APPENDIX E

Port of Hay Point bathymetric analysis predictive model

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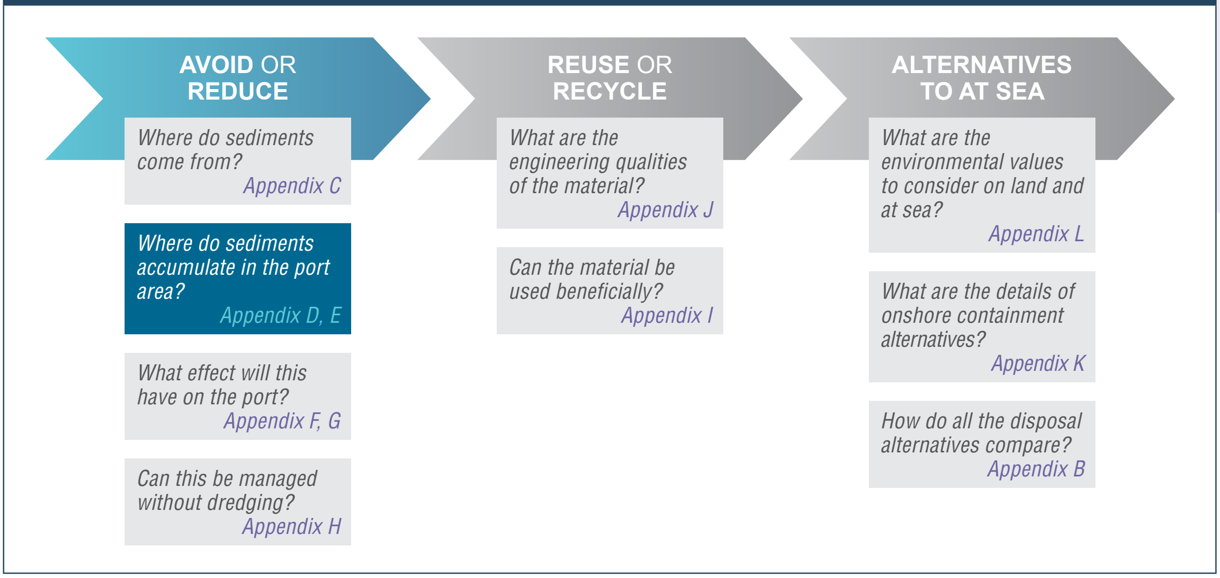
SYNOPSIS

Independent technical specialist

Royal Haskoning DHV | **4 March 2016**

Hay Point sustainable sediment management assessment approach



Purpose of study:

The purpose of this study was to develop a model that could predict future siltation within the maintained areas at the Port of Hay Point to assist with the strategic planning of future maintenance dredging activity at the Port.

The model will be updated periodically over the next 10 years, using the most recent bathymetric survey data.

Broad study approach:

Utilising results from the Port of Hay Point Bathymetric Analysis and Modelling Report (refer SSMA Appendix D), a model was developed using the industry standard Matlab suite which has a standalone Graphical User Interface (GUI). This programming environment was chosen as it is user friendly, easy to install, refinement is simple, and uses powerful graphical output and data export to common file structure.

The study report provides details on how to run the predictive model on a computer in detailed steps.

Key model assumptions:

The model assumed a conservative scenario for siltation resulting from tropical cyclones, based on lessons learned from TC Dylan and TC Ului. It assumed that large waves and strong winds generated currents, but did not directly impact Hay Point through erosion. It assumed that cyclones had an influence on other areas in the vicinity of Hay Point which mobilised a thick layer of bed sediment transporting this material to the Port and depositing it into the maintenance dredge areas.

Key findings:

This study was designed to develop a model which could predict and optimise future maintenance dredging requirements at the Port of Hay Point. Key steps included:

- Assessing dredging frequency
- Considering tropical cyclones
- Predicting future siltation rates using the model.

In the absence of cyclones (note: this work was undertaken pre-TC Debbie), maintenance dredging or other sediment management measures, the results predicted between 885,000m^3 and 1.2 Mm^3 of siltation above design depth occurring over a 20-year period (approximately 220,000m^3 to 300,000m^3 every five year period).

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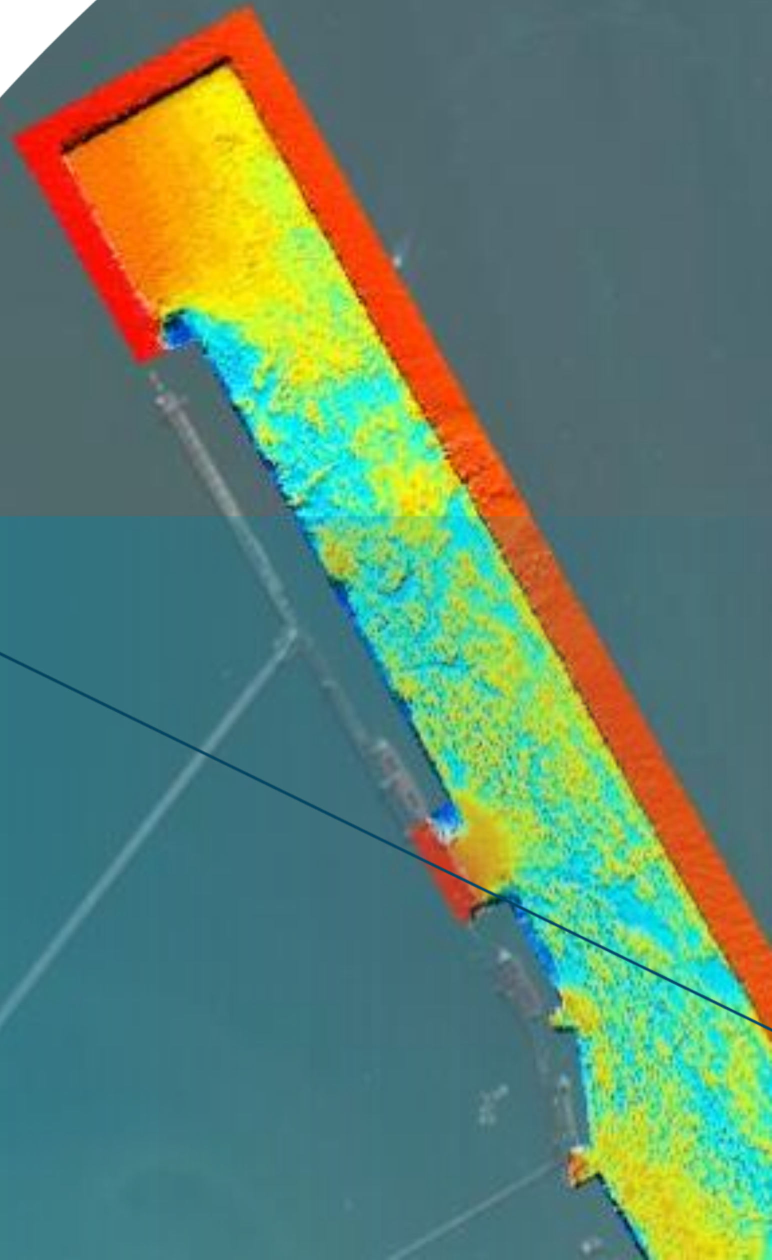
REPORT

Hay Point Bathymetric Analysis

Predictive Model

Client: North Queensland Bulk Ports Corporation

Reference: M&APA1163R001F01
Revision: 01/Final
Date: 04 March 2016



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Document title:	Hay Point Bathymetric Analysis
Document short title:	Hay Point Predictive Model
Reference:	M&APA1163R001F01
Revision:	01/Final
Date:	04 March 2016
Project name:	Hay Point Bathymetric Analysis
Project number:	PA1163
Author(s):	Andy Symonds, Heiko Loehr
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Date / initials:	04/03/2016
Approved by:	Dan Messiter
Date / initials:	04/03/2016

Classification
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Table of Contents

Table of Tables

Table of Figures

1 Introduction

1.1 Preamble

North Queensland Bulk Ports Corporation (NQBP) commissioned Royal HaskoningDHV (RHDHV) to undertake a study to better understand historic siltation in the channel, apron and berths at the Port of Hay Point. This study forms part of a larger investigation being undertaken by NQBP which focuses on the sustainable sediment management at the port.

This report addresses the third of the study aims detailed below:

1. to provide quantitative changes in bathymetry since the completion of the capital dredging work in October 2006;
2. to analyse the drivers behind the changes; and
3. to develop a predictive tool for use in future maintenance dredging decision making.

1.2 Port of Hay Point

The Port of Hay Point is located on the central east coast of Queensland, approximately 15km south of Mackay, and is one of the largest coal export ports in the world. It is located close to the neighbouring communities of Louisa Creek, Salonika Beach and Half Tide Beach, and is comprised of two separate export terminals, Dalrymple Bay Coal Terminal (DBCT) and Hay Point Coal Terminal (HPCT). Theseterminals service mines in the Central Bowen Basin of Queensland. The limits of Hay Point Port extend 1.75km offshore of the berths, 3.75km to the south of HPCT Berth 3 and 7.5km to the north-west of DBCT Berth 4 (**Figure 1**). The port lies within the Great Barrier Reef World Heritage Area (GBRWHA) but is excluded from the Great Barrier Reef Marine Park (GBRMP).

The port has a dredged departure channel, apron and seven berths; these are shown in hydrographic charts AUS249 and AUS250 in **Figure 1** and **Figure 2**, respectively.

Further details of the port,the natural environment and the associated processes where the port is located are provided in RHDHV (2016).

1.3 Report Structure

The report herein is set out as follows:

- details of the predictive model are provided in **Section 2**;
- an overview of how to use the model, an example dredging strategy and future predicted siltation are provided in **Section 3**; and
- details of the proposed future updates to the model, data requirements and associated costs are outlined in **Section 4**.

Unless stated otherwise, levels are reported to Lowest Astronomical Tide (LAT). Zero metres LAT is equal to Chart Datum (CD) at Hay Point. Volumes presented throughout are in-situ cubic metres.

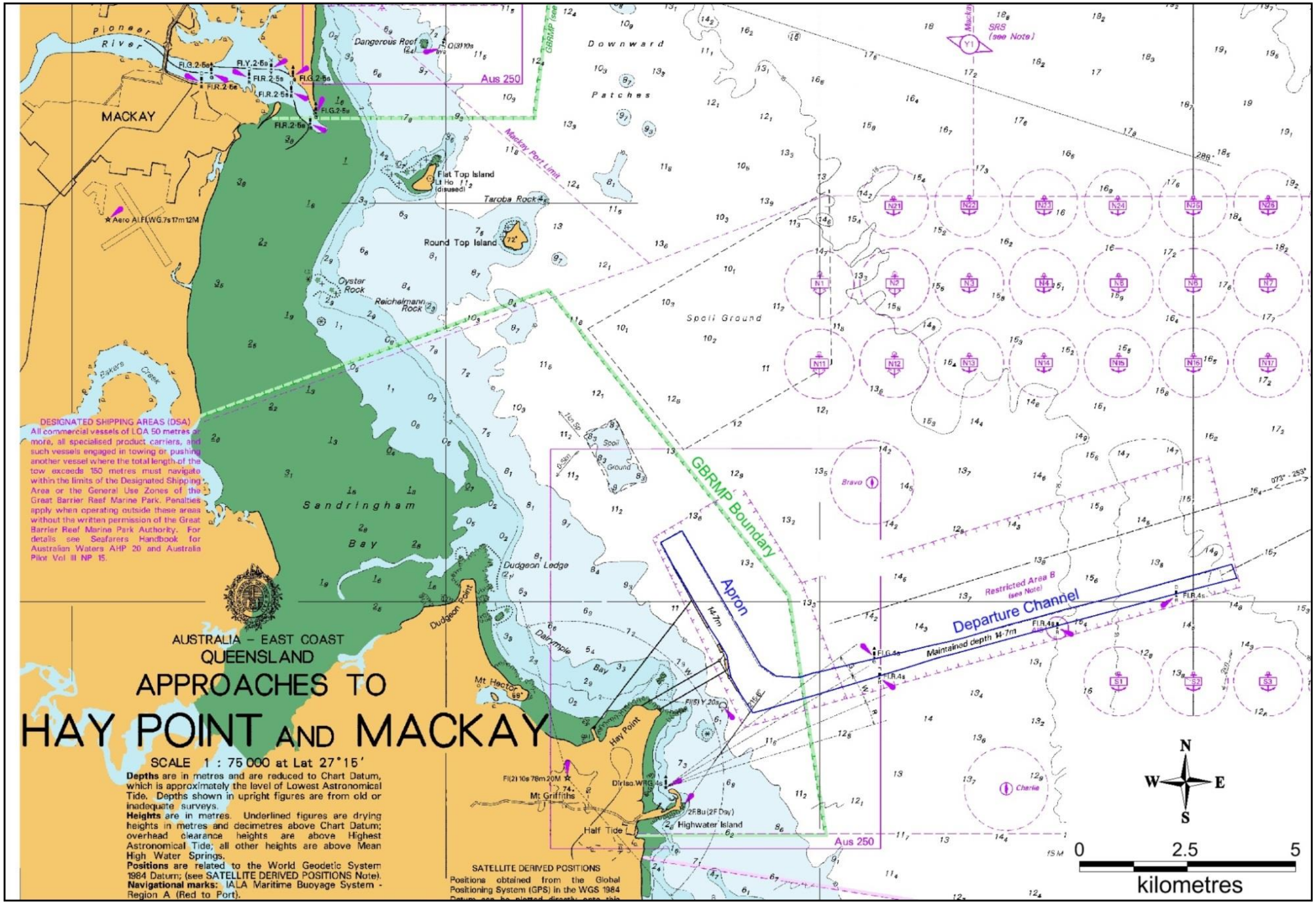

Figure 1. Location of Hay Point Port relative to the GBRMP. Note: the dredged areas are represented by the blue outline.

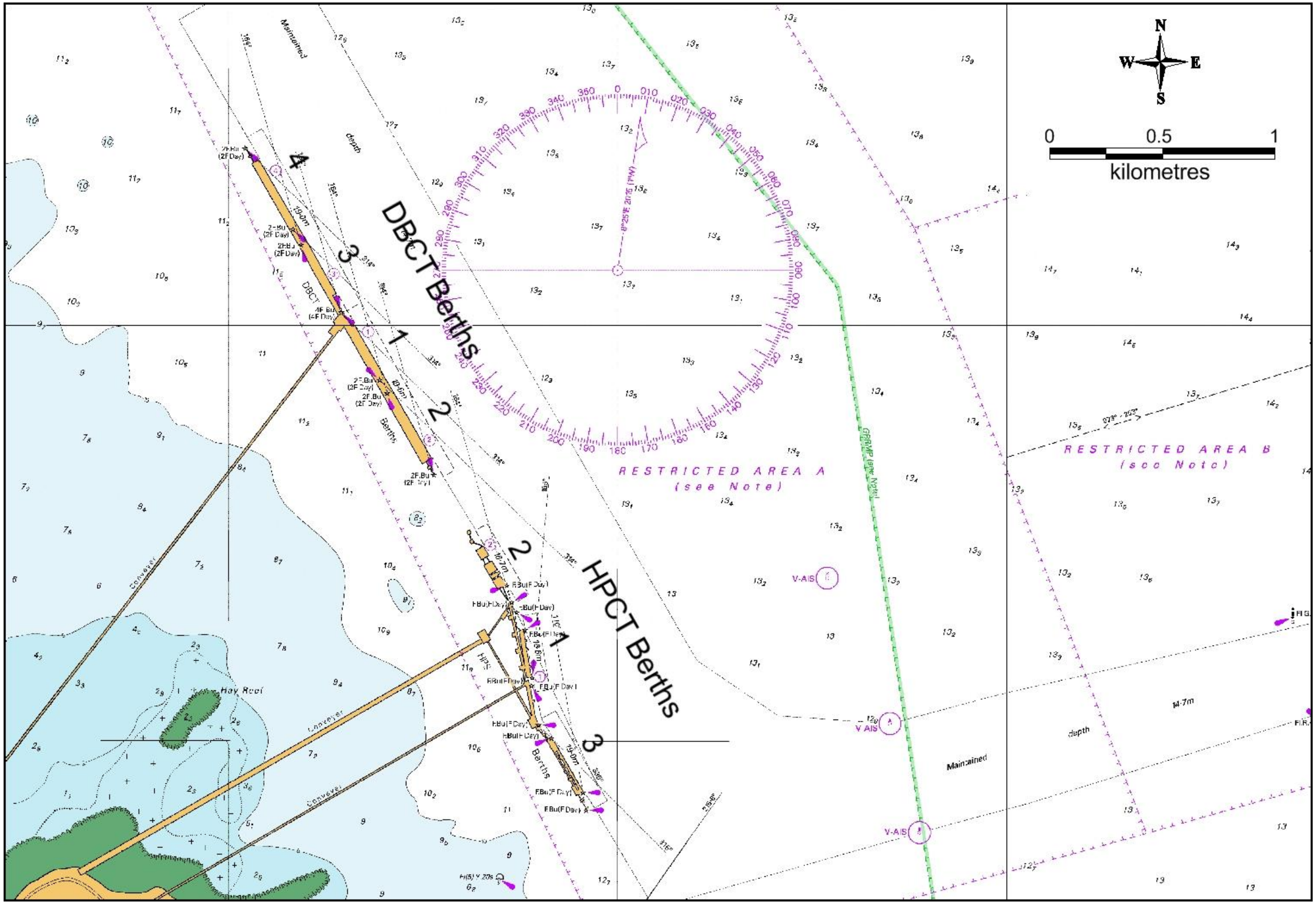

Figure 2. Configuration of the berths, apron and channel at Hay Point Port.

2 Predictive Model

2.1 Introduction

Based on the analysis reported in RHDHV (2016), a predictive model has been developed to predict future siltation within the maintained areas of the Port of Hay Point. As part of the analysis the areas of the port with maintained depths were split into a number of regions as shown in Error! Reference source not found.. The regions were selected based on results from the spatial change analysis as well as the configuration of the dredged areas. This allows volumetric changes to be calculated at a regional resolution as well as for the entire dredged area.

The analysis found that regular ongoing siltation only occurred in the berths and in areas of the apron. Accordingly, the predictive model is only able to predict future ongoing siltation in these areas. However, it can predict episodic future siltation in all areas due to tropical cyclones (to a low degree of accuracy due to limited data). The interactive model has been developed to provide a decision support tool to allow for strategic planning of future maintenance dredging activity at Hay Point.

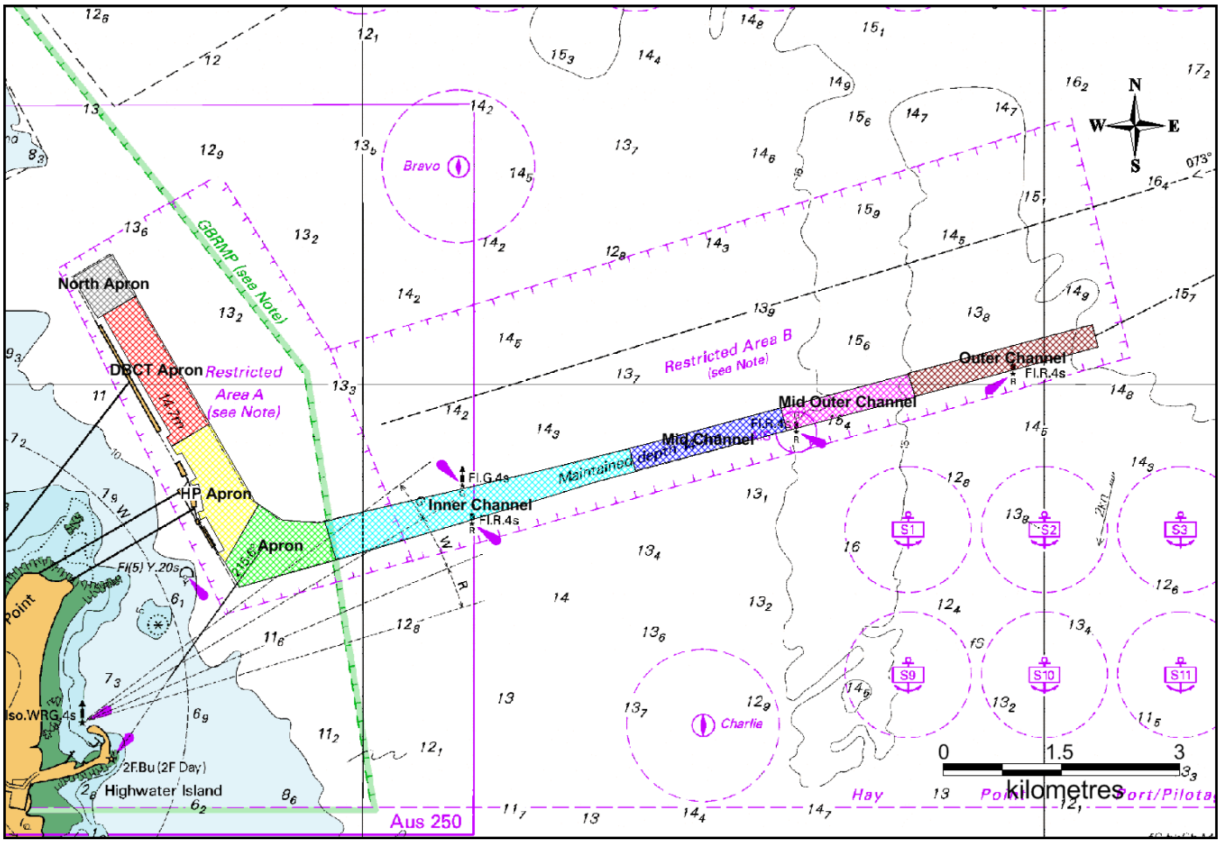

Figure 3. Regions used in the volumetric analysis.

2.2 Development

The analysis detailed by RHDHV (2016) showed that the key driver for sedimentation at the Port of Hay Point is the wave conditions, with no other natural drivers (vessel propeller wash is also a driver within the apron) resulting in resuspension and sedimentation. In addition, based on the available data it was not possible to identify a trend based on the ENSO state or the season.

Comparison of process and time based relationships for siltation reported in RHDHV (2016) showed that a time based relationship provides a greater level of accuracy based on the available data. On this basis, an approach incorporating the time based relationship was considered appropriate to adopt in the predictive model.

The siltation rates derived through the analysis for the areas subject to regular siltation are shown in **Table 1.** The r^2 value also presented, provides a statistical measure of how well the data fits to a linear regression line. The closer to 1, the better the fit, with a value of 1 representing an exact fit. The 95% confidence interval presented is discussed in **Section 2.3**.

Table 1. Estimated siltation rates North Apron and DBCT Berths.

Area	Siltation Rate (m^3/day)	r^2 Value	95% Confidence Interval (m^3/day)
North Apron	43.1	0.88	17.4
DBCT Berths 1&2	32.4	0.89	16.1
DBCT Berths 3&4	38.8	0.95	14.0

An additional area between the DBCT and HPCT berths (included in the DBCT Apron and HPCT Apron areas) was noted in the analysis as being subject to localised ongoing accretion. Further analysis of the data as part of the model development was undertaken for this area (called Apron 2 in the predictive model) and based on this a siltation rate of 1m^3/day was derived ($r^2 = 0.99$).

Two cyclones directly influenced Hay Point over the period of the surveys:

- TC Ului (2010): It was not possible to accurately determine the impact that TC Ului had on the bed elevation in the channel and apron as insufficient data was available (the post TC Ului survey was only 4 transects along the centre of the channel and the only available survey prior to the cyclone was 15 months earlier). However, based on the available information it appeared that TC Ului resulted in limited volumetric change in the departure channel; and

- TC Dylan (2014): TC Dylan resulted in erosion throughout the apron and departure channel with erosion of between 300,000 and 725,000m^3 (this range is due to uncertainty in the survey accuracy of the survey before TC Dylan). In the four months immediately after TC Dylan, accretion of 335,000m^3 occurred within the apron and departure channel.

Based on the limited data, the model has assumed a conservative scenario for siltation resulting from tropical cyclones. The model assumes that all future cyclones result in no erosion during the event and the same siltation which was experienced in the four months immediately after TC Dylan occurs. In terms of coastal processes this approach assumes that the large waves and strong wind induced currents resulting from a cyclone do not impact on Hay Point (and therefore there is no erosion). However, it is assumed these processes do influence other areas in the vicinity of Hay Point mobilising a thicker layer of bed sediment than typical conditions. Accordingly, over the period following a cyclone this material is transported to Hay Point and subsequently deposited in the dredged areas.

To enable the volumetric changes predicted for each region to be associated to a bed elevation change such that siltation can be related back to the design and/or declared depths, the following was undertaken:

- Relationships were developed between siltation volumes and the region spatial areas to allow a bed elevation change to be calculated. In the areas where ongoing siltation has occurred the relationships were between the historic siltation and bed elevation change. Historically, siltation in the North Apron has not been uniform, instead the siltation has resulted in a sloping bed with higher siltation occurring along the western (landward) side of the area. Accordingly, two relationships between siltation volumes and bed elevation where developed, the first determines the increase in bed elevation due to the siltation rate, and the second determines the volume of sediment above the design depth due to the predicted increase in bed elevation; and

- A representative existing bed elevation was defined for each region. For the areas which have been subject to regular ongoing siltation the bed elevation was selected to represent the shallower areas within the region where siltation occurs, while for the areas without regular siltation an average depth for the region was adopted.

The model has been developed to also allow planned maintenance dredging volumes to be included. Within the prediction period this allows simulation of the removal of sediment from the planned dredge areas so that the impact this has on the final maintenance requirement and bed elevations can be determined.

The model can also allow bed raking to either be included, or not, at the HPCT berths. The bed raking process has historically prevented siltation in these berths and so there is no historic siltation data available. In the model, the siltation rates adopted for the HPCT berths are based on the DBCT berth 1 and 2 rates. However, the rates have been scaled to account for the different sizes of the berths relative to the DBCT berths 1 and 2. Based on the spatial variability in siltation within the berths and apron it is likely that this rate will over predict the siltation in the HPCT berths. As no other data is available at this stage, this is considered to be the best approach to predict siltation when there is no bed raking.

2.3 Model Limitations

To represent the limitations and uncertainty associated with the siltation rates predicted by the model, 95% confidence intervals were calculated for the areas where regular siltation has occurred (North Apron and DBCT berths). These confidence intervals are presented in **Table 1, Section 2.2**. The 95% confidence interval represents the range of values (distributed equally above and below the mean value) that we can be 95% certain contains the true mean of the statistical population. The sample size is a major factor in determining the magnitude of the confidence internal, with smaller sample sizes resulting in larger intervals. Therefore, as additional siltation data becomes available the confidence intervals are expected to reduce and more confidence can be placed in the predictions.

As the data used to predict siltation resulting from tropical cyclones was only from one event it has not been possible to calculate statistical confidence intervals for the siltation from tropical cyclones. Based on this and the inherent uncertainty in predicting siltation due to extreme events, the 95% confidence interval was set to be the same value as the siltation. This reflects the uncertainty associated with these events as it indicates that the tropical cyclone could result in no siltation (as would be the case if the cyclone was erosional) or it could result in twice as much siltation as predicted based on TC Dylan.

3 Model Use

3.1 Installation

The model has been developed using the industry-standard Matlab suite and has a standalone Graphical User Interface (GUI) to ensure operational ease (**Figure 4**). The benefits of using this programming environment are:

- easy installation of the predictive tool on any PC due to a single Windows executable file (no third-party software required);
- use of industry standard data processing suite to perform underlying model calculations as well as GUI development and software compilation;
- simple refinement and updating of any component of the software in the future; and
- powerful graphical output as well as data export to common file structures, e.g. Excel, ASCII.

Figure 4. Predictive model GUI.

To install and run the Hay Point bathymetric model (HPBM) the following should be undertaken:

- unzip HPBM.zip and extract the files to the location where you want the model to be saved;
- if you do not have the MATLAB Compiler Runtime (MCR) version 7.15 installed on your machine this needs to be installed first (this can be checked in Control Panel/Programs and Features – the program will be called MATLAB Compiler Runtime 7.15). An installation file for this MATLAB compiler is provided in the zipped files of the HPBM (MCRInstaller.exe);
- navigate to the extracted files and then click on HPBM.exe. Depending on your computer performance, it might take a minute or two to open so do not repeatedly double click; and
- the model GUI should then open and the tool is ready to use.

Once installed, subsequent use of the model will only require navigation to the HPBM.exe and double clicking on it to open the model (Note: a Desktop shortcut can be created but the HPBM.exe file has to remain in the original folder).

3.2 Running the Model

The model has been designed to be as simple and self-explanatory as possible. The user input items are as follows:

- **Number of Months**: this represents the number of months which the model will predict siltation over;
- **Planned Dredging (North Apron)**: the user can input the in-situ volume (in m^3) of dredging that is proposed for the North Apron region over the duration of the model simulation;
- **Planned Dredging (DBCT Berths)**: the user can input the total in-situ volume (in m^3) of dredging that is proposed for the DBCT berths over the duration of the model simulation (Note, the model will automatically distribute this volume over the number of berths as per dredging requirement);
- **Planned Dredging (HP Berths)**: the user can input the total in-situ volume (in m^3) of dredging that is proposed for the HPCT berths over the duration of the model simulation (Note, the model will automatically distribute this volume over the number of berths as per dredging requirement);
- **Number of Tropical Cyclones**: the user can input the number of tropical cyclones which should be assumed to result in siltation at Hay Point. Historically on average 1 cyclones passes within 100km of Hay Point every 4.6 years (24 since 1906 according to BoM), but not all of these will result in increased siltation. This option allows the user to test different frequencies and understand the potential impact of cyclones on siltation and therefore maintenance dredging requirements at Hay Point;
- **Baseline Depth**: the starting depth for the model simulations can be specified to be either based on the 2015 survey, the current declared depth or the design depth. When the current declared depth or the design depth are selected these bed levels are only adopted in the regions where the current survey bed level is higher (i.e. where siltation has occurred), if the areas are lower then the current survey level is adopted. As such, this approach assumes that maintenance dredging has been undertaken in the areas where siltation has occurred to remove the shallower areas above the design or declared depths;
- **Bed Raking and Levelling (HPCT berths)**: this tick box allows the user to turn bed raking and levelling in the HPCT berths on and off. When bed raking and levelling is turned on there is no siltation in the berths and when it is turned off the predicted siltation assumes the same rate as in the DBCT berths 1 and 2 (but scaled based on the size of the berths); and
- **Select Area**: a drop down box allows the user to focus the predictions on specific areas of the Hay Point dredged region or to undertake the predictions for all areas. Area options are:
    - All;
    - DBCT Berths;
    - HP Berths;
    - Apron;
    - Inner Channel; and
    - Mid/Outer Channel.

The model has the following operational buttons located directly below the User Input box:

- **Start Prediction**: this undertakes a model prediction and results in all the plots and the results table being updated based on the User Input values specified;

- **Reset**: this is to reset the model back to its default settings as it first appears when you start it up; and
- **Export Results**: this allows the plots (saved as .png image files) and table (saved as .xlsx file) to be exported. When this button is pressed a pop up window opens to allow the user to navigate to the folder location to save the results. The user will then be prompted for a file name which is used to create a new folder in the location selected and within this folder the results will be saved.

Along the top bar of the GUI there are also options to save a screenshot from the model and to pan and zoom in and out on any of the figures.

It is suggested that when using the model to determine future dredging requirements and to optimise dredging frequency the model should initially be used to predict siltation without any dredging and then once the siltation is known the dredging should be included. Further information on the use of the model along with an example dredging strategy developed using the model is provided in **Section 3.4**.

3.3 Model Outputs

As detailed in **Section 3.2**, it is possible to extract results from the model so that further analysis can be undertaken offline. The following information is output from the model:

- **Plots**: all of the plots shown in the model GUI are extracted as .png image files. Plots are of; change in depth, change in volume and spatial change of depth above or below the model starting depth; and
- **Quantitative Results**: the table shown in the model GUI is extracted to an .xlsx file. The table includes quantitative results for all the areas considered in the analysis as well as all the input values selected (**Table 2**).

Table 2. Example results from the predictive model extracted to Excel format.

	North Apron	DBCT 1&2
Number of Months	36	36
Number of Cyclones	0	0
Dredging Volume (m3)	0	0
Design Depth (m LAT)	-14.9	-19.6
Current Depth (m LAT)	-14.9	-19.6
Predicted Depth (m LAT)	-14.50 +/-0.15	-18.73 +/-0.50
Sedimentation (m3)	46548.00 +/-17688.24	34992.00 +/-19945.44
Sedimentation (m)	0.40 +/-0.15	0.87 +/-0.50
Volume above/below Design Depth (m3)	46548.00 +/-17688.24	34992.00 +/-19945.44
Depth above/below Design Depth (m)	0.40 +/-0.15	0.87 +/-0.50

3.4 Example Dredging Strategy Development

As the predictive tool can predict future siltation volumes and depths, it can also be used to help develop and optimise future maintenance dredging strategies. The following approach is suggested when developing maintenance dredging strategies (note that this strategy assumes no bed raking or levelling activities in the berths):

1. **Predict future siltation rates**: set the model starting elevation to design depths and run the model for a 12 month period with no cyclones. Note down the change in depth which has occurred over this period in the areas of interest. For example, over this period the North Apron has silted up by 0.13m (15,520m^3 in total with 6,540m^3 above the design depth) while the DBCT berths 1 & 2 have silted up by 0.21m (11,660m^3), the DBCT berths 3 & 4 have silted up by 0.24m (13,970m^3) and the HPCT berths 1, 2 and 3 have all silted up by 0.14m (combined volume of 11,665m^3).

2. **Assess dredging frequency**: based on the likely over dredging which can be undertaken (or siltation which can occur above design depths without influencing operations) it is now possible to calculate the expected dredging frequency for ambient conditions. If we assume that over dredging of 0.3m can be undertaken, then to maintain the design depths for ambient conditions we can determine that maintenance dredging of the DBCT berths should be required approximately two out of every three years (in-situ volume of 38,450m^3), the HPCT berths every two years (in-situ volume of 23,330m^3) and the North Apron every three years (in-situ volume of 19,620m^3).

3. **Consider Tropical Cyclones**: it is important to consider the potential impacts of Tropical Cyclones on the future siltation and therefore any maintenance dredging strategy. This should be done by rerunning the model simulation for 0 months with a tropical cyclone included. This provided the predicted siltation resulting from a cyclone. For example, the siltation is predicted to be 0.19m at the North Apron (21,730m^3 in total with 9,150m^3 above the design depth), 0.2m at all the DBCT berths (combined volume of 22,880m^3) and 0.2m at the HPCT berths (combined volume of 16,920m^3). The predicted siltation rates show that maintenance dredging could be required at the North Apron and the DBCT and HPCT berths after a cyclone. Owing to the significant uncertainty in predicting siltation due to tropical cyclones the actual siltation should be confirmed through hydrographic survey prior to planning any dredging (see RHDHV (2016) for further details).

The example dredge strategy developed is summarised in **Table 3**. The assessment reported in RHDHV (2016) details that limited siltation has occurred in other areas of the apron and channel since 2007, with minor siltation occurring in the area between the DBCT berth 2 and the HPCT berth 2 (called Apron 2 in the model), as well as some gradual encroachment of the southern bank of the channel in the Inner and Outer Channel areas. These areas are not expected to require regular maintenance dredging in the future, for example volumes in the order of 10,000m^3 might be required every 10 years.

Table 3. Details of an example maintenance dredging strategy for the areas subject to regular siltation.

Area	Annual siltation depth (m/yr)	Annual siltation above design depth (m^3/yr)	Proposed Dredging Frequency (yrs)	Predicted Dredging Volume (m^3 / campaign)	Potential TC Volume above design depth (m^3)
North Apron	0.13	6,540	3	19,620	9,150
DBCT Berths 1&2	0.21	11,660	1.5	17,500	11,115
DBCT Berths 3&4	0.24	13,970	1.5	20,950	11,765
HPCT Berths 1,2 and 3	0.14	11,665	2	23,330	16,920

Note: the siltation rates for HPCT berths 1, 2 and 3 are based on scaled siltation rates from the DBCT berths 1 and 2 as the bed raking and levelling activity has resulted in no historic siltation.

3.5 Future Siltation

The predictive model has been used to estimate siltation above the design depth for the next 20 years, assuming no maintenance dredging is undertaken. The following scenarios have been assessed:

- assuming a starting bed elevation based on the October 2015 survey and no tropical cyclones occurring. The siltation volumes for this scenario are shown in **Table 4**;
- assuming a starting bed elevation of the design depth or the bed level from the October 2015 survey, whichever is lower, and no tropical cyclones occurring. The siltation volumes for this scenario are shown in **Table 5**; and
- assuming a starting bed elevation of the design depth or the bed level from the October 2015 survey, whichever is lower, and a tropical cyclone occurring every four years. The siltation volumes for this scenario are shown in **Table 6**.

The total siltation volume above the design depth over the next 20 years is predicted to be between 885,000m^3 and 1,129,000m^3 depending on the occurrence of tropical cyclones. It is important to note that the tables do not provide any indication of the errors associated with the predictions. These errors can be determined from the predictive model.

Table 4. 20yr predicted siltation (no maintenance dredging and no tropical cyclones). Starting bed elevation - 2015 survey depths.

Area	Volume above design depth (m^3)					
	Current	1 year	3 years	5 years	10 years	20 years
Outer Channel*	6,960	7,646	9,015	10,385	13,810	20,660
Mid Outer Channel	0	0	0	0	0	0
Mid Channel	0	0	0	0	0	0
Inner Channel*	3,613	3,645	3,709	3,773	3,933	4,253
Apron 1	0	0	0	0	0	0
HP Apron	0	0	0	0	0	0
DBCT Apron	0	0	0	0	0	0
North Apron	19,823	26,359	32,895	52,503	85,183	150,543
DBCT Berths 1&2	80,555	92,219	115,547	138,875	197,195	313,835
DBCT Berths 3&4	58,824	72,792	100,728	128,664	198,504	338,184
HPCT Berth 1	2,300	5,449	11,748	18,046	33,793	65,286
HPCT Berth 2	0	0	2,498	8,563	23,726	54,053
HPCT Berth 3	3,960	9,442	20,406	31,370	58,781	113,602
TOTAL	**176,035**	**217,552**	**296,546**	**392,179**	**614,925**	**1,060,416**

* the rates for the Outer and Inner Channels are not from the predictive model as they represent a gradual siltation at the edge of the channel, they have been calculated based on findings from RHDHV (2016).
Note: the siltation rates for HPCT berths are based on scaled siltation rates from DBCT Berths 1 and 2 as bed raking and levelling activity has resulted in no HPCT berth historic siltation.

Table 5. 20yr predicted siltation (no maintenance dredging and no tropical cyclones). Starting bed elevation - design depth or existing bed level, whichever is lower.

Area	Volume above design depth (m^3)				
	1 year	3 years	5 years	10 years	20 years
Outer Channel*	686	2,058	3,430	6,860	13,720
Mid Outer Channel	0	0	0	0	0
Mid Channel	0	0	0	0	0
Inner Channel*	32	96	160	320	640
Apron 1	0	0	0	0	0
HP Apron	0	0	0	0	0
DBCT Apron	0	0	0	0	0
North Apron	6,536	19,608	32,680	65,360	130,720
DBCT Berths 1&2	11,664	34,992	58,320	116,640	233,280
DBCT Berths 3&4	13,968	41,904	69,840	139,680	279,360
HPCT Berth 1	3,149	9,447	15,745	31,490	62,980
HPCT Berth 2	0	2,498	8,563	23,726	54,053
HPCT Berth 3	5,482	16,446	27,410	54,820	109,640
TOTAL	**41,517**	**127,049**	**216,148**	**438,896**	**884,393**

* the rates for the Outer and Inner Channels are not from the predictive model as they represent a gradual siltation at the edge of the channel, they have been calculated based on findings from RHDHV (2016).
Note: the siltation rates for HPCT berths are based on scaled siltation rates from DBCT Berths 1 and 2 as bed raking and levelling activity has resulted in no HPCT berth historic siltation.

Table 6. 20yr predicted siltation (no maintenance dredging and a tropical cyclone occurring every 4 years). Starting bed elevation - design depth or existing bed level, whichever is lower.

Area	Volume above design depth (m^3)				
	1 year	3 years	5 years	10 years	20 years
Outer Channel*	686	2,058	3,430	6,860	13,720
Mid Outer Channel	0	0	0	0	0
Mid Channel	0	0	0	0	0
Inner Channel*	32	96	160	320	640
Apron 1	0	0	0	0	0
HP Apron	0	0	0	0	0
DBCT Apron	0	0	0	0	0
North Apron	6,536	19,608	41,834	83,667	176,488
DBCT Berths 1&2	11,664	34,992	69,431	138,862	288,835
DBCT Berths 3&4	13,968	41,904	81,605	163,210	338,185
HPCT Berth 1	3,149	9,447	20,346	40,693	85,986
HPCT Berth 2	0	2,498	12,963	32,526	76,053
HPCT Berth 3	5,482	16,446	35,330	70,661	149,242
TOTAL	**41,517**	**127,049**	**265,099**	**536,799**	**1,129,149**

* the rates for the Outer and Inner Channels are not from the predictive model as they represent a gradual siltation at the edge of the channel, they have been calculated based on findings from RHDHV (2016).
Note: the siltation rates for HPCT berths are based on scaled siltation rates from DBCT Berths 1 and 2 as bed raking and levelling activity has resulted in no HPCT berth historic siltation.

4 Future Development

4.1 Introduction

To ensure the model remains up to date and fit for purpose, NQBP have requested that it is periodically updated over the next 10 years using the most recent bathymetric survey data. When the tool includes the next 10 years of bathymetric data, it will be based on almost 20 years of data which should significantly improve the confidence which can be placed in its predictions. It is suggested that the model should be updated annually as it will provide a number of benefits:

- allow regular validation of the model to ensure it is providing accurate predictions;
- ensure the model includes the most accurate siltation rates and the latest bathymetric survey elevations for future calculations;
- provides regular (annual) analysis of siltation during both typical and extreme conditions (if experienced) to help further our knowledge and understanding of the sediment transport and siltation processes; and
- enables the existing maintenance dredging requirement to be assessed and understood each year.

4.2 Data

The following data will be required as part of the proposed annual model updates:

- xyz data of the MSQ surveys which have been undertaken since the previous analysis; and
- details of any maintenance dredging and bed raking and levelling which has been undertaken over the period. If possible, for the dredging this should include an approximate breakdown of the volumes dredged in each of the regions.

4.3 Costs

Based on the assessment undertaken, costs to update the model annually have been estimated as $9,500 (ex GST) per year over the next three years. This includes the following:

- process and analyse the latest bathymetric survey for the apron, channel and berths and calculating the current maintenance dredging requirement (this includes analysing a single bathymetric survey, if multiple surveys have been undertaken over the year due to maintenance dredging or extreme events then additional costs of $1,200 (ex GST) per survey would apply). The results would then be used to update the siltation rates and confidence intervals used in the predictive model;
- update the predictive model based on the latest analysis and recompile the model and deliver updated model to NQBP;
- provide a concise technical note to detail the latest findings and the updated rates which the model is based on; and
- attendance in an online meeting to discuss the findings of the assessment.

It could also be beneficial over the 10 year period to periodically update the bathymetric analysis and modelling report with the most recent data. This could be undertaken as part of every third annual update with the report being updated to include the latest bathymetric data (with the volumes, spatial and long and cross-sectional plots updated) and the associated changes to the conceptual sediment transport understanding and siltation rates. This additional analysis and reporting is estimated to cost $12,500 (ex GST) per update.

NQBP previously noted that in the future they would like the model to form part of their online GIS based information system. Cost estimates for undertaking this task have not been included here as further details about the online system are required. However, if this information was provided an estimate could be undertaken as required.

5 References

RHDHV 2016. Hay Point Port: Bathymetric Analysis and Modelling. Prepared for North Queensland Bulk Ports Corporation, February 2016.