

# Flood Modeller Pro

Case Study

## Scenario analysis for future flood management, Taihu Basin, China

In order to understand and communicate the potential flood impacts and responses, 1D modelling for the Taihu Basin Authority (TBA) in China was carried out to generate credible evidence of current and future flood risk for very large areas.

In many parts of Asia, economic factors are driving rapid urban development in flood-prone locations. At the scale of individual developments, it may be possible to mitigate the flood risk to a level considered acceptable or at least for normal weather events. However, the combined impacts of widespread development in regions susceptible to flooding, potentially amplified by climate change, may pose severe pressures on the longer-term sustainability of communities, regions and even countries.

The Taihu Basin is a particularly challenging application for broad scale strategic analysis of flood risk. It is large (about 37,000 km<sup>2</sup>) and is located in the delta region of the Yangtze River, so is very low-lying with many channels and complex hydraulic controls. Major floods occurred in 1991 and 1999. This resulted in extensive damage to an economically important and rapidly developing region of China that includes Shanghai and other major cities.

Flood modelling was a key component of the Taihu Basin scenario analysis study. The selected approach consisted of broad scale rainfall-runoff modelling of the hilly areas, feeding an extensive hydrodynamic model representing the main conveyance channels in the 'plains' area (using the full solution of the Flood Modeller 1D solver's Saint-Venant equations). This was linked to a very broad scale representation of the polder regions (using a storage cell concept representing mass conservation of inflows/outflows over embankments or from direct rainfall).

Flood Modeller Pro can be used for a range of applications, including:

- 1D and 2D floodplain modelling
- Floodplain mapping
- Flood forecasting
- Hydrological analysis
- Embankment/levee failure
- Dam breach analysis
- Options' appraisal
- Detailed design
- Structure blockage



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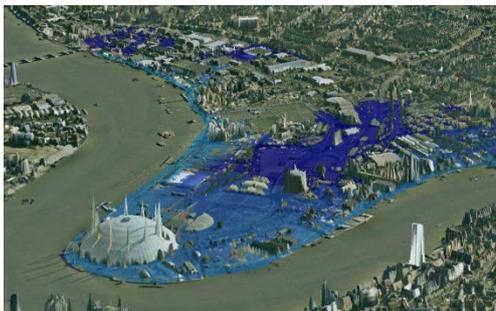
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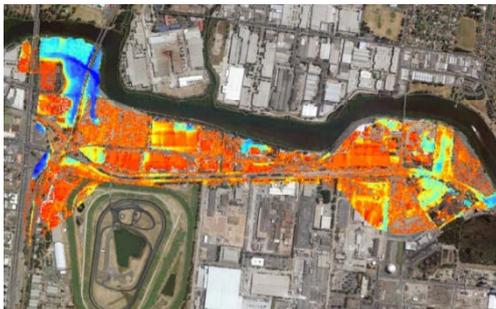
With a legacy stretching back 40 years, Flood Modeller allows users to model rivers, floodplains and urban areas, using our powerful 1D and 2D solvers.

“The industry-leading 1D and 2D solvers in Flood Modeller Pro have been applied to flood modelling projects across the globe, including the Shanghai, New York, London and Sydney.”

Vijay Jain  
(CH2M)



Floodplain modelling in London, England



Floodplain modelling in Sydney, Australia

Alternative simpler and more complex approaches were considered but rejected. Simpler approaches (such as 10 to 20 linked lumped conceptual ‘reservoir’ components) would not have been able to represent the main flooding processes in the Basin. More complex approaches (such as a 2D representation of the floodplain) would have required long run times and would have been severely constrained by major data gaps and resource issues.

Key boundary inputs were rainfall inputs to the rainfall-runoff models of the hilly areas and direct rainfall to the polder areas together with water level boundaries for the Yangtze River and coastal boundaries. Water entered the polder regions either through direct rainfall or through overtopping of the levees. In addition, a decoupled representation of potential breaching inflows to the polders was provided as part of the Taihu Basin risk analysis model that was run following the hydrological and hydraulic model simulations.

## Hydrodynamic modelling

The hydrodynamic model of the Taihu Basin was built using data principally provided by the Taihu Basin Authority (TBA). The main reasons for the decision to use our solvers were that it enabled an appropriately scaled channel and flood-cell model to be constructed (as opposed to a solely in-bank model that was possible using TBA’s existing HOHY2 model) and that the software allowed flexible control rules to be developed for sluice and pump operation. The existing data and schematisation held within the HOHY2 model were extracted and used to build the initial 1D model of the network.

The model used inputs of direct net rainfall, upland inflows, Yangtze river and coastal tide levels, Taihu lake initial water levels, sluice gates control rules and polder pumping rules. Simulations took about 30 minutes to run a 90-day period (based on June to August rainfall profiles). Outputs included channel water levels and flood volumes in the floodplain cells. This data, together with calculated expected flood volumes from breaching, were passed to a GIS model of the flood cells and receptors (the TBRAS system) for use in the calculation of risk estimates.

The schematisation of the system was based on that previously used in the HOHY2 in-bank model but extended onto the floodplain and updated for recent flood control projects.

Not all channels were explicitly included in the model as smaller channels were concatenated into equivalent channels. The concatenated channels have the same capacity as their component channels and thus the overall conveyance capacity was preserved. The model for the Taihu Basin consists of 2,394 river cross-sections, 22 inflow boundaries (19 nodes are western upland inflow nodes and the other three are fixed discharge inflow nodes), and 42 water level boundaries.

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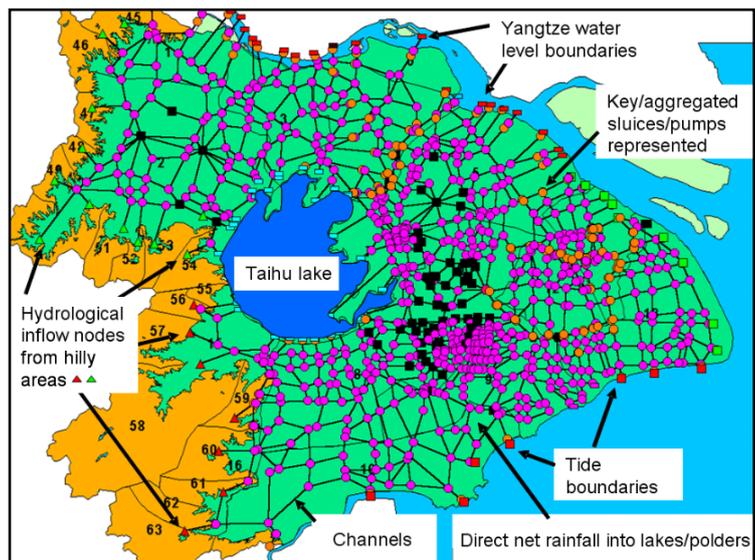
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“Flood Modeller Free features the same industry-leading solvers as Flood Modeller Pro. It provides 250 1D nodes and 100,000 2D cells (for all three 2D solvers; ADI, TVD and FAST) making it ideal for use on smaller modelling projects.”

Richard Crowder  
(CH2M)



Model system schematisation

The floodplain was represented by flood cell units, each covering an area of about 100 km<sup>2</sup>, connected to the channel system by overbank spill units (weir equations representing flow over the flood banks). The approximate level-volume relationship in the flood cell units were derived from STRM-90 DEM data (projected to GCS\_WGS\_1984) using tools in our software to extract level-area data sets.

In the model, the flows into and out of the flood cells consist of net direct rainfall, flood flow over the dikes and pumped/gravity flow from the flood cells into the channels. The boundary conditions consisted of water level boundaries along the Yangtze River and coastline, flows from the hilly region in the west of the basin, net rainfall on the ‘plains’ area, and gate operations represented using control rules of gate operation as a function of local in-channel or lake levels.

## Results

The evidence from the comparison of water levels and from the assessment results, derived from the TBRAS risk assessment model, suggest that the broad scale model is able to generate results of suitable accuracy for the scenario analysis.

The broad scale hydrology/hydraulic model of the Taihu Basin provides a key component of the flood risk analysis framework that was developed during the Taihu Basin project. During the final phase of the project a set of initial scenarios were simulated to demonstrate the value of the framework.

The initial scenarios covered climate change and socio-economic change to 2050. The simulations suggested that climate change or socio-economic change acting in isolation could lead to five-fold increases in flood risk; acting together flood risk could increase by a factor of 20 or more. These estimates provided strong evidence of the need for change.

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