WHAKATANE RIVER ENTRANCE NAVIGATION IMPROVEMENT – CONSIDERING MULTIPARTY INTERESTS

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ABSTRACT

Navigation through the entrance of the Whakatane River in Bay of Plenty, New Zealand has deteriorated due to shallow draft conditions to the point where safe access is not possible for significant periods of the time. This is affecting the viability of commercial and tourist operations based in Whakatane as well as posing a danger to recreational users. DHI were commissioned by Whakatane District Council to investigate the effectiveness of a range of options to achieve the best results in terms of improved navigation whilst keeping in mind the constraints that exist for the site.

KEYWORDS

River entrance, navigation, sediment transport, numerical modelling

PRESENTER PROFILE

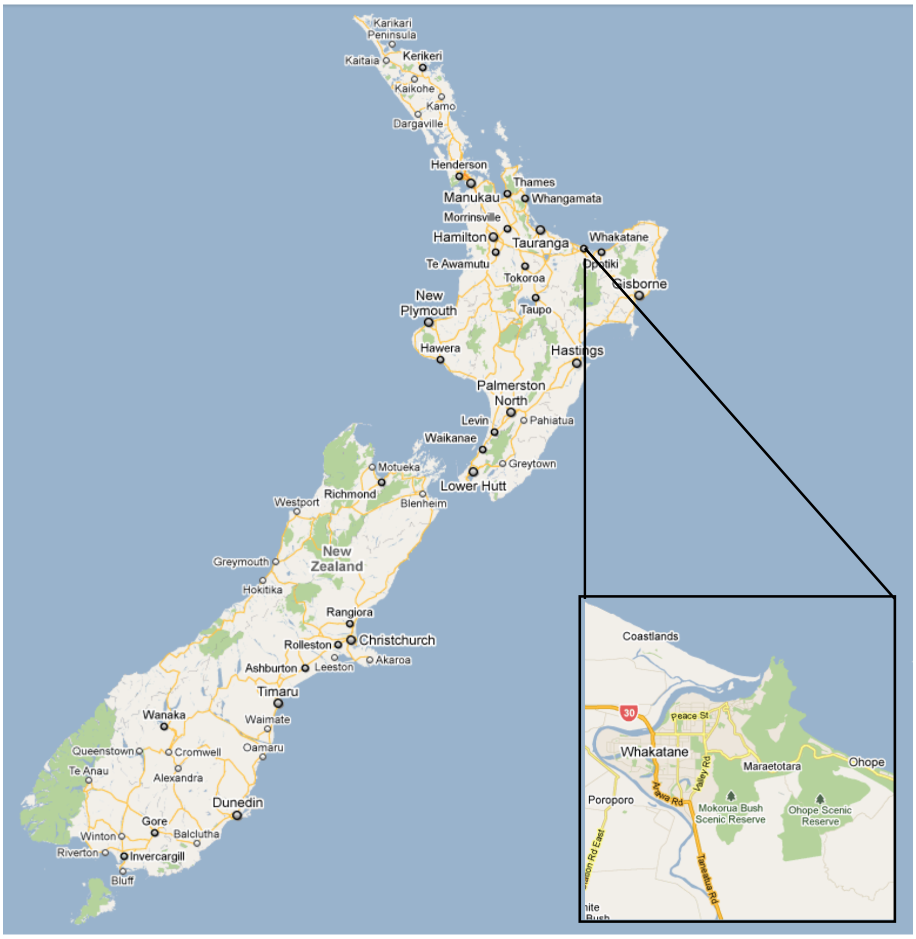
Ben Tuckey is a coastal scientist with DHI in Auckland. He has been involved with numerous coastal studies in New Zealand, Australia, England and the Middle East, including harbour entrance stability for navigation; impact assessments for proposed wastewater outfalls; aquaculture and sedimentation and water quality in estuaries.

1 INTRODUCTION

The Whakatane River in Bay of Plenty (see Figure 1) is important locally and regionally since it has an economical and recreational role in providing access to the sea. Human impacts on the estuary and the catchment are threatening this access by inducing shallow draft conditions at the entrance.

DHI were commissioned by Whakatane District Council to investigate the effectiveness of a range of options to achieve the best results in terms of improved navigation whilst keeping in mind the constraints that exist for the site. The investigation was performed using DHI's suite of state-of-art numerical models including a detailed morphological model, MIKE 21 ST (DHI, 2011) to assess the entrance behaviour for the existing situation and with proposed options during typical and extreme conditions. A boussinesq wave model, MIKE 21 BW (DHI, 2011) was utilised to assess the surf break at the entrance.

Figure 1: Locator map.



There are a range of options available that will lead to improved navigation conditions in the Whakatane Entrance. These generally fall into three categories; structural solutions that aim to increase the tidal flushing power, dredging options to increase the tidal prism, and maintenance dredging options. Maintenance dredging is currently undertaken over the entrance bars, with success, however this is not perceived as a viable long term option.

Several studies aimed at improving the navigation through the entrance have been carried out since 1977. Most of these studies considered the creation of training walls around the entrance to channel the flow. The reliability of their conclusions was mainly undermined by the lack of available data.

2 CONSTRAINTS

There are a number of constraints which are unique to the Whakatane entrance and must be considered for any potential works at the entrance. These include:

- Cultural constraints, centred around the spiritual significance of the rocks to tangata whenua (indigenous peoples of New Zealand), as well as the ownership by Ngati Awa (Maori tribe centred in the eastern Bay of Plenty Region) of these rocks and land on the Piripai spit.

- The existing scouring behaviour of the river mouth across the sand spit plays an important part in flood level reduction in Whakatane township and any solution to improve navigation depths cannot adversely affect flood risks in the town.

- The physical constraint of the Whakatane Headland complicates the local littoral sediment transport processes which are not well understood. The headland also restricts potential training wall solutions which ideally extend to deep water, which is only found past the headland.

- The existing natural amenity value of the entrance is held in high regard by the local community and highly visual solutions will probably not be favoured.

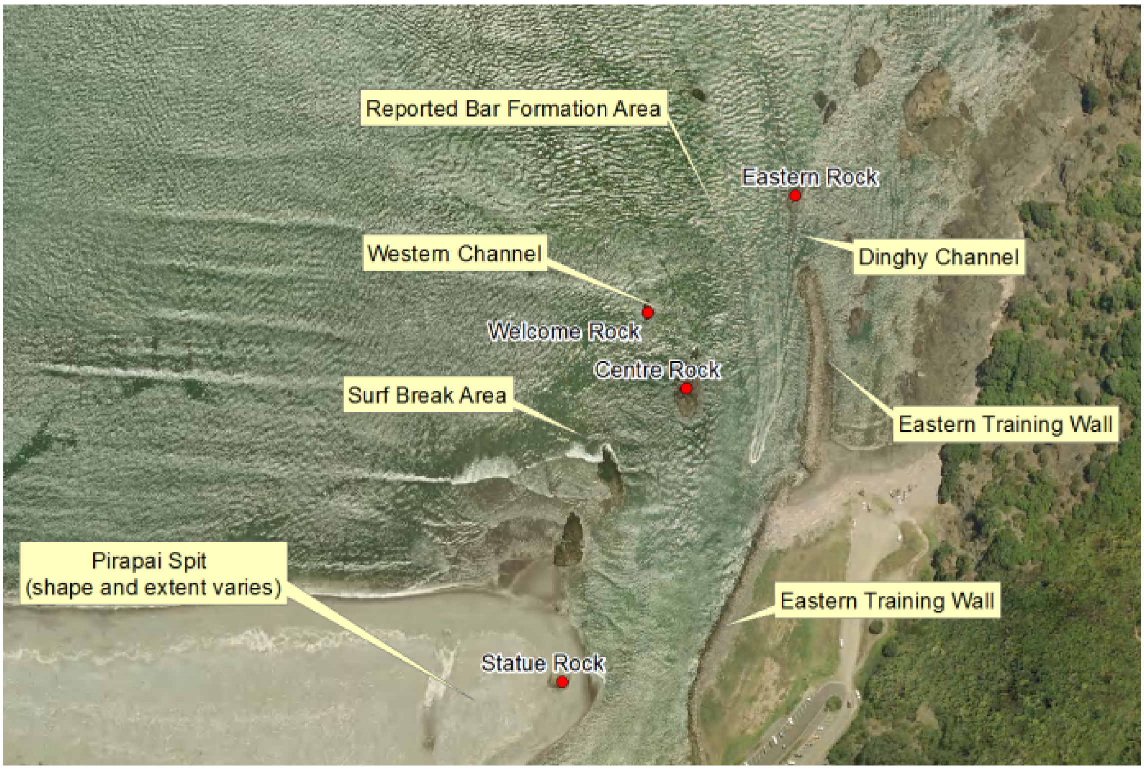
- The surf break at the river mouth, though intermittent, is valued by the local surfing community and will invariably be affected by any physical works at the entrance.

- Changes to flow or sedimentation patterns, water levels or salinity may affect ecology of the harbour estuary and wetlands.

- The proposed solution must be economically feasible.

Figure 2 presents an overview of the harbour entrance with significant features noted such as the observed area where entrance bars form and culturally significant areas (i.e. entrance rocks and Pirapai Spit).

Figure 2: Overview of harbour entrance with significant features.



During the course of the study, there have been a series of meetings and public open days with the local recreational boating community, local surfing community, local Iwi, commercial boat operators and general public to obtain a better understanding of the constraints for the entrance and also tap into local knowledge of prevalent conditions at the site.

3 DATA COLLECTION

A comprehensive field campaign was carried out July – October 2010, to obtain a data set suitable for constructing a detailed morphological model of the study area.

3.1 BATHYMETRIC DATA

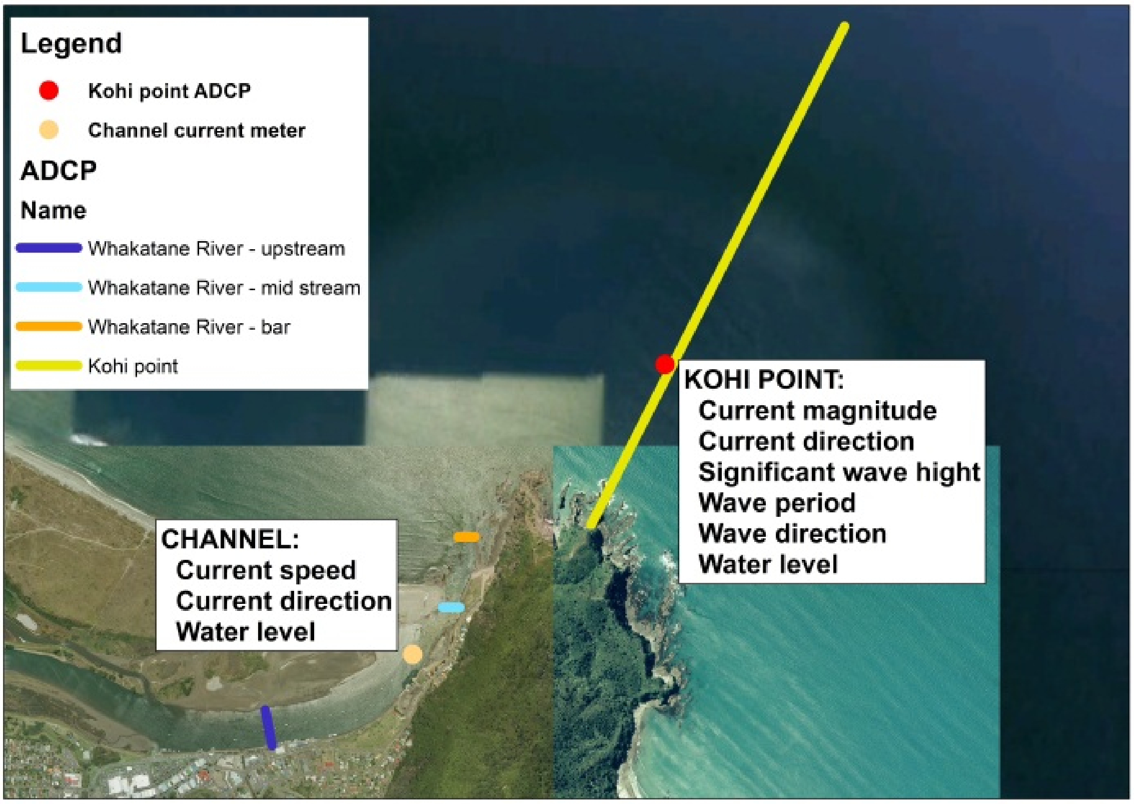
Discovery Marine Limited carried out a bathymetric survey (DML, 2010) of the Whakatane Harbour entrance and Whakatane River from 26th to 30th July 2010 (see Figure 3 for coverage). On the 15th August 2010, a significant flood event (30 – 50 year flood event) occurred on the Whakatane River. Discovery Marine Limited carried out another, more limited, survey of the harbour on the 20th August. This was collected as it was seen as a very good data set to be able to assess the ability of the morphological model to reproduce the scour of the harbour mouth during flood events.

Figure 3: Discovery Marine Limited bathymetric survey coverage.

3.2 HYDROGRAPHIC DATA

Cawthron Institute was commissioned to collect hydrographic data within the vicinity of Whakatane Harbour during September and October 2010. An overview of the data collected is presented in Figure 4. Cawthron collected wave, current and water level data off Kohi Point, water level and current data at the entrance and flow measurements (via transects) within the harbour, across the bar and off Kohi Point.

Figure 4: *Cawthron Institute hydrographic data collection overview.*



4 WAVE CLIMATE

The wave climate at the study site plays a significant role in the morphological response of the harbour entrance. Waves are the main driving force for littoral sediment transport into the entrance, which builds the bars and ultimately makes navigation difficult through the entrance.

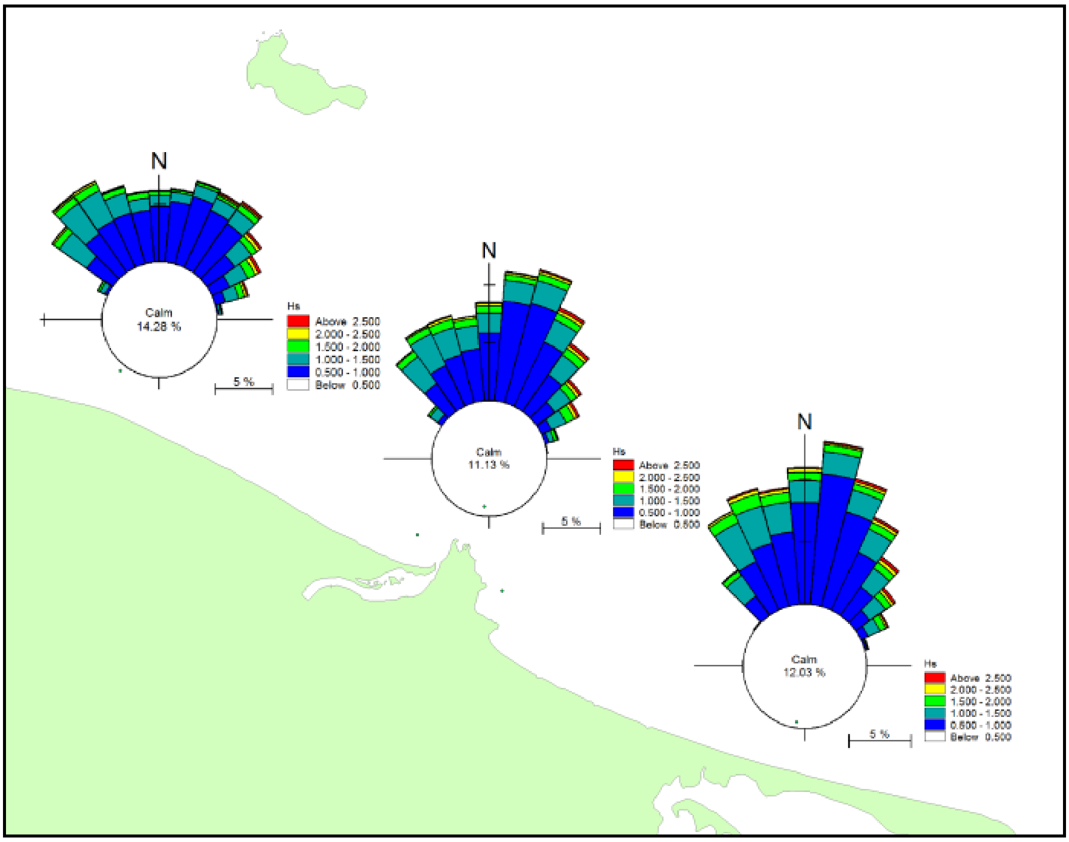
No wave data is available for the study site, hence it was required to generate a long term time series through numerical modelling. DHI's Pacific Ocean model was utilised to provide boundary conditions for a regional Bay of Plenty model, from which a 10 year (1st January 2000 to 1st January 2010) time series of wave data was generated for the study site.

The wave modelling was undertaken using DHI's Spectral Wave Model, MIKE 21 SW (DHI, 2011) which propagates waves from deep water into near shore areas. Six hourly global wind data derived from satellites was obtained from National Oceanic and Atmospheric Administration (NOAA) as wind forcing for both the Pacific Ocean and regional Bay of Plenty wave models.

To provide confidence in the predictive ability of the wave model, the model was calibrated and verified using wave data obtained from the Bay of Plenty Regional Council wave gauge located 13 km offshore from Pukehina Beach in western Bay of Plenty. A visual comparison of observed and predicted wave data indicated that the regional wave model was reasonably calibrated and sufficient for predicting waves in the Bay of Plenty.

Wave roses presenting the simulated wave climate for several locations along the 15 m depth contour for the Whakatane coastline extracted from the regional Bay of Plenty model are shown in Figure 5. The influence of Moutohora Island is apparent with significant sheltering of waves from both north westerly and north easterly directions. This is illustrated by the salient that exists for this stretch of the coastline. It can also be concluded that Moutohora Island will have some type of sheltering effect on wave climate at the entrance.

Figure 5: Wave climate for 2000 - 2010 at 15m depth contour for Whakatane coastline.



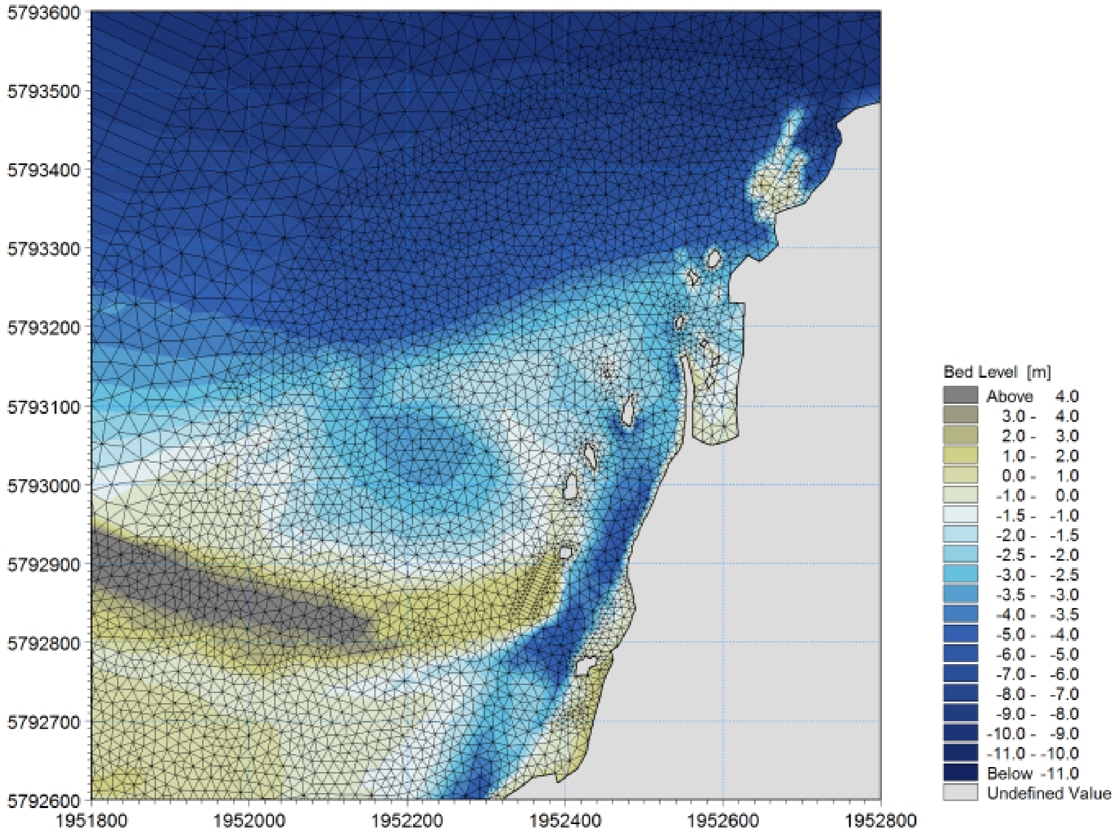
The seasonal wave climate at Whakatane was also investigated. From December to April the dominant wave direction is from the north east due to swell generated waves, while from August to November the waves are most likely wind generated and are predominantly from the north west.

5 MORPHOLOGICAL MODEL

To be able to assess the behaviour of the harbour entrance for a variety of conditions (i.e. build up of the entrance bars during low flow conditions and scour of entrance bars during higher river flow) for the existing situation and with potential improvement options a calibrated morphological model of the study area was required.

The local morphological model was developed by coupling hydrodynamic (MIKE 21 HD (DHI, 2011)), wave (MIKE 21 SW) and sediment transport (MIKE 21 ST) models using a flexible mesh (FM). The hydrodynamic and wave components of the model were calibrated using the hydrographic data collected by Cawthron in the vicinity of the harbour mouth and Kohi Point. The model bathymetry and extent is shown in Figure 6.

Figure 6: Local model bathymetry zoomed into Whakatane Entrance (Moturiki Datum).



A regional Bay of Plenty hydrodynamic model was utilised to generate the open ocean boundary conditions. Flow data from a gauge on Whakatane River at Valley Road was used as the upstream inflow boundary condition. The six hourly spatially varying NOAA wind data was used to force the model.

The comparison for the measured and predicted flow through transects in the mid harbour and at the harbour entrance is shown in Figure 7. This is probably the most important aspect of the hydrodynamic model calibration, since it shows that the model is able to reproduce the tidal prism for the harbour. Most potential improvement options will either increase the tidal prism or focus the ebb tide across the entrance bars.

The morphological model was validated using pre and post flood bathymetry data collected by Discovery Marine Limited. The flood event that occurred on the 15th August 2010 was simulated to illustrate that the model was able to reasonably reproduce the scour of the navigation channel.

As an example of the morphological model validation, a comparison of observed and predicted bed levels for a cross section across the navigation channel is shown in Figure 8. There is a good agreement between the observed and predicted bathymetry.

Figure 7: Comparison of measured and predicted flow through transect in mid harbour (top) and at entrance (bottom). Observed flow (red triangles) and predicted flow (blue line). A positive flow corresponds to ebb tide and a negative flow corresponds to flood tide.

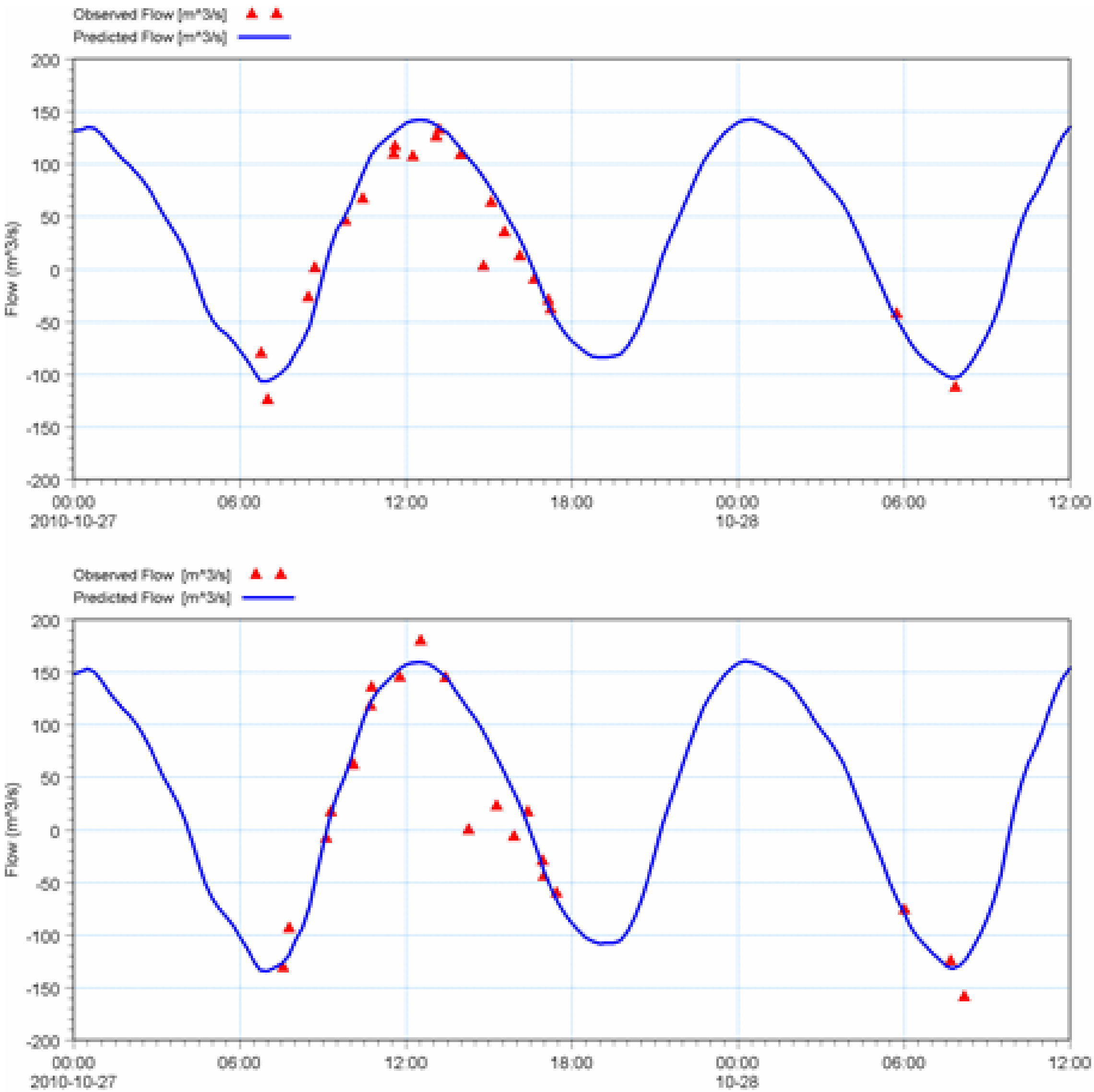
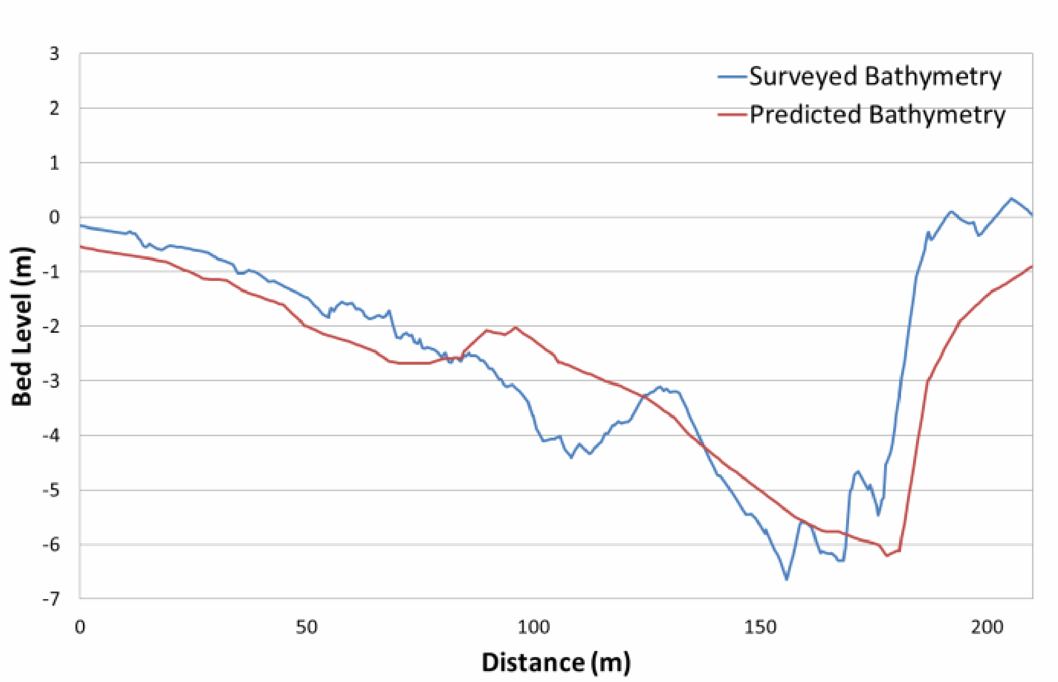


Figure 8: Comparison of observed and predicted bed levels for cross section across navigation channel. Surveyed bathymetry (blue) and predicted bathymetry (red).



6 SURF BREAK ASSESSMENT

Whakatane Heads is a renowned surf break under favourable wave and wind conditions. A detailed investigation of the surfing characteristics of the site was assessed for two wave scenarios considered both representative and highly favourable for surfing. A detailed 10 year record of observed wind at Whakatane Airport and generated wave conditions at Kohi Point was used to identify representative events potentially suitable for surfing at Whakatane. The selected offshore wave conditions for surf break modelling scenarios are listed in Table 1.

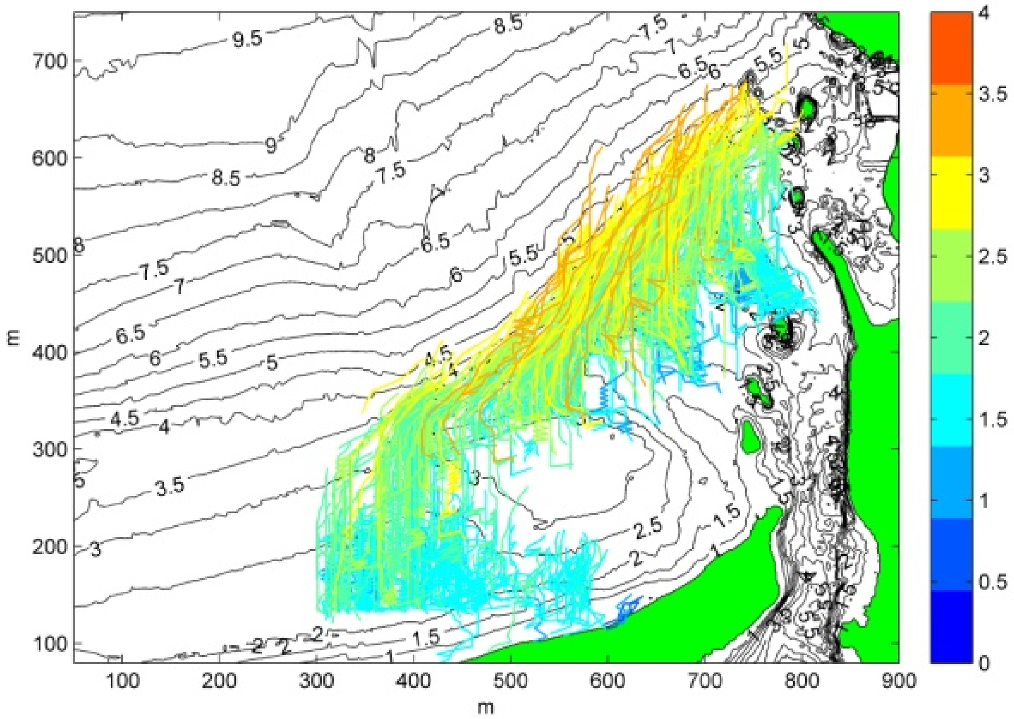
Table 1: Selected offshore wave conditions for surf break modelling scenarios.

Scenario	Hs	Tp	Wave Direction	Representative Historic Event
One	2.8 m	15.0 sec	5°	June 29 2000
Two	1.5 m	11.2 sec	26°	July 27 2008

The DHI Boussinesq wave model, MIKE21 BW was used to calculate the detailed wave transformation and breaking for each selected scenario. MIKE21 BW solves Boussinesq type equations used for the simulation of propagation of non-linear directional waves from deep to shallow water. The pre flood bathymetry data set was used for the bathymetry in the MIKE21 BW model, as this is more likely to represent normal conditions at the site.

The program OPTISURF was then used to analyse the surf quality of the produced wave field. For each breaking wave the transition point between broken and unbroken wave was traced until the wave breaking terminated. Each cycle was logged as a surf able ride along with information on the ride length, peeling speed and breaking wave height. An example of the output from OPTISURF is shown in Figure 9.

Figure 9: Wave Scenario One – Distribution of surf able rides.



From the ride trajectory plots it was observed how the initiation zone of each ride (surf term: take-off zone) extends from approximately 100 m offshore the eastern training wall and along the full length of bar, with the longest rides starting at the offshore entrance of the river mouth and terminating at the western end of the bar.

Both Scenario One and Two provided occasional rides of more than 400 m long with a return period of one ride every 5.5 minutes and 12 minutes respectively. For Scenario One the breaking wave height exceeds 3.5 m for some rides. For rides with lengths of 200-400 m the frequency increased to about three rides per minute for both scenarios.

This surf break assessment for the existing situation will be the benchmark against which impacts of potential navigation improvement options will be assessed.

7 ASSESSMENT OF POTENTIAL OPTIONS

At the time of the submission of this paper a detailed assessment of potential options had not yet been performed. The numerical models (some models not described in this paper) will be used to determine the following for potential options:

- Channel siltation rates and the required frequency of maintenance dredging works.
- Suitability for navigation purposes.
- Potential flood level impact due to improvement works.
- Mitigation options to address potential adverse effects.

- Changes to coastal processes and morphology in the vicinity of the improvement works.
- Impacts on saline intrusion in the Whakatane River.
- Effects of climate change.
- Impacts on the surf break.

The following will also be considered qualitatively:

- Potential for conflict with sites of significance to local Iwi.
- Potential ecological impacts on surrounding beaches and wetlands.
- Landscape and amenity values.

During the first stage of the study, a preliminary assessment of twelve potential options was carried out using an uncalibrated (pilot) morphological model. The reason for the preliminary assessment was to provide an initial understanding of what type of options would be required to improve navigation through the harbour and then gauge opinion from the local community and Iwi about whether this type of option would be considered acceptable.

There were two basic types of options modelled:

- options consisting of an western training wall with or without a refinement or extension of the eastern training wall; and
- options where the harbour or upper reaches of the river were dredged to increase the tidal prism.

Basic assessments were carried out with the pilot model to determine whether the options would have the potential to scour the entrance bars for a spring tide with mean river flow for the Whakatane River (40 m^3/s) and whether they would have an impact on peak flood levels compared with the existing situation for selected locations upstream of the river for a flood event with a peak flow of 2900 m^3/s that occurred in July 2004.

Two examples of the type of options that were assessed are Option A1, a western training wall connecting the entrance rocks (see Figure 10) and Option G, with 500,000 m^3 of material dredged from the inner harbour (see Figure 11).

The predicted change in bed level for a spring tide with option A1 is shown in Figure 12. The wall confines the flow during the ebb tide across the bars and forces the bars to migrate further seaward into deeper water, which suggests this is an option that would work from a technical point of view.

The predicted change in bed level during a spring tide for Option G is shown in Figure 13. Although there is an increase in the tidal prism, the additional flow is able to escape through the entrance rocks and is not focused across the entrance bars. It appears that this option would not scour the entrance bars and therefore would not work from a technical point of view.

Figure 10: Option A1 – western training wall connecting entrance rocks.

Figure 11: Option G with proposed dredging extent.

Figure 12: Predicted change in bed level for training wall option with spring tide. Blue indicates erosion, while red indicates deposition.

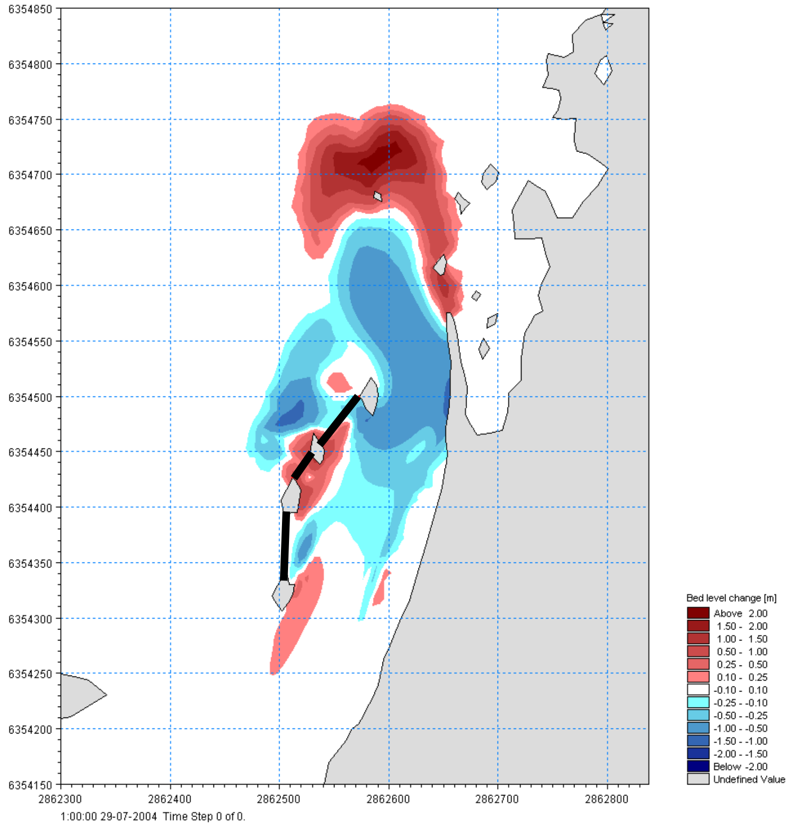
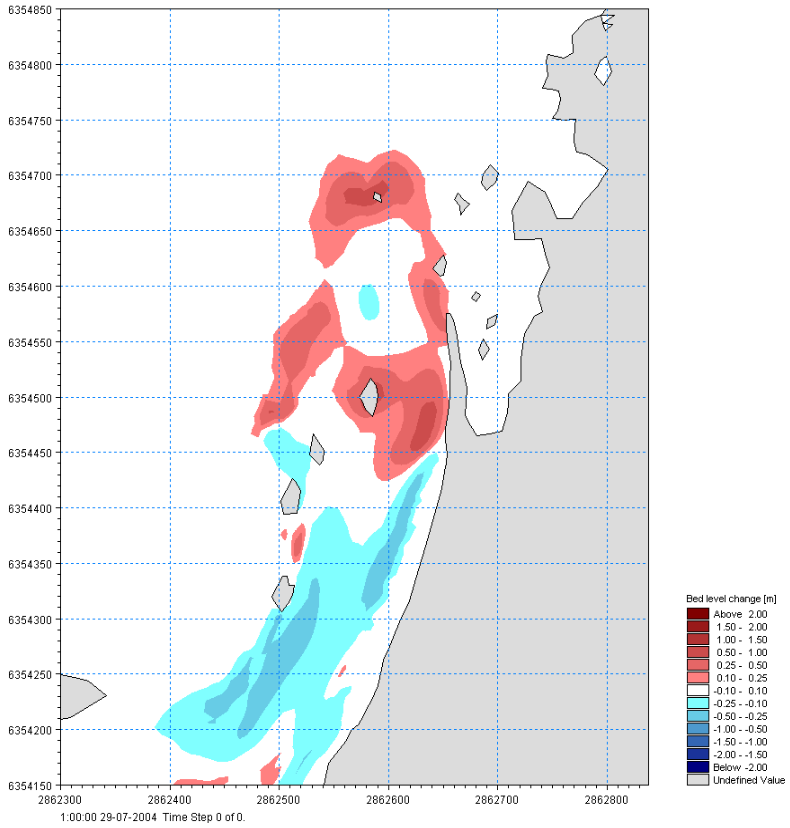


Figure 13: Predicted change in bed level for dredged harbour option with spring tide. Blue indicates erosion, while red indicates deposition.



The flood impact assessment indicated that the training wall options are likely to increase peak flood levels upstream of the entrance (0.0 to 0.6 m), while there will be a small decrease in peak flood levels (-0.1 to 0.0 m) for the dredging options.

The conclusion of the preliminary assessment was that a dredging option will not be sufficient to maintain a navigable channel. Most training wall options will be sufficient to maintain the navigation channel, however they will most likely increase the flood risk. It was concluded that a combined dredging and training wall option should also be investigated further.

8 CONCLUSIONS

Navigation through the entrance of the Whakatane River has continued to deteriorate to a point where safe access is not possible for significant periods of the time. The entrance is important to many different parties in the community, with interests that sometimes conflict.

DHI have developed a suite of models including a coupled morphological model, using a comprehensive data set. These models have been used to obtain a better understanding of the existing situation, including assessing the surf break.

The models will be utilised to investigate the performance of a range of options (predominantly training wall and dredging options) primarily in terms of achieving improved navigation. However there are a number of constraints that exist, some unique to the location, which must also be considered when assessing the performance of the options.

ACKNOWLEDGEMENTS

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