Port Expansion Project EIS

Appendix List

Appendix List

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Port Expansion Project EIS

Appendix H2

Modelling Peer Review Memo

AECOM BMT WBM

Our Ref LJ3017/L2582:sge

Contact P.D. Treloar

9 October 2012

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Port of Townsville Limited
PO Box 1031
TOWNSVILLE QLD 4810

Attention: Melinda Louden - Environmental Project Manager

Dear Melinda,

PORT OF TOWNSVILLE – REVIEW OF REVISED BMT WBM REPORT

Preamble

Cardno have been engaged by the Port of Townsville Limited to undertake a Technical Peer Review of the 2D/3D Hydrodynamic Modelling work and reporting being undertaken by BMTWBM for an EIS being prepared by AECOM, for Port of Townsville's proposed Outer Harbour expansion.

This will be a staged reporting and review process that is intended to ensure that the completed work will be appropriate for the project and comply with the requirements of the regulatory authorities – Queensland and Federal Government authorities. Of these two, the requirements of the Federal Government through the Great Barrier Reef Marine Park Authority,. are the more demanding.

This document provides the details of the review process undertaken by Cardno for POTL.

Review Stage 1

In the first instance, Cardno reviewed the report "Townsville Port Expansion EIS: Hydrodynamic and Advection-Dispersion Modelling Calibration Report" – R.B17733.011.003.EIS_Model_Calibration.doc (May 2012).

That review report provided some general comments in regard to the regulatory authority requirements and then made comments on specific points in the report document. Many of the issues were addressed at a review meeting held in BMT WBM's office in Brisbane on 31 May 2012.

Details are presented in **Annexure 1a**, with BMT WBM's responses presented in **Annexure 1b**.

Review Stage 2

Cardno then reviewed the BMTWBM report 'Appendix X: Townsville Port Expansion EIS, Hydrodynamic and Advection-Dispersion Modelling, Technical Report (R.B 17733.003.01.EIS – Hydrodynamics.doc', dated July 2012, which accompanied the BMT WBM's response presented in **Annexure 1b**.

Those comments were provided to the Port of Townsville Limited (POTL) in Cardno letter LJ3017/L2572, see **Annexure 2a**.

BMT WBM provided their detailed responses in their letter L.B17733.016.Modelling_Peer_Review_Final dated 12 September 2012, see **Annexure 2b**. A revised version of the report dated September 2012 was provided at the same time.

Cardno have reviewed these comments and the revised report and are satisfied with BMT WBM's responses. The report is of high technical quality and provides detailed descriptions of the likely outcomes in terms of suspended sediment plumes that are likely to occur during the dredging work that is part of the port expansion project.

Yours faithfully

P. D. Treloar

P.D. Treloar
Senior Principal - Coastal and Ocean
for **Cardno(NSW/ACT) Pty Ltd**

Annexure 1a
Review Stage 1 – Cardno Comments

Our Ref LJ3017/L2553 :sge

Contact P.D. Treloar

Cardno
Shaping the Future

5 June 2012

Port of Townsville Limited
PO Box 1031
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Attention: Melinda Louden - Environmental Project Manager

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Dear Melinda,

PORT OF TOWNSVILLE

Preamble

Cardno have been engaged by the Port of Townsville Limited to undertake a Technical Peer Review of the 2D/3D Hydrodynamic Modelling work and reporting being undertaken by BMT WBM for an EIS being prepared by AECOM, for Port of Townsville's proposed Outer Harbour expansion.

This will be a staged reporting and review process that is intended to ensure that the completed work will be appropriate for the project and comply with the requirements of the regulatory authorities – Queensland and Federal Government authorities. Of these two, the requirements of the Federal Government through the Great Barrier Reef Marine Park Authority, are the more demanding.

In the first instance, Cardno have reviewed the report "Townsville Port Expansion EIS: Hydrodynamic and Advection-Dispersion Modelling Calibration Report" – R.B17733.011.003.EIS_Model_Calibration.doc (May 2012).

This review report provides some general comments in regard to the regulatory authority requirements and then makes comments on specific points in the report document. Many of the issues were addressed at a review meeting held in BMT WBM's office in Brisbane on 31 May 2012.

General Comments

The reviewer believes that the EIS, or BMT WBM's proposed appendix, will need to describe the existing environment and history and outcomes of works and monitoring of previous dredging work at the Port of Townsville more than is the case at present. BMT WBM refer to JCU/AIMS (1991), but there appears to be no summary of the outcomes. Details of the staging of the proposed work, and where that may be documented need to be included.

Specific Comments

1.1 Background

A short description of TUFLOW-FV, in particular its 3D and source application capabilities would be useful. This may be a summary description and appendix, for example.

2.1 Approach

Line 2 " . . . coupled . . ." – is this correct, in that wave parameters were incorporated into the hydrodynamics and vice versa?

Page 2-1, second dot-point. Ross Creek details? Or does the third dot-point need correction/expansion? Was there recorded tidal prism data for Ross River/Ross Creek for calibration?

2.3 Advection-Dispersion Modelling

The draft report does not seem to include any information on position(s) in the water column where the sediment solids were introduced in the model.

What is the source of the tidal boundary constants for the open boundaries?

There does not seem to be any data describing background suspended solids concentrations and their spatial/temporal variations. Does the Burdekin River contribute to this? If so, what information is available to assist with the modelling of that input?

2.4 SWAN Wave Models

Were the NCEP winds verified using recorded wind data? Were there any Coral Sea swell boundary conditions? If not, is there some confirmation that it is not needed?

2.5 Bathymetry

First dot-point is there any source/date information for the "Local hydrographic survey data" What about data for Ross River/Ross Creek?

2.6 Tidal Boundary Conditions

A little more information about the 'existing calibrated model . . .', such as owner and model extent would be helpful.

2.7 Salinity and Temperature Boundary Conditions

Was the model set-up with internal stratification as well? If not, was the model given sufficient time for quasi-equilibrium to be developed. Did these boundaries vary with time, space, season?

2.8 Meteorological Wind Boundary Conditions

This reviewer is confused about how the BoM and NCEP winds were used. If NCEP winds were used for SWAN and the interpolated BoM winds for TUFLOW-FV, then has there been a calibration/comparison in a common area?

2.9 Other Meteorological Boundary Conditions

Did a heat model algorithm and TUFLOW-FV develop realistic temperature profiles; given also that the model included freshwater inflows of some unknown temperatures? Does BMT WBM have a measure of how important this overall solar heating process was to particle settling rates? Was it more detail than was needed?

2.10 Fluvial Discharge Boundary Conditions

Were these catchment loads generalised, or time-series consistent with the ocean model boundary time-series? How realistic are they? What was done for the Burdekin River?

3 Model Calibration and Validation

The reader is not able to really glean much information on vertical resolution in this section. This resolution may affect where the dredged sediments are discharged to the model.

3.1.3 Hydrodynamic Model Calibration Results

The report advises that one calibration period was 1 November to 1 December 2010. However, Figure 3.6 appears to show times up to 11 December? In this figure, are the current vectors in the model rotating in a direction different from the measured data? Current roses may not identify such a difference. How was the latter and top division found to be appropriate? Could it be top 30% and bottom 70%? How does it matter, anyway, if the plume can be advected – dispersed in all of the model layers? Is this discussion only for demonstrating model calibration?

Figure 3.15

Seems too isolated with little or no description about it. Does it show a SE wind driving upper water column water NW with an underlying tidal flow to the SE? (about).

Generally, hydrodynamic and wave calibration results appear to be good.

3.3 Advection – Dispersion Plume Modelling Validation

There are many example calibration plots presented in Appendix A with little descriptive documentation. The tide-time indicator could be made clearer and the dredge location dots and colour scheme could be clarified.

The reviewer believes that some of the field to model comparisons are sufficiently different for them to require explanatory notes.

The dates of these plots are different from the hydrodynamic calibration plot times. Was there no ADCP data at the times of dredge spoil dumping to validate the modelled hydrodynamics at that time? A difference between modelled and actual currents at the time of the spoil disposal cannot be totally dismissed as a cause of difference between observed and modelled plumes.

There appears to be no documented information about the spoil disposal source in the model – location in the water column, how frequently its position was moved as the dredge moved, location accuracy?

Reviewer believes that the number of Appendix A plots would be reduced.

We hope that these review comments are helpful. I am happy to discuss these points, or any other, with you or BMT WBM directly.

Yours faithfully

P. D. Treloar

P.D. Treloar
Senior Principal - Coastal and Ocean
for **Cardno (NSW/ACT) Pty Ltd**

Annexure 1b
Review Stage 1 – BMT WBM Responses

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Our Ref: L.B17733.014.PEP Modelling Peer Review.docx

31 July 2012

Port of Townsville Limited
PO Box 1031
Townsville Qld 4810

Attention: Melinda Louden - Environmental Project Manager

Dear Melinda,

RE: PORT OF TOWNSVILLE PEP EIS MODELLING PEER REVIEW

A Peer Review was undertaken on the POTL PEP Hydrodynamic and Advection-Dispersion Modelling Calibration Report, which forms part of the broader Hydrodynamic and Advection-Dispersion Modelling Technical Report (to be included in the PEP EIS as a Technical Appendix). BMT WBM has now revised the calibration section of the report in response to the comments of the Peer Reviewer. Specific responses to the comments and descriptions of the changes that have been made to the report are outlined in the table below.

Peer Reviewer Comment	BMT WBM Response and Report Reference
General - The reviewer believes that the EIS, or BMT WBM's proposed appendix, will need to describe the existing environment and history and outcomes of works and monitoring of previous dredging work at the Port of Townsville more than is the case at present. BMT WBM refer to JCU/AIMS (1991), but there appears to be no summary of the outcomes. Details of the staging of the proposed work, and where that may be documented need to be included.	Additional information is provided in the chapter reports in the main body of the EIS. Section 1.4 of the Coastal Processes chapter describes the geological and geomorphological setting of the Port, and existing coastal and marine physical processes. Section 7.3.5.4 of the Marine Ecology chapter describes the monitoring activities that were carried out for the 1993 capital dredging campaign. The staging of the work is described in Part A of the EIS. These sections of the EIS can be provided to the Peer Reviewer for context if desired.
1.1 Background A short description of TUFLOW-FV, in particular its 3D and source application capabilities would be useful. This may be a summary description and appendix, for example.	An attachment will be added to the Technical Appendix which describes the TUFLOW-FV modelling system (work in progress). If the peer reviewer would like specific information in the meantime we are happy to provide details.
2.1 Approach Line 2 " . . . coupled . . ." – is this correct, in that wave parameters were incorporated into the hydrodynamics and vice versa?	This reference to coupling was removed.

Page 2-1, second dot-point. Ross Creek details? Or does the third dot-point need correction/expansion? Was there recorded tidal prism data for Ross River/Ross Creek for calibration?	An additional dot point provides information on Ross Creek coverage. No recorded tidal prism data was available.
2.3 Advection-Dispersion Modelling The draft report does not seem to include any information on position(s) in the water column where the sediment solids were introduced in the model. What is the source of the tidal boundary constants for the open boundaries? There does not seem to be any data describing background suspended solids concentrations and their spatial/temporal variations. Does the Burdekin River contribute to this? If so, what information is available to assist with the modelling of that input?	The following text was added to Section 3.3.3: "The dredge plume boundary condition was applied as a depth-averaged source into the model as there was no consistent indication in the near-field ADCP data that the source was particularly concentrated in any one part of the water column during either dredging or dumping." Section 2.6 has been expanded to describe the regional tidal model and the source of its boundary forcing data The Coastal Processes chapter includes a discussion of the background suspended solids concentrations, the source of the material (ultimately mostly from the Burdekin) and some model outputs showing the existing net sediment fluxes in the Bay.
2.4 SWAN Wave Models Were the NCEP winds verified using recorded wind data? Were there any Coral Sea swell boundary conditions? If not, is there some confirmation that it is not needed?	The NCEP winds were not formally verified, but they were only used for the large scale "regional" SWAN model. The nested SWAN model used the same data-driven interpolated wind field as the TUFLOW-FV model. No Coral Sea swell boundary conditions were needed, confirmed by the excellent SWAN model calibration results.
2.5 Bathymetry First dot-point - is there any source/date information for the "Local hydrographic survey data" What about data for Ross River/Ross Creek?	The source of the data has been added to the text (Port of Townsville). Data for Ross River / Ross Creek was derived from the charts.
2.6 Tidal Boundary Conditions A little more information about the 'existing calibrated model . . .', such as owner and model extent would be helpful.	The extents of the regional tidal model (developed by BMT WBM) have been provided.
2.7 Salinity and Temperature Boundary Conditions Was the model set-up with internal stratification as well? If not, was the model given sufficient time for quasi-equilibrium to be developed. Did these boundaries vary with time, space, season?	The following text was added to Section 2.7: "The model was warmed up for a minimum period of 6 weeks prior to all calibration and impact assessments, in order to develop the internal salinity and temperature distributions contributing to density stratification." "These model input fields were spatially uniform but varied in time in order to represent both seasonal and higher-frequency variations (e.g. diurnal)."

2.8 Meteorological Wind Boundary Conditions This reviewer is confused about how the BoM and NCEP winds were used. If NCEP winds were used for SWAN and the interpolated BoM winds for TUFLOW-FV, then has there been a calibration/comparison in a common area?	The NCEP winds were only used for the large scale "regional" SWAN model. The nested SWAN model used the same data-derived interpolated wind field as the TUFLOW-FV model. This is explained in Section 2.4.
2.9 Other Meteorological Boundary Conditions Did a heat model algorithm and TUFLOW-FV develop realistic temperature profiles; given also that the model included freshwater inflows of some unknown temperatures? Does BMT WBM have a measure of how important this overall solar heating process was to particle settling rates? Was it more detail than was needed?	Section 3.1.3.2 has been added which presents a validation of modelled water temperature. No attempt has been made to quantify the effect on particle settling rates. Inclusion of density coupled temperature and salinity, improved model validation to ADCP's deployed during the summer 2010/11 period. The improvement related mainly to improved representation of vertical mixing of momentum in the presence of temperature and salinity induced stratification.
2.10 Fluvial Discharge Boundary Conditions Were these catchment loads generalised, or time-series consistent with the ocean model boundary time-series? How realistic are they? What was done for the Burdekin River?	This section has been expanded to describe the nature of the catchment loads and the TSS-flow relationship for the Burdekin River.
3 Model Calibration and Validation The reader is not able to really glean much information on vertical resolution in this section. This resolution may affect where the dredged sediments are discharged to the model.	The first part of Section 3.1.1 has been expanded to describe the vertical discretisation of the model in more detail.
3.1.3 Hydrodynamic Model Calibration Results The report advises that one calibration period was 1 November to 1 December 2010. However, Figure 3.6 appears to show times up to 11 December? In this figure, are the current vectors in the model rotating in a direction different from the measured data? Current roses may not identify such a difference. How was the latter and top division found to be appropriate? Could it be top 30% and bottom 70%? How does it matter, anyway, if the plume can be advected – dispersed in all of the model layers? Is this discussion only for demonstrating model calibration?	Section 3.1.3 has been modified to include the correct date range (1/12/2010 to 1/2/2011). During the 2010 validation period the model and data do rotate in different directions on occasion, but the flow magnitude is generally small during these times (i.e. small effect on plume advection). The 50/50 split of the vertical profile was chosen for compact presentation of results, and because the profile stratification is often split approximately 50/50 (refer, for example, Figure 3-5).
Figure 3.15 Seems too isolated with little or no description about it. Does it show a SE wind driving upper water column water NW with an underlying tidal flow to the SE? (about).	This is now Figure 3-5, and discussion has been added to Section 3.1.3.4.

3.3 Advection–Dispersion Plume Modelling Validation	
There are many example calibration plots presented in Appendix A with little descriptive documentation. The tide-time indicator could be made clearer and the dredge location dots and colour scheme could be clarified. The reviewer believes that some of the field to model comparisons are sufficiently different for them to require explanatory notes.	The number of plots in the Appendix has been reduced, and the tide-time indicator and dredge location dots have been made clearer. The colour scheme has been improved. Most of the discrepancies between the model and measurements were due to artefacts in the recorded ADCP data (e.g. bubbles). The plots which included these artefacts have been removed.
The dates of these plots are different from the hydrodynamic calibration plot times. Was there no ADCP data at the times of dredge spoil dumping to validate the modelled hydrodynamics at that time? A difference between modelled and actual currents at the time of the spoil disposal cannot be totally dismissed as a cause of difference between observed and modelled plumes.	There was ADCP data available for hydrodynamic validation, and the model performance during this period has been assessed. The results were similar to those presented in the hydrodynamic validation section (Dec 2010).
There appears to be no documented information about the spoil disposal source in the model – location in the water column, how frequently its position was moved as the dredge moved, location accuracy?	The vertical distribution of the plume source is now stated, and the dredge position was obtained from dredging logs (with frequent GPS location data).
Reviewer believes that the number of Appendix A plots would be reduced.	The number of plots in the Appendix has been reduced.

We would like to thank the Peer Reviewer for their constructive comments and we believe the report is much improved as a result of these modifications.

We now provide the full modelling Technical Appendix, including impact assessments, for further review. We would appreciate Peer Review comments on the additional work presented in this Appendix within two weeks of receipt of this letter.

Please do not hesitate to contact me if you require any further information.

Yours faithfully,

Dr Paul Guard

Senior Coastal Engineer

BMT WBM

Annexure 2a
Review Stage 2 – Cardno Comments

Our Ref LJ3017/L2572:sge

Contact P.D. Treloar

24 August 2012

Port of Townsville Limited
PO Box 1031
TOWNSVILLE QLD 4810

Attention: Melinda Louden - Environmental Project Manager

Cardno
Shaping the Future

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Dear Melinda,

PORT OF TOWNSVILLE – REVIEW OF REVISED BMT WBM REPORT

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This will be a staged reporting and review process that is intended to ensure that the completed work will be appropriate for the project and comply with the requirements of the regulatory authorities – Queensland and Federal Government authorities. Of these two, the requirements of the Federal Government through the Great Barrier Reef Marine Park Authority, are the more demanding.

Cardno previously reviewed the report "Townsville Port Expansion EIS: Hydrodynamic and Advection-Dispersion Modelling Calibration Report" – R.B17733.011.003.EIS_Model_Calibration.doc (May 2012) – L2553. POTL have now provided Cardno with BMT WBM's responses to the review comments, together with a revised and expanded report that incorporates changes made as part of BMT WBM's responses. This report is "Appendix X: Townsville Port Expansion EIS Hydrodynamic and Advection Dispersion Modelling Technical Report" – R.B17733.003.01.EIS – Hydrodynamics___ July 2012.

This review report provides some general comments in regard to the regulatory authority requirements and then makes comments on specific points in the report document. Many of the issues were addressed at a review meeting held in BMT WBM's office in Brisbane on 31 May 2012.

BMT WBM's response notes are acknowledged and I am satisfied with those.

Specific Comments

Section 2.10 – Reef ks = 100. How does this function 2m depth say? Why not set reef levels to 0.5m above LAT, perhaps?

Section 3.1.2, Para 1. What happens below -25m AHD? Is there one thick layer?

Figure 3.4. Model flow possibly shows more Burdekin River momentum – but seems to get no more mention later in the report.

Figure 3.16. Do the % add up to 100%?

Figure 3.8. Some explanation of what happened on 9-11 Dec would be good.

Figure 3.18. Why is the dump area Hs a bit low? Any comment?

TSHD Brisbane. Are there times when it is not overflowing?

Page 3-26. Was more than one sediment case considered and what was the data used to determine the clay, silt, sand mix?

Page 3-26. Are the plan-plot data sets over-plotted in the dredge polygon?

Figure 3.21, lower panel. >5 NTU or > 35NTU in header line?

Page 3.30, equations. What is the O symbol?

Page 3-30, calibration parameters. How were they calibrated, selected? Selected or multivariate least squares? A little more please.

Page 3.30. It seems that many of the analyses relate to November with SE winds. Was any consideration of a summer case given with northerly winds?

Page 4-10, second line. SE winds are not onshore, I believe?

Figure 4.14. Although BMT WBM say otherwise elsewhere, might not the increased current speeds for vessels going to/coming from Ross River be slightly affected?

Figure 4.16. Label of 'Percent Dry'??

Figure 5.1. Is residual really the net over one month? Did the runs start and end so that tidal cycles were complete? Some discussion please?

Figure 5.3. Small label says monthly, but really it is only a November case.

Figure 5.4. Why is siltation in Ross River reduced? Different in Figure 5.7.

Table 5.1. Increases and decreases in siltation volumes don't add to zero??

Figure 5.11 and 5.12 don't seem to match. Why would there be more siltation to the NW of Magnetic Is if the plume is less concentrated. It must be concentrated enough some of the time before siltation occurs?

Section 6.2, paragraph 2. There appears to be no data on background suspended solids concentrations and their spatial and temporal variations. This helps to place the results in context.

Table 6.1. This data and section do not appear to describe work hours or duration per day?

Section 6.2, paragraph 3. Do WBM have time-series plots that show how quickly plumes disappear once dredging ceases?

Figures 6.2 and 6.3, for example. Are these depth averaged concentrations from a 3D model?

Section 6.2.1. Monthly siltation results are presented. What would be the total dredging period for these scenarios.

Section 6.3. Are the wind and wave conditions for summer and winter reasonably representative of summer and winter conditions over more than the data collection period? Some comment has been made, but no quantitative type statement has been made.

Section 6.3.1. Are the figures for this section depth averaged SS? Why is there high SS concentration in the port are (top panel of Figure 6.21) when the dredge is working in area A, NE corner of Magnetic Island?

Figure 6.24. Is there overflow from the dredge as it travels from the channels to the spoil ground? Appears not to be?

Figure 6.26. Is there an estimated total sedimentation depth? Is this net sedimentation, including re-suspension processes? Appears to be the case in Figure 6.28 (doesn't specify which panel is summer and which is winter)? Is there a figure showing Cape Pallarenda? How do we know that figure 6.28 shows dredging/spoil ground caused SS – how much would have occurred by wave action without the spoil ground build-up? How do we know that it is 'above background'? Have I missed a statement saying that the only re-suspendable sediments are in the spoil ground? Perhaps the report should note that these results would be different for other summer and winter periods.

Figure 6.34 doesn't specify the channel TSHD case that it is, for example. It can be compared with Figure 6.23 (none of this type of figure clearly specifies by itself what dredging scenario is being addressed)? If winds are from the north why is SS not pushed further south like Figure 6.23? At least in the upper water column of the 3D model? Are they both Scenario 4a?

Section 6.3.4. Can the improvement be quantified in terms ecological benefit versus any increased dredging costs?

Section 6.4

Do you have background data?
How would it be obtained realistically given the extent of plumes? For given weather conditions for comparison purposes.
Would it be best to provide some typical background data?
There appears to be no mention of adsorbed contaminant release during dredging. Will there be? Do you have data for this?

Yours faithfully

P. D. Treloar

P.D. Treloar
Senior Principal - Coastal and Ocean
for **Cardno(NSW/ACT) Pty Ltd**

Annexure 2b
Review Stage 2 – BMT WBM Responses

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Our Ref: L.B17733.016.Modelling_Peer_Review_Final.docx

12 September 2012

Port of Townsville Limited
PO Box 1031
Townsville Qld 4810

Attention: Melinda Louden - Environmental Project Manager

Dear Melinda,

RE: PORT OF TOWNSVILLE PEP EIS MODELLING PEER REVIEW

A Peer Review was undertaken on the POTL PEP Hydrodynamic and Advection-Dispersion Modelling Technical Report (to be included in the PEP EIS as a Technical Appendix). BMT WBM has now revised the hydrodynamic and advection-dispersion modelling technical report in response to the comments of the Peer Reviewer. Specific responses to the comments and descriptions of the changes that have been made to the report are outlined in the table below.

Peer Reviewer Comment	BMT WBM Response and Report Reference
Section 2.10 – Reef ks = 100. How does this function 2m depth say? Why not set reef levels to 0.5m above LAT, perhaps?	The approach of specifying a very high roughness has the effect of setting the conveyance across these areas close to zero. In reality the flow conveyed through these reef structures is minimal. However, they tend to be under-resolved both in the underlying bathymetric datasets and in the model representation. The high roughness approach was found to be a preferable means of approximating reality than imposing a specified reef level.
Section 3.1.2, Para 1. What happens below -25m AHD? Is there one thick layer?	That is correct. This is now clarified in the report.

Figure 3.4. Model flow possibly shows more Burdekin River momentum – but seems to get no more mention later in the report.	This is a qualitative comparison given the nature of the dataset available for comparison. Rather than a validation, this is included more as a means to highlight that the Burdekin River inflows are included in the model, and that they do have an appreciable influence on the vertical structure and hence hydrodynamics within the study area to the North. The complete set of MODIS satellite images from the Bainbridge et al (2012) paper have now been reproduced in Attachment B in order to show that the model reproduces spatial and temporal trends that are reasonably consistent with the satellite images.
Figure 3.16. Do the % add up to 100%?	This has been double-checked and it can be confirmed that rose plot frequency bins do add up to 100%.
Figure 3.8. Some explanation of what happened on 9-11 Dec would be good.	A closer inspection of the model predictions for this period has shown that this is when the Burdekin River plume first starts to significantly influence the monitoring sites. The following text has been added to the report Sectiom 3.1.3.4: *During the 2010 monitoring campaign it is understood that the salinity influence from the Burdekin River flood plume may have begun to influence the DMPA and Magnetic Island monitoring sites from around the 9th December. At this time, the surface currents at the DMPA site are seen in both the data and the model predictions to "decouple" from the near-bed currents. While the agreement at the DMPA site is good the model skill at predicting the Magnetic Island ADCP current behaviour is not as good as for the preceding period.*

Figure 3.18. Why is the dump area Hs a bit low? Any comment?	The following text has been added to Section 3.2: *Agreement between the measured and modelled wave heights, directions and peak periods is generally good, particularly with the DERM wave buoy and the Magnetic Island ADCP. Some under-prediction bias is evident relative to the DMPA ADCP significant wave height measurements; however it is unclear why this would be significantly different from the DERM wave buoy which was located within a relatively short distance of the DMPA. Some under-prediction bias is probably attributable to the non-stationary assumptions made in the wave model predictions.*
TSHD Brisbane. Are there times when it is not overflowing?	Yes there are some times when the TSHD Brisbane is dredging but not overflowing (according to the logs). Generally the measured plumes are insignificant during these times relative to the periods where it is overflowing. For this reason the validation comparisons are generally carried out with plumes generated during overflow dredging.
Page 3-26. Was more than one sediment case considered and what was the data used to determine the clay, silt, sand mix?	The water samples collected during plume monitoring had been analysed for suspended sediment particle size distribution. A figure showing these results has been added (Figure 3-22).
Page 3-26. Are the plan-plot data sets over-plotted in the dredge polygon?	We are not sure what is meant by this question. The plan view in Figures 3-22 and 3-23 does include the depth-averaged TSS data recorded by the ADCP (enclosed by a black line).
Figure 3.21, lower panel. >5 NTU or > 35NTU in header line?	The lower panel is in fact showing the least-squares fitted linear relationship for data points with turbidity >5 NTU.
Page 3.30, equations. What is the O symbol?	The O symbol is a 0 (zero), representing the limit where deposition or erosion becomes zero due to shear stress above or below the respective critical values.

Page 3-30, calibration parameters. How were they calibrated, selected? Selected or multivariate least squares? A little more please.	The model calibration process involved starting with parameter values that are consistent with published literature ranges and previous modelling exercises in similar environments. Individual parameters were firstly adjusted to determine the sensitivity of results to these changes. The erosion rate model parameter was selected as the parameter most appropriate for "tuning" the model TSS predictions to match the data. Comparisons between model results and measured data were made by visual inspection.
Page 3.30. It seems that many of the analyses relate to November with SE winds. Was any consideration of a summer case given with northerly winds?	A northerly wind case was carried out for the channel dredging scenario and the difference in results was not large. It is expected that hydrodynamic impacts (already small) would not vary significantly depending on the meteorological conditions of the assessment period.
Page 4-10, second line. SE winds are not onshore, I believe?	That is correct. The text has been edited to read "trade winds" not "onshore winds".
Figure 4.14. Although BMT WBM say otherwise elsewhere, might not the increased current speeds for vessels going to/coming from Ross River be slightly affected?	Text has been added to Section 4.3 as follows *Velocity increases of less than 0.2m/s are predicted to occur in the Ross River entrance channel to the east of the existing port reclamation on flooding tides.* *In general the current velocity changes are unlikely to create any additional problems for ship navigation except perhaps at the entrance to the Marine Precinct harbour, which can expect up to a 0.2 m/s increase in entrance cross-currents during flood tides.*
Figure 4.16. Label of 'Percent Dry'??	The x-coordinate of this plot has been changed and the axis legend is now "Percent Exceedance".

Figure 5.1. Is residual really the net over one month? Did the runs start and end so that tidal cycles were complete? Some discussion please?	This has been clarified in the text as follows: *Residual sediment transport rates were calculated by averaging results over a period of approximately 1 month, ensuring that the start and end points both coincided with similar high tide levels. It is acknowledged that the long-term residual may differ from the values derived over this limited time period, however the selected period was adopted based on being representative of prevailing climatic conditions and should not therefore be grossly different from the longer term residual. The morphological and sediment transport impacts are also based on predicted changes over the November 2010 simulation period, and a similar caveat applies.*
Figure 5.3. Small label says monthly, but really it is only a November case.	This is now made clear to the reader of the report (see text inserted above).
Figure 5.4. Why is siltation in Ross River reduced? Different in Figure 5.7.	Marine supply is apparently reduced to the Ross River due to the future port expansion reclamation. The difference between Figure 5-4 which is showing the broader (and more subtle) sedimentation impacts and Figure 5-7 which is showing the (more obvious) channel siltation impacts is the scale. Figure 5-4 is scaled between +-2mm/month, whereas Figure 5-7 is scaled between +-50mm/month. Additional text has been added to clarify these aspects.
Table 5.1. Increases and decreases in siltation volumes don't add to zero??	The siltation volumes increases and decreases do not add to zero as the total siltation volume in areas requiring maintenance dredging is predicted to decrease with the construction of the enclosed outer harbour. The modelling indicates a 25% reduction in channel/harbour siltation relative to the base case.

Figure 5.11 and 5.12 don't seem to match. Why would there be more siltation to the NW of Magnetic Is if the plume is less concentrated. It must be concentrated enough some of the time before siltation occurs?	The seeming inconsistency is a matter of two things: Firstly the scale for the suspended concentration 1% exceedance plot is relatively higher (shows less spatial extent) than the siltation plot. Secondly the siltation is a function of both suspended sediment concentration and shear stress and won't exhibit exactly the same spatial distribution as the suspended sediment concentration.
Section 6.2, paragraph 2. There appears to be no data on background suspended solids concentrations and their spatial and temporal variations. This helps to place the results in context.	Some background turbidity data is presented in the validation section (Figures 3-25 and 3-26), and a detailed assessment of background suspended solids concentrations is included in the Water Quality chapter of the EIS. This can be provided to the peer reviewer.
Table 6.1. This data and section do not appear to describe work hours or duration per day?	Table 6.1 does included cycle times and discharge time per cycle, based on a 24-hour working day. A statement has been added to clarify this assumption.
Section 6.2, paragraph 3. Do WBM have time-series plots that show how quickly plumes disappear once dredging ceases?	The time series plots presented in Attachment D show the decrease in plume concentrations following cessation of dredging (channel dredging ceased on 20 January for Scenario 4a, and 20 July for Scenario 4b).
Figures 6.2 and 6.3, for example. Are these depth averaged concentrations from a 3D model?	The following text has been added to Section 6.2: *Results from the 3D hydrodynamic model have been depth-averaged for presentation.*
Section 6.2.1. Monthly siltation results are presented. What would be the total dredging period for these scenarios.	The total duration of each stage of dredging operations (and consequent total siltation) is considered in the impact assessment presented in the marine ecology chapter.

Section 6.3. Are the wind and wave conditions for summer and winter reasonably representative of summer and winter conditions over more than the data collection period? Some comment has been made, but no quantitative type statement has been made.	Section 6.3 has been modified as follows: *The summer period used for modelling purposes (Scenario 4a) was 1/11/2010 to 1/02/2011. The wind and wave roses for this period are shown in Figure 6 18. The conditions during this period were similar to the average conditions during 2008 to 2011 (shown in Figure 4 3) and are consistent with long term (1998-2011) summer wind records from the Townsville Aero weather station..* *The winter period used for modelling purposes (Scenario 4b) was 1/05/2010 to 1/08/2010. The wind and wave roses for this period are shown in Figure 6 19. The wave conditions during this period included a greater proportion of E-ESE waves than the average conditions during the period 2008 to 2011 (shown in Figure 4 3). The selected winter period wind conditions are consistent with the long term (1998-2011) winter wind records from the Townsville Aero weather station. The wind speed and wave energy are greater overall for the winter period than for the summer period, and this is shown in subsequent model results to have implications for dredge plume material resuspension.*
Section 6.3.1. Are the figures for this section depth averaged SS? Why is there high SS concentration in the port are (top panel of Figure 6.21) when the dredge is working in area A, NE corner of Magnetic Island?	These are residual plumes from the previous dredge cycle. This is explained in the report text introducing the figures.
Figure 6.24. Is there overflow from the dredge as it travels from the channels to the spoil ground? Appears not to be?	No there is no overflow outside of the channel dredging. The superposition of the DMPA placement plume with the channel dredging plume does provide some appearance of there being a plume generated between the channel and the DMPA, however this is not the case.
Figure 6.26. Is there an estimated total sedimentation depth? Is this net sedimentation, including re-suspension processes? Appears to be the case in Figure 6.28 (doesn't specify which panel is summer and which is winter)? Is there a figure showing Cape Pallarenda? How do we know that figure 6.28 shows dredging/spoil ground caused SS – how much would have occurred by wave action without the spoil ground build-up? How do we know that it is 'above background'? Have I missed a statement saying that the only re-suspendable sediments are in the spoil ground? Perhaps the report should note that these results would be different for other summer and winter periods.	Yes, the sedimentation plots are net sedimentation (including re-suspension processes). The location of the Cape Pallarenda model output (Site 8) is shown in Figure 6-1. The only sediment introduced into the model during the simulation is due to the dredging operation – therefore all results are "above-background" (natural sediment resuspension is not modelled explicitly in the plume simulations).

Figure 6.34 doesn't specify the channel TSHD case that it is, for example. It can be compared with Figure 6.23 (none of this type of figure clearly specifies by itself what dredging scenario is being addressed)? If winds are from the north why is SS not pushed further south like Figure 6.23? At least in the upper water column of the 3D model? Are they both Scenario 4a?	Additional description of the scenario has been added to the figure title. The northerly wind scenario was not run for as long a time period as scenarios 4a and 4b, so sediment did not advect/disperse as far from the dredging track (despite the more northerly wind condition). Nevertheless, the conclusion can be drawn that sediment plumes are unlikely to affect sensitive receptors on the southern coastline of Cleveland Bay (which was the primary objective of the sensitivity test). Discussion has been added to Section 6.3.3
Section 6.3.4. Can the improvement be quantified in terms ecological benefit versus any increased dredging costs?	This type of quantification is beyond the scope of the Hydrodynamic Modelling Technical report. However, it is unlikely that the mitigation case modelled would result in a significant cost penalty as it is primarily re-ordering the dredging tracks in order to avoid dredging certain areas during particular tidal conditions.
Section 6.4: Do you have background data? How would it be obtained realistically given the extent of plumes? For given weather conditions for comparison purposes. Would it be best to provide some typical background data? There appears to be no mention of adsorbed contaminant release during dredging. Will there be? Do you have data for this?	Background data is provided in the Water Quality chapter of EIS. This can be provided to the peer reviewer. An assessment of potential adsorbed contaminant release is also included in the Water Quality chapter.

We would like to thank the Peer Reviewer for their constructive comments and we believe the report is substantially improved as a result of these modifications.

Please do not hesitate to contact me if you require any further information.

Yours faithfully,

Dr Paul Guard

Senior Coastal Engineer

BMT WBM

Port Expansion Project EIS

Appendix I1

Summary of Available Literature

AECOM BMT WBM

Item	Reference	Report Purpose/Objectives and Summary of Key Findings
1	POTL Water Quality Monitoring 2004 – 2010.	**Objectives** To provide a historical summary of water quality at various sites throughout the inner harbour, outer harbour, Ross Creek and Ross River. The program was first implemented in November 2004 and sampling has been conducted on a regular basis. **Summary of Key Findings** Based on assessment of median values the following trends were found: • Existing inner harbour sites generally did not exceed guideline values for nutrients, but some inner harbour locations showed exceedances of suspended solids guidelines. • Ross River and Ross Creek locations commonly exceeded suspended sediment and nutrient guideline values. Harbour locations seaward of the existing eastern breakwater/revetment commonly exceeded suspended sediment and nitrogen guidelines.
2	Townsville Port Expansion Preliminary Engineering and Environment Study Oceanographic Data Collection (BMT WBM, 2009).	**Objectives** To provide a summary of Suspended Summary Concentrations (SSC) at various locations in Cleveland Bay during dredging and non-dredging periods. **Summary of Key Findings** The sampling indicated that: • Across outer Cleveland Bay sites the average SSC was 22.4 mg/l. • Ambient SSC for the area close to the dredge footprint (the Port of Townsville outer harbour and the Strand) had an average across the sites of 88.2 mg/L. • Site S6 (the Strand) recorded much higher SSC in the period when dredging was not occurring, highlighting the influence that natural processes have on turbidity levels in Cleveland Bay, with the natural variation in SSC fluctuating over a broad range. • For short periods of time during the dredging period, SSC reached over 2000 mg/L and 1000 mg/L at various outer harbour sites which adjoin the Platypus Channel.
3	Rasheed, M.A. and Taylor, H.A. (2008) Port of Townsville seagrass baseline survey report, 2007-2008. Queensland Government Department of Primary Industries and Fisheries, Publication PR08-4014, Cairns.	**Objectives** To provide spatial data and descriptions of the seagrass (including by predominant) species that occur in Cleveland Bay. **Summary of Key Findings** • Six seagrass species were identified in the 20 seagrass meadows found in Cleveland Bay. • Dugong feeding trails observed near Cape Pallarenda.

4	Muslim I.R and Jones G. (2003), The seasonal variation of dissolved nutrients, chlorophyll a and suspended sediment at Nelly Bay, Magnetic Island. Estuarine, Coastal and Shelf Science 57:445-455	**Objectives** To undertake a seasonal study of dissolved nutrients and chlorophyll *a* at Nelly Bay, Magnetic Island, in the central Great Barrier Reef (GBR) during 1993–1994, one of the driest climatic years in the previous century. **Summary of Key Findings** Comparison of nutrient concentrations in Nelly Bay with previous measurements suggested that significant changes in chlorophyll *a*, ammonium, and total dissolved nitrogen levels had occurred at this site during the last 5–6 years, prior to the study.
5	Orpin A.R., Ridd P.V. and Stewart L.K. (1999) Assessment of the relative importance of major sediment-transport mechanisms in the central Great Barrier Reef lagoon. Australian Journal of Earth Sciences 46:883-896.	**Objectives** To assess the relative importance of major sediment transport mechanisms in the central Great Barrier Reef lagoon **Summary of Key Findings** • Wave-induced bed stress is the most significant mechanism of sediment re-suspension in the Great Barrier Reef, and field data and mathematical modelling indicates that the combined effects of short-period wind waves, longer period swell waves, and tidal and wind-driven currents can often exceed the critical bed stress for re-suspension. • Suspended-sediment concentrations at 20 m water depth indicate re-suspension seldom occurs on the middle shelf under normal wave conditions.
6	Dredeco (1996) Environmental Monitoring Program, Outer Berth Development Contract No. 333 prepared for the Townsville Port Authority	**Objectives** To measure Suspended Sediment Concentrations in Cleveland Bay by water sampling at various depths and sites. **Summary of Key Findings** SSC ranged between 0.3 mg/L to > 50 mg/L, with higher concentrations generally associated with strong winds and lower concentrations with calm conditions.
7	Larcombe P., Ridd P.V., Prytz A. and Wilson B. (1995) Factors controlling suspended sediment on inner-shelf coral reefs, Townsville, Australia. Coral Reefs 14:163-171.	**Objectives** To describe the characteristics of suspended sediment concentrations (SSCs) of marine waters near inner-shelf fringing coral reefs and relate these to the prevailing oceanographic and meteorological conditions. **Summary of Key Findings** • Temporal and spatial variation in near-bed SSCs is high. • Periods of strong south-easterly regional winds generate swells, which, in 1 km of the reefs, produce near-bed SSCs of well over 200 mg/l. • At the fringing coral reefs at Arthur and Geoffrey Bays, SSCs were less than 5 mg/l for most of the time and rarely exceeded 40 mg/l, but there were a number of periods of over 24 h when near-bed SSCs continuously exceeded 20 mg/l. • The height of locally produced, short-period wind-waves is the dominant control on the magnitude of near-bed SSCs at the reef sites, and thus the wind regime heavily influences conditions for coral communities. • The magnitude of the tide is of lesser importance. However, it is likely that flushing of these bays by tidal currents is

		important in preventing a long-term build-up of SSC in the water around the coral reefs.
8	Larcombe P. and Ridd P.V. (1994) Data Interpretation. In 'Townsville Port Authority Cpaital Dredging Workss 1993: Environmental Monitoring Programme'(Eds: Benson L.J., Goldsworthy P.M., Butler I.R. and Oliver, J.) pp 165-194. Townsville Port Authority.	**Objectives** To describes and summarise key aspects of the 1993 Monitoring Program undertaken by scientists and consultants commissioned by the GBRMPA associated with the 1993 dredging campaign. **Summary of Key Findings** Key chapters of the document report on outcomes of coral monitoring, seagrass monitoring, remote sensing, sediment transport, oceanographic data collection (undertaken by WBM) and outputs of hydrodynamic modelling by various researchers at JCU and consultants.
9	Comarine Consulting (1993) Sediment Data – Final Report Submitted as art fulfilment of Environmental Monitoring Program, Townsville Port Authority, Townsville Port Development Stage 1 Contract 62376-12 Oceanographic and Sediment Data	**Objectives** Historical sediment and water quality data prepared by Comarine Consulting and other entities. **Summary of Key Findings** • Provides an historical baseline for sedimentation and turbidity. • Sedimentation rate assessment methodology is out-dated and has issues.
10	JCU Researchers (1993), Characterisation and Fate of Suspended Sediments Associated with Dredging Activities in Cleveland Bay	**Objectives** JCU report to the GBRMPA examining sediment transport associated with the 1993 dredging campaign. **Summary of Key Findings** • Provides a partial baseline of the nature of dredge plumes. • Found increases in trace metal concentration on coral surfaces port dredging. • Middle Reef and Cockle Bay most affected by dredge plumes. • Florence Bay and Radical Bay most affected by dredge spoil disposal.
11	Mud Dynamics Group (1989) Sediment Plumes Following Dredging and Spoil Dumping, Cleveland Bay, Townsville.	**Objectives** Report to GBRMPA by the Mud Dynamics Group . **Summary of Key Findings** • Short term study (less than 5 days of fieldwork) to measure extent and concentration of dredge plumes. • Provides a partial baseline of the nature of dredge plumes. • Confirms that waters in Cleveland Bay and Platypus Channel are well mixed and not stratified with respect to salinity and temperature.
12	Archibald S. and Kenny R. (1980). A Compilation of Hydrological Data for the Cleveland Bay Area;	**Objectives** A compilation of historical (pre-1974) regional water quality data by JCU researchers. **Summary of Key Findings**

		Report reproduces data from a range of sources including information on turbidity, salinity and water temperature.
13	JCU researchers (1980), A compilation of Hydrological Data for the Cleveland Bay Area;	**Objectives** A compilation of historical (pre-1974) regional water quality data by JCU researchers. **Summary of Key Findings** Report reproduces data from a range of sources including information on turbidity, salinity and water temperature.
14	C and R Consulting (2007). Impact of Proposed Townsville Ocean Terminal on the Water Quality of Cleveland Bay. Report prepared for City Pacific Limited.	**Objectives** To evaluate the status of the water quality that supports the different environments in Cleveland Bay (eg, seagrass beds, coral reefs). The study focussed on the near shore habitats coastal habitats of Cleveland Bay. To provide a locally based set of guidelines against which the impacts of the Townsville Ocean Terminal could be assessed. **Summary of Key Findings** • Water and sediment samples were taken at 11 points in the Bay. They were analysed for a broad range of chemical species including metals and nutrient species. • Data indicated that all the flushed water quality exiting the development will be in current ambient range or 95% ANZECC 2000 Species Protection Guidelines or both.
15	BMT WBM (2011). Proposed Berth 12 Development Integrated Assessment Report. Report prepared for Port of Townsville Limited.	**Objectives** To provide the referral and assessment agencies with relevant information for the consideration and assessment of the required approvals for the proposed Berth 12 development. **Summary of Key Findings** The report outlines water quality guidelines and policies that are applicable to the development, summarises previous studies and outlines the potential impacts and mitigation measures for the development.

Appendix I2

Percentile Plots
Scenario 3

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Predicted Impact Zones as per McArthur (2002) Method – Nearshore Areas

Figure C 1

Legend

- BMT WBM (2009) Monitoring Sites
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- 2007 Coastal Seagrass (Permanent and Semi-permanent Meadows)
- 2007 Deepwater Seagrass (Sparse Ephemeral Meadows)

TSS Threshold (mg/L)

- Greater than 71
- 46 to 71
- 30 to 46
- 21 to 30
- 0 to 21

Scale: 1:20,000 approx. (when printed at A4)

0 200 400 800
Metres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_088

Data Source:
Predicted Impact Zones as per McArthur (2002) Method – Nearshore Areas, Figure C.1 - BMT WBM 2012.

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Appendix I3

Site-specific McArthur (2002) Plots

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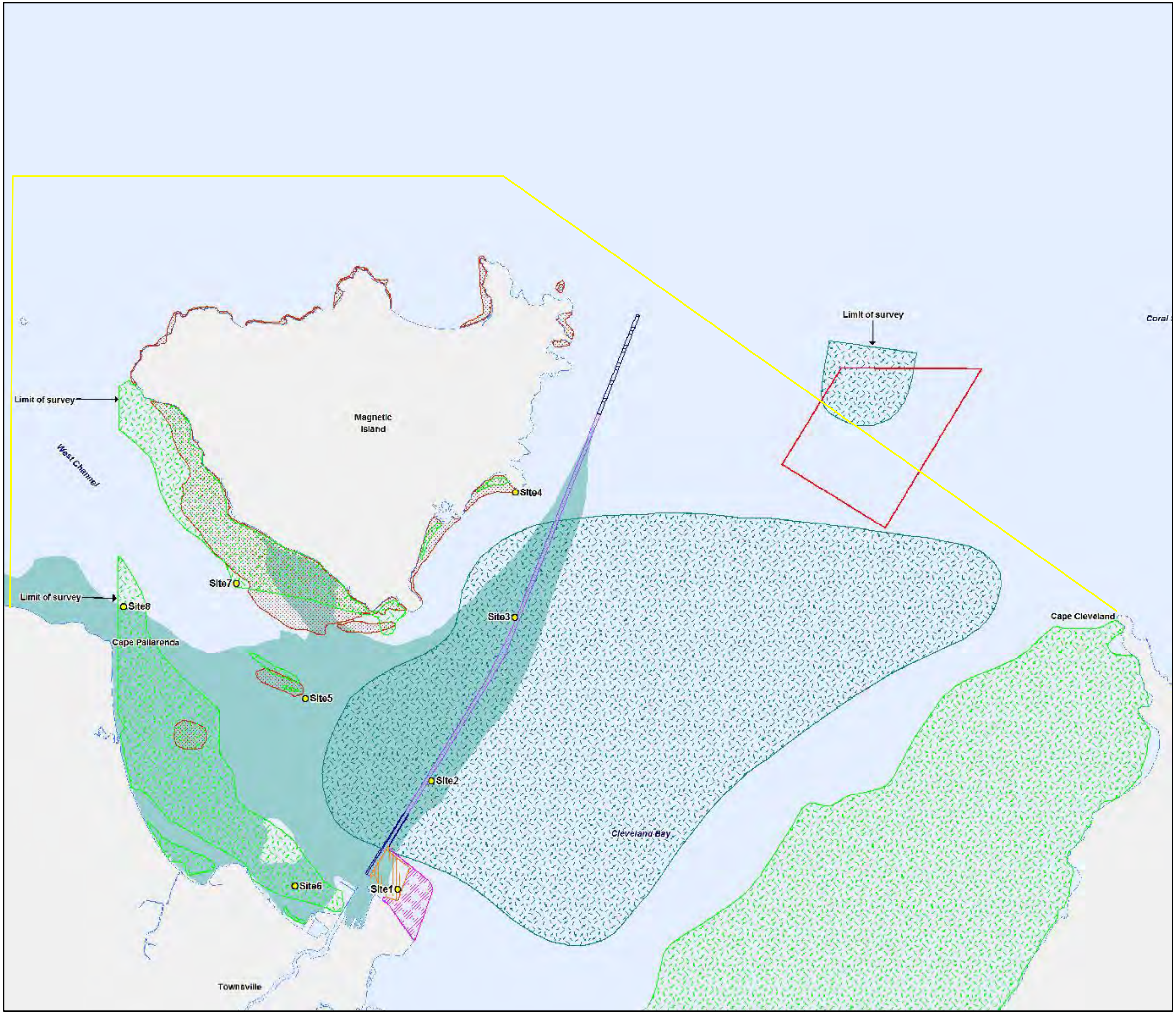
The contour plots below have been developed based on the site-specific thresholds as per the McArthur *et al.* (2002) method. The site-specific thresholds are presented Table 1 and each plot in Figure D-1 to Figure D-10 represents a monitoring site. At monitoring sites where the contour extends out to its location, impacts are expected (i.e. based on the McArthur method). As can be seen from these figures, Site 7 in winter (Figure D-4) is the only monitoring site where impacts are likely.

Table 1 Site Specific No Change Thresholds (mg/L)

Monitoring Site	95th percentile	Median (ambient)	Threshold (95% minus median ambient)*	Area description	Sensitive receptors
S2	44	9	35	Inner Central Cleveland Bay	Deepwater seagrass
S3	33	8	25	Outer Central Cleveland Bay	Deepwater seagrass
S4	41	11	30	Eastern Magnetic Island	Coral and seagrass
S5	54	8	46	Middle Reef	Coral and seagrass
S6	218	47	171	The Strand	Seagrass
S7	30	9	21	Southern Magnetic Island	Coral and seagrass
S8	76	5	71	Cape Pallarenda	Seagrass

Note: * Ambient TSS was subtracted from the 95th percentile since receiving water quality model results exclude ambient conditions.



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Predicted Impact Zones as per McArther (2002) Method - Winter - Site 4

Figure D.1

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 30

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_065

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 4, Figure D.1 - BMT WBM 2012.

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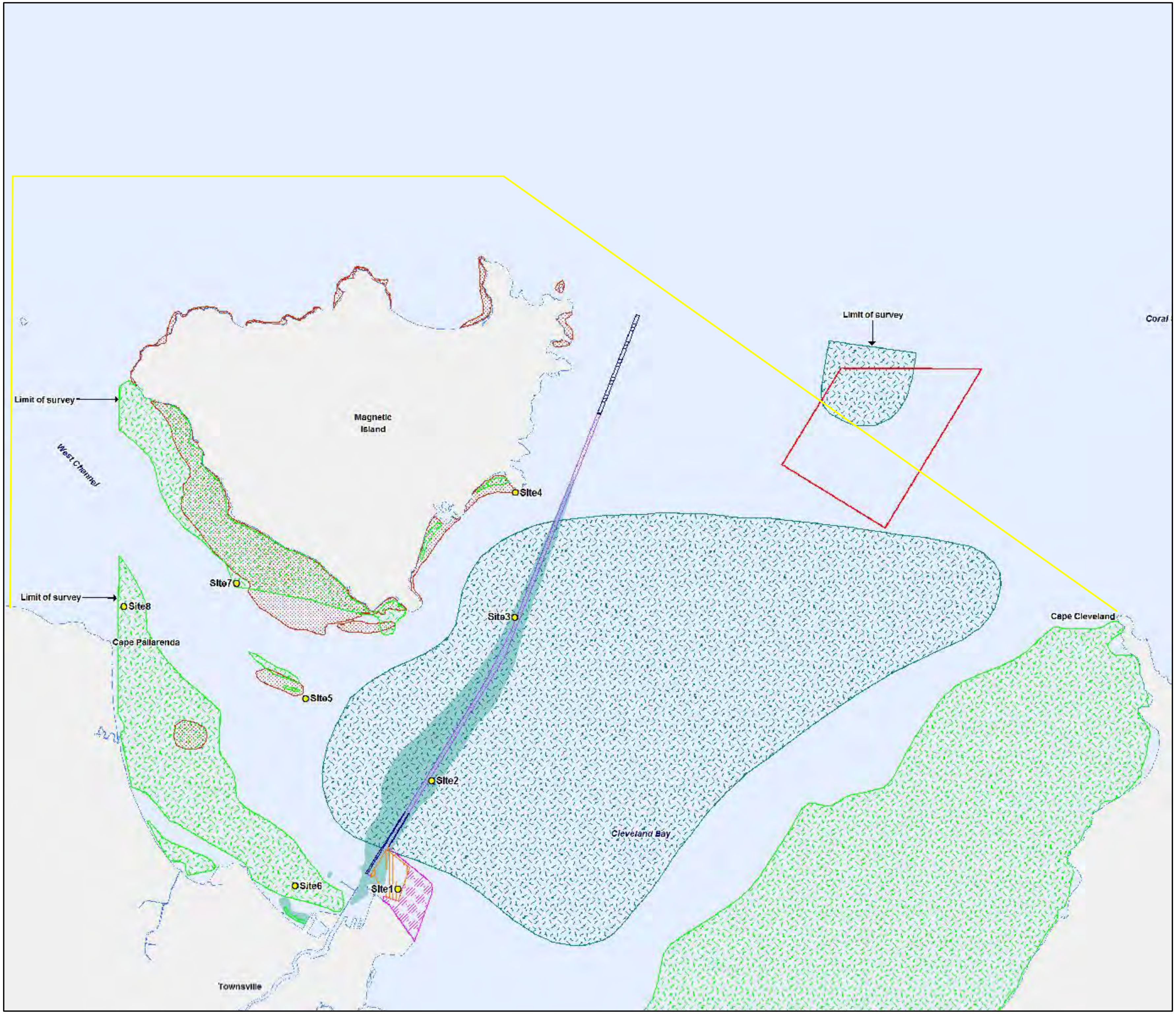
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 5

Figure D.2



Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 46

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_066

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 5, Figure D.2 - BMT WBM 2012.

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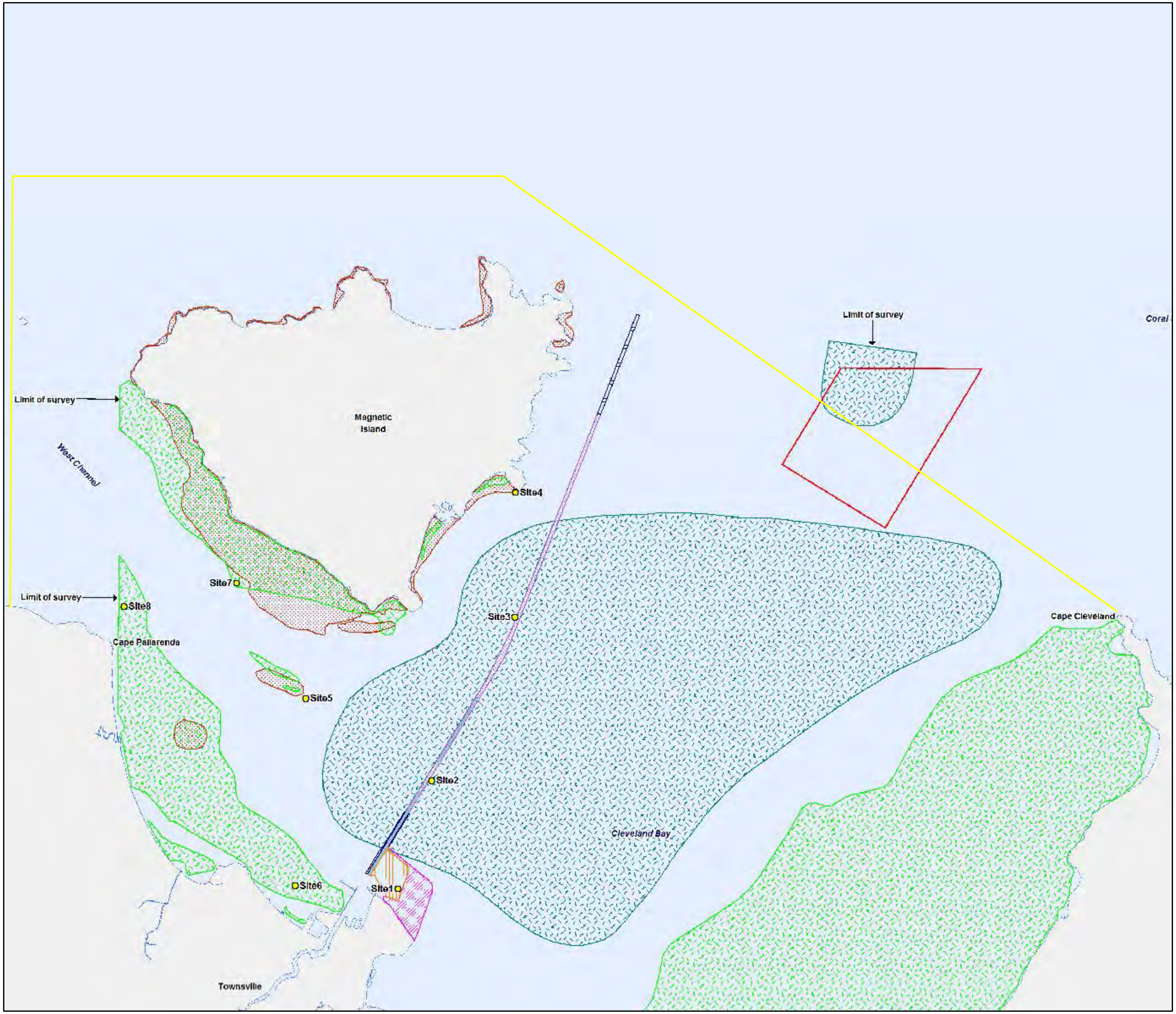
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 6

Figure D.3



Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 171

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_067

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 6, Figure D.3 - BMT WBM 2012.

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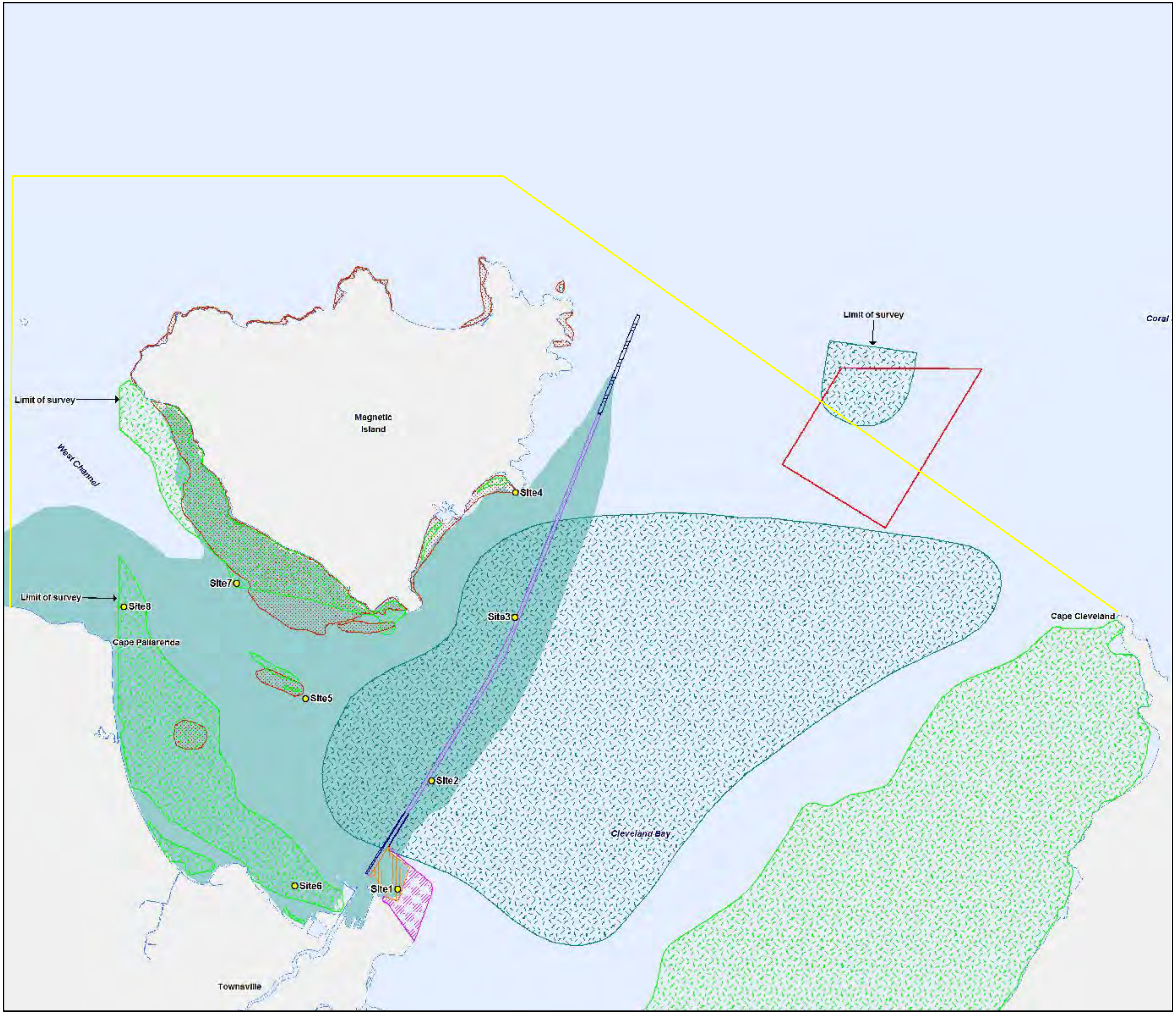

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Predicted Impact Zones as per McArther (2002) Method - Winter - Site 7

Figure D.4

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 21

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_068

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 7, Figure D.4 - BMT WBM 2012.

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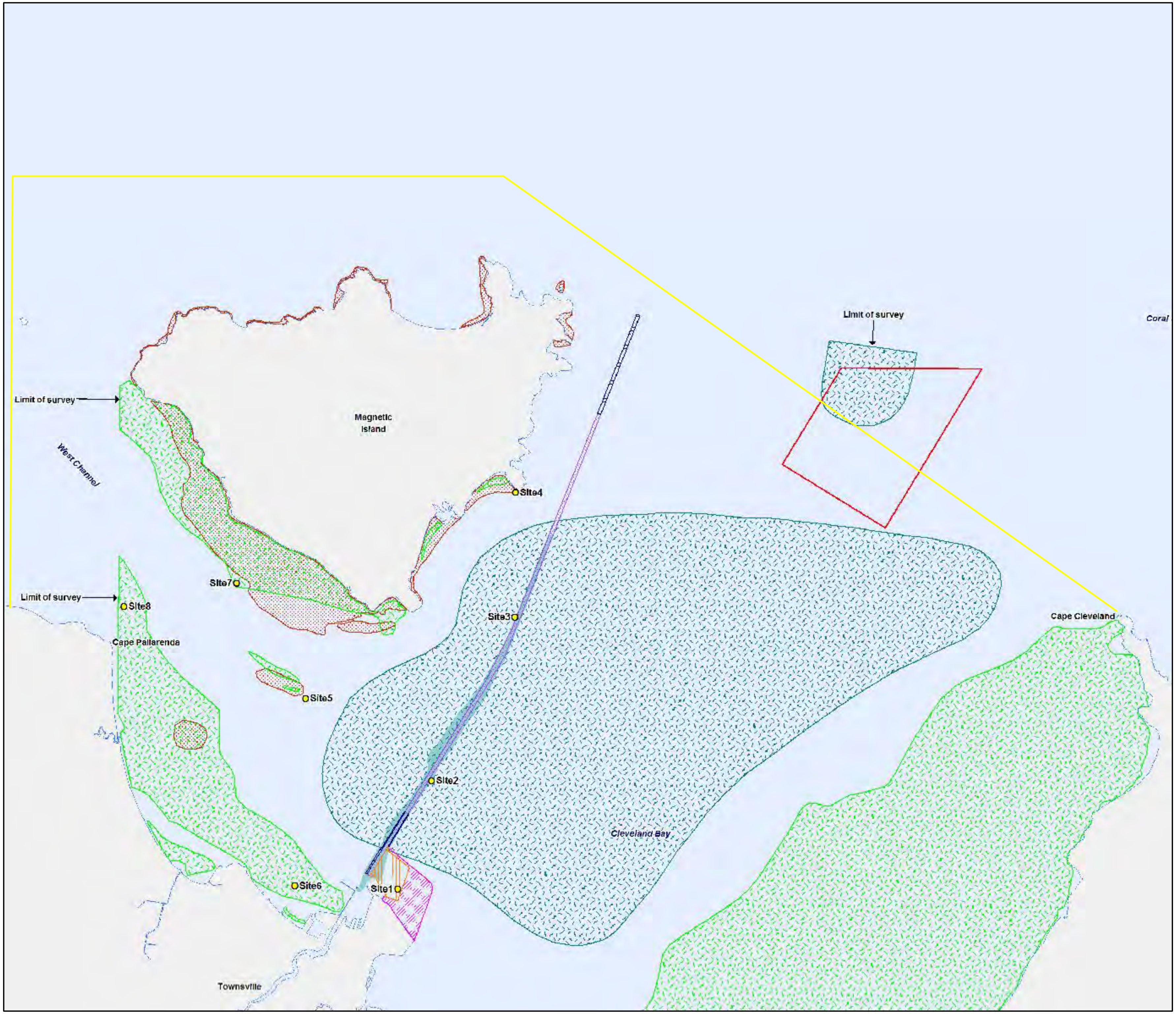

PORT EXPANSION PROJECT
EIS

Predicted Impact Zones as per McArther (2002) Method - Winter - Site 8

Figure D.5

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 71

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_069

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Winter - Site 8, Figure D.5 - BMT WBM 2012.

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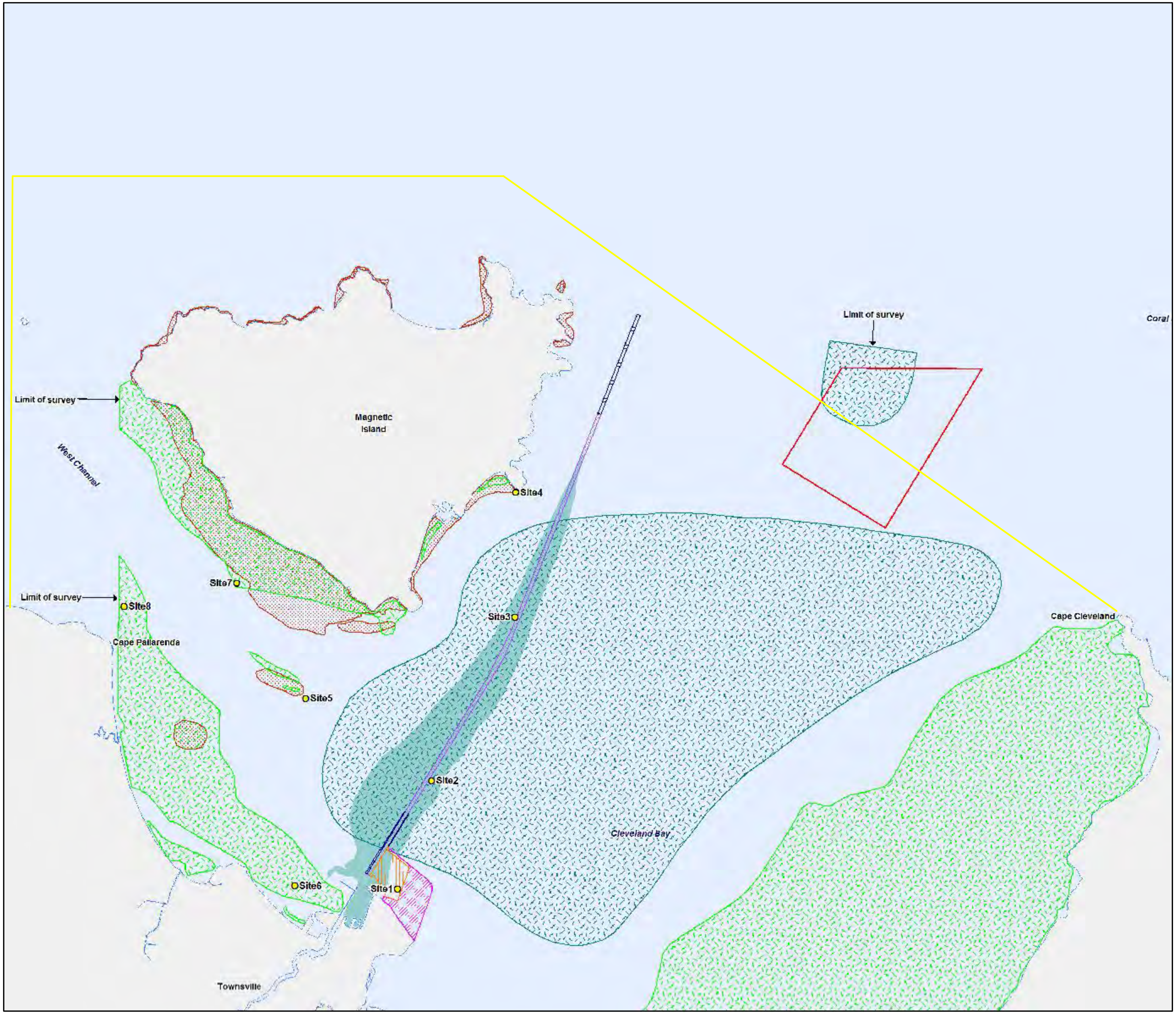

PORT EXPANSION PROJECT
EIS

Predicted Impact Zones as per McArther (2002) Method - Summer - Site 4

Figure D.6

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 30

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996
LAST MODIFIED CFS 16-Oct-2012
FILE NAME 60161996_PLN_070

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Summer - Site 4, Figure D.6 - BMT WBM 2012.

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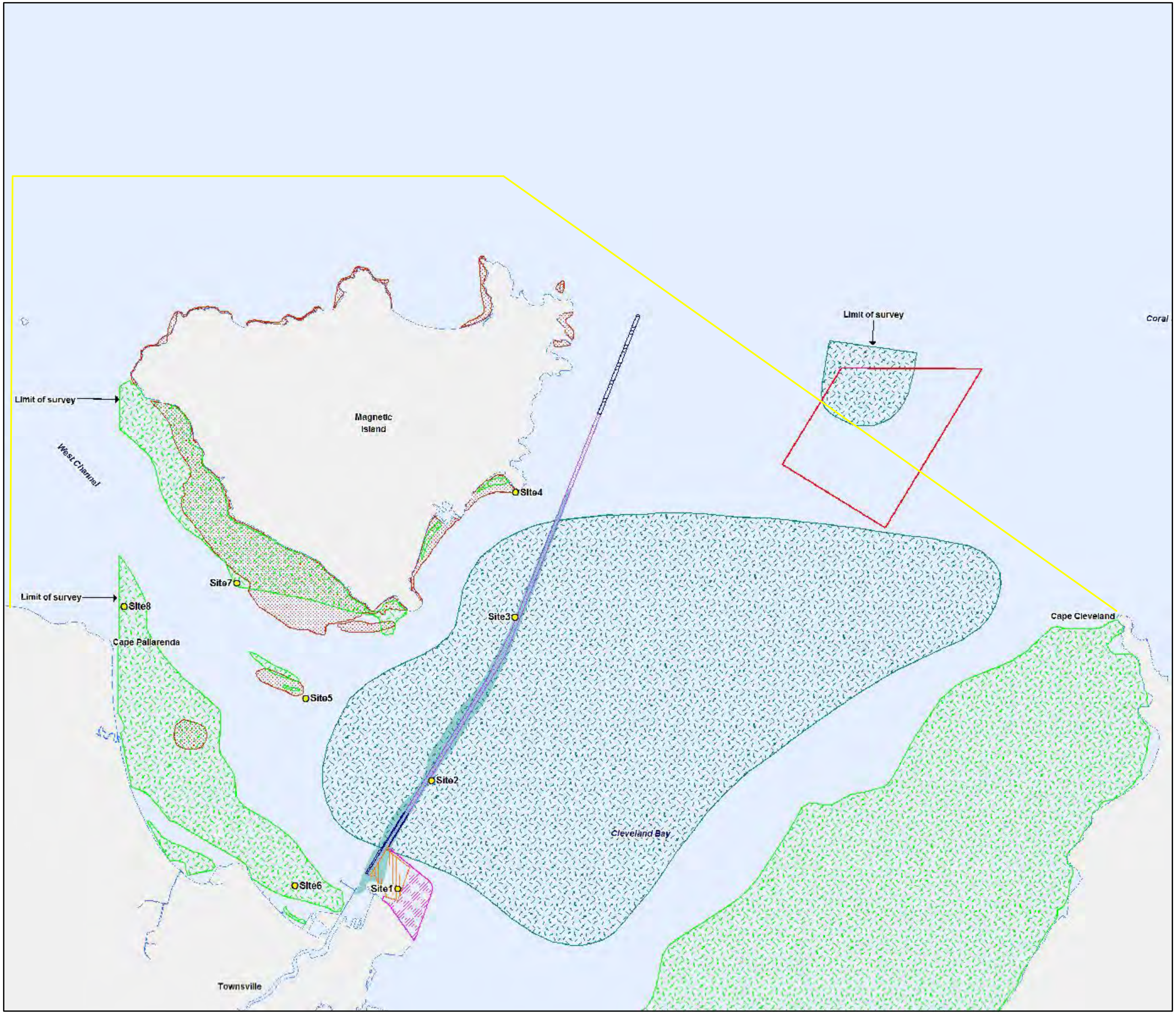

PORT EXPANSION PROJECT EIS

Predicted Impact Zones as per McArther (2002) Method - Summer - Site 5

Figure D.7

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 46

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5

Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_071

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Summer - Site 5, Figure D.7 - BMT WBM 2012.

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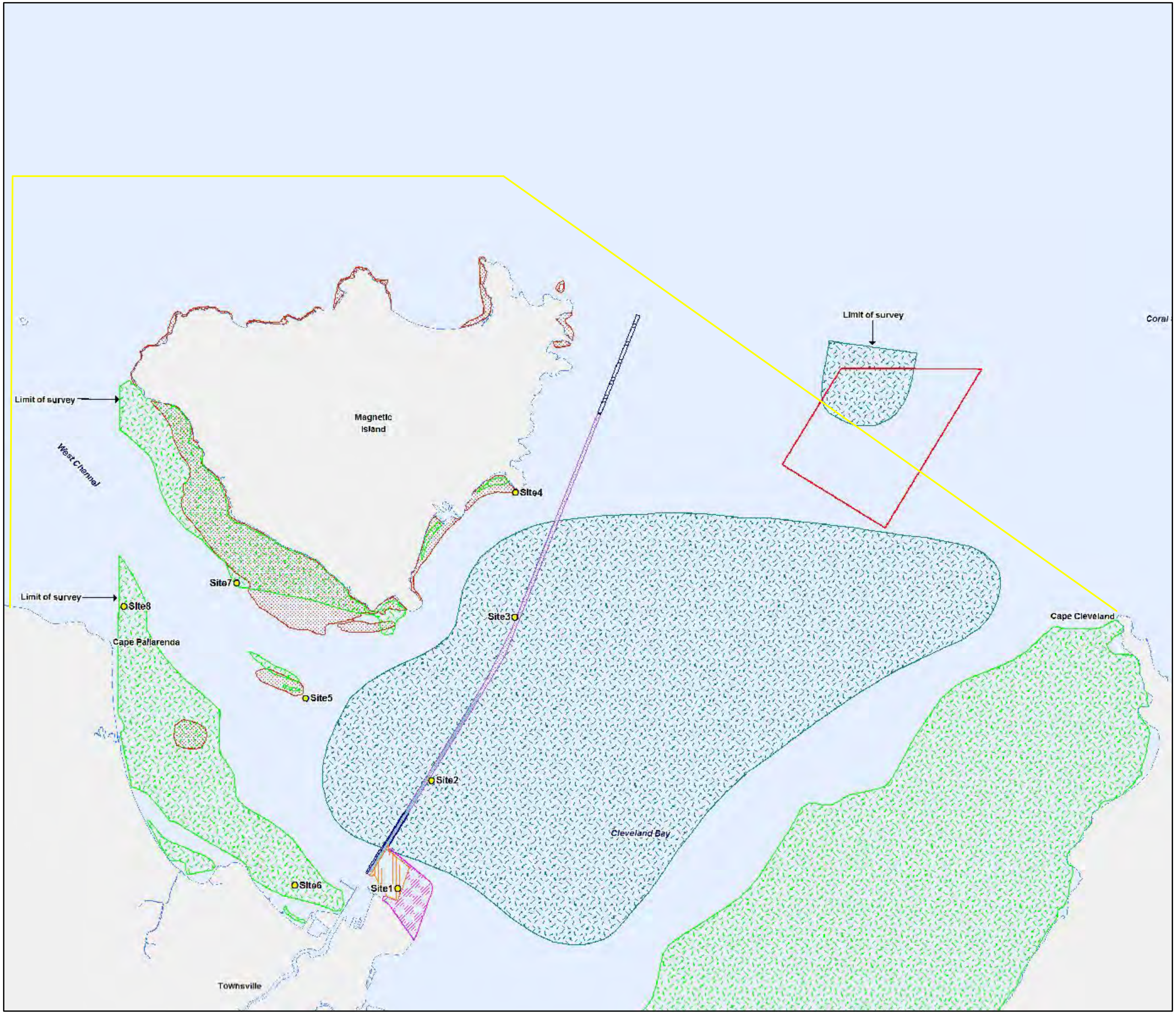

PORT EXPANSION PROJECT
EIS

Predicted Impact Zones as per McArther (2002) Method - Summer - Site 6

Figure D.8

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 171

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_072

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Summer - Site 6, Figure D.8 - BMT WBM 2012.

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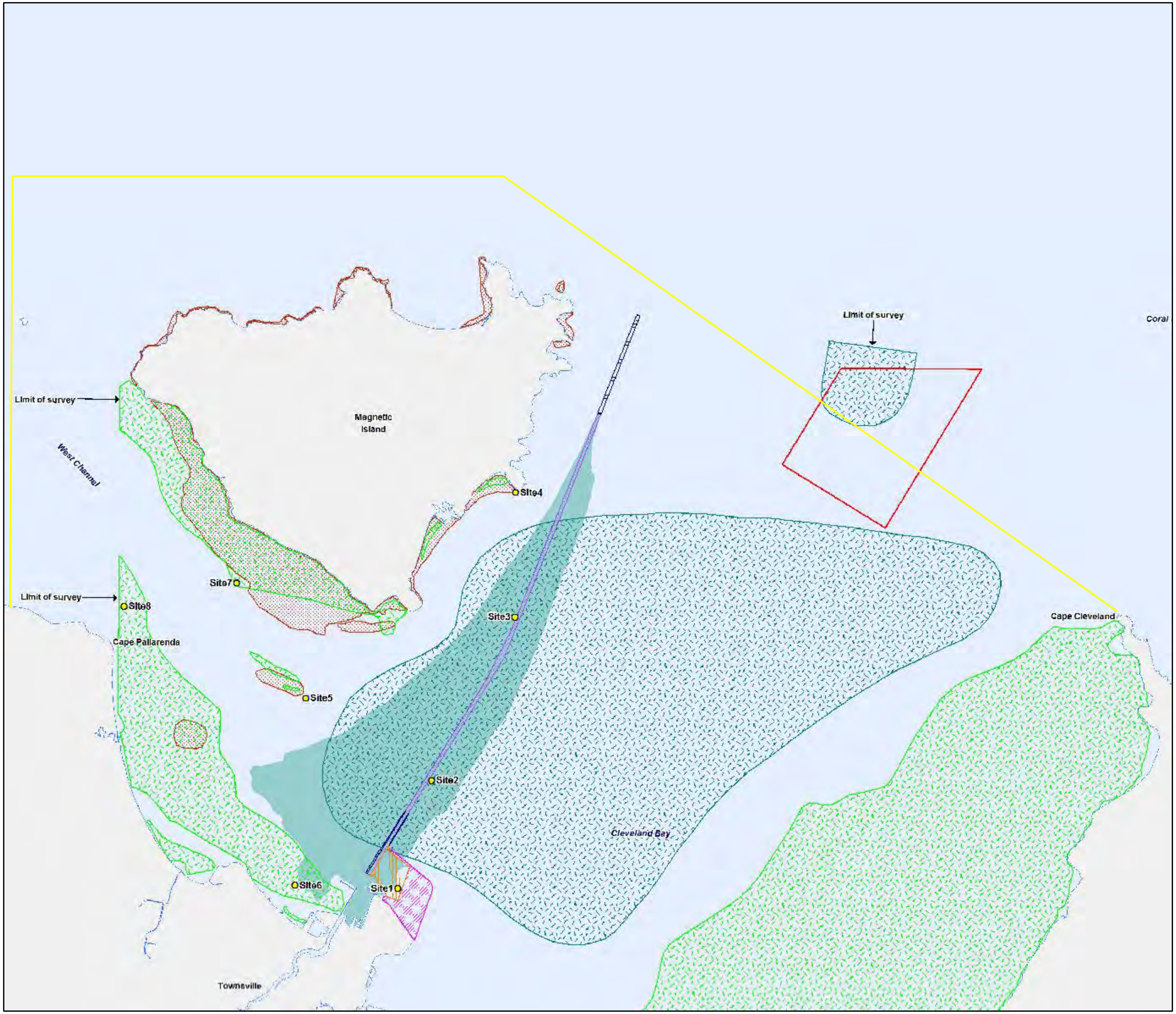

PORT EXPANSION PROJECT
EIS

Predicted Impact Zones as per McArther (2002) Method - Summer - Site 7

Figure D.9

Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 21

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_073

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Summer - Site 7, Figure D.9 - BMT WBM 2012.

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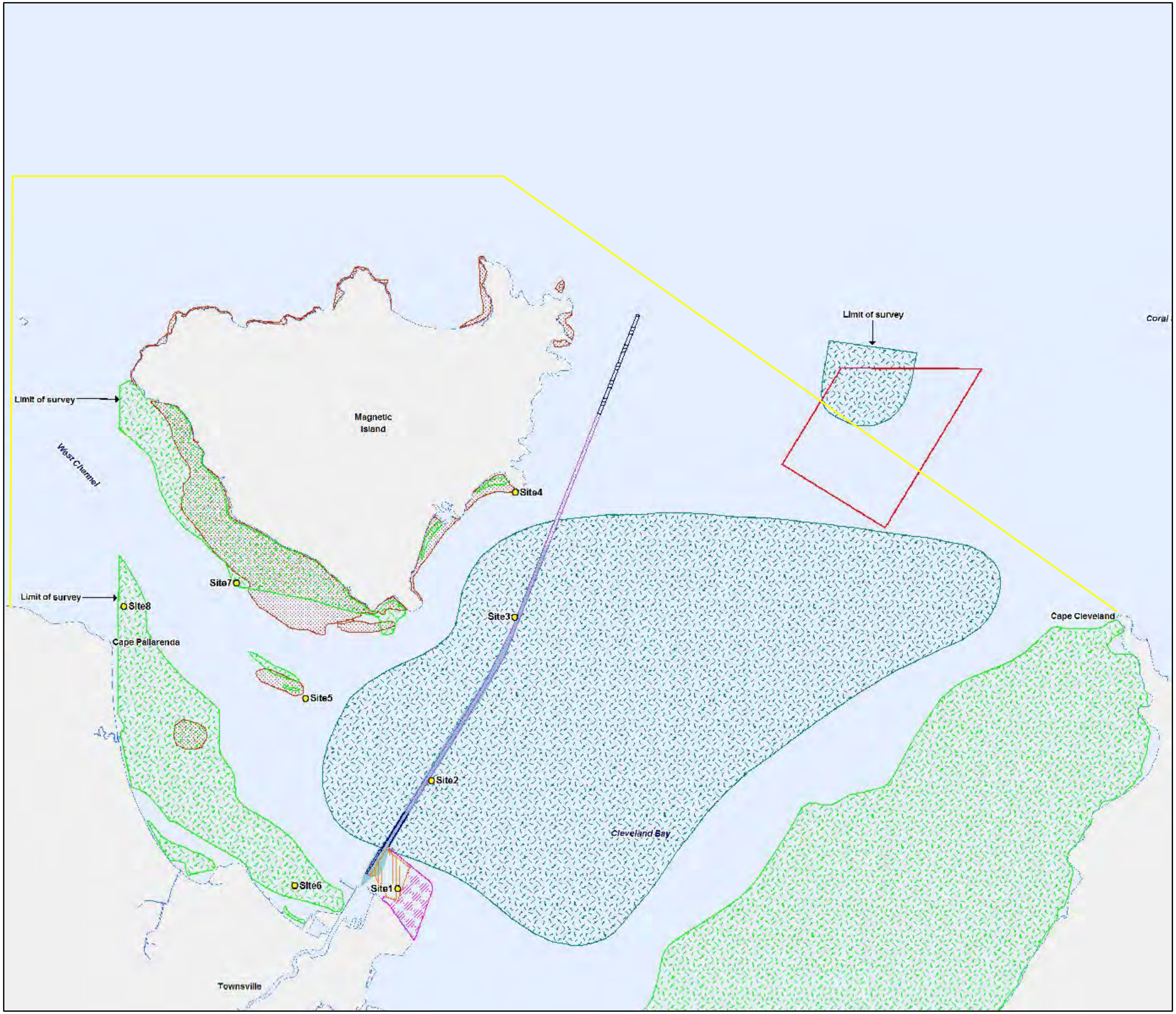
EIS

Predicted Impact Zones as per McArther (2002) Method - Summer - Site 8

Figure D.10



Legend

- BMT WBM (2009) Monitoring Sites
- Port Limits
- Dredge Material Placement Area
- Channel to be Dredged
- Existing Channel to be Deepened
- Harbour Basin
- Reclamation Area
- Coastal Seagrass (Permanent and Semi-permanent Meadows)
- Deepwater Seagrass (Sparse Ephemeral Meadows)
- Corals

TSS Threshold (mg/L)

- Greater than 71

N

Scale: 1:125,000 approx. (when printed at A4)

0 0.5 1 2 3 4 5
Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_074

Data Source:
Predicted Impact Zones as per McArther (2002) Method - Summer - Site 8, Figure D.10 - BMT WBM 2012.

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Port Expansion Project EIS

Appendix J1

Sediment Stratigraphy and Subsurface Cross Sections

AECOM BMT WBM

SEDIMENT TYPE DEPTH PROFILES

Stratigraphy at four representative boreholes in the Outer Harbour and sediment surface cross sections for boreholes collected along two transects across the Outer Harbour

Diagrams provided courtesy of Golder Associates Pty Ltd. All diagrams show data collected during borehole drilling during a geotechnical investigation undertaken for the Port of Townsville. *From: Golder (2008) Offshore Geotechnical Investigation and Acid Sulfate Soils Investigation. Prepared for Port of Townsville Limited by Golder Associates, Townsville.*

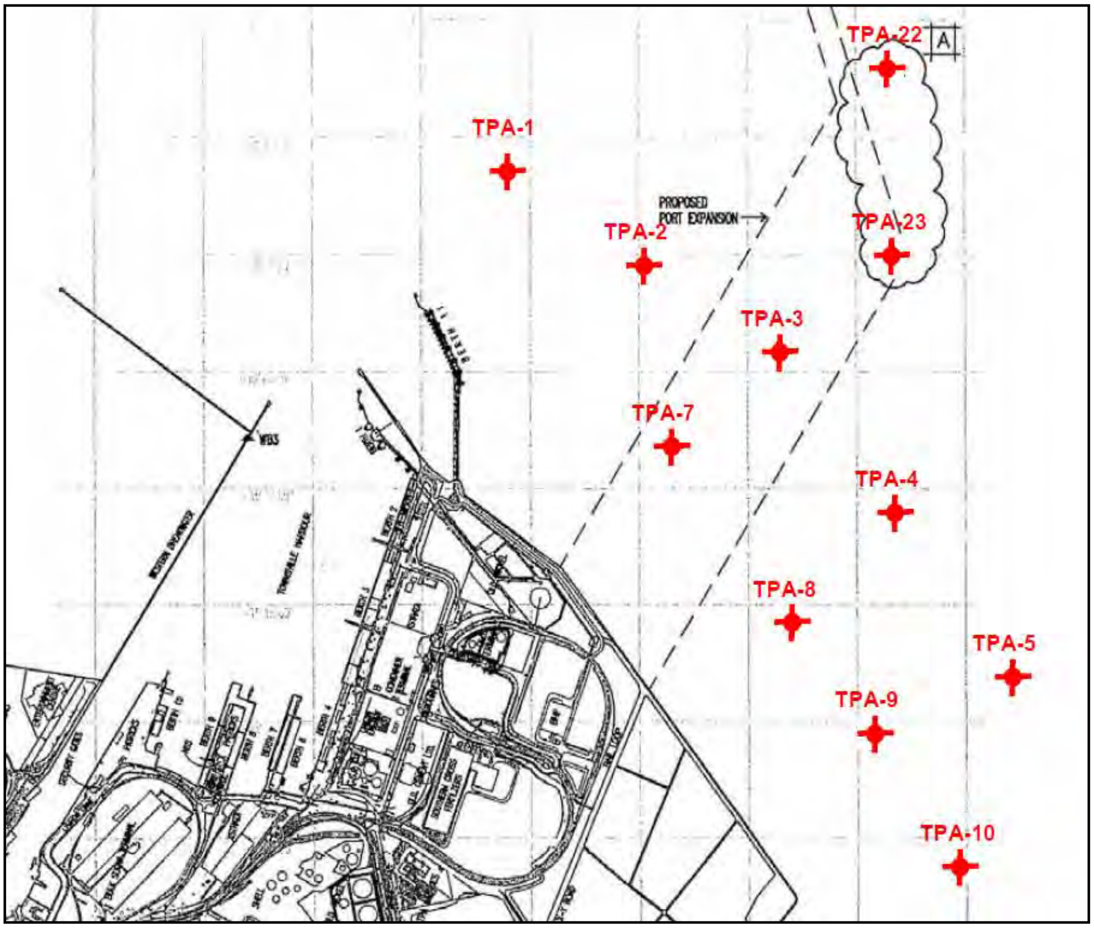

Figure 1 Locations of Golder (2008) boreholes tested within the Outer Harbour area

REPORT OF BOREHOLE: TPA01

Golder Associates

CLIENT: Townsville Port Authority	COORDS: 483182 m E 7872658 m N 55 AMG66	SHEET: 1 OF 1	
PROJECT: Offshore Drilling Project	SURFACE RL: -4.00 m DATUM: LAT	DRILL RIG: Rason	
LOCATION: Townsville Port - Cleveland Bay	INCLINATION: -90°	DRILLER: Double J Drilling	
JOB NO: 077692009	HOLE DIA: 100 mm HOLE DEPTH: 11.95 m	LOGGED: KSR	DATE: 11/12/07
		CHECKED: SE/SA-B	DATE: 14/3/08

Drilling: METHOD WB; PENETRATION RESISTANCE L

DEPTH / RL	SAMPLE OR FIELD TEST	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
-4.15	DS 0.00-0.25 m PP = 90 kPa	CH	Sandy CLAY Medium to high plasticity, dark grey, fine to coarse sand, wet, soft, occasional shell fragments	W	S
1.10 / -5.20	DS 0.25-0.50 m PP = 220 kPa DS 0.50-0.75 m PP = 240 kPa DS 0.75-1.00 m PP = 220 kPa DS 1.00-1.25 m PP = 230 kPa U50 1.25-1.55 m PP = 260 kPa	CH	CLAY High plasticity, dark grey, moist, some fine to coarse sand and trace of gravel . Grading to brown at 1.1m depth . Some fine to medium gravel at 1.2m depth	M	F
2.50 / -6.50	U50 2.50-2.90 m PP = 160 kPa		. Grading to stiff and orange-brown at 2.5m depth		St
3.50 / -7.50			. Grading to sandy CLAY at 3.5m depth		
4.00 / -8.00	U50 4.00-4.32 m PP = 250 kPa	CH	Sandy CLAY High plasticity, orange-brown, fine to coarse sand, with some fine to medium gravel		
5.50 / -9.50	SPT 5.50-5.95 m 7,11,17 N = 28 PP = 350 kPa		. Grading to pale brown with fine sand at 5.5m depth		
6.50 / -10.50		SC/CI	Clayey SAND/Sandy CLAY Medium plasticity, brown, fine sand, moist		MD-Vst
7.20	SPT 7.00-7.45 m 8,11,15 N = 26		. Grading to pale brown at 7.2m depth		
7.50 / -11.50		CH	Sandy CLAY High plasticity, brown, fine to coarse sand		
8.60	SPT 8.50-8.95 m 4,7,13 N = 20	SC	Clayey SAND Fine to coarse sand, red/brown, medium plasticity, wet, medium dense	W	
8.95 / -13.10			. Grading to sandy CLAY at 8.9m depth . Grading to clayey SAND at 9.1m depth		VSt
10.00 / -14.00	SPT 10.00-10.45 m 13,17,21 N = 38 PP = 480 kPa	SC	Clayey SAND Fine to coarse sand, pale brown, medium plasticity, moist, dense	M	D
11.50 / -15.50	SPT 11.50-11.95 m 7,12,19 N = 31	CI	CLAY Medium plasticity, dark brown, moist,dense, intermitted sand layers		
11.95 / -15.95			END OF BOREHOLE @ 11.95 m		

DEPTH (metres): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

STRUCTURE AND ADDITIONAL OBSERVATIONS

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a RL2

REPORT OF BOREHOLE: TPA02

Golder Associates

CLIENT: Townsville Port Authority	COORDS: 483384 m E 7872392 m N 55 AMG66	SHEET: 1 OF 1	
PROJECT: Offshore Drilling Project	SURFACE RL: -3.80 m DATUM: LAT	DRILL RIG: Rason	
LOCATION: Townsville Port - Cleveland Bay	INCLINATION: -90°	DRILLER: Double J Drilling	
JOB NO: 077692009	HOLE DIA: 100 mm HOLE DEPTH: 12.45 m	LOGGED: KSR	DATE: 10/12/07
		CHECKED: SE/SA-B	DATE: 14/3/08

Drilling: METHOD: WB; PENETRATION RESISTANCE: L; WATER; DEPTH (metres)

DEPTH / RL	SAMPLE OR FIELD TEST	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
0.20 / -4.00	DS 0.00-0.25 m	CH	Sandy CLAY Medium to high plasticity, dark grey, fine to coarse sand, wet, soft	W	S	
1.50 / -5.30	DS 0.25-0.50 m PP = 180 kPa DS 0.50-0.75 m PP = 190 kPa	CH	CLAY High plasticity, dark grey, moist, trace of fine sand	M	F-St	
2.80	DS 0.75-1.00 m PP = 190 kPa DS 1.00-1.25 m PP = 190 kPa U50 1.50-1.80 m		. Grading to pale grey at 1.5m depth			
3.00 / -6.80	PP = 1.60 kPa		. Grading to orange/brown at 2.8m depth			
3.50 / -7.30	U50 3.00-3.40 m PP = 110 kPa		. Some pockets of sand at 3.2m depth		St	
4.50 / -8.30			. Grading to orange/brown CLAY at 3.5m depth			
5.50 / -9.30	SPT 4.50-4.95 m 7,6,7 N = 13 PP = 340 kPa		. Some fine to medium grave and fine to coarse sand at 4.5m depth			
6.00 / -9.80		SC	Clayey SAND Fine to coarse sand, orange/brown, medium plasticity, some fine to medium gravel, medium dense	W	MD	
7.50 / -11.30	SPT 6.00-6.45 m 8,12,15 N = 27		. Grading to fine sand, orange/grey at 6.0m depth			
8.20 / -12.00	SPT 7.50-7.95 m 8,7,12 N = 19	CH	Sandy CLAY High plasticity, grey, orange/brown, fine to medium sand, moist, very stiff	M	VSt	
9.00 / -12.80			. Grading to medium to high plasticity, orange/brown, fine to medium sand			
10.50 / -14.30	SPT 9.00-9.45 m 12,18,23 N = 41		. Grading to fine sand, high plasticity, pale brown/brown		H	
12.00 / -15.80	SPT 10.50-10.95 m 7,14,20 N = 34	MH	SILT High plasticity, orange/brown, trace of fine sand			
12.45 / -16.25	SPT 12.00-12.45 m 10,16,19 N = 35	CH	CLAY High plasticity, grey/brown, some fine to medium sand			
			END OF BOREHOLE @ 12.45 m			

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a RL2

REPORT OF BOREHOLE: TPA03

Golder Associates

CLIENT: Townsville Port Authority	COORDS: 483747 m E 7872147 m N 55 AMG66	SHEET: 1 OF 1	
PROJECT: Offshore Drilling Project	SURFACE RL: -3.40 m DATUM: LAT	DRILL RIG: Rason	
LOCATION: Townsville Port - Cleveland Bay	INCLINATION: -90°	DRILLER: Double J Drilling	
JOB NO: 077692009	HOLE DIA: 100 mm HOLE DEPTH: 12.45 m	LOGGED: KSR	DATE: 12/12/07
		CHECKED: SE/SA-BT	DATE: 14/3/08

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB	L		0	-3.40	DS 0.00-0.25 m DS 0.25-0.50 m DS 0.50-0.75 m			CH	CLAY High plasticity, dark grey, wet, soft, some fine to coarse sand, occasional shell fragments	W	S-F	
			0.75	-4.15	DS 0.75-1.00 m PP = 190 kPa DS 1.00-1.25 m				. Trace of sand, firm at 0.75m depth	M	F	
			1.70		PP = 200 kPa				. Grading to orange-brown at 1.7m depth		St	
			2.00	-5.40	U50 1.50-1.78 m PP = 230 kPa				. Grading to dark grey, trace of fine sand and gravel at 2.0m depth			
			3.00	-6.40	U50 3.00-3.40 m PP = 160 kPa			CH	Sandy CLAY/CLAY High plasticity, orange-brown, fine sand			
			4.50	-7.90	SPT 4.50-4.95 m 5,8,10 N = 18 PP = 260 kPa			CH	CLAY High plasticity, orange-brown, intermitted layers of fine to medium white gravel with some sand		VSt	
			5.50	-8.90					. Becoming sandy CLAY at 5.5m depth			
			6.00	-9.40	U50 6.00-6.40 m PP = 420 kPa			CH	Sandy CLAY High plasticity, orange-brown, fine to coarse sand, some fine gravel			
			6.50	-9.90					. Grading to fine sand at 6.5m depth			
			7.00	-10.40	SPT 7.50-7.95 m 8,9,15 N = 24 PP = 320 kPa			CI/CH	Sandy CLAY/CLAY Medium to high plasticity, orange-brown with some grey pockets of fine sand			
			9.00	-12.40	SPT 9.00-9.45 m 15,20,28 N = 48 PP = 550 kPa			CH	CLAY High plasticity, pale grey, with some fine to coarse sand, moist, hard		H	
			10.50	-13.90	SPT 10.50-10.95 m 9,14,19 N = 33				. Grading to grey and orange/brown at 10.5m depth			
			12.00	-15.40	SPT 12.00-12.45 m 8,14,22 N = 36				. Grading to brown and grey at 12.0m depth			
			12.45	-15.85					END OF BOREHOLE @ 12.45 m			

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01a RL2

REPORT OF BOREHOLE: TPA04

Golder Associates

SHEET: 1 OF 1

CLIENT: Townsville Port Authority	COORDS: 484059 m E 7871715 m N 55 AMG66	DRILL RIG: Rason	
PROJECT: Offshore Drilling Project	SURFACE RL: -3.00 m DATUM: LAT	DRILLER: Double J Drilling	
LOCATION: Townsville Port - Cleveland Bay	INCLINATION: -90°	LOGGED: KSR	DATE: 13/12/07
JOB NO: 077692009	HOLE DIA: 100 mm HOLE DEPTH: 12.45 m	CHECKED: SE/SA-B	DATE: 14/3/08

METHOD	PENETRATION RESISTANCE	WATER	DEPTH / RL	SAMPLE OR FIELD TEST	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
WB	L		-3.00		CI	Sandy CLAY Medium to high plasticity, dark grey, fine to coarse sand	W	F	
			1.20			. Grading to clayey SAND at 1.2m depth	M	VSt	
			1.40 -4.40	U50 1.50-1.75 m PP = 280 kPa	SC	Clayey SAND Fine to coarse sand, dark grey, medium plasticity, wet, medium dense	W	MD	
				SPT 3.00-3.45 m 9,8,8 N = 16					
			3.80 -6.80			. Grading to SAND with some clay			
			4.50 -7.50	SPT 4.50-4.95 m 7,8,8 N = 16	SW	SAND Fine to coarse sand, grey, wet, medium dense with some clay and fine to medium gravel			
			5.00 -8.00			. Grading to clayey SAND at 5.0m depth			
			5.50 -8.50			. Grading to SAND at 5.5m depth			
			6.00	SPT 6.00-6.45 m 7,8,12 N = 20		. Grading to brown/orange, grey with some clay at 6.0m depth			
			6.30			. Layer of fine to medium gravel at 6.3m depth			
			6.40 -9.40		SW-SC	Clayey SAND/SAND Fine to coarse sand, brown, medium plasticity, wet, medium dense with some bands of fine to medium gravel			
			7.80 -10.80	SPT 7.50-7.95 m 9,9,8 N = 17		. Band of fine to medium gravel at 7.8m depth			
			9.00 -12.00	SPT 9.00-9.45 m 10,10,9 N = 19	SC	Clayey Gravelly SAND Fine to coarse sand, grey and brown, medium plasticity, fine to medium gravel, wet, medium dense			
			10.50 -13.50	SPT 10.50-10.95 m 11,13,20 N = 33		. Grading to dense at 10.5m depth	M	D	
			12.00 -15.00	SPT 12.00-12.45 m 8,11,16 N = 27	SC	Clayey SAND Fine to coarse sand, grey, high plasticity, wet, medium dense	W	MD	
			12.45 -15.45			END OF BOREHOLE @ 12.45 m			

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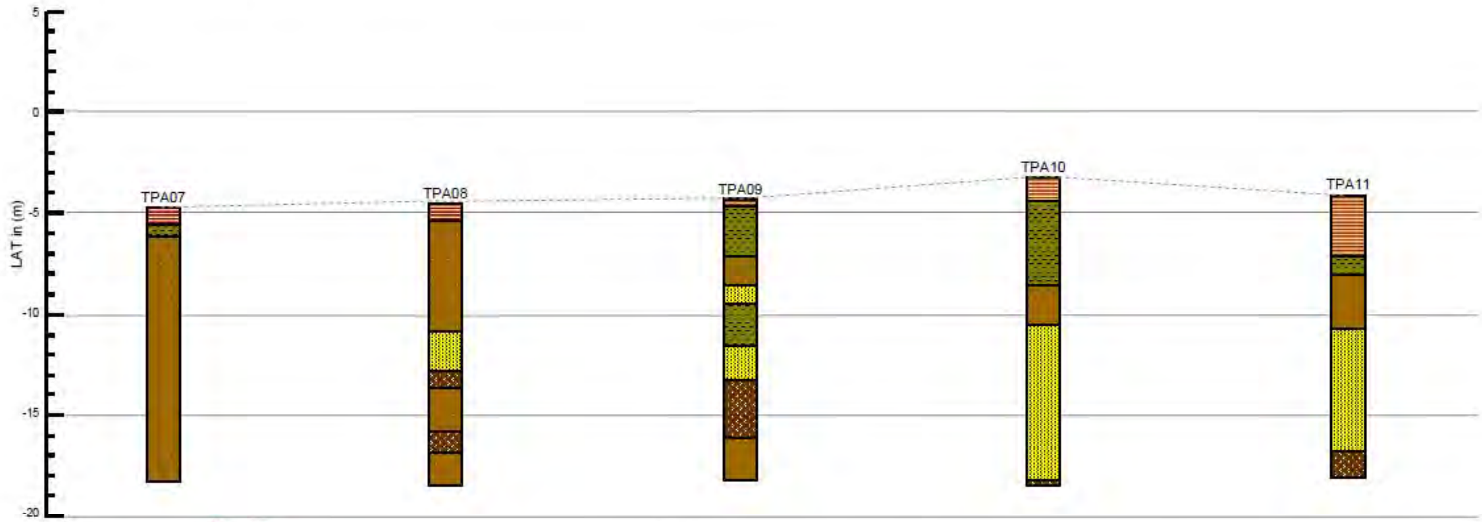

NOTES

This figure is diagrammatic only and is not precise in all details. It provides one interpretation of the Borehole and CPTu data (other interpretations could be made). Refer to Borehole records and CPTu test reports in Appendices A for detailed information. Sea bed surface shown is diagrammatic only. This figure should not be used for design or costing.

- **Soft and very soft**
- **Loose and very loose**
- **Firm and stiff**
- **Medium dense**
- **Very stiff and hard clay**
- **Dense and very dense**

Golder Associates

CLIENT: Maunsell		PROJECT: **Sea and Platypus Channel Profiles**	
DRAWN: SE	DATE: 01/10/2008	TITLE: **Cross Section C-C'**	
CHECKED: WSB	DATE: 02/10/2008		
SCALE: NTS	A3	PROJECT No: 087692015	FIGURE No: **B3**

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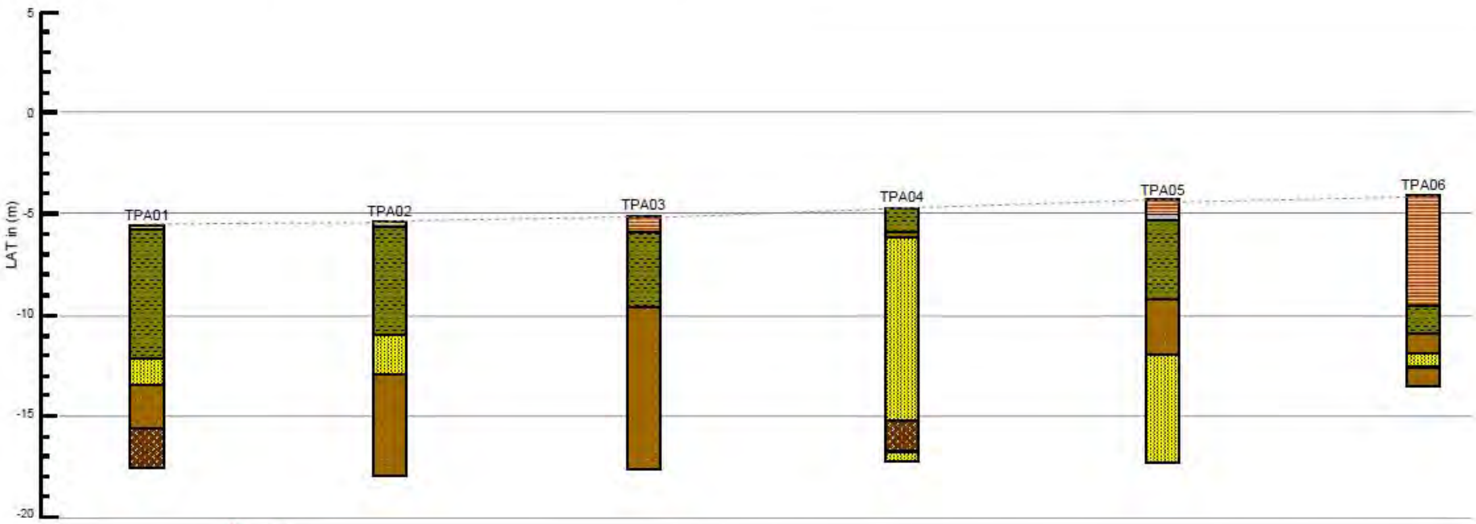


NOTES

This figure is diagrammatic only and is not precise in all details. It provides one interpretation of the Borehole and CPTu data (other interpretations could be made). Refer to Borehole records and CPTu test reports in Appendices A for detailed information. Sea bed surface shown is diagrammatic only. This figure should not be used for design or costing.

Soft and very soft

Loose and very loose

Firm and stiff

Medium dense

Very stiff and hard clay

Dense and very dense

Golder Associates

CLIENT Maunsell			PROJECT **Sea and Platypus Channel Profiles**	
DRAWN SE	DATE 01/10/2008		TITLE **Cross Section D-D'**	
CHECKED WSB	DATE 02/10/2008			
SCALE NTS	A3		PROJECT No 087692015	FIGURE No **B4**

Port Expansion Project EIS

Appendix J2

Mapping of Distribution of Surface Sediment Types

AECOM BMT WBM

The following figures indicate the current distribution of surface sediment types within the project area, based on acoustic mapping. Figures are extracted from the project's Marine Ecology Baseline Report – refer to this report for further information. Sediment types (classes) mapped include the following:

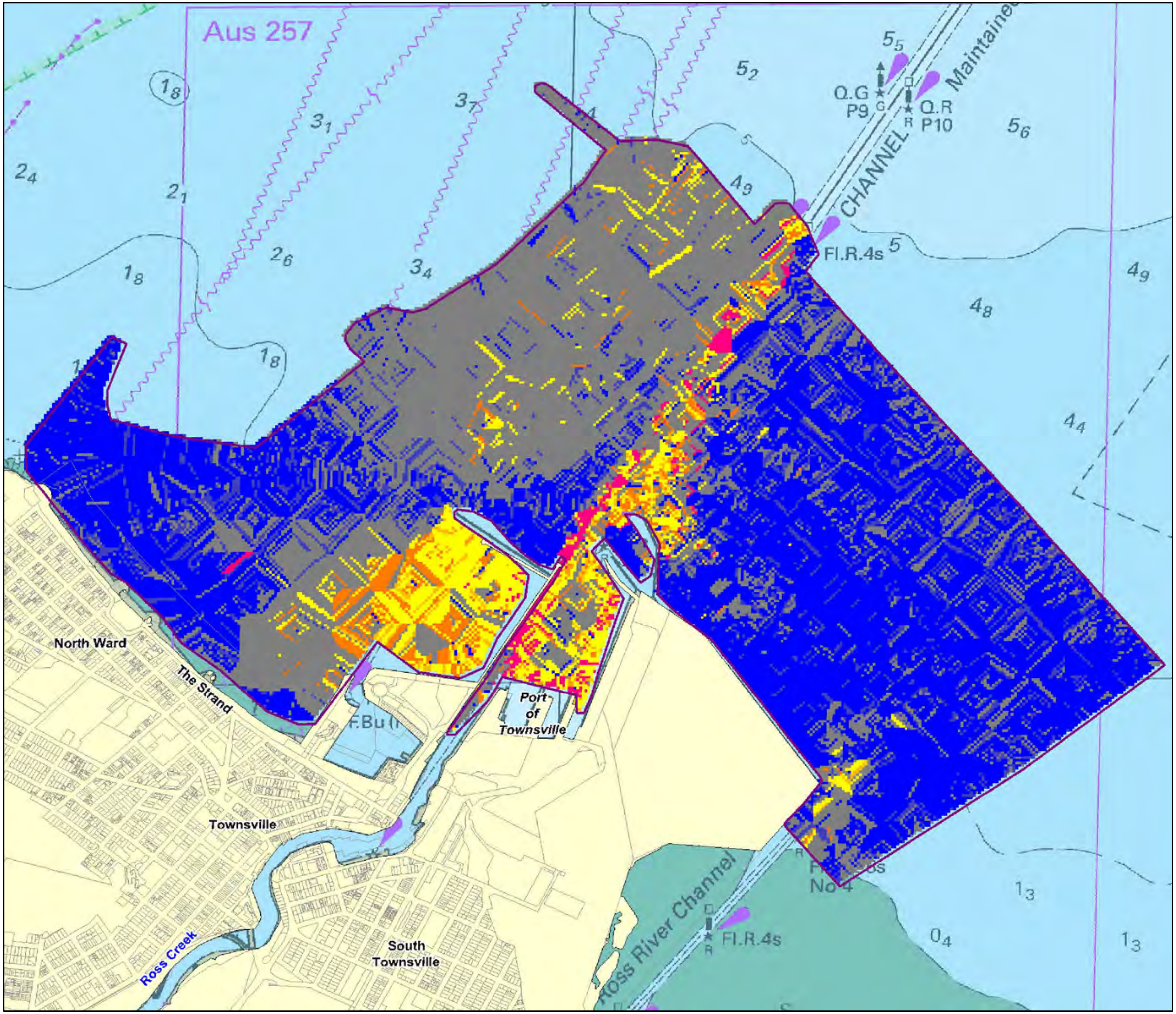
Class 2 (grey) – muddy sand with gravel

Class 3 (navy) – Silty fine sand

Class 4 (yellow) – Silt with sand

Class 6 (orange) – Silt

Class 7 (pink) – Rock with silt and sand



PORT EXPANSION PROJECT
EIS

Acoustic Classes Surrounding the Outer Harbour Project Area

Figure 1

Legend

- Survey Boundary
- Cadastre

Acoustic Class

- 2
- 3
- 4
- 6
- 7

Scale: 1:25,000 approx. (when printed at A4)

0 0.5 1

Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_054

Data Source:
Acoustic Classes Surrounding the Outer Harbour Project Area, Figure 3.9 - BMT WBM 2012.
Chart - Australian Hydrographical Service

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PORT EXPANSION PROJECT
EIS

Acoustic Classes Surrounding the DMPA

Figure 2

Legend

Port Limits

Dredge Material Placement Area

Acoustic Class

2

3

4

6

7

N

Scale: 1:35,000 approx. (when printed at A4)

0 0.5 1

Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_055

Data Source:
Acoustic Classes Surrounding the DMPA, Figure 3.10 - BMT WBM 2012.
Chart - Australian Hydrographical Service

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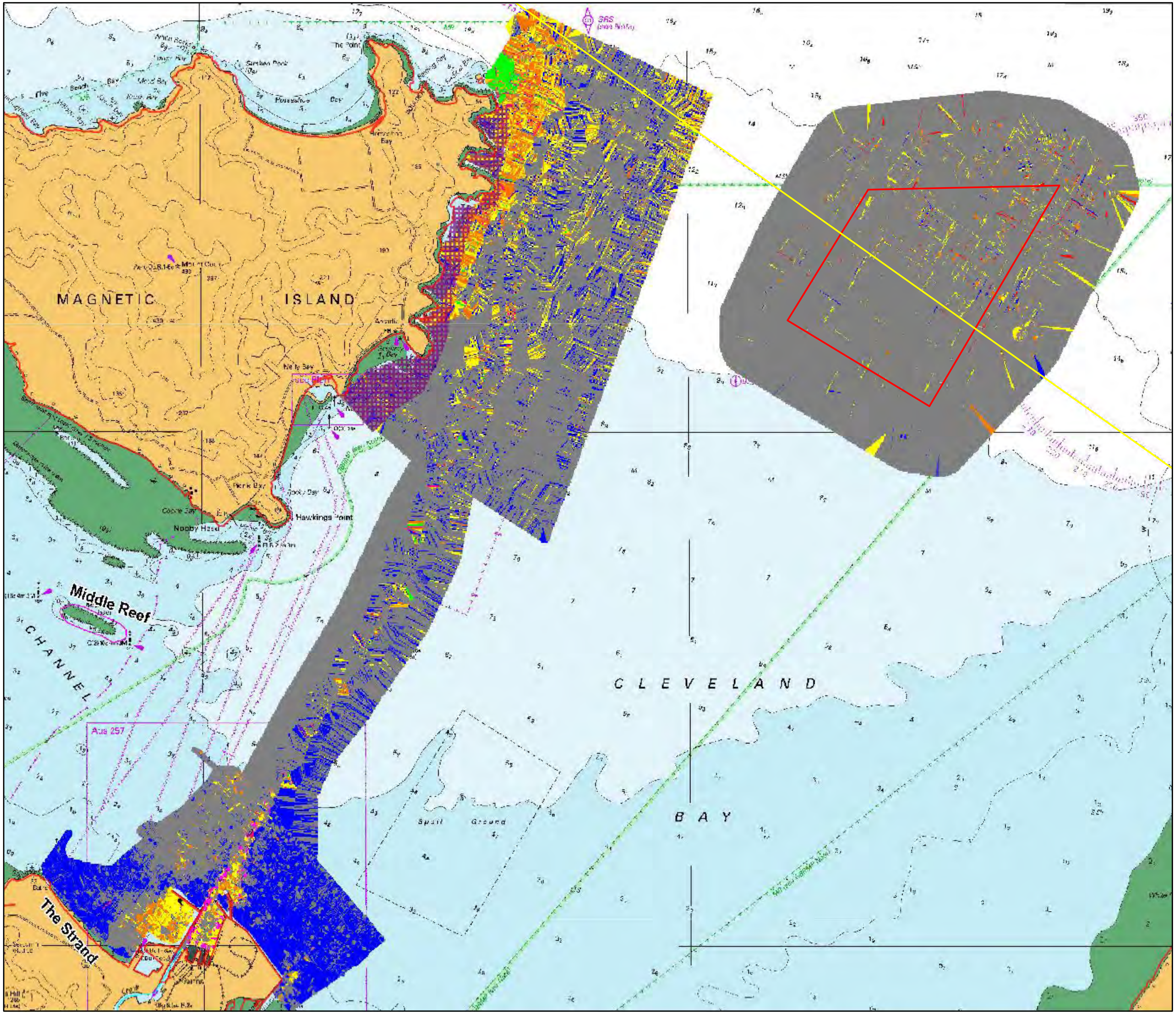
PORT EXPANSION PROJECT EIS

Acoustic Classes Surrounding the Project Area

Figure 3



Legend

- Port Limits
- Sediment Class
- Dredge Material Placement Area

Acoustic Class

- 2
- 3
- 4
- 6
- 7
- 9

N

Scale: 1:90,000 approx. (when printed at A4)

0 0.5 1 2 3 4

Kilometres

PROJECT ID 60161996

LAST MODIFIED CFS 16-Oct-2012

FILE NAME 60161996_PLN_057

Data Source:
Acoustic Classes Surrounding the Existing Channels and the Channel Extension Project Area, Figure 7.19 - BMT WBM 2012.
Chart - Australian Hydrographical Service

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