Modelling Coastal Environments
Professional Consulting Services

Coastal Inundation
Tsunamis
Coastal Hazard Adaptation Strategies
Coastal Processes
Coastal Inundation Risk Assessments

Long-term storm tide risk assessments allow inundation hazards to be mapped and community vulnerability to be quantified.

Detailed numerical modelling and robust statistical methods underpin storm tide inundation risk assessments. Modelling assessments include the development of a parametric cyclone wind and atmospheric pressure models, hydrodynamic modelling of tides and tropical cyclone storm surges and modelling of cyclone-induced waves.

Extensive validation of modelling systems must be undertaken by comparing wind, pressure wave and water level predictions with historical records.

BMT WBM has completed coastal inundation risk assessments for a number of Local Government Areas in Queensland and New South Wales, including the following:

- Bundaberg
- Mackay
- Cardwell
- Cairns
- Coffs Harbour
- Newcastle

Targeted assessments for specific locations or ports, include:

- Gladstone (QLD)
- Bing Bong (NT)
- Pipavav (India)
Tsunami Inundation Risk Assessments

TUFLOW FV (Finite Volume) is a hydrodynamic model engine which solves the Non-Linear Shallow Water Equations on a "flexible" mesh comprising triangular and quadrilateral cells.

TUFLOW FV is particularly applicable to tsunami inundation risk assessment due to key features of the solution scheme:

- Intrinsically handles shocks
- Locally (and globally) conservative to numerical precision
- Robust wetting/drying
- Explicit scheme ideally suited to parallelisation

Mixed sub/super-critical flow regimes are well handled by the TUFLOW FV scheme which intrinsically accounts for flow discontinuities such as hydraulic jumps or bores that may occur in trans-critical flows typically observed during extreme coastal inundation events.

TUFLOW FV accommodates a wide variety of boundary conditions, initial conditions and other input specifications to ensure its applicability and ease of use for a range of applications. Tsunami risk assessments have been completed by BMT WBM for various locations, including:

- Japan, West Coast
- Papua New Guinea, New Island Province
- Solomon Islands

Predicted Tsunami Propagation and Inundation at outputs 15, 30, 45, 60, 75 and 90 minutes from simulation start.
Coastal Inundation Model Validation

Analytical solutions and controlled laboratory scale experiments are the benchmark tests used to determine the suitability of a numerical model for coastal inundation applications. TUFLOW FV has participated in a number of international benchmarking exercises with a focus on flood and coastal risk management (e.g. Environmental Agency UK, 2013; IAHR, 2013).

Further model validation for specific coastal inundation applications involves hindcasting significant historical events for which recorded data is available. Typical data sources may include:

- Weather stations that provide winds and pressure recordings
- Storm tide gauges that record coastal water levels
- Wave buoys that record offshore wave parameters
- Debris lines used as an indicator of maximum inundation extent
- Offshore water level monitoring systems (tsunami)

References
Coastal Inundation Forecasting

Validated TUFLOW FV modelling systems have been used to predict the surge and coastal inundation associated with tropical cyclone threat forecast maps, such as those by the Bureau of Meteorology during an event.

Efficient TUFLOW FV forecasting models can be used to predict surge response and coastal inundation associated with tropical cyclone track forecasts. These assessments are carried out when a tropical cyclone system is threatening to cross the coastline with model predictions used to inform disaster management operations.

Damaged Vessels in Port Hinchinbrook following Tropical Cyclone Yasi Storm Tide

Storm Tide Forecast Predictions based on Tropical Cyclone Track Scenarios
Coastal Hazard Adaptation Strategies

Coastal hazards include coastal erosion, storm tide inundation and sea level rise inundation. Urban localities may be considered ‘high risk coastal hazard areas’ if they exist within:

• The part of the erosion prone area that is within the coastal management district
• Land that is projected to be permanently inundated due to sea level rise
• The part of the storm tide inundation area that is projected to be temporarily inundated to a depth of 1m or more during a defined design storm tide event

Coastal hazard adaptation strategies generally focus on urban areas (including areas subject to development commitments) within a high coastal hazard area. Strategies typically assess options that mitigate the hazard and will analyse the costs-benefits, including the long-term social, financial and environmental factors, to determine the most cost effective solutions.

BMT WBM is a leader in providing storm tide and coastal hazard assessments, risk assessment and adaptation planning throughout Australia, and can assist clients to prepare and implement coastal hazard adaptation strategies. Studies addressing coastal hazards and adaptation planning have been completed by BMT WBM for a number of locations, including:

• Bundaberg
• Cairns
• Mackay
• Cardwell
• Metung (Gippsland Lakes)
• Kakadu National Park
• Wooli Wooli
• Batemans Bay
• Coffs Harbour
• Newcastle
• Kempsey
• Lake Macquarie
• Barwon Heads
• Altona

Joint Probability Ocean Water Level and Fluvial Discharge

Fluvial flood levels in lower rivers and estuaries are sensitive to the concurrent ocean water level (tailwater) condition. BMT WBM has experience investigating the joint probability relationship between flood flow and ocean water level, including the extreme scenario of a coastal surge coinciding with fluvial flood discharge.

The outcomes of an ocean water level/fluvial discharge joint probability assessment are used to guide hydraulic modelling to determine which combination gives the highest water level at a particular location in the catchment. The combination providing the highest level will vary throughout the lower river or estuary, at the ocean the high tailwater with low flow combination will give the highest level, but higher up the estuary a different combination of flow and tailwater may dominate. Sufficiently upstream of the tidal limit the flood level will no longer have any dependence on the tailwater condition.
Obtaining a sound technical understanding of coastal processes on regional and local scales is a key element in the development of coastal inundation risk assessments and coastal hazard adaptation strategies. Limited information is typically gained through historical records and site visits. Predicting future hazards and coastal flooding (storm tide) and the associated risks generally involves modelling tidal hydrodynamics, waves (day-to-day and extreme) and sediment transport potentials.

BMT WBM has a long history of modelling coastal processes both in-house and in collaboration with Universities and Government agencies. This commitment has lead to the development and release of commercial software packages:

- **TUFLOW Classic** – 1D and 2D floodplain and tide simulation software
- **TUFLOW FV** – Finite-volume, flexible mesh hydrodynamic engine used to model coastal hydrodynamics, storm tide and flood inundation in 2D or 3D
- **TUFLOW AD** – Advection-dispersion module for simulating the transport and fate of dissolved and particulate constituents used for water quality assessments
- **TUFLOW ST** – Sediment transport module for simulating the transport and fate of cohesive (muds) and non-cohesive (sands) sediment used for shoreline evolution and dredging assessments.

Using these tools BMT WBM has developed and calibrated models for numerous locations within Queensland, including regional-scale 2D hydrodynamic models of the Coral Sea/Great Barrier Reef, Moreton Bay, Gold Coast and Sunshine Coast. Detailed, local-scale 2D/3D hydrodynamic models can be readily developed using inputs from the existing regional models. The detailed hydrodynamic models form the basis for sediment transport, shoreline evolution and water quality assessments.

Ongoing research, in collaboration with the University of Queensland, has led to the development of new coastal modelling tools capable of:

- Quantifying coastal and estuarine responses (e.g. coastal erosion, coastal inundation, estuarine flushing, eutrophication, modification to estuary entrances) to a range of climate change projections
- Predicting short to geological time-scale coastline evolution associated with longshore and cross shore coastal processes in response to major sea level change

These tools are presently being used to deliver state-of-the-art outcomes for clients in Queensland and NSW.
BMT WBM has a proven record in addressing today’s engineering and environmental issues. We aim to continue to enhance our services, capabilities and areas of application to meet the community’s future development and environmental protection needs.