APPENDIX D

HYDRODYNAMIC MODEL RESULTS

HYDRODYNAMIC MODELING

The hydrodynamic evaluation of Bogue Inlet was performed using the Advanced Three-Dimensional Circulation Model for Shelves, Coasts, and Estuaries (ADCIRC, Luettich, et al., 1992). The version used for Bogue Inlet is a two-dimensional, depth-averaged model able to simulate the wetting and drying of shallow tidal flats. Inputs to the model include bathymetry, shorelines, friction factors, and lateral viscosity.

Bathymetric Data

Bathymetric data for the seaward portion of Bogue Inlet was collected by Coastal Science and Engineering (2001) between September and October 2001. The data covered the area bounded by Dudley Island to the north, the Atlantic Ocean to the south, Bear Island to the west, and Emerald Isle to the east. The CSE (2001) data also included a survey of the main inlet channel between the northwest edge of Emerald Isle and the Intracoastal Waterway (ICWW).

Additional soundings were collected in 2002 by the U.S. Army Corps of Engineers, Wilmington District (2002). These soundings covered the ICWW between Topsail Beach and Bogue Inlet. They also included the main channel of Bogue Inlet between the Atlantic Ocean and the ICWW.

To supplement this data, soundings were taken from National Ocean Service (2001) Nautical Chart 11541. These soundings included Bogue Sound, the southern end of the White Oak basin, and the southern end of the Queen's Creek basin. Where no soundings were shown inside the White Oak and Queen's Creek basins, a depth of -2 feet below MLLW (-3.8 feet NGVD) was assumed. This depth was based on the limited number of soundings shown for these areas. Where no soundings were shown inside the Bogue Sound, a depth of 0 feet below MLLW (-1.8 feet NGVD) was assumed. This depth was based on the numerous tidal flats inside the sound and the 1993 USGS aerials (2002).

The fourth bathymetry source was the National Geophysical Data Center's (2002a) Digital Terrain Model of the Atlantic coastal shelf and the continental U.S. This data was used to extend the ADCIRC model into deep water (~45 feet).

Shoreline Data

Boundary conditions for the model consisted of a seaward boundary, a "mainland" shoreline, and a number of islands. Near the White Oak basin, the Queen's Creek basin, and Bogue Sound, mainland shorelines were traced from the georeferenced 1993 aerials (USGS, 2002). Near the seaward portion of the model, the "mainland" shoreline was defined as the Mean Low Water (-1.6 feet NGVD) contour to ensure stability.

Additional shoreline information was taken from NGDC (2002b) shoreline database, which provided the locations of Dudley Island, Huggins Island, the spoil island east of Huggins Island, and a fourth island near the southern end of the White Oak basin. The remaining islands were traced from the 1993 aerials (USGS, 2002).

Model Mesh

Using the shoreline and bathymetric data, a two-dimensional finite element mesh was generated for the model (Figure 1). The spacing of the mesh nodes increases with depth and with distance from the center of the inlet. This setup allows the model to remain stable. The various channel and closure dike configurations were tested by changing the elevations of individual nodes.

Calibration

Water levels and currents were measured by CSE (2001) on September 19-21, 2001 and October 16-17, 2001, at the locations appearing in Figure 2. Water levels corresponded well with the predicted tides used as forcing in the model (Figure 3).

Currents were measured with electromagnetic current meters and an acoustic Doppler current profiler (ADP). The electromagnetic current meters allowed comparisons of the current's direction and phase. The ADP measurements permitted a depth-average current estimate by measuring the current over the entire water depth. As the Bogue Inlet model was depth-averaged, the ADP measurements were better suited for comparing the magnitudes of the current. As the velocity measurements were more extensive during the later period, October 16-17, 2001 was chosen for the calibration of the model.

To calibrate ADCIRC, the parameters governing friction, energy dissipation, flow near the shoreline, wetting, and drying were assigned:

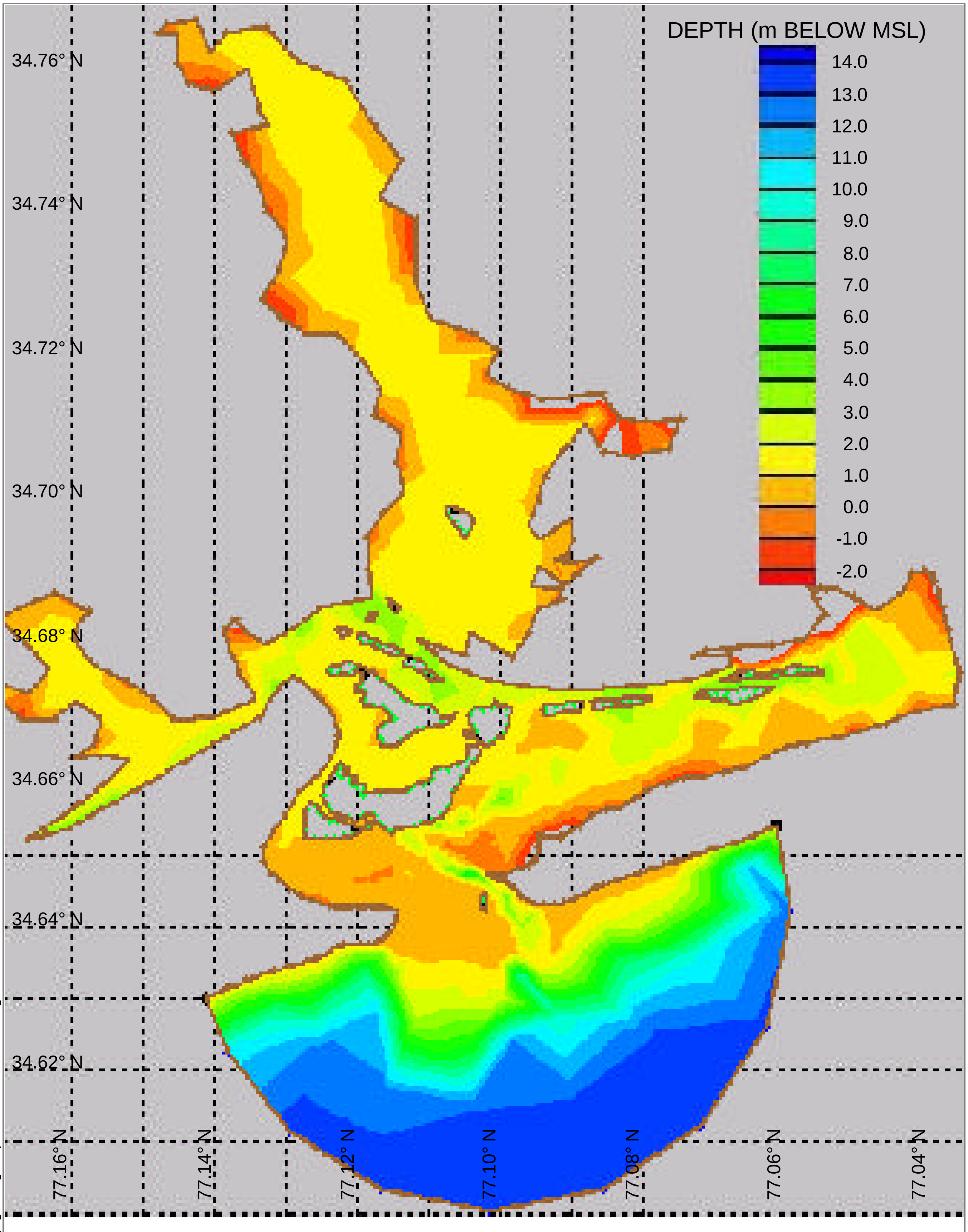
Lateral viscosity = 2.0 m^2/s (6.6 ft^2/s)
Bottom friction coefficient C_f = 0.0025
Wave continuity factor τ_o = 0.01
Minimum angle for tangential flow = 90^o
Minimum water depth for wetting and drying = 0.05 m (0.16 feet)

The lateral viscosity governs the turbulent and viscous energy dissipation. The friction coefficient C_f and wave continuity factor govern energy dissipation by bottom friction. At Bogue Inlet, bottom friction is assumed to be proportional to

$$(C_f|\mathbf{u}|/H - \tau_o)\mathbf{u}H$$

where

C_f = bottom friction coefficient
$\mathbf{u}$ = velocity vector



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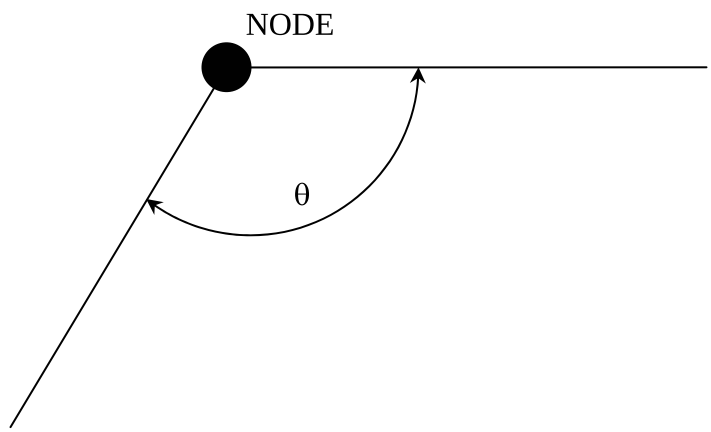
TITLE :

ADCIRC MODEL BATHYMETRY EXISTING CONDITIONS BOGUE INLET, N.C.

DATE: 11/15/02	BY: TW	COMM. NO.: 4500.00	FIGURE NO. 1

$|\mathbf{u}|$ = current speed
τ_o = wave continuity factor
H = time-dependent water depth.

The minimum angle for tangential flow determines where flow may occur along a bend in the shoreline:



Where θ is less than the minimum angle, the velocity at the node is zero.

Comparisons of the model results to the measurements appear in Appendix A. Agreement between the observed and hindcast water levels is reasonable. Phases and tide ranges are comparable to the observations. Agreement between the observed and hindcast velocities is reasonable. Accordingly, the calibration is considered suitable for simulating the tidal flow in Bogue Inlet.

Existing Conditions

The peak flood and ebb flows given the existing conditions appear in Figure 4. The flow regime consists of a sheet flow across the mouth of the inlet, with a heavy concentration of flow near Emerald Isle. This heavy concentration of flow, which is highest during the ebb cycle, is the primary cause of the erosion near that location. Another concentration of flow occurs near Dudley Island, where the main channel switches orientation by approximately 135^o. Erosion has occurred at this location, in addition to the west end of Emerald Isle.

Extending from the northwest edge of Emerald Isle is a low sand spit. This sand spit has changed considerably over the past 50 years (CSE, 2001). Figure 4A shows that sheet flow occurs across this sand spit during the flood cycle. Sheet flow also occurs during the ebb cycle. However, during the peak ebb cycle, the flow from the sheltered area circles around the northwest end of the sand spit into the main channel.