A Critical Analysis of the BMT WBM 'Preliminary Coastal and Hydrodynamic Investigations' 2013

TOS 'best beach break in Australia'

A Critical Analysis of the BMT WBM 'Preliminary Coastal and Hydrodynamic Investigations' 2013

The BMT WBM 'Gold Coast Broadwater - *Preliminary Coastal and Hydrodynamic Investigations for Cruise Ship Terminal Options -July 2013'* was commissioned by the Gold Coast City Council in February 2013 at a cost to ratepayers of approximately $80,000.

BMT WBM claim, 'this preliminary impact assessment has been commissioned to inform government and short-listed proponents during the BMP [Broadwater Marine Project tendering process]. Following submissions of Expressions of interest, a Request for Detailed Proposal (RFDP) has been extended to a short-list of proponents.' (BMT WBM 2013, p.31)

An independent review of BMT WBM's 'Preliminary Investigations' was undertaken. Following careful analysis and cross-referencing of existing engineering data and information, it was revealed that BMT WBM's investigative results and conclusions are in many instances inaccurate or significantly flawed.

Editor's Introduction to Hydrodynamic Investigations

One of the most serious problems for ports around the world, especially those located in shallow coastal waters or exposed to the open sea, is wave reflection caused by deep channel dredging for large vessels.

As major components of the BMP, the proposed navigational channels, port infrastructure and locations for a cruise ship terminal on the Gold Coast are exposed to the open Pacific Ocean and the shallow coastal waters of the Gold Coast Seaway and Nerang River estuary, commonly known as The Broadwater.

The effects and changes on a wave field caused by channel dredging are significant.

Appropriate validation of numerical models for complex refraction and reflection processes near dredged channels and basins is essential to have confidence in operational and extreme wave climate predictions for a proposed port facility.

Executive Summary

A summary of the 'Critical Analysis of the BMT WBM Gold Coast Broadwater *- Preliminary Coastal and Hydrodynamic Investigations 2013'* contained in this detailed review.

BMT WBM's use of SWAN 'spectral wave modelling' is inadequate for estimating the effects of wave actions in dredged channel areas since it cannot account for wave reflection or partial wave reflection.

Studies have assessed the performance of various numerical models in representing wave interactions with dredged areas, with Boussinesq models being the preferred option. (Knight et al, 2013 p.3)

Wave modelling using Boussinesq models can accurately replicate the refraction and reflection processes surrounding dredged areas and is a primary component of any port study. (Knight et al, 2013 p.1)

The MIKE 21 BW Boussinesq Wave model system developed by the Danish Hydraulic Institute (DHI) is used to simulate propagation and transformation of waves in coastal regions and harbours. Processes that are described in the model include shoaling, refraction, diffraction, reflection (including partial and full reflection) and transmission, bottom friction, non-linear wave-wave interactions, wave breaking and run-up, wave induced currents and wave-current interaction. (Taylor et al. 2013. p.2-3)

In 'Preliminary Investigations', such as the those conducted by BMT WBM, 'Boussinesq wave modelling' should have been applied as global industry best practice in order to estimate the effects of wave reflection on the Gold Coast Seaway and South Stradbroke surf break (TOS) following the dredging of channels for a cruise ship terminal.

BMT WBM suggests 'spectral wave modelling' can be used to simulate 'wave/swell propagation in two dimensions, including shoaling and refraction due to spatial variations in bathymetry and currents' (BMT WBM 2013; p.35 2.1) but BMT WBM fail to mention spectral wave modeling's ineffectiveness in simulating wave reflection or partial wave reflection.

Boussinesq wave modelling reveals that wave reflections caused by dredging for cruise ships on the northern side of a seaward (outer approach) channel on the Gold Coast may cause more than double the height of existing recorded significant wave heights inside the Seaway with the possibility of extreme over-topping by waves of the existing northern Seaway wall.

The excavation of an outer approach 'channel to -12.0 LAT will cut across essentially the entire sand transport zone. The channel will effectively intercept and trap the majority of any sand transported to it from upcoast and downcoast directions. (Qld. Govt. *Initial Advice Statement* 2005 (IAS), p.4-6)

'An initial estimate of the rate of sedimentation is about 250,000cubic metres/yr. However, importantly, more than 20% (50,000cubic metres) of this may be deposited in a short period (e.g. one week) during a major storm event which could be expected to occur every 1 to 2 years on average. During an extreme event such as a cyclone, in excess of 100,000cubic metres may be deposited over the duration of the storm.' (Qld. Govt. IAS 2005, p.4-6)

'It is considered possible that single large events such as the March 2006 or May 2009 storms could cause up to 100,000cubic metres of sedimentation' (BMT WBM 2013, p.102) in the proposed dredged 'Outer Approach Channel' on the Gold Coast. This constitutes an additional 50% of the estimated total for annual maintenance dredging of the Outer Approach Channel caused by sediment infill following a single weather event.

'While the requirement for additional dredging may reduce in time, there would still be a risk of not maintaining the necessary navigational depth.' (Qld. Govt. IAS 2005)

The ebb tide delta bar (located ENE of the Seaway training walls) is acknowledged in reports by Professor Andy Short and BMT WBM as being a focus point for wave direction (refraction) to South Stradbroke (TOS) surf amenity.

'Depending on the location of maintenance dredge sand placement, the ebb delta bar could gradually lose volume over time, which would in turn reduce the average rate of channel infilling. However, if the ebb delta volume was to become substantially diminished then this would have a further negative effect on surf quality at TOS.' (BMT WBM 2013, p. 102)

No detailed estimate of the extent of the diminishment of the delta through the interruption to sediment transportation caused by a shipping channel was calculated by BMT WBM and therefore the extent of the 'negative' effects on the TOS surf amenity cannot be accurately assessed from the BMT WBM study.

BMT WBM suggest that extension of the sand-bypass system may have potential to reduce the size and volume of the storm bar which generates the majority of the storm induced sand transport to the Seaway delta. (BMT WBM 2013, p.116) However, the Queensland Government *Initial Advice Statement* 2005 for the Gold Coast Marine Development Project clearly concluded that 'extending the sand bypassing system alone (without extending the southern training wall) is not a viable option.' (Qld. Govt. IAS 2005, p.4-7)

The BMT WBM investigations fail to address the likely effects of the operation of vessel bow-thrusters on the stability of the training walls, dredged channel batter-slopes and the marine environment. BMT WBM dismisses other vessel operation impacts with the unsupported statement, 'Vessel operation impacts on the physical environment (due to wake and wash) should be able to be readily mitigated at the detailed design stage.' (BMT WBM 2013, p.116)

The BMT WBM Gold Coast Broadwater - *'Preliminary Coastal and Hydrodynamic Investigations for Cruise Ship terminal Options -July 2013'* is unreliable as an accurate assessment of the likely hydrodynamic effects of dredged channels and other engineering actions required for the construction of a cruise ship terminal on the Gold Coast Spit and Broadwater.

Boussinesq Wave Model System

BMT WBM cannot use cost restraints as an excuse for failing to apply Boussinesq wave modelling in their 'Preliminary Investigations', especially given Boussinesq is available as free-ware to the global coastal engineering industry.

The effectiveness of the Boussinesq Wave Model System was examined most recently in the 'Case Study - Townsville Port Expansion', presented at the 'Coast and Ports 2013' Conference – Sydney, September 11-13th 2013.

http://www.coastsandports2013.com.au/pages/programme.html

Wave Interactions with Dredged Areas
Sam J. F. Knight and Stuart H. Bettington

> The primary mechanisms of wave transformation associated with dredged areas are wave refraction and reflection. These processes can be accurately assessed using phase resolving numerical wave models, such as Boussinesq…
>
> Studies have assessed the performance of various numerical models in representing wave interactions with dredged areas, with Boussinesq models being the preferred option. Although Boussinesq models will accurately resolve refraction, reflection, and diffraction associated with dredged areas, there are a number of model limitations that impact the assessment of these. Understanding operational and extreme wave climates at berth and along wharf structures is a critical aspect of the site selection and engineering phases for developing an exposed, open water port facility. The extreme wave climate will impact on the design of any marine structure and the day-to-day operational wave climate may impact on the port operability as short and long waves can induce unacceptable at-berth vessel motions.

(Knight et al, 2013 p.3)

> From the theory… it can be seen that the extent of wave refraction is sensitive to changes in incident wave period and direction. When waves approach a channel at an angle close to critical angle, small changes in wave period or incident direction could change whether waves are reflected or refracted. If this is not properly considered, dangerous conclusions about operational and design wave climates could be drawn. This is particularly important for navigational channels. If waves meet a channel at critical angle, they will be directed down the channel into the harbour.

(Knight et al, 2013 p.2)

Wave Reflection and TOS Surf Amenity

Wave blocking or partial wave blocking occurs when a wave passes over a channel and partial wave signals are reflected back from the leeward side of a channel; for example, inside the Gold Coast's northern Seaway training wall, especially during the predominant ESE swells, wind and wave conditions experienced on the Gold Coast.

Boussinesq wave modelling reveals that wave reflection on the northern edge of a seaward navigational channel dredged for cruise ships on the Gold Coast may cause **more than double the height of existing**

recorded significant wave heights in the Seaway with the possibility of extreme over-topping by waves of the existing northern Seaway wall.

In this confused wave field, when Boussinesq wave modelling is applied, the TOS wave amenity will likely experience a 25% drop in significant wave height. This data contradicts conclusions drawn earlier by Professor A. Short and BMT WBM:

- Following Professor Short's 'investigations' in 2012 (which were apparently conducted from the back of a jet ski using visual observations and some measuring of depths and the ebb tide delta carried out while snorkelling), Short suggested that significant wave heights on TOS may increase with the dredging of a channel for a cruise ship channel.

- In contrast, BMT WBM estimated a '5% decrease in wave amplitude' (BMT WBM 2013. p. 102 8.6) at TOS caused by cruise ship channel dredging, despite using only spectral wave modelling which is inadequate for accurately measuring the effects of wave reflection or partial reflection on TOS surf breaks.

However, BMT WBM admits:

> …a phase-averaged spectral model such as SWAN does not necessarily possess all of the "physics" required to accurately simulate the complex wave interactions that occur at abrupt bathymetric transitions such as introduced by the proposed dredged channel. (BMT WBM 2013. P. 99 8.3)

And

> …simulations did not include wave driven currents. (BMT WBM 2013. P. 68 6.2.1)

Ebb Tide Delta and TOS Surf Amenity

The ebb tide delta bar (located ENE of the Seaway training walls) is acknowledged by both Professor Andrew Short and BMT WBM as being a focus point for wave direction (refraction) to TOS surf amenity. However, no detailed estimate of the extent of the diminishment of the delta, owing to the interruption to sediment transportation caused by a dredged shipping channel, was calculated by BMT WBM.

Detailed and well-documented littoral and other sediment transport quantity estimates both inside and outside the Gold Coast Seaway are available (and even quoted by BMT WBM 2013. P.60 4.8), yet they chose not to attempt the arithmetic calculations necessary to estimate the potential depletion of the ebb tide delta, a relatively simple exercise for a coastal engineering company.

Nevertheless, having not made these calculations, BMT WBM suggests the following 'Impact Mitigation':

> in particular the placement of sand dredged from the outer bar channel should ideally be placed in a way that minimises any loss of volume from the northern ebb tide delta bar and continues

> the ongoing supply of sand to South Stradbroke Island littoral system. (BMT WBM 2013. P.115-116 9.1)

There is no historical evidence presented by BMT WBM that such an action has previously been attempted, costed or successful. BMT WBM undertook no modelling to ascertain if the topping up of an ebb tide delta from dredge spoils is even possible in a configuration and height which replicates its current state or that such action could 'continue the ongoing supply of sand to South Stradbroke Island littoral system'. This 'impact mitigation' action is pure supposition with no scientific modelling provided by BMT WBM to support such an action.

However, BMT WBM does admit:

> Depending on the location of maintenance dredge sand placement, the ebb delta bar could gradually lose volume over time, which would in turn reduce the average rate of channel infilling. However, if the ebb delta volume was to become substantially diminished then this would have a further negative effect on surf quality at TOS. (BMT WBM 2013, p. 102)

Validation of the Boussinesq Wave Model System

Despite not using Boussinesq modelling to estimate wave reflection or potential wave height increases inside the Seaway or the 'complex wave interactions that occur at abrupt bathymetric transitions such as introduced by the proposed dredged channel', BMT WBM came to the dubious conclusion that:

> Aside from the deeper channel depths, navigability of the Seaway would be expected to be generally enhanced by current speed reductions. Navigability of the bar would in particular be enhanced for all vessel sizes by the deep channel that would limit wave breaking. (BMT WBM 2013. P.68 6.2.1)

BMT WBM appear to have also conducted inadequate testing on sensitivities which require the application of differing wave periods, directions and wave heights; for instance, 'Coastal infra-gravity waves ("long waves") have not been considered in this preliminary assessment.' (BMT WBM 2013. P. 71 6.6)

The most recent validation of the Boussinesq Wave Model System's accuracy was achieved in a comparison with physical modelling in research presented at the 'Coast and Ports 2013' Conference – Sydney, September 11-13th 2013.

Physical Model Validation of a Boussinesq Wave Model for Exposed Channel and Port Environments
D. Taylor, J. Wiebe, D. Scott and S. Garber

> Wave transformation within the vicinity of navigation channels and exposed ports is an important physical phenomena which can impact on operational and extreme event design criteria for a port facility. Boussinesq wave models are commonly utilised during the engineering

design phase to investigate wave conditions surrounding steep sided channels and within port harbours. In the case of large port developments in open water, during the design phase there may be no field data which can be used to validate the Boussinesq wave model results.

A large scale physical modelling study was undertaken for a proposed offshore port development containing eight Cape Class berths.

The port included deep berth pockets, turning basins and channels all of which had batters slopes of up to 1V:3H. The physical model was constructed at a 1:100 (length) scale in a large wave basin measuring 54m (long) by 32m (wide) by 1m deep. A series of model simulations were undertaken for operational short and long wave conditions in order to validate the Boussinesq wave model.

(Taylor et al. 2013. p.1)

The numerical model applied in this study was the MIKE 21 BW Boussinesq Wave model system developed by the Danish Hydraulic Institute (DHI).

The model is used to simulate propagation and transformation of waves in coastal regions and harbours. Processes that are described in the model include shoaling, refraction, diffraction, reflection (including partial and full reflection) and transmission, bottom friction, non-linear wave-wave interactions, wave breaking and run-up, wave induced currents and wave-current interaction.

(Taylor et al. 2013. p.2-3)

Knight supports Taylor's contention that the Boussinesq Wave Model System is the most comprehensive and appropriate numerical model to apply to a port such as that proposed for the Gold Coast in the Broadwater Marine Project (BMP):

Wave modelling using Boussinesq models can accurately replicate the refraction and reflection processes surrounding dredged areas and is a primary component of any port study.

(Knight et al, 2013 p.1)

Capital and Maintenance Dredging

In relation to dredge estimates, the BMT WBM report claims the following:

Development of a cruse ship terminal inside the Broadwater will require dredging in excess of to construct the approach channels and swing basins. GHD (2006) as part of the Notional Seaway Project EIS prepared a Dredge Management Plan for a single option requiring 3.3 million cubic metres of capital dredging. (BMT WBM 2013, p.97)

However, the 2006 GHD dredge estimates were based on the 2006 'Notional Gold Coast Marine Development Project' cruise terminal being located at the far northern end of The Spit, close to the Seaway entrance. Inexplicably the BMT WBM dredge estimates are 25% lower than the GHD estimates for a Seaway terminal which was situated in the same location as Option S1 in the BMP.

Moreover, two of the three terminal options studied by BMT WBM for the 2012 Broadwater Marine Project were located between 0.5 and 1.5 kilometres further south inside the Broadwater (Option S2 and Option S3). According to BMT WBM these locations require channel bends of 210 metres width and depths of -11m LAT. Yet, BMT WBM quote only the (incorrect) Option S1 dredge estimate of '2.5 million cubic metres of sand'.

One must to go to Fig 1-1 (p.34) in the BMT WBM study to discover that actual capital dredge estimates are 3.6 million cubic metres for terminal OptionS2 and 3.7 million cubic metres for terminal Option S3. The question needs to be asked why these figures were not also mentioned in text section 8-1 (p.97) of the BMT WBM report pertaining to 'Capital Dredging' in addition to the '2.5 million' quoted above.

Furthermore, the BMT WBM dredge estimates are based on channel design dimensions specified in the 2006 GHD EIS and 'subsequently refined during 2012 Navigation Simulations'. (BMT WBM 2013, p.63). These studies used the dimensions of cruise vessels of the time which had shorter lengths overall (LOA), shallower drafts and narrower beams than post-2012 cruise vessels.

Therefore, if post-2012 cruise company fleets were to safely navigate to a terminal inside the Gold Coast Broadwater, the dredged channels would require greater than the 140 metres width and -12m LAT (Outer Approach channel) and -12m LAT (Seaway and Inner southern channels) depths; and a swing basin substantially wider than the 500 metre diameter and deeper than the -9.2m LAT, used in the BMT WBM dredge calculations.

In fact, the capital dredge estimates from the 2006 GHD EIS and 2005 State Government IAS were based on channel and swing basins sizes that were already too small for the safe navigation of the cruise vessels of that era because incorrect formulas were applied to estimate channel dimensions in the Queensland Government's 2004 Malaysian *Navigational study Gold Coast Cruise Ship Terminal Queensland, Australia at Star Cruises Ship Simulator* study.

These mistakes were repeated and further compounded in the 2012 Meridian Maritime Services (MMS) 'Smartship Australia' Brisbane simulations in the report, *An investigation into the feasibility of piloting large cruise ships to and from a proposed terminal within the Gold Coast Broadwater.*

The flawed data in the two previous simulation reports resulted in underscored channel dimensions as revealed when using Royal Caribbean's Australian summer-cruise season vessel, 'Voyager of the Seas' as an example:

Voyager of the Seas: 311.12 metres length overall (LOA);

38.6 metres beam;

8.6 metres draft.

The following channel dimension calculations were made under the guidelines of:

The Permanent International Association of Navigation Congresses (PIANC), an Association that inter alia sets guidelines for Approach Channel Design Parameters.

'Voyager of the Seas' with a beam of 38.6 metres (x 4.3) requires the Approach and Seaway Channels to be 166 metres wide (not 140m as in the BMT WBM report).

'Voyager of the Seas' with LOA of 311.12 metres x average 1.9 (1.8 to 2.0 times LOA) requires a Swing Basin of 591 metres diameter (not 500m dia. in BMT WBM)

Based on the same PIANC guidelines the 'Queen Mary' at 345m LOA would require a swing basin of 655.5 metres diameter.

There is also the question of the depth of channels. The 2004 Malaysian Navigational study used the following dimensions in simulations:

-12m LAT for the Approach Channel;

-12m LAT for the Seaway Channel;

-10m LAT for the Swing Basin;

500 metre diameter for the Swing Basin

130 metres width for both Outer (approach) and Seaway (inner) Channels

Based on PIANC guidelines it is recommended that ‘Voyager of the Seas’ requires a minimum -10.6m LAT in the Swing Basin to achieve the recommended safe 2 metre under keel clearance (UKC) at LAT (not -9.2m LAT as in the BMT WBM report).

The increase in the drafts of more recently constructed cruise vessels will require new calculations for channel depths to achieve the recommended safe 2.0 metres UKC, especially vessels with drafts greater than 10.4 metres (Queen Mary)

These channel depths also need to take into account the increases in vessel drafts caused by heeling, squat, turning and winds. These factors will further increase the draft of vessels beyond their construction dimensions while attempting to enter ports and during the processes of docking in the highly active wind, swell and wave climates experienced on the Gold Coast.

Therefore, newer vessels with greater than 345 metres LOA (sometimes described as mega-cruises) are more likely to require Approach Channel depths of -13m to -15 m LAT; Swing Basin depths in excess of -12m LAT and Swing Basin diameters greater than 656 metres, as demonstrated using 'Voyager of the Seas' and the 'Queen Mary' as examples.

See, *A Critical Analysis of the 2012 Meridian Maritime Services Navigational Report* (p.10-14) at: http://www.saveourspit.com/No_Terminal/resources/2012-CST-Nav-Report-Analysis.pdf

The annual maintenance dredging estimates proposed by BMT WBM contained further inaccuracies because they were based on the 2006 Notional Gold Coast Marine Development's single location option for a cruise ship terminal at the far northern-end of The Spit:

> In 2006, a Notional Seaway EIS (GHD 2006) considered a single cruise Ship terminal. Two-dimensional hydrodynamic and wave modelling and a conceptual analysis of sediment transport were used to assess impacts of the development. An annual rate of 350,000cubic metres/annum maintenance dredging was estimated based on this assessment, with 200,000cubic metres/annum inside the Seaway and 150,000cubic metres/annum in the outer approach channel. (BMT WBM 2013, p.32)

The above-mentioned estimates, applied by BMT WBM in their calculations, do not take into account the southern Broadwater location options (Options S2 & S3) for a cruise ship terminal as proposed in the 2012 Broadwater Marine Project. These two cruise terminal options would require additional capital and maintenance dredging of southern channels beyond that of the Seaway and Outer Approach Channels mentioned above in terminal location Option S1 in the BMP.

BMT WBM estimated the following in regards to the amount maintenance dredging required of the Outer Approach Channel based on the previous MMS navigational study dimensions recommending 140metres channel width, dredged 12m below the lowest astronomical tide (LAT):

> The predicted average rate of sedimentation of the outer channel has been assessed to be in the range of ≈ 150,000-250,000cubic metres/annum. (BMT WBM 2013, p.102)

The 2005 Initial Advice Statement (IAS) for the 'Gold Coast Marine Development Project' states:

> An initial estimate of the rate of this sedimentation is about 250,000cubic metres/yr. However, importantly more than 20% (50,000cubic metres) of this may be deposited in a short period (e.g. one week) during a major storm event which could be expected to occur every 1 to 2 years on average. During an extreme event such as a cyclone, in excess of 100,000cubic metres may be deposited over the duration of the storm. (Qld. Govt. IAS 2005, p.4-6)

BMT WBM concedes that in relation to the potential infill of the Outer Approach Channel:

> It is considered possible that single large events such as the March 2006 or May 2009 storms could cause up to 100,000cubic metres of sedimentation. (BMT WBM 2013, p.102)

Therefore, a single weather event could cause the proposed Outer Approach Channel for the 2012 Broadwater Marine Project to infill with 50,000 – 100,000cubic metres of sediment, an additional 20% - 50% of the annual maintenance dredging estimate. This information has huge implications for the viability of the Gold Coast as a safe and reliable cruise destination, as concluded in the 2005 IAS:

> The excavation of a channel to -12.0 LAT will cut across essentially the entire sand transport zone. The channel will effectively intercept and trap the majority of any sand transported to it from upcoast and downcoast directions. (Qld. Govt. IAS 2005, p.4-6)
>
> While the requirement for additional dredging may reduce in time, there would still be a risk of not maintaining the necessary navigation depth. (Qld. Govt. IAS 2005, p. 4-7)

Storm Surge and Flood Mitigation

The BMT WBM report claims:

> The efficiency of storm surge propagation into and out of the Broadwater will be increased by the dredging, as will the release of flood water. (BMT WBM 2013. P. 70 6.5)

and

> Tidal range within the Broadwater is predicted to increase by 1-5cm. The magnitude of the impacts depends on the extent of the dredge footprint within the Broadwater (larger footprint generates larger impact). (BMT WBM 2013. P. 117 10.1)

The BMT WBM report fails to acknowledge that on the Gold Coast a storm surge is regularly accompanied by flood waters; that is, these events often occur in tandem not as separate events. And an estimated 1-5cm increase in tidal range based on the Broadwater's existing 1.0 – 1.5m tidal range is potentially a 3-5% increase in tidal range which has strong implications for potential flooding of existing canal and waterside properties.

Coffee Rock and Acid Sulphate Indurate

In terms of the geomorphology of the Seaway and Broadwater, BMT WBM relies substantially on a 2006 GHD sediment sampling report but admit:

> The extent of sampling undertaken for the Notional Seaway Project EIS covers the footprint of Options S1 and S3 shortlisted in this study, however the south channel dredge area of Option S2

> is not covered by GHD sampling and analysis. The presence of coffee rock and/or PASS [acid sulphate soil] within the Option S2 South Channel Dredge cut would need to be established with borehole sampling. (BMT WBM 2013. P.97 8.1)

BMT WBM’s preliminary assessment should have included such sampling in the South Channel dredge area, especially as it is well known by local sand-miners that ‘Parrot Rock’ is an acid-sulphate ridge that runs under the current recreational boat channel depths (-4.5m LAT) from Nind Street on the Southport side of the Broadwater, east across the Broadwater to Seaworld on the west side of the Spit.

Even in ‘Preliminary Investigations’, global best industry practice requires a toxicology expert to be engaged and samples taken to assist in the assessment of the likelihood of acid-sulphate and other sediments in all proposed channel dredge areas. BMT WBM failed to employ such actions.

Contradictions and Ambiguities

Despite BMT WBM’s earlier claims that a deeper Approach channel ‘would limit wave breaking’, they later suggest:

> The model also predicts that wave penetration in through the Seaway entrance may be substantially higher due to the approach channel dredging, which may have implications for vessel mooring and shoreline stability along Wave Break Island. (BMT WBM 2013. P. 102 8.6)

The report fails to note that this ‘wave penetration’ may also have implications for the safe navigation of cruise vessels through the Seaway.

And the BMT WBM ‘investigations’ verge on negligence if they expect readers of their report to make an informed decision regarding the impacts of channel dredging for cruise vessels during storm events and storm surge with the following confused and ambiguous statement:

> It is evident that a dredged cruise ship channel has potential to reduce storm surge impacts for some storm events and also increase storm surge impacts in other storm events. (BMT WBM 2013. P. 117 10.1)

BMT WBM then signals a perceived need for:

> stabilisation of foreshore areas that may be prone to increased erosion. An example of one of these locations might be the eastern foreshore of Wave Break Island. Stabilisation might involve soft options (e.g. nourishment) or hard options such as revetments or a combination. Hard options would need to be carefully assessed in order to demonstrate that the mitigation works themselves do not have substantial negative impacts. (BMT WBM 2013, p.115)

It is well-documented that the design parameters for the 1985-86 construction of the Gold Coast Seaway included the topping up of an existing Broadwater sandbank with dredge spoils to create Wave Break Island. This sand-island was created to act as a buffer to absorb the energy of storm surge and cyclone swells, thus protecting the structures of western Broadwater revetment walls from being undermined and preventing properties from water inundation, damage and/or destruction.

> Wave Break Island was created in the process using sand spoil from channel dredging. As the name suggests, the purpose of this island is to absorb the energy of ocean waves entering the Broadwater via the Seaway. (Qld. Govt. IAS 2005, p.1-2)

The construction of 'hard options', as suggested by BMT WBM, would in fact work directly against the engineering purposes of Wave Break Island.

The BMT WBM report 'Summary' also contains an unscientific 'each-way bet' regarding the effects of channel dredging on the stability of the Seaway training walls:

> Modelling suggest that the training wall stability should not be significantly altered by the proposed channel. However, the stability is currently assessed to be marginal and stabilisation works may be necessary in the event of any potential disruption to the system, such as induced by dredging. (BMT WBM 2013, p. 118)

The BMT WBM report 'Summary' fails to address the likely effects of the operation of modern cruise vessel bow-thrusters on the stability of the training walls, dredged channel batter-slopes and the marine environment and dismisses other vessel operation impacts with the following unsupported statement:

> Vessel operation impacts on the physical environment (due to wake and wash) should be able to be readily mitigated at the detailed design stage. (BMT WBM 2013, p.116)

BMT WBM also claims that:

> Extension of the sand-bypass system may have potential to reduce the size and volume of the storm bar which generates the majority of the storm induced sand transport to the Seaway delta. (BMT WBM 2013, p.116)

However, the above-stated conclusion by BMT WBM ignores existing information contained in the 2005 Queensland Government *Initial Advice Statement*:

> Extending the sand bypassing system alone (without extending the southern training wall) is not a viable option. It would necessitate similar mobile dredging to the dredging only scenario initially, with the additional cost and limited benefit of the extended bypassing system. (Qld. Govt. IAS 2005, p.4-7)
>
> It is considered that extension of the southern training wall by 300m to 400m would provide substantial benefit by extending across the primary long-shore transport zone… (Note that the extension of the southern training wall by about 700m would be required to reach the -12.0m LAT contour). (Qld. Govt. IAS 2005, p.4-8)

While extension of the training walls would conceptually provide a longer channel and added resistance with the potential for increased flood levels, this would somewhat be offset by the dredged/scoured channel. (Qld. Govt. IAS 2005, p.4-5)

Conclusions

Boussinesq wave modelling should have been employed as a first priority in BMT WBM's 'Preliminary Investigations', rather than the veiled plea for future contracts from the GCCC contained in the following statement:

> it is expected that further studies will be undertaken as a part of assessing the options for a future Gold Coast Ship Terminal' (BMT WBM 2013. P. 119 10.3)

As a matter of maintaining industry and scientific standards in these 'Preliminary Investigations', the GCCC should have demanded that BMT WBM employ,

> Alternative wave transformation modelling (Boussinesq or similar) in order to verify SWAN wave impact predictions. (BMT WBM 2013. P. 119 10.3)

In fact, the SWAN modelling conducted by BMT WBM did no testing of wave reflection or partial reflection and therefore could not possibly 'verify…wave impact predictions' at the entrance to the Gold Coast Seaway.

The following directions from industry experts again reinforce the inadequacies of the BMT WBM investigations:

> Appropriate validation of numerical models for complex refraction processes near dredged channels and basins is essential to have confidence in operational and extreme wave climate predictions for a proposed port facility.

(Taylor et al. 2013. P.1)

> **Wave modelling using Boussinesq models can accurately replicate the refraction and reflection processes surrounding dredged areas and is a primary component of any port study.** However, due to the sensitivity of wave refraction in relation to wave period, water depth and wave direction, extensive modelling efforts are required to fully understand the wave interactions and the resulting impacts.

(Knight et al, 2013 p.1)

Furthermore,

> Understanding operational and extreme wave climates at berth and along wharf structures is a critical aspect of the site selection and engineering phases for developing an exposed, open water port facility. The extreme wave climate will impact on the design of any marine structure

and the day-to-day operational wave climate may impact on the port operability as short and long waves can induce unacceptable at-berth vessel motions.

(Taylor et al. 2013. P.1)

According to industry bench-marks, the likely minimum cost to the GCCC (and therefore the Gold Coast rate-payer) of commissioning the BMT WBM 'Preliminary Investigations' was approximately $75,000 - $90,000. Unfortunately, the BMT WBM report reveals a huge basic flaw with the choice of SWAN 'spectral wave modeling' rather than the Boussinesq modeling as advised, recommended and validated by the global coastal engineering industry.

In addition to ignoring information in existing reports such as the 2005 Queensland Government *Initial Advice Statement*, the BMT WBM report is full of quantitative data and statistical information when the statistics lean towards potentially positive outcomes for cruise ship dredging on the Gold Coast and falls into qualitative and subjective generalizations or selective inclusion of information to underplay research results when the impacts tend towards the negative outcomes of cruise ship dredging and associated activities.

Therefore, the BMT WBM Gold Coast Broadwater - 'Preliminary Coastal and Hydrodynamic Investigations for Cruise Ship terminal Options -July 2013' is unreliable as an accurate assessment of the likely hydrodynamic effects of dredging and other engineering actions required for the construction of a cruise ship terminal on the Gold Coast Spit and Broadwater.

References and Works Cited

BMT WBM. Gold Coast Broadwater - *Preliminary Coastal and Hydrodynamic Investigations for Cruise Ship terminal Options -July 2013.* Gold Coast City Council, 2013.

Caspersen, Bo. Captain. *Navigational study Gold Coast Cruise Ship Terminal Queensland, Australia at Star Cruises Ship Simulator (Malaysia).* Queensland Government, 2004.

D. Taylor, J. Wiebe, D. Scott and S. Garber. *Physical Model Validation of a Boussinesq Wave Model for Exposed Channel and Port Environments.* Presented at the 'Coast and Ports 2013' Conference – Sydney, September 11-13th 2013.

GHD. *Notional Seaway Project Draft Environmental Impact Statement*. Gold Coast Marine Development Project Board, 2006.

Meridian Maritime Services. *An investigation into the feasibility of piloting large cruise ships to and from a proposed terminal within the Gold Coast Broadwater.* Gold Coast City Council, 2012.

Queensland Government. *Initial Advice Statement*. Gold Coast Marine Development Project, 2005

Sam J. F. Knight and Stuart H. Bettington. *Wave Interactions with Dredged Areas.* 'Case Study - Townsville Port Expansion'. Presented at the 'Coast and Ports 2013' Conference – Sydney, September 11-13th 2013.

SOSA, et al. *A Critical Analysis of the 2012 Meridian Maritime Services Navigational Report*. Save Our Spit Alliance, 2012.
(http://www.saveourspit.com/No_Terminal/resources/2012-CST-Nav-Report-Analysis.pdf)

Edited by Dr Steven Gration
BEd (Melb) PhD (Griffith)
November 2013