APPENDIX A: The CH3D Hydrodynamic Salinity Model for the St. Lucie and Caloosahatchee Estuaries

1 INTRODUCTION

The curvilinear hydrodynamic three-dimensional model (CH3D; Sheng 1986) uses a horizontal boundary-fitted curvilinear grid and vertical sigma grid system capable of simulating complicated hydrodynamic processes including wind and density-driven and tidal circulation. The model contains a robust turbulence closure scheme for accurate simulation of stratified flows in estuaries and lakes (Sheng 1986; 1987; Sheng and Villaret 1989). The non-orthogonal nature of the model enables it to represent the complex geometry of an estuary such as the St. Lucie Estuary (SLE) and Caloosahatchee River Estuary (CRE). The model is driven by external forcing prescribed at the boundaries, including tidal forcing at the ocean boundary, freshwater inflow from controlled structures and runoff from the watershed, and meteorological forcing including wind and rainfall/evaporation. Major assumptions for the CH3D hydrodynamic model are the hydrostatic approximation (shallow water equation), Reynold stress turbulence closure, and log law boundary layer approximations (Sheng 1986).

2 THE ST. LUCIE ESTUARY CH3D MODEL

The model domain covers the North Fork, North Fork Narrow, South Fork, the estuary proper down to the St. Lucie Inlet, and part of the southern Indian River Lagoon up to Vero Beach, including some offshore areas outside the St. Lucie Inlet (**Figure 1**). The horizontal grid has approximately 1200 cells with higher resolutions for the navigation channel, and coarser grids in the offshore and out of the inlets. The smallest grid size ranges from 30–100 m. Vertically, four evenly spaced sigma-layers enable simulation of vertical stratification within the estuary. The CH3D model was converted from the EFDC (Environmental Fluid Dynamics Code) and validated with data from two years (1999 and 2000). It was later extended and further validated with six more years (2001–2006) of salinity data observed at three continuous monitoring stations (A1A, US1, and HR1 [**Figure 1**]) together with monthly grab samples from additional monitoring stations in the estuary (Sun 2009). The model has been applied to the St. Lucie North Fork Water Reservation Study (Sun 2009). It was also coupled with a standalone water quality model to study nutrient, phytoplankton and dissolved oxygen dynamics in the estuary (Sun et al. 2018).

For this Salinity Envelope Performance Measure (PM) update, the model was used to simulate salinity for the period 51 years from January 1, 1965 to December 31, 2015 using historical daily flow data at S80, S48, S49, Gordy Road Structure and modeled tidal basin runoff, hourly tides at the offshore boundaries and meteorological forcing (hourly wind and daily rainfall/evaporation) at the water surface. The major output application for this Salinity Performance Measure was 14-day averaged salinity at every grid cell. However, daily and even finer temporal output options are also available since the model uses a 60 seconds time step.

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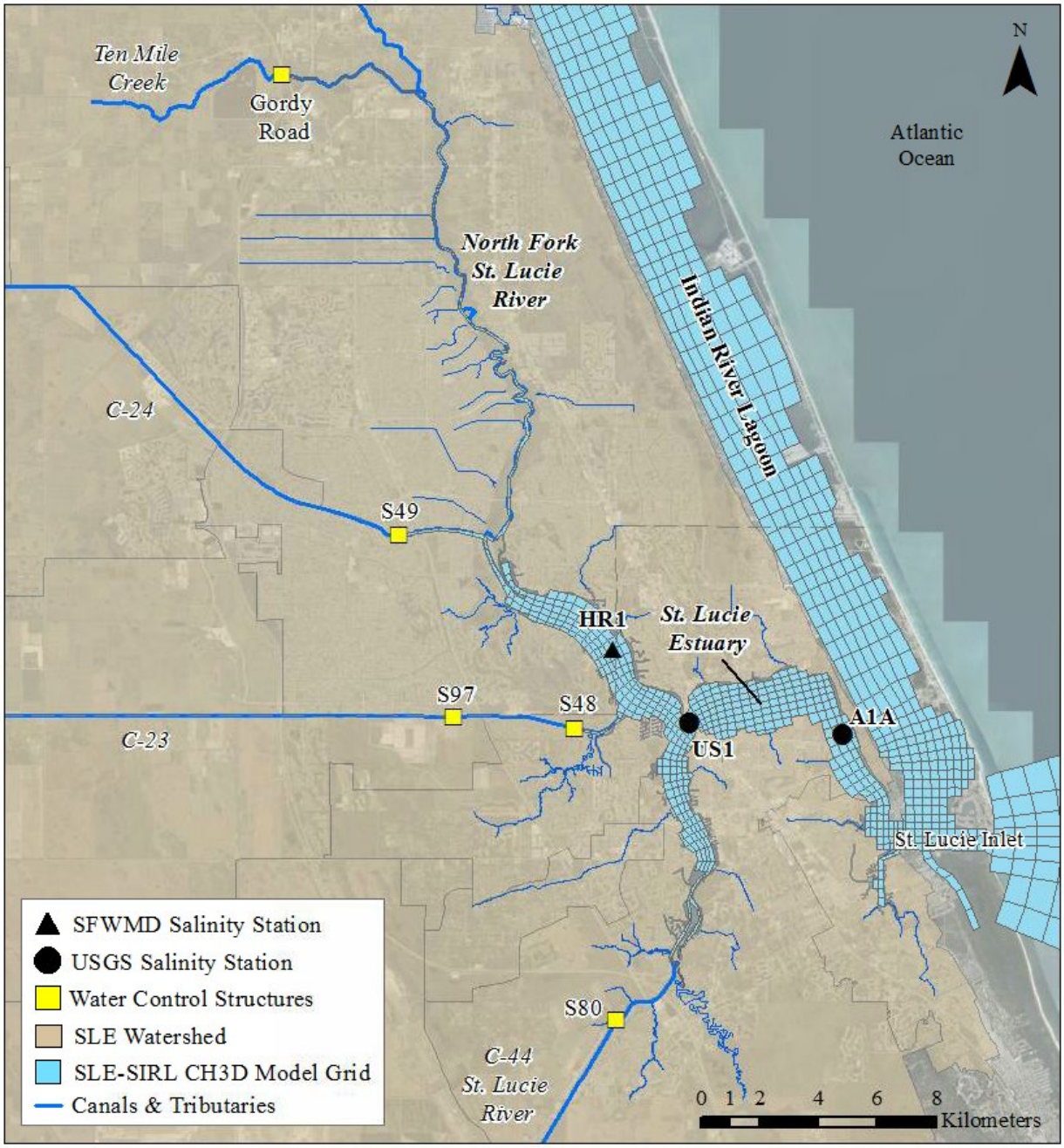

***Figure 1**. The CH3D model grid for the St. Lucie Estuary (SLE) and continuous data monitoring stations used for model calibration.*

3 THE CALOOSAHATCHEE RIVER ESTUARY CH3D MODEL

The model domain covers the CRE, Charlotte Harbor, Pine Island Sound, San Carlos Bay, Estero Bay, and all the major tributaries (**Figure 2**). The fine model grid permits the representation of the numerous islands, including the islands of the Sanibel Causeway. The horizontal grid has 163 x 120 m cells. Inside the CRE and San Carlos Bay, higher resolution provides detailed representation of a complex shoreline and the navigation channel. The smallest grid size ranges

from 50–100 m. Vertically, five evenly spaced sigma-layers enable simulation of vertical stratification within the estuary. The original model development of CH3D in Charlotte Harbor and adjacent areas began in 1999 for the Charlotte Harbor National Estuary Program (Sheng 2002), now the Coastal and Heartland Estuary Partnership (CHNEP). The SFWMD extended the model calibration to the CRE portion using a 16-month time series for the 2003 Minimum Flows and Minimum Water Levels (MFL) update (Qiu 2002). In 2005, the Caloosahatchee portions of the model were calibrated with three years of measured data (2001–2004) from five stations in the Caloosahatchee Estuary (Qiu et al. 2006). Recently, the calibration of the model was further refined using salinity and tide data collected at seven monitoring stations (S-79, BR31, ValI75, Ft. Myers/Marker 52, Cape Coral, Shell, Point, and Sanibel [**Figure 2**]) in the CRE (Sun et al. 2016). The model was one of the major tools used for the most recent CRE Minimum Flow and Level (MFL) update (SFWMD 2020).

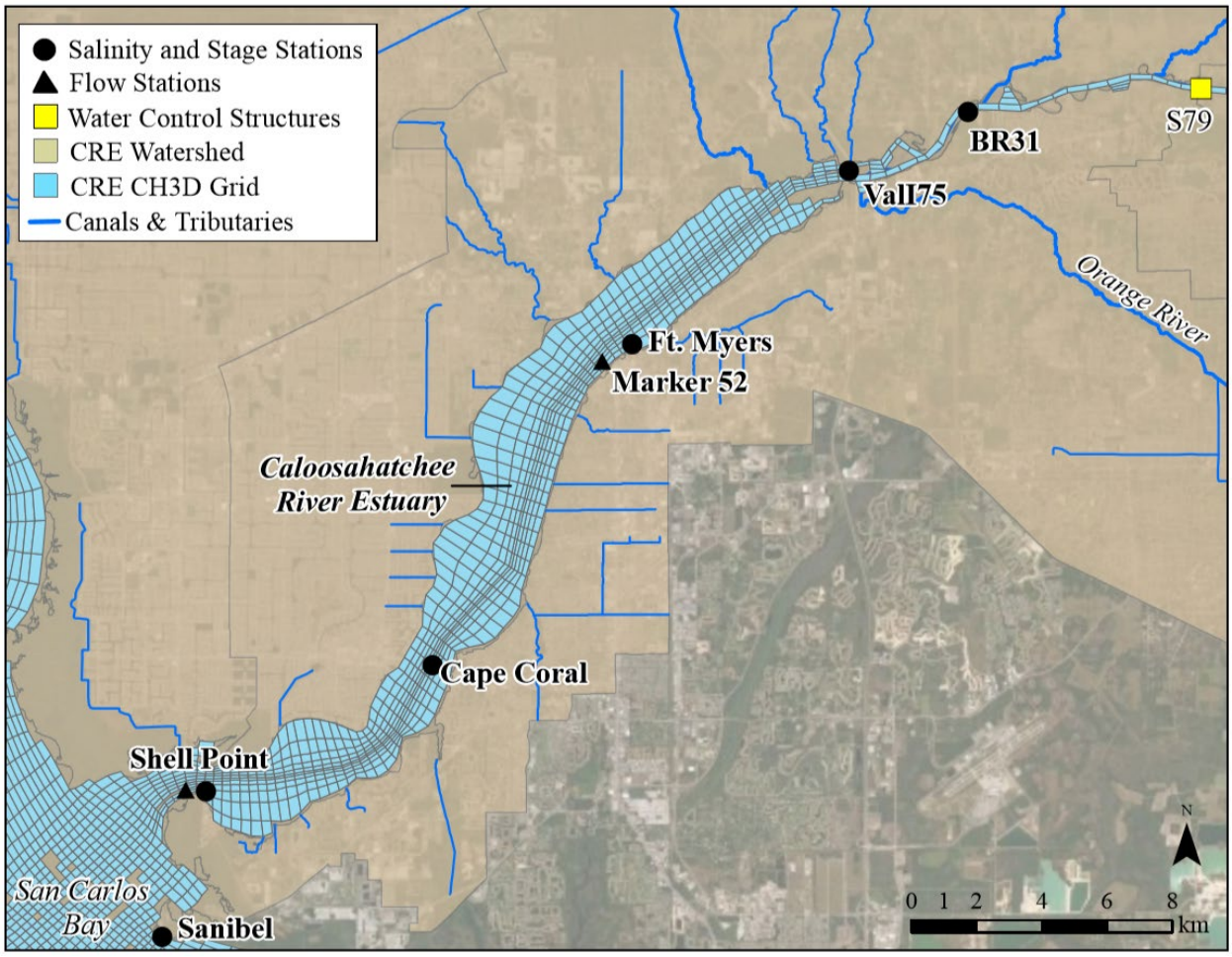

Figure 2. The CH3D model grid for the Caloosahatchee Estuary (CRE) and continuous data monitoring stations used for model calibration.

For this Salinity Envelope PM update, the model was used to simulate salinity for the period 51 years from January 1, 1965 to December 31, 2015 using historical daily flow data at S-79 and modeled tidal basin runoff (SFWMD 2020; Appendix D), hourly tides at the offshore boundaries and meteorological forcing (hourly wind and daily rainfall/evaporation) at the water surface. The

major output for the Salinity Performance Measure Application was 14-day averaged salinity at every grid cell. However, daily and finer temporal outputs are also available since the model uses a 90 seconds time step.

4 LITERATURE CITED

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