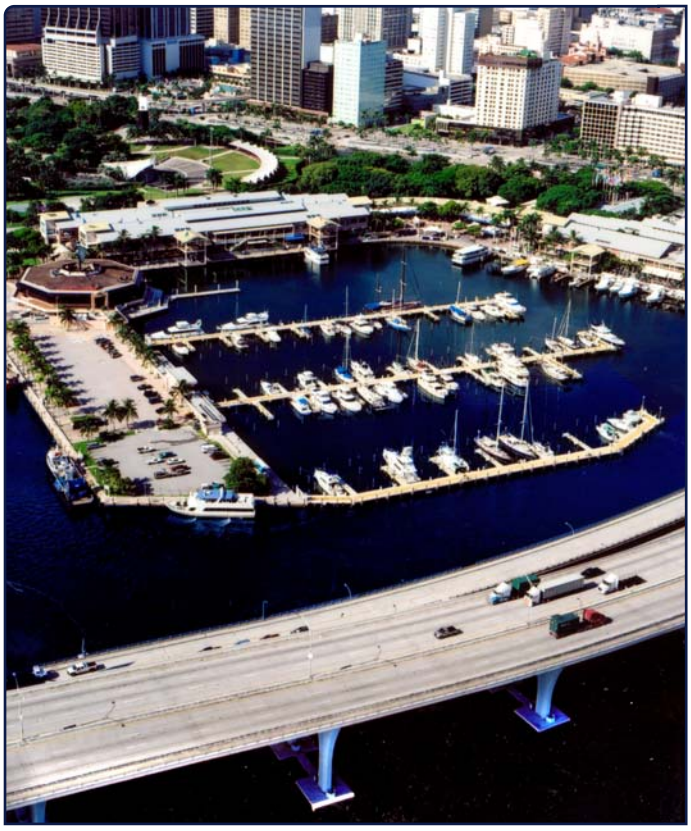
Perspective
Volume 4



Miamarina: Miami, Florida (In Use)

Miamarina: Miami, Florida (Under Construction)

Water Quality at Marinas: Flushing

By: Coastal Systems International, Inc.

The demand for marinas is on the rise in Florida and the Caribbean. Waterfront properties are continually being developed at a fast pace. Either by reducing available land for marina and docking facilities. Furthermore, the trend of waterfront development is increasingly private which limits public access.

There are few remaining natural marina sites and stringent regulatory environmental policies preclude marina development. Additionally, strict regulatory policies on ownership of submerged lands need to be addressed and may introduce further complexity to such projects. To overcome these difficulties, developers and engineers are seeking alternatives for marina development. One of the alternatives is to create a marina basin and navigation channel by excavating upland properties.

A major concern for these new basins as well as existing facilities is water quality. Proper flushing is required to ensure that the water quality is maintained and to avoid debris accumulation. For any proposed marina development, professional engineering assistance must be retained to thoroughly study the flushing characteristics of the proposed marina and to demonstrate minimal environmental impact. Very often, the analysis of tidal hydraulics in conjunction with complex geometries of basins with docks requires advanced numerical analysis that are beyond desktop engineering solutions. In such cases, sophisticated computer generated numerical models are used to study flushing characteristics through numerical simulation of tidal hydrodynamics. Through a

calibration procedure against field tide/current measurement, the advanced numerical models can further be used to optimize flushing characteristics by evaluating alternative configurations. This perspective will discuss hydrodynamic numerical models that can be used to study flushing characteristics of a proposed basin, and present three case studies of flushing studies completed for marina development projects.

Hydrodynamic Models

To simulate tidal hydraulics and to evaluate flushing characteristics of a marina basin, sophisticated engineering software is required. Among several advanced two-dimensional hydrodynamic numerical models, the state-of-the-art MIKE21 HD Model, developed by the Danish Hydraulics Institute, is commercially available. The MIKE21 HD Module simulates the water level variations and flows in response to a variety of forcing functions in lakes, estuaries and coastal areas. The water levels and flows are resolved on a rectangular grid covering the area of interest when provided with the bathymetry, bed resistance coefficients, wind field, hydrographic boundary conditions, etc. The numerical model solves the full time-dependent non-linear equations of continuity and conservation of momentum. The solution is obtained using an implicit finite difference scheme of second-order accuracy.

Calibration of the model is essential to simulate tidal hydrodynamic processes accurately. Generally, the model is calibrated for existing conditions using the field data, and the calibrated model is further modified to account for proposed basin geometries. To calibrate a numerical model, extensive field data collection is required such as tidal current and tidal elevation measurements at the project site. The field data can be collected by deploying remote sensing equipment in the form of electronic gauges that measure both tide elevation and current velocity.

Case Study 1:
Cap Cana, Dominican Republic

Cap Cana is located on the east coast of the Dominican Republic near Punta Cana, just across the strait from Puerto Rico. The 29,000-acre development includes five miles of shoreline. The developer intends to excavate an entrance channel to create a large marina basin with 1.2 miles of navigation canals to accommodate 1,000 marina slips. This will be the largest marina in the Caribbean and the only one between Nassau and Puerto Rico capable of docking vessels over 150 feet in length. Flushing and water quality were a major concern based on master plan concepts developed for the canal/marina basin, primarily due to the small tidal range (1.5 feet) and length of canals large marina basin.

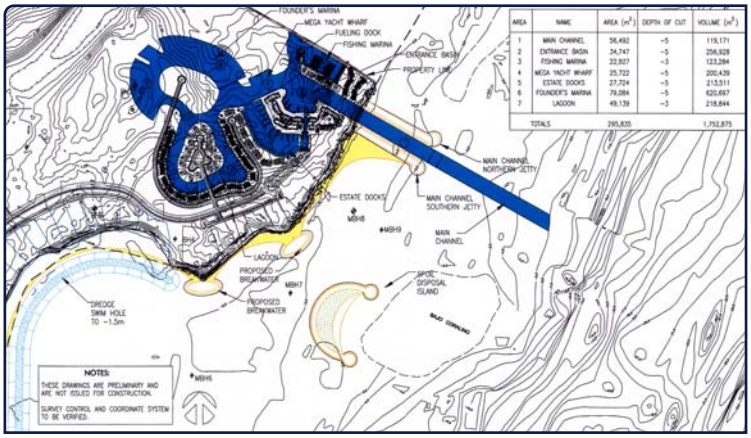


Figure 1: Cap Cana: Initial Master Plan with Entrance Channel and Basin.

The initial marina concept that involved a single entrance channel did not provide sufficient flushing for the marina. Alternatives including cutting a flushing channel at various locations were evaluated. Comprehensive numerical model simulations were conducted to assist in the flushing analysis and optimization of a flushing channel configuration. Further basin geometry was refined based on the HD modeling results to avoid "no circulation areas." The resulting simulation and refined design of the Cap Cana Marina will enhance water quality and assure proper flushing. The added flushing channel (Figure 2) presented the developer with valuable real estate by providing oceanfront lots with a navigation channel for yachts.

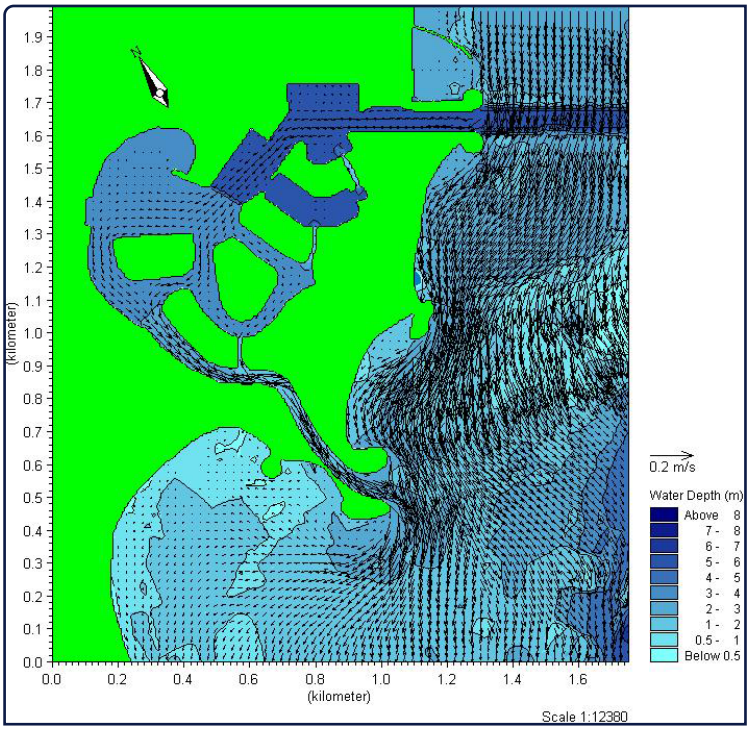


Figure 2: Cap Cana: Numerical Model of Revised Marina Plan

Case Study 2:
Harbour Isle, Ft. Pierce, Florida

The developer envisioned a marina basin for this 108-acre residential condominium development on Hutchinson Island, in Ft. Pierce, Florida.

The basin would create additional waterfront property for the condominiums and safe harbor for a 63-slip marina. Initial concept designs for the basin did not provide sufficient flushing to meet regulatory flushing criteria due to the small tidal fluctuation of 2 feet from the Intercostal Waterway and the proposed length of the entrance channel. As an alternative, a flushing culvert was designed to access the Fort Pierce Inlet and increase tidal flushing with the tidal phase difference between the inlet and the

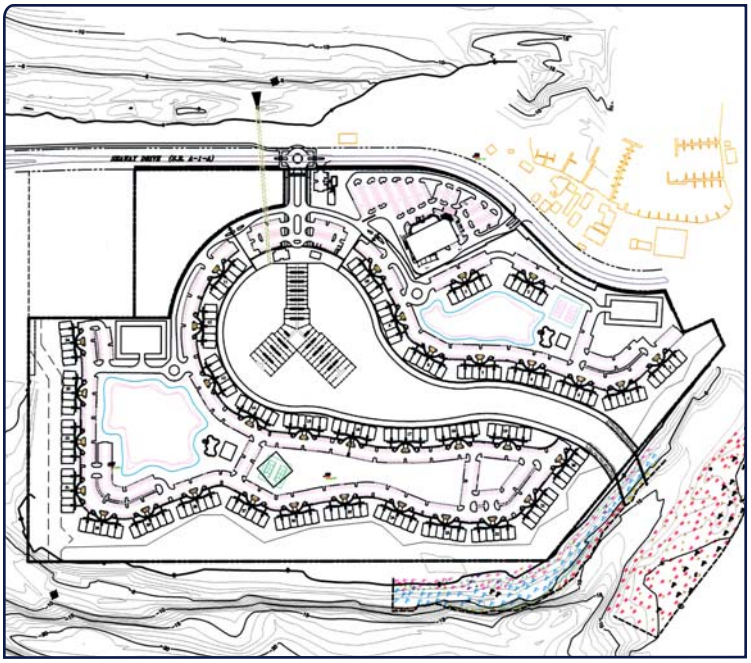


Figure 3: Harbour Isle Master Plan

waterway. The flushing of the basin was significantly improved allowing the basin to flush in 1.6 days or 3 tidal cycles, thereby meeting the flushing criteria established by the environmental regulatory agencies.

Figure 4: Pre-construction Harbour Isle

Case Study 3:
Hurricane Cove, Miami, Florida

A new condominium development is proposed for this site to convert the existing boat yard facilities to a residential condominium development on the Miami River. The existing 150-slip marina will be

rehabilitated, and an existing barge basin will be filled to create additional real estate. The Miami River has a combination of riverine flow and tidal flow, requiring the use of the MIKE 21 HD model to simulate the site hydraulics.

To justify the environmental impact of filling of the basin to regulatory agencies, a numerical study using MIKE21 HD model was conducted. The model was initially set up and calibrated against measured tide/current data for the existing conditions. The bathymetric information of the calibrated model was then modified to simulate various basin fill geometries. Flushing analysis were then conducted to evaluate the impact of various fill alternatives, and the results were submitted to the regulatory agencies.

Based on the results of the numerical model, environmental permits were secured for the filing of the basin.

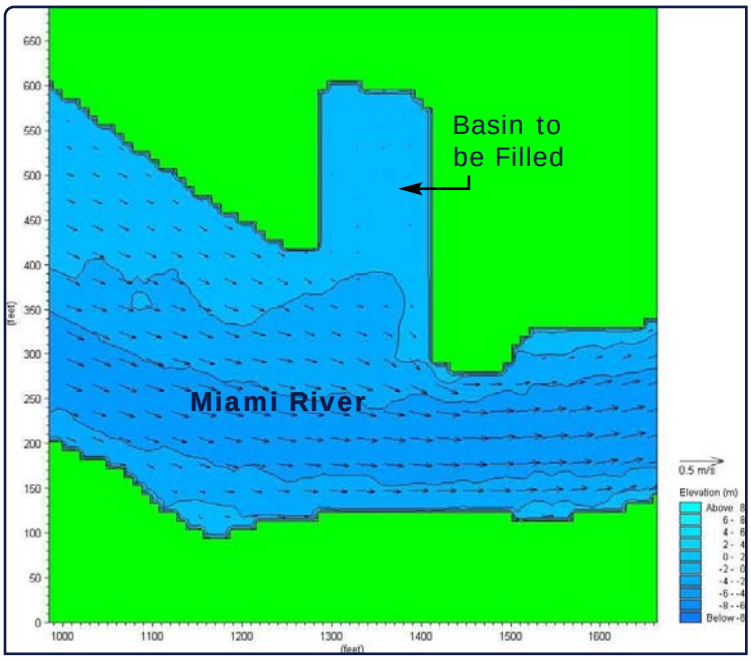


Figure 4: Harbour Cove: Tidal Hydrodynamic Model

Conclusions

Water quality in marina basins is a major concern for developers and regulatory agencies. Sufficient flushing must be provided to ensure water quality in accordance with specified standards, as well as to minimize debris collection. Advanced numerical models are commercially available to be utilized to simulate flow patterns of proposed/existing marina basins, to optimize basin geometry and to evaluate flushing characteristics for various alternatives to meet regulatory flushing criteria.

References

Coastal Engineering Manual, U.S.Army Corps of Engineers

Tobiasson and Kollmeyer, Marinas and Small Craft Harbors, Second Edition, 2000

South Florida Water Management District, Basis of Review Section 4.2, 4.3

COASTAL SYSTEMS INTERNATIONAL

Coastal Systems International, Inc.
464 South Dixie Highway
Coral Gables, FL 33146
Tel: 305-661-3655 Fax: 305-661-1914
www.coastalsystemsint.com
info@coastalsystemsint.com