Delft3D Flexible Mesh modelling of the Guayas River and Estuary system in Ecuador

by

Pedro D. Barrera Crespo

in partial fulfillment of the requirements for the degree of

Master of Science
in Civil Engineering, Hydraulic Engineering track
at the Delft University of Technology,

and the degree of

Master of Science
in Hydraulic Engineering and Water Resources Management
at the National University of Singapore,

to be defended publicly on Tuesday May 10, 2016 at 09:00 AM.

TUD student number: 4341147
NUS student number: A0118976
Author’s contact: pdbc_1985@hotmail.com

Supervisor: Dr. ir. E. Mosselman, Deltares / TU Delft
Thesis committee: Prof. dr. ir. W. S. J. Uijttewaal, TU Delft
Prof. dr. ir. Z. B. Wang, TU Delft
Dr. V. P. Chua, National University of Singapore

An electronic version of this thesis is available at http://repository.tudelft.nl/.
ABSTRACT

The Guayas River estuary supports extensive socio-economic processes. It is formed at the confluence of the Babahoyo and Daule Rivers and runs for around 65 km before discharging into the Pacific Ocean. Its relevance within the national context is linked to the city of Guayaquil, the most populated city and commercial capital of Ecuador. Recently it was considered the main seaborne trading route for the country. Nowadays the estuary experiences a number of sedimentation related issues which hinder its navigability and increase the potential risk of flooding in the northern low lying areas of Guayaquil. Although these problems have been accentuating over the years, little is known about the estuary’s morphological evolution. Therefore, the main focus of this study is to provide a comprehensive explanation of the estuary’s morphological development and the processes behind its evolution. In this regard, a morphodynamic numerical model was implemented using the software Delft3D Flexible Mesh.

The estuary itself has not been the subject of many studies related to morphology. The lack of information was one of the major challenges for this research, especially in relation to bed topography. In order to cope with this, state of the art techniques were applied to derive the missing data. This is the basis to set up the model for the different scenarios that simulate natural events and anthropic interventions carried out within the estuary and that have been identified as some of the potential causes of sedimentation. A total of five events or so called ‘interventions’ were defined, namely: the reduction of intertidal areas due to mangrove deforestation and shrimp farms, El Niño phenomenon, the construction of the Daule-Peripa dam at the headwaters of the Daule River, the construction of the ‘Puente de la Unidad Nacional’ bridge over the Daule and Babahoyo Rivers near their confluence and finally the sediment overload due to deforestation of the upstream basin.

The final analysis of the different cases determined that the changes in tidal asymmetry are the main causes of sedimentation and the overall estuary morphological evolution. Amongst others, the leading contributors to this tidal variability can be attributed to the discharge of the Daule and Babahoyo Rives and the decimation of intertidal areas.

Depending on the magnitude of the discharges, the predominant flood dominant character of the estuary is either reduced or even shifted towards ebb dominance. This is verified when the hydrographs peak during the wet season particularly in the higher regions near the confluence of the rivers.

The intertidal flats, on the other hand, have been severely reduced due to increased shrimp farming practices and the sequential loss of mangrove forests along the estuary banks. This has principally reduced hydraulic friction and natural wave damping effects which has ultimately enhanced flood dominance.

It was also concluded that events such as the bridge construction over the Daule and Babahoyo Rivers as well as the sediment overload related to deforestation of the upstream basin are of minor importance.

In view of the above, in order to control the sedimentation in the estuary and especially around Guayaquil, three alternatives are proposed (or a combination of them) as potential mitigating measures. The first is to control the discharge of the Daule River through the operation of the Daule-Peripa dam. The second is to recover some of the intertidal flats which have been decimated by aquaculture practices. The third is to dredge the area of the estuary close to Guayaquil. The final solution requires a more detailed study. However it will involve a compromise between the cost of dredging and the decreased profit from hydro power generation and aquaculture.