GREAT BARRIER REEF MARINE PARK AUTHORITY REVIEWER'S REPORT

Australian Government
Great Barrier Reef Marine Park Authority

PROJECT TITLE
Hay Point Maintenance Dredging: Dredge Plume Modelling Assessment

AUTHOR: Andy Symonds

ORGANISATION: North Queensland Bulk Ports

BRIEF OVERVIEW OF FINDINGS

Detailed findings are in a separate report

The overall report is well written and the approach to the dredging conceptualisation and sediment resuspension scenarios are well considered and sound. The models applied have the necessary physics and ability to model the behaviour of suspended sediment concentrations associated with dredging operations and resuspension weather and tide events.

An issue however is that there is no description of the 3D grid that was employed in the hydrodynamic modelling. There is a description of the horizontal 2D grid but there is a lack of detail about the vertical grid. The only reference is from the general model description.

"In the horizontal plane an unstructured grid is used, while in the vertical domain a structured mesh is applied (DHI, 2017a)." S3.2 P26

The report does not provide a clear indication of vertical shear and the existence of any bottom boundary layer at the timescales presented so that the significance or not of these phenomena is accounted for. Tidal currents can have significant phase lags in the current profile and can at times have reversals from top to bottom. These are important considerations that will impact SSC behaviour.

Regardless of the adequacy of the 3D hydrodynamic modelling the sedimentary module applied only uses the depth averaged hydrodynamics not the full water column profile.

"As all of the natural SSC simulations were undertaken in two dimensional depth averaged mode, all of the dredging runs are presented as depth averaged to ensure they are directly comparable to the natural conditions." P96 S7.1

Assumptions of other aspects of the model setup are appropriate and reasonable however the boundary forcing for waves is less than optimal. The Mackay wave rider buoy to the north is used to force the deeper southern boundary.

The model in general does perform well in the validation exercises however there are some areas that should be improved in any future effort. The short period spiking in SSC at key resuspension events are not well replicated by the model.

The availability of data for validation and calibration of currents and SSC is limited and spread across a number of years rather than simultaneously made. It is recommended that a more comprehensive spatial and concurrent set of observations be made over periods long enough to capture all weather conditions that impact Hay Point are made to improve any future modelling and inform any dredging campaigns in the future.

As presented this report needs to provide further clarification and justification as there remains uncertainty over the adequacy of the 3D hydrodynamic model implementation and that:

"The sediment transport model of natural conditions was setup in two dimensional depth averaged model as the underlying equations were all derived in two dimensions." S4.5 P66

The comment P96 S7.1: "As all of the natural SSC simulations were undertaken in two dimensional depth averaged mode, all of the dredging runs are presented as depth averaged to ensure they are directly comparable to the natural conditions." Assumes that SSC is uniform through the water column. This assumption needs rigorous validation.

Further details are provided in the accompanying detailed report.

OVERALL ASSESSMENT: Adequately meets requirements, with modification

NAME OF REVIEWER*	TITLE	INSTITUTION
Craig Steinberg	Mr	Australian Institute of Marine Science
Richard Brinkman	Dr	Australian Institute of Marine Science

(*Please complete your details, noting that* *review are provided anonymously)

Please return this form and the report to:

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INSTRUCTIONS TO EXPERT PEER REVIEWER

Background
The Authority requires expert peer review of the Hay Point Maintenance Dredging – Dredge Plume Modelling Assessment report (the report) as part of a ten year maintenance dredge and disposal permit application. The report forms a critical part of the predicted impact of the dredging activity and the management of potential impacts. The report is 239 pages in length plus references and appendices. The report has a large number of dredge/weather scenarios and figures.

The report specifically compares the modelling approach used in the report to the GBRMPA Hydrodynamic Modelling Guidelines (Table 24, pg 94). Please ensure the report meets these guidelines (Guidelines for the Use of Hydrodynamic Numerical Modelling for Dredging Projects in the Great Barrier Reef Marine Park), and where it does not, assess if there is a material effect on the prediction of sediment transport and deposition. These guidelines and the expert opinion of the peer reviewer(s) should be used to decide if the report adequately meets requirements or not (see previous page). Please provide a detailed report of the assessors' findings as an appendix.

Please assess all the technical aspects that are relevant to the results and conclusions drawn within the report. The criteria outlined below should be considered in addition to the expert assessment.

In addition to your expert assessment, please address these criteria when conducting your assessment –

1. Baseline information on site/environmental conditions
    a. Is the baseline site/environmental data used within the model, and the period of time that it was collected, sufficiently representative of all possible weather/metocean events to reasonably predict sediment plumes, deposition and long term resuspension of sediment caused by dredging/disposal to be undertaken periodically over a ten year period?
    b. Have all seasonal and multi-year climatic variables been accounted for in the environmental data and represented in the model outputs?
2. Modelling approach
    a. Is the numerical model used for the report adequate to predict sediment transport for the dredging/disposal activity and has it been sufficiently tested in similar applications?
    b. The majority of the hydrodynamic and sediment plume modelling conducted is 3D, however the long-term resuspension model is 2D depth averaged. Does this have a material effect on the prediction?
    c. Have all relevant impact pathways (e.g. SSC, sediment deposition etc) been accounted for within the model?
    d. Are the assumptions reasonably conservative?
3. Dredging description
    a. Is the predicted sediment composition reasonably supported?
    b. Is the dredging approach realistic in the context of the proposed dredging activity described in the Introduction?
4. Model Calibration and Validation
    a. Is the level of accuracy demonstrated through calibration and validation reasonably adequate to reliably predict sediment transport from the dredging activity to be undertaken periodically over a ten year period?
5. Results and Conclusions
    a. Are the conclusions supported by the results?
    b. Have any results or conclusions not been reported that may be relevant to impacts on the environment?

Australian Government

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

Review of Report:
Hay Point Maintenance Dredging Dredge Plume Modelling Assessment

REPORT PREPARED FOR GBRMPA

Craig Steinberg and Richard Brinkman

AIMS: Australia's tropical marine research agency

Townsville
2018

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	Approved by:	*Richard Brinkman*	*7/06/2018*	Final
2				

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Background

The GBRMPA requires expert peer review of the Hay Point Maintenance Dredging – Dredge Plume Modelling Assessment report (the report) as part of a ten year maintenance dredge and disposal permit application. The report forms a critical part of the predicted impact of the dredging activity and the management of potential impacts. The report is 239 pages in length plus references and appendices. The report has a large number of dredge/weather scenarios and figures.

The report specifically compares the modelling approach used in the report to the GBRMPA Hydrodynamic Modelling Guidelines (Table 24, pg. 94). The report must meet these guidelines (Guidelines for the Use of Hydrodynamic Numerical Modelling for Dredging Projects in the Great Barrier Reef Marine Park), and where it does not, assess if there is a material effect on the prediction of sediment transport and deposition. These guidelines and the expert opinion of the peer reviewer(s) should be used to decide if the report adequately meets requirements or not.

This report assesses all the technical aspects that are relevant to the results and conclusions drawn within the report. The criteria outlined below has also been be considered in addition to the expert assessment.

Review Criteria Assessment

1. ***Baseline information on site/environmental conditions***
    a. ***Is the baseline site/environmental data used within the model, and the period of time that it was collected, sufficiently representative of all possible weather/metocean events to reasonably predict sediment plumes, deposition and long term resuspension of sediment caused by dredging/disposal to be undertaken periodically over a ten year period?***

        The availability of data for validation and calibration of currents and SSC is limited at the Hay point location requiring access to data further north as far as Mackay and is spread across a number of years rather than a more preferable situation where multiple site, long term observations were made over a common period.

        In spite of these limitations the available data is considered adequate and the model cal/val undertaken takes a sensible approach to deal with the staggered observations. The report covers the most important weather and metocean events required for planning the dredging/disposal over the 10 year period.

The existence of an offshore branch of the EAC in the outer lagoon has not been included in the modelling and is justified in this case as its impact on this exercise would be negligible.

It is recommended that a more comprehensive spatial and concurrent set of observations be made over periods long enough to capture the most significant weather conditions that impact the Hay Point locale rather than further afield and are made to improve any future modelling and inform any dredging campaigns in the future.

b. Have all seasonal and multi-year climatic variables been accounted for in the environmental data and represented in the model outputs?

The seasonal and multi-year climatic variables that are relevant to this study have been accounted for.

2. Modelling approach

a. Is the numerical model used for the report adequate to predict sediment transport for the dredging/disposal activity and has it been sufficiently tested in similar applications?

Yes – subject to the implementation issues identified in 2b.

b. The majority of the hydrodynamic and sediment plume modelling conducted is 3D, however the long-term resuspension model is 2D depth averaged. Does this have a material effect on the prediction?

Clarification is needed over the 3D grid specification and time stepping to resolve spatial and temporal resolutions. The technical requirement for 2 grid cells with the shipping channel does not seem to have been met in the outer channel.

All SSC simulations (not just the long term re-suspension model) however use 2D depth averaged currents from the 3D model. The significance of this simplification needs to be ascertained. It may be acceptable in shallow regions however it may have ramifications in the deeper offshore areas such as the outer DMPA in 25-20m of water.

A 2D depth averaged model run for the longer term 12 month run is deemed to be acceptable.

c. Have all relevant impact pathways (e.g. SSC, sediment deposition etc.) been accounted for within the model?

Yes.

d. Are the assumptions reasonably conservative?

Yes.

3. ***Dredging description***
    a. ***Is the predicted sediment composition reasonably supported?***

        Yes. Detail on the assumptions, approach was adequately provided and informed by analysis of sediment samples.

    b. ***Is the dredging approach realistic in the context of the proposed dredging activity described in the Introduction?***

        Yes.

4. ***Model Calibration and Validation***
    a. ***Is the level of accuracy demonstrated through calibration and validation reasonably adequate to reliably predict sediment transport from the dredging activity to be undertaken periodically over a ten year period?***

        Yes it is reasonably adequate. However some further investigation is warranted to improve model performance for short timescale spiking events and to improve wave boundary forcing.

5. ***Results and Conclusions***
    a. ***Are the conclusions supported by the results?***

        Yes.

    b. ***Have any results or conclusions not been reported that may be relevant to impacts on the environment?***

        No.

GBRMPA Hydrodynamic Modelling Guidelines

Table 24. P94 of the report summarises the approaches the authors have taken to ensure the relevant requirements of the GBRMPA Hydrodynamic Modelling Guidelines have been met.

This has been reproduced below:

Table 24: Details as to how the modelling relates to the GBRMPA modelling requirements.

Relevant Requirement (GBRMPA, 2012)	Adopted Modelling Approach
3D hydrodynamic and sediment transport modelling is required.	All of the modelling has been undertaken using 3D hydrodynamic and sediment transport models.
Hydrodynamic model should take into account the tides, the wind, the waves and the mean prevailing circulation and potential stratification from river discharges.	The hydrodynamic model has been setup and calibrated to include astronomical tides, wind and waves. The GBR Lagoon circulation processes do not influence this area and so no mean prevailing circulation will be included (see **Section 2.3**). Stratification from river discharges is not required due to the setting of the Port of Hay Point and the proposed material placement sites.
The model must be calibrated and validated against collected baseline information.	The hydrodynamic, wave and sediment transport models have been calibrated to measured data (collected using ADCPs and WRBs) to demonstrate that the model can accurately replicate the natural conditions (see **Section 4**). The plume model has been validated based on observations during a previous maintenance dredging campaign.
The modelling must include all types of potential resuspension including current and wave-induced bottom shear stress and wave-induced mud fluidization.	These are included in the modelling as both currents and waves are included as driving forces for the sediment transport model. The MIKE3 FM MT module also includes liquefaction by waves as a weakening of the bed due to the breakdown of the bed structure.
Baseline data must at a minimum be twice the duration of the dredging campaign. Data must be measured in close proximity to the disposal sites and include tidal range, wave height, current, wind direction and intensity and sediment dynamics.	Six months of hydrodynamic data was collected in the area from August 2011 to May 2012, and a further three months from January 2017 to April 2017. Measured directional wave data at the Hay Point WRB is available from 2008. Ambient water quality monitoring has been ongoing for the last three years.
Sediment transport modelling must consider the range of particle sizes and take into account the process of flocculation.	The sediment transport modelling considers all clay and silt sized sediment (makes up between 80 and 90% of the maintenance dredge material). The process of flocculation has been included for the silt and clay particles.

It is the considered opinion of the reviewers that the above self-assessment is accurate and adequate except in the following areas:

1 - The sediment transport models have used depth averaged current from the 3D hydrodynamic model rather than the required 3D current profiles.

Vertical shear and the existence of any bottom boundary layer are likely to be of significance in the controlling the behaviour of SSC. Tidal currents can have significant phase lags through the current profile and can at times have reversals at different water depths. These are potentially important considerations that will impact SSC behaviour, particularly for near bed processes at deeper disposal areas.

The comment P96 S7.1: "As all of the natural SSC simulations were undertaken in two dimensional depth averaged mode, all of the dredging runs are presented as depth averaged to ensure they are directly comparable to the natural conditions." Assumes that SSC is uniform through the water column. This assumption needs more rigorous validation.

2 – The model does not perform well in simulating the observed short time-scale spiking during some weather events as acknowledged by the authors and some underestimation of waves is apparent.

3 - Need clarification that the wave-current interaction that improved the model performance was included in the SSC model runs not just for the validation run. See S4.41 P59.

4 – The baseline observational current data is borderline in adequacy due to its patchiness and being spread out over a number of years. The authors have however done well to bring it all together for the cal/val.

Detailed Expert Assessment.

The overall report is well written and the approach to the dredging conceptualisation and sediment resuspension scenarios are well considered and sound. The models applied have the necessary physics and ability to model the behaviour of suspended sediment concentrations associated with dredging operations and resuspension weather and tide events.

An issue however is that there is no description of the 3D grid that was employed in the hydrodynamic modelling. There is a description of the horizontal 2D grid but there is a lack of detail about the vertical grid. The only reference is from the general model description.

"In the horizontal plane an unstructured grid is used, while in the vertical domain a structured mesh is applied (DHI, 2017a)." S3.2 P26

S4.3.2 Figures 32-40 shows near bed, mid and near surface observations vs model however all others throughout the report are mid column or depth averaged. Figures 32-40 do not provide a clear indication of vertical shear and the existence of any bottom boundary layer at the timescales presented. More highly resolved temporal plotting of the vertical profiles of observed and model current would be informative to indicate the significance or not of these phenomena. Tidal currents can have significant phase lags in the current profile and can have reversals from top to bottom. These are important considerations that will impact SSC behaviour however any appraisal of that remains lacking.

Regardless of the adequacy of the 3D hydrodynamic modelling the sedimentary module applied only uses the depth averaged hydrodynamics not the full water column profile.

"As all of the natural SSC simulations were undertaken in two dimensional depth averaged mode, all of the dredging runs are presented as depth averaged to ensure they are directly comparable to the natural conditions." S7.1 P96

It is possible a pseudo 3D model effect is achieved by applying some form of profile that includes a bottom boundary layer, however the 3D hydrodynamic model should be providing the full dynamic water column structure. There is no information supplied on the details of the physical assumptions behind this component of the modelling just a reference to the commercial software. See Section S3.3 P27 & P32

Assumptions of other aspects of the model setup are appropriate and reasonable however the boundary forcing for waves is less than optimal. The Mackay wave rider buoy to the north is used to force the deeper southern boundary. The buoy data would have been affected by shoaling and have limited swell propagation through Capricorn Channel than what would be incident at the southern boundary when that was significant.

The model in general does perform well in the validation exercises however there are some areas that should be improved in any future effort. The short period spiking in SSC at key resuspension events are not well replicated by the model.

The availability of data for validation and calibration of currents and SSC is limited and spread across a number of years rather than simultaneously made. It is recommended that a more comprehensive spatial and concurrent set of observations be made over periods long enough to capture all weather conditions that impact Hay Point are made to improve any future modelling and inform any dredging campaigns in the future.

As presented this report needs to provide further clarification and justification as there remains uncertainty over the adequacy of the 3D hydrodynamic model implementation and that:

"The sediment transport model of natural conditions was setup in two dimensional depth averaged model as the underlying equations were all derived in two dimensions." S4.5 P66

Specific Comments:

S2 P9: Long met and wave records. Currents patchy Jan-Apr 2017 off Mackay & Sep –Nov 2011-2012,

S2.3 P9: "only one tidal current direction for each tidal cycle" inference only one tide – but it was still there it was just dominated by the wind. Would have also had an effect on the wave height

P10 & Fig 8 P13: these do use coastal stations to influence the estimation of altimeter derived geostrophic currents. It is very much tide and wind dominated in the shallow coastal region. The Coral Sea circulation is more about the SEC forming the EAC along the outer GBR that can also drive a lagoonal branch along the lagoon inside of the outer reef matrix (Brinkman et al 2006)

P14: Characterisation of east to west movement of cyclones is typical e.g. TC Hamish and many other tracks

S2.9 P20: WQ & deposition 2014-17 by JCU – frequency of sampling unknown.

P21 Fig 16: A better explanation of the box & whisker plots are needed – definition (fig 17 does better). Would like to see the sampling locations and depth of water for each site.

P24: Replace 'reliability' with reliably

P27 S3.3: Only a 2D horizontal grid specified for MIKE3 hydrodynamics =>3d for MIKE21 wave & MIKE3 Mud. Only the horizontal grid is defined – no mention of the vertical resolution

P28 Fig 21: horizontal grid – 2 cells in the channel? 60m is the average size in the HTTH

P29 S3.4: Nav charts and local surveys – why not Beaman 3DGBR 100m or now the 30m interpolated grid?

P30 3.6: How were tides forced for the offshore/east boundary?

P30 3.7: the use of a non-spatially varying wind isn't well argued nor evidence provided. SE trades correlate well over the entire region but sea breeze and storm/cyclone events are key events with more complex structure in any resuspension

P30 S3.7: Wind stress units are missing. Wind stress is the square of the wind – so not sure why a linear interpolation was used. Are we talking about the wind stress coefficient here? Needs clarification.

P30 S3.8: The justification for using the Mackay waverider buoy located at the northern end of the grid as a boundary condition has little evidence of adequacy for the southern and eastern model boundary.

P32: 2D runs to keep the long term model runs manageable. There will still be boundary layers. Current variability within the profile – especially at the deeper off shore site in 25-30m is likely.

P34: S4.3.1: water level validation 2 weeks over 2 periods Sep and Nov 2011 & 1 month in March 2017 TC Debbie – goes into April though (Mar 23-Apr 7 as an extratropical low)

P36 Figs 24-29, 30-31: should also plot the residuals on the same plot scale to more easily identify the timing and amplitudes

P40: high winds should include strong SE Trades not just TCs

P36 Figs 32-40: Should show winds to assist with determination if residuals are from them – and again the residual currents – preferably along the tidal principal component directions

Fig 41-46: Near bed & near surface - what height? Are the top line plots current residuals? Not documented. Would be good to see a few plots showing the vertical profile from both the model and observations on a shorter time frame – e.g. turn of tide

P59 S4.4.1: Were wave-current interactions included in the final dredge model? Under-representing waves probably due to the use of Mackay waverider as forcing – waves would have shoaled at that location so when applied to the southern boundary forcing it is likely to be too weak.

P66 S4.5: Sediment model is 2D depth averaged

P69 table 19: Victor Island model is lower than obs. Obs higher at most locations except round Top Island – not all resuspension events replicated in the model. Concludes the short duration wind wave spikes are not replicated – just works on average

P89 S5.3: PSD acronym needs defining – only apparent in Fig67

P93: Results of water column effect of dispersion and advection suggested no different from a uniform release throughout the water column – but no evidence provided

P96 S7.1: "As all of the natural SSC simulations were undertaken in two dimensional depth averaged mode, all of the dredging runs are presented as depth averaged to ensure they are directly comparable to the natural conditions."