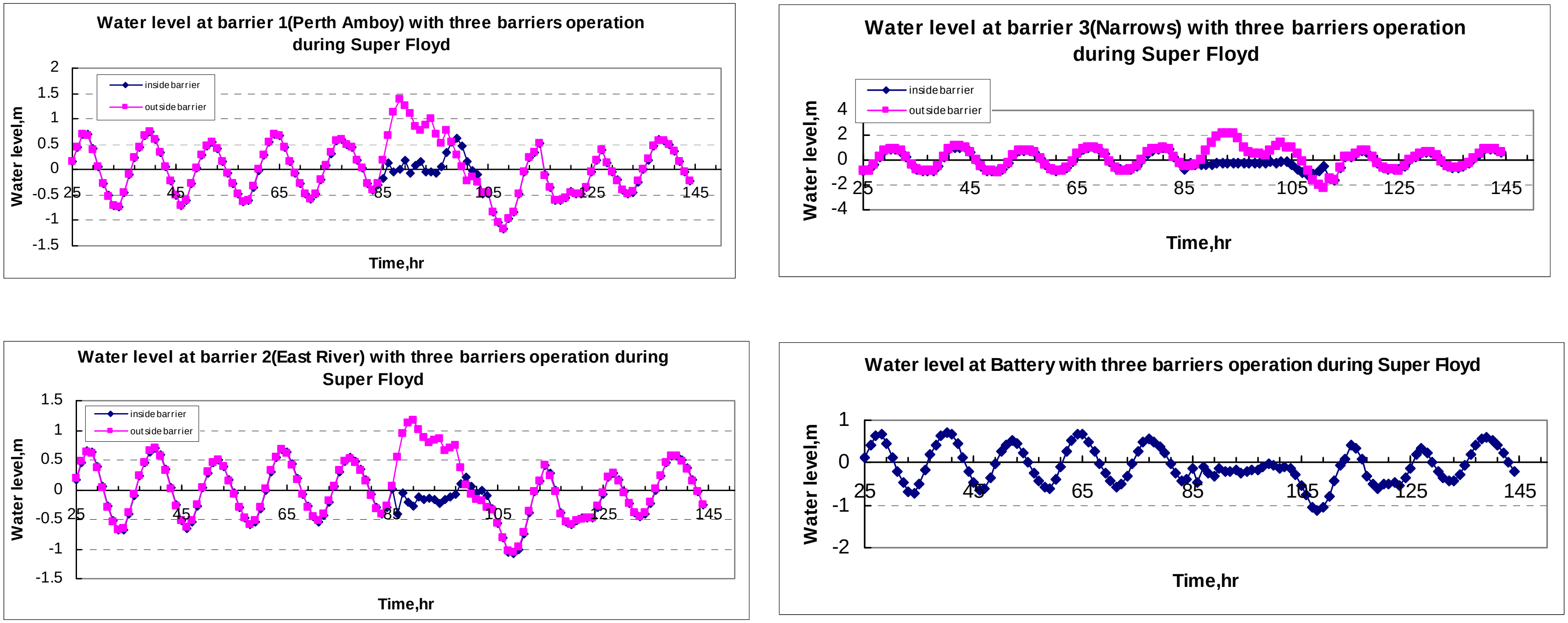
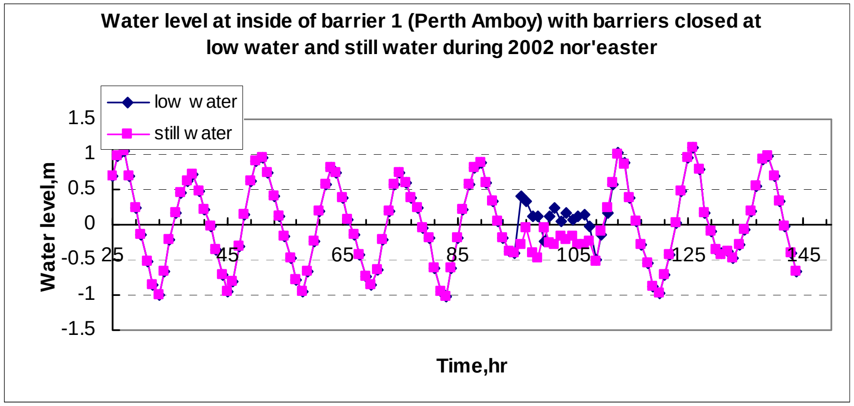
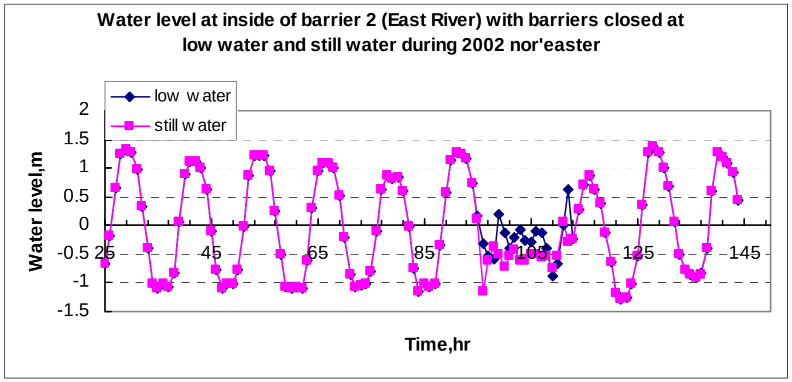


Fig. 16. Closing the three barriers at local slack water during Super Floyd lowers the water level inside the barriers to approximately mean sea level.





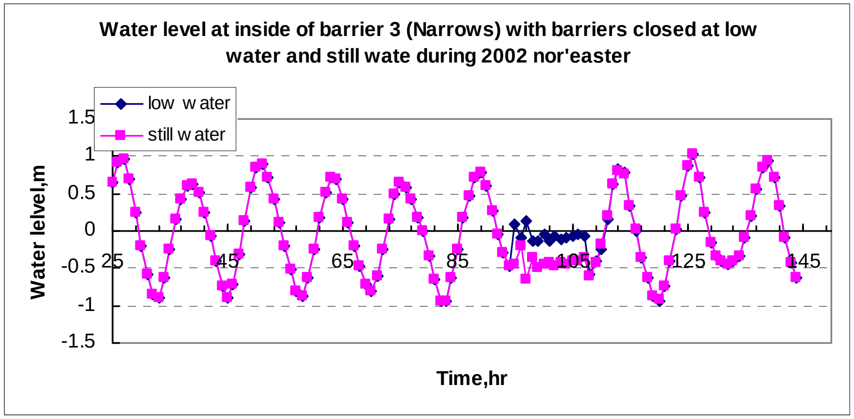
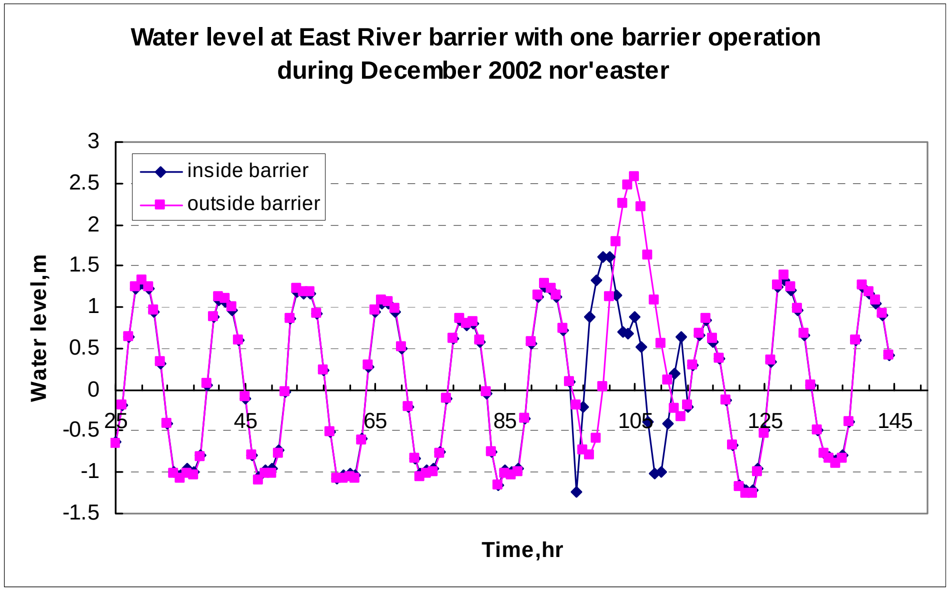


Fig. 17: For the 2002 Christmas nor'easter storm, closing the barriers at local slack (still) water leads to slightly lower water levels behind the barriers than if they were closed at local low water.



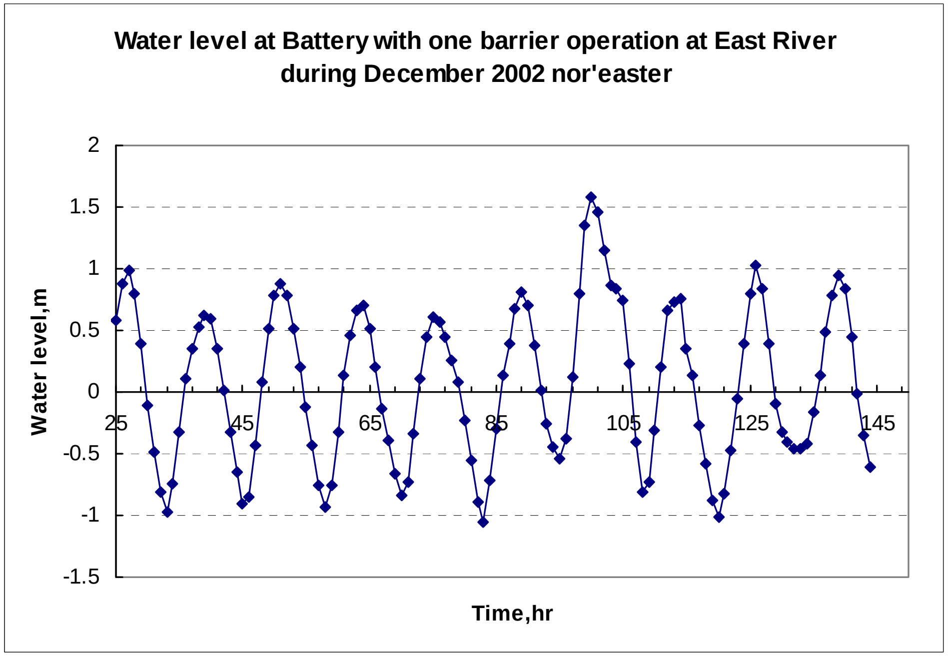
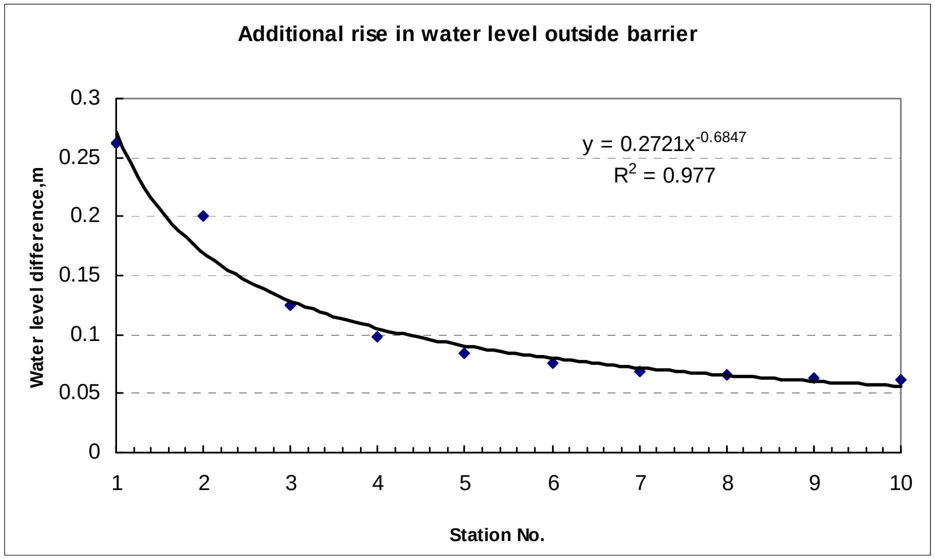


Fig. 18. With a single East River barrier, the storm surge propagating from Long Island Sound is blocked, but the water elevation west of the barrier nevertheless reaches flood level.



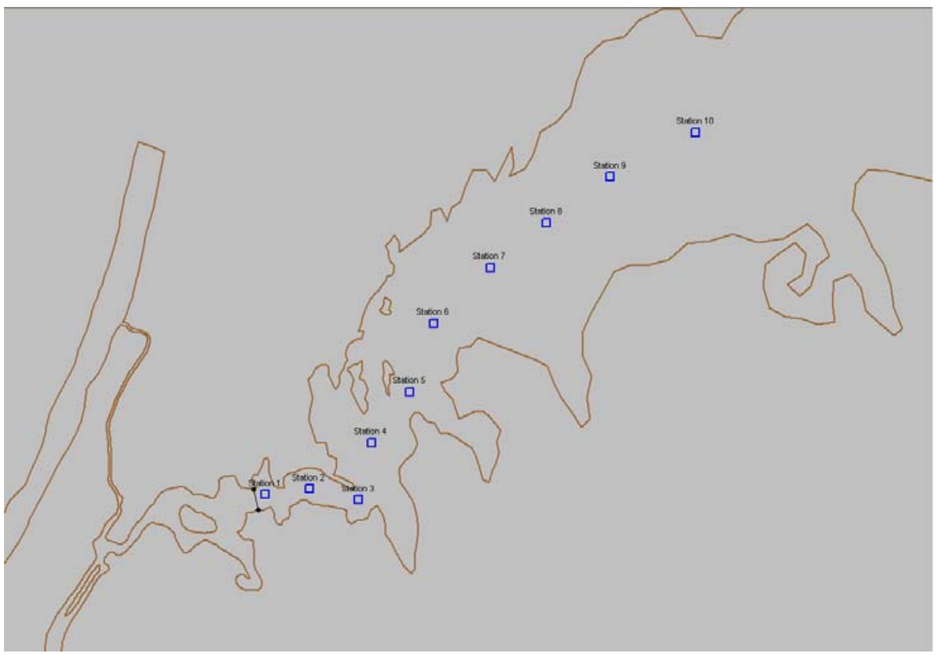


Fig. 19. Loaded against the closed East River barrier in the simulated 2002 nor'easter, the water level on the eastern face of the barrier rose + 0.27 m than would have occurred had the barrier not been operational during the same storm.

This additional rise diminished exponentially with distance from the barrier, dropping by about one-third at Willets Point.

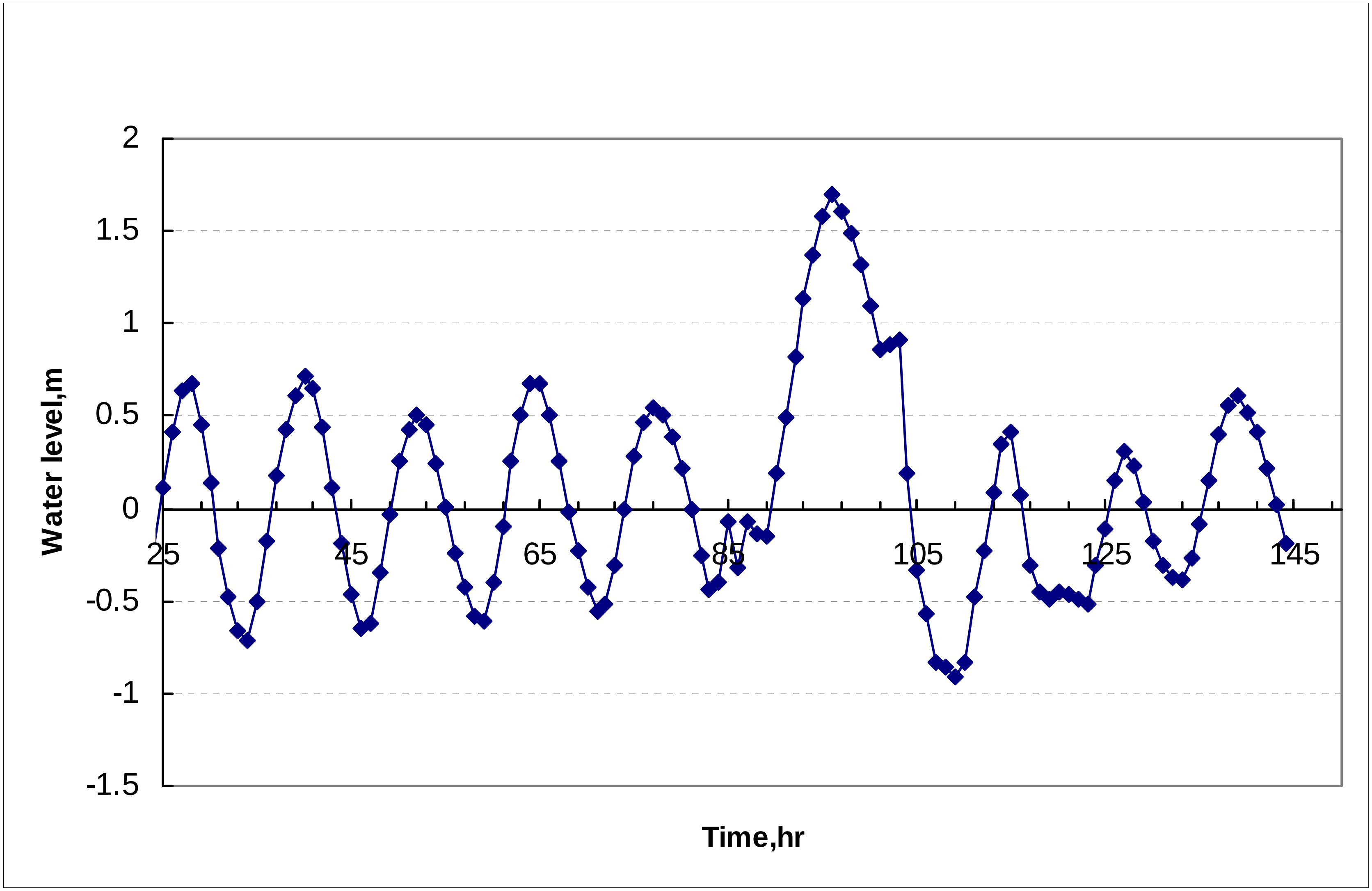


Fig. 20: With two barriers closed and the East River open during Super Floyd, the peak water level at the Battery is higher than if all three barriers were open.

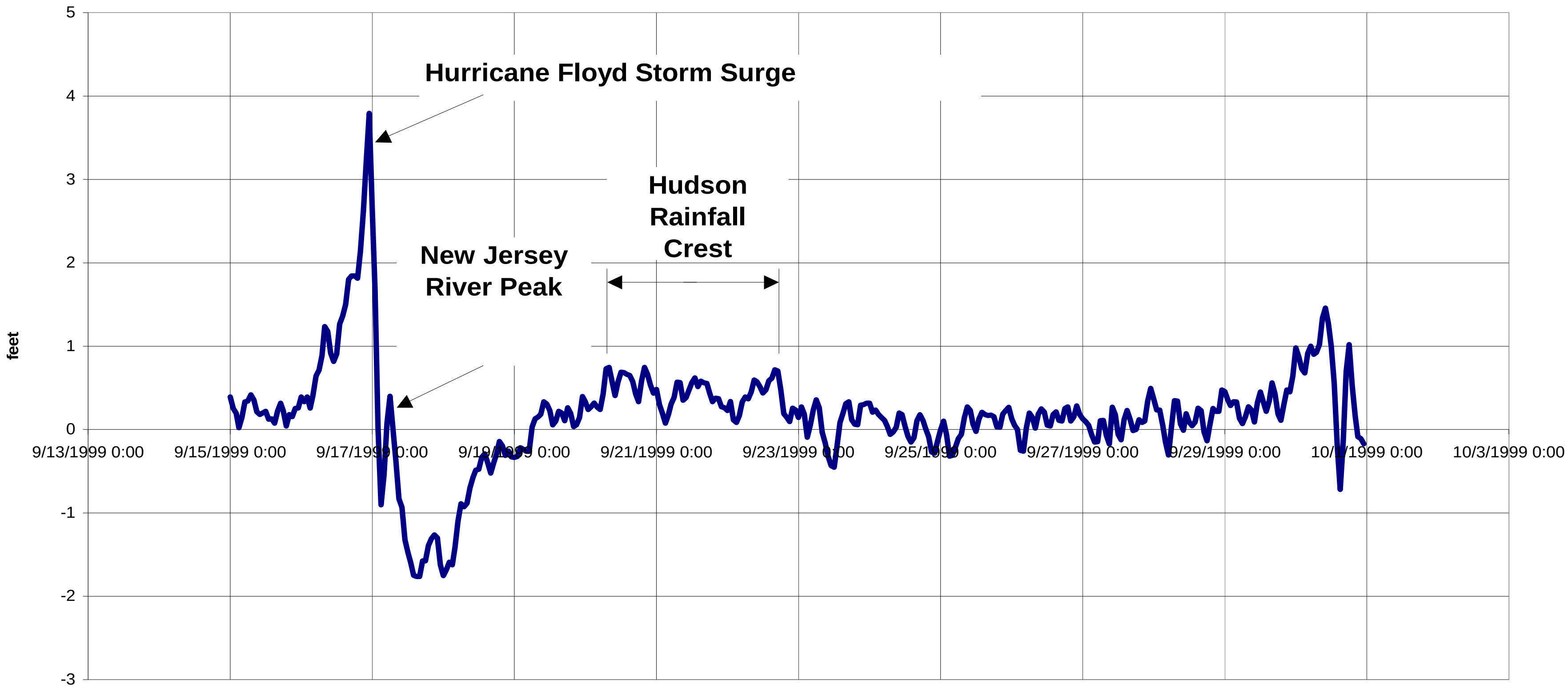


Fig. 21. Surge levels at the Battery during extra-tropical storm Floyd. From Bowman et al., 2005.

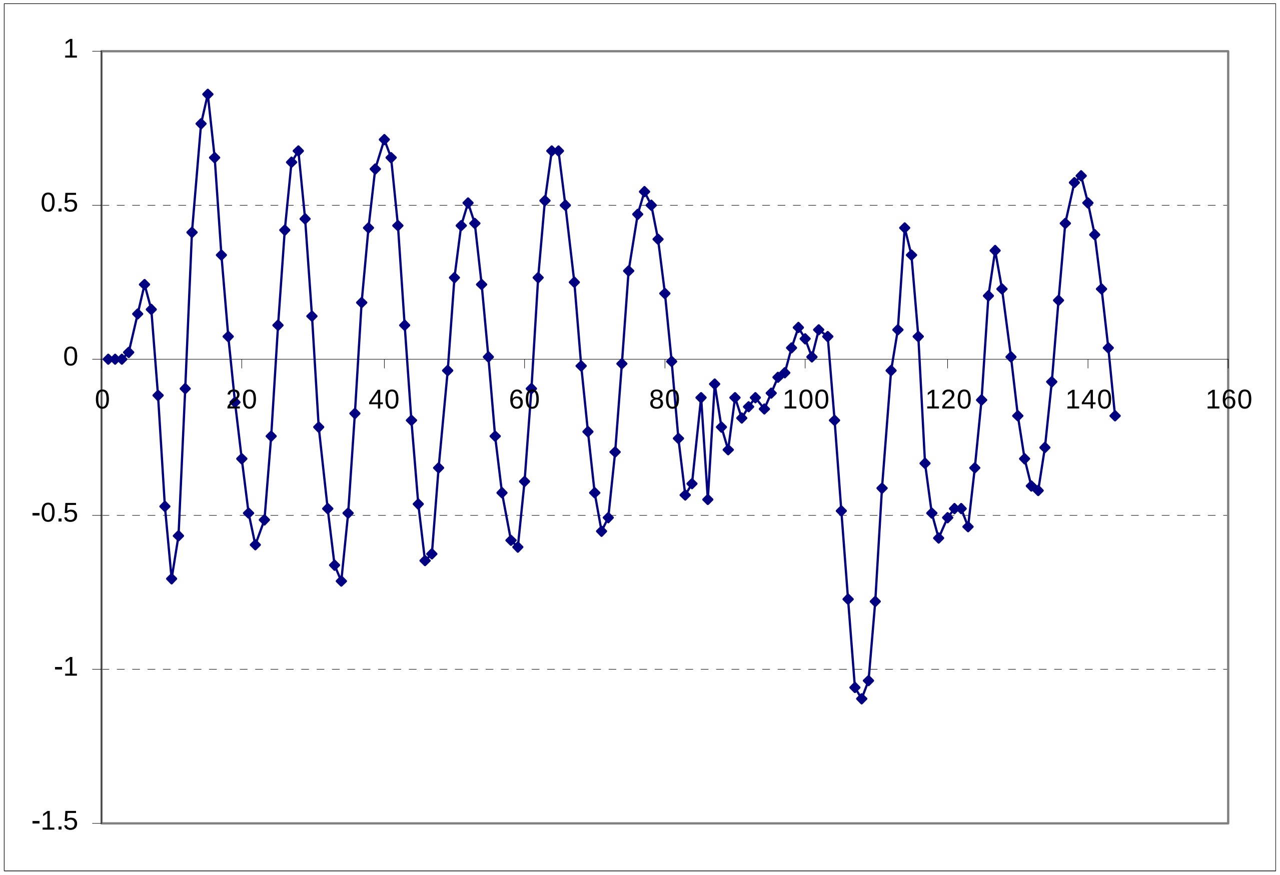


Fig. 22. The SBSS simulation indicates that the water level behind the barriers would have risen about 0.25 meters due to the inflow from rain-swollen rivers during the 20 hours the barriers were closed in extra-tropical storm Floyd.

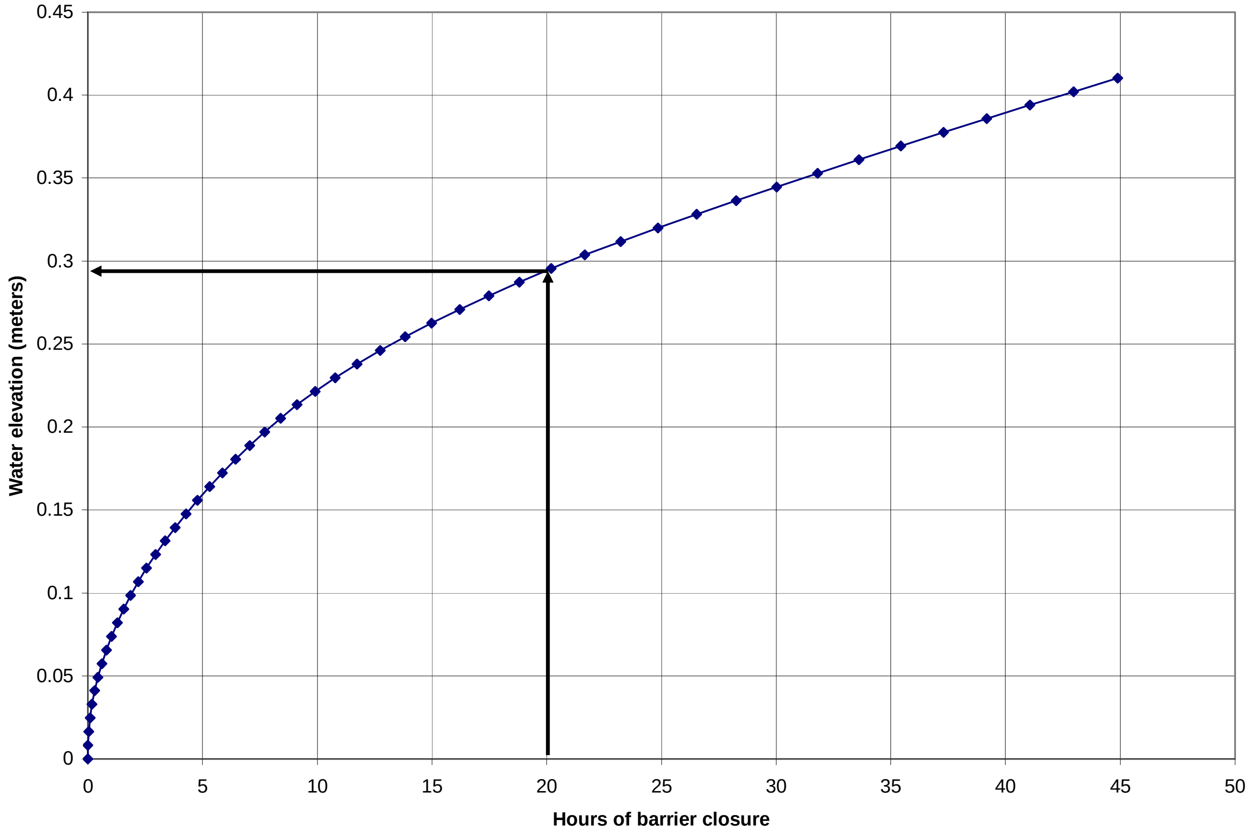


Fig. 23. Considering only the upstream storage volume available in the Hudson River, the rainfall runoff crest would raise the water level behind the barriers < 0.3 m during the 20 hr that the barriers would have been closed for extra-tropical storm Floyd, and less than 0.4 m in 40 hr.