increased potential for sedimentation within the marina, which will need to be catered for in estimating ongoing maintenance requirements.

- Absolute values of shear stress appear to remain relatively low (i.e. less than the 1 N/m2 threshold for erosion) under the majority of conditions, with increases in bed shear typically less than 0.5 N/m2. However, during spring tide flood flows, bed shear values exceed 1.25 N/m2 with differentials as high as 1.0 N/m2.
- Under major river flood conditions, bed shear stresses could potentially increase by 5 – 20 N/m2 in the entrance and at the tail of the eastern breakwater. This imposes a risk of scour, which will need to be addressed during design.
- The flushing time for contaminants increases by approximately 12 hours (i.e. an increase of 35%) over the existing conditions for most sites within the Marine Precinct, including the proposed marina. This potential increase in flushing time is not like to have a high impact as most passive contaminants are flushed within 1.6 days, which is a relatively short time. No mitigation measures are recommended, other than ongoing monitoring of water quality.
- Dredge plume modelling was undertaken for a period of one month to assess the potential impacts of dredging in the navigation channel closest to the breakwater entrance. The sediment plume has maximum concentration of approximately 20 mg/l in the vicinity of the dredge source and extends a few hundred meters radially outwards. Management of the dredge program will require monitoring, as undertaken for similar programs. Given the low magnitude of predicted turbidity, the modelling suggests that measures such as silt curtains are unlikely, though use of one near the mouth of the Ross River should be considered.
- Depths of sediment deposition are estimated to be of the order of 2 to 3mm per 2 month period. Actual values will depend on ambient wind and wave conditions, the dredge used, and the amount of material in suspension during natural turbidity events, which have been measured at an order of magnitude higher than those predicted for the dredging activity. If dredging were to continue for a period of 6 months, then 6 to 9mm of material is predicted to settle.

3.9 Water and sediment quality

3.9.1 Description of environmental values

3.9.1.1 Overview

The TMPP is located in the tidally influenced river mouth of the Ross River. The mouth of the Ross River has been highly modified over the past 100 years, particularly with the development of urban areas and Port of Townsville facilities on the northern bank. Potential influences on water and sediment quality from the urban areas and Port operations include stormwater run off, accidental spills of hydrocarbons and other products and dust and spillage of bulk commodities that are imported and exported through the Port. Other impacts on water and sediment quality within the Project Area include inputs of heavy metals, hydrocarbons, pesticides and herbicides from catchment activities such as urbanisation, agriculture, Ross River Dam and the presence of light industry. The Ross River discharges into Cleveland Bay, which forms part of the Great Barrier Reef World Heritage Area. The Ross River is located within the Port of Townsville Limits, which do not form part of the Great Barrier Reef Marine Park.

A review of existing data and the collection of baseline water and sediment quality data was undertaken to provide a means of assessing the current state of the environment and to allow for the assessment of potential impacts from the development of the Precinct. The construction and operation of the Precinct will include activities such as dredging, dredged material disposal, construction of bunds and the introduction of various commercial marine industries, all of which have the potential to impact on water quality in both the short and long term. Management and mitigation measures have been identified to reduce these impacts on water and sediment quality and to assist in maintenance of the environmental values of the area.

3.9.1.2 Previous water quality studies

There is a substantial amount of literature and information available on the existing water quality environment, both in the study area and throughout Cleveland Bay a review of this information is provided in Appendix J. The following data on water quality was summarised from the available reports:

- Data recorded between March 1971 and October 1973 at the Mouth of Ross River had a temperature range from 17.8 to 30.7 ºC and a dissolved oxygen (DO) percent (%) saturation that ranged from 38.4 to 110.0% (Archibald and Kenny, 1980). These low DO levels were generally attributed to the Ross River receiving heavy organic pollutant loading from the meatworks, urban drainage and raw sewerage, at that time (Geoffrey Mill Pty Ltd, 1974);
- The typical maximum and minimum surface water temperature reported for the Port of Townsville area ranges from 19.3 to 32.4ºC over a yearly cycle (Hilliard *et al*., 1997); and
- Summer and winter surface salinities, under ambient conditions, range between 25 – 34 ppt and 33 – 35 ppt, respectively in the Port of Townsville (Neil *et al*., 2007).

Water quality data is collected is a part of the POTL Long-term Sediment Monitoring Program. This program encompasses a number of different locations over the Port of Townsville; the sites of interest to this report are the sites in Ross River adjacent to the Precinct area (RR3, RR5, RR7, and RR9). An indication of which POTL long term monitoring sites correspond to which EIS water quality monitoring sites is provided in Table 3-37 and these sites are shown in Figure 3-50.

Table 3-37 Comparison of POTL and GHD Water Quality Monitoring Sites in Ross River

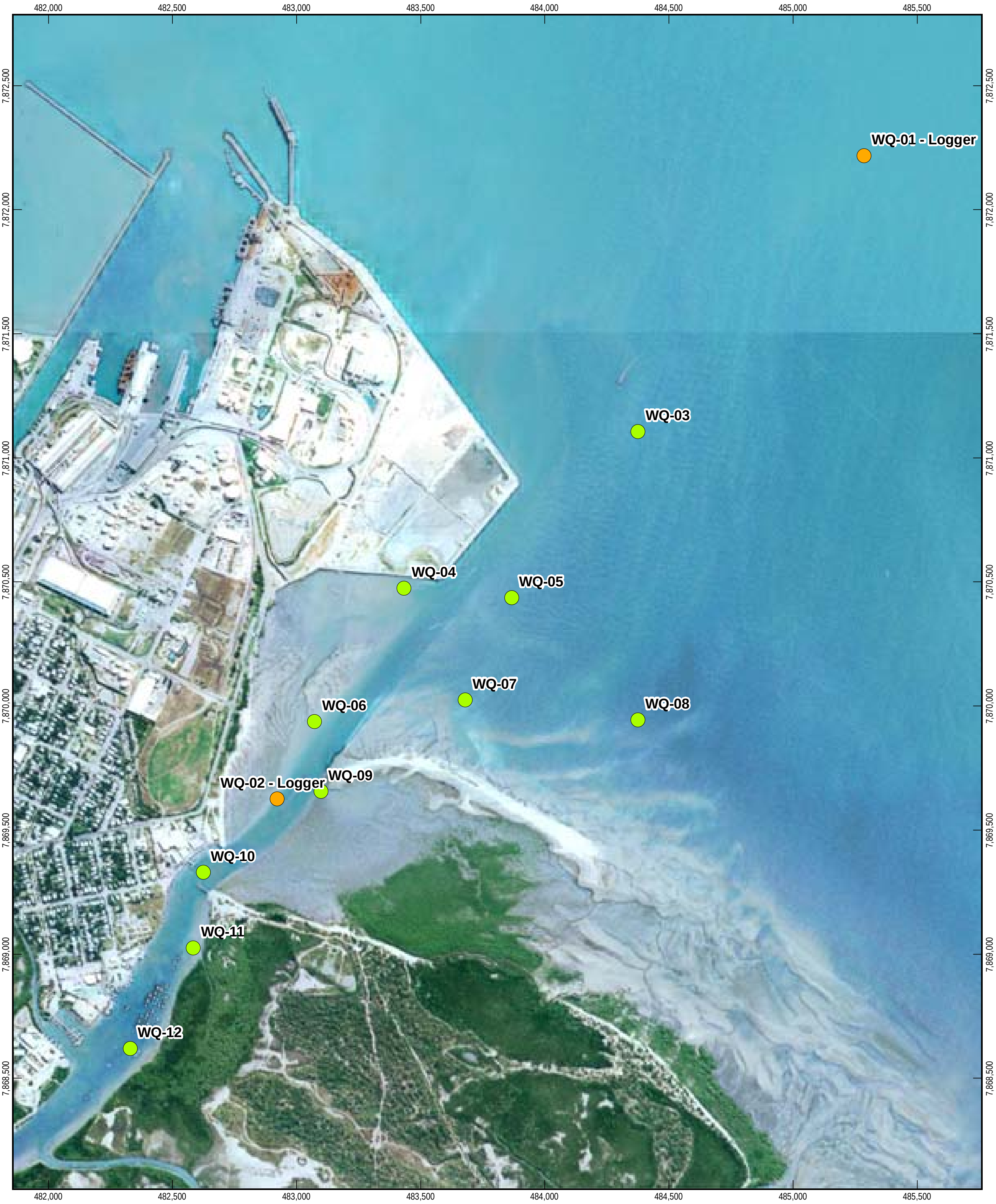
POTL Long Term Monitoring Sites	POTL Monitoring at this Site	GHD EIS Monitoring sites
RR9	Water quality and sediment quality	Near WQ3
RR7	Water quality and sediment quality	Near WQ7
RR5	Water quality and sediment quality	Just upstream of WQ10
RR3	Water quality and sediment quality	Upstream of WQ12

Water samples have been collected by POTL at these locations bi-annually since 2004. Samples were analysed for:

- Suspended solids;
- Total oil and grease;
- Petroleum Hydrocarbon;
- Silver, Barium, Cadmium, Cobalt, Chromium, Copper, Manganese, Molybdenum, Nickel, Lead, Antimony, Zinc, Arsenic;
- Total Nitrogen; and
- Total Phosphorus.

A review of the POTL data set indicates that the concentrations of suspended solids, total nitrogen and total phosphorus exceeded the QWQG (2006), while all the other results were compliant to the ANZECC (2000) 95% guidelines for toxicants and Secondary Recreation guidelines. Exceedances can be summarised as follows:

- The concentrations of suspended solids exceeded the QWQG (2006) of 15 mg/L in 26 out of 32 samples, with concentrations ranging from 7 to 55 mg/L;
- The concentrations of Total Nitrogen exceeded the QWQG (2006) of 0.2 mg/L in 14 out of 32 samples, with concentrations ranging from 0.13 to 0.32 mg/L; and
- The concentrations of Total Phosphorus exceeded the QWQG (2006) of 0.02 mg/L 15 out of 32 samples, with concentrations ranging from 0.01 to 0.044 mg/L.



LEGEND

- Long-term Logger Sites
- Sample Sites

1:20,000 (at A4)

0 100 200 300 400 500

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Port of Townsville
Marine Precinct EIS

Location of Sedentary Water Loggers and Water and Sediment Quality Monitoring Sites

Job Number	42-15399
Revision	A
Date	01 July 2009

Figure 3-50

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Level 4 201 Charlotte Street Brisbane QLD 4000 Australia **T** +61 7 3316 4496 **F** +61 7 3316 333 **E** bnemail@ghd.com.au **W** www.ghd.com.au

Data source: Marine Precinct - ©The State of QLD (Port of Townsville LTD) 2009; Monitoring Locations - GHD; Aerial (flown 2004) - ©The State of Queensland (Department of Environment and Resource Management). Created by: TH

3.9.2 Description of environmental values – baseline water quality studies

3.9.2.1 Overview

To describe existing water quality conditions of areas associated with the Precinct a baseline water quality monitoring program was implemented in Ross River as part of the Precinct Project EIS. The program involved six months of data collection from two sources:

- Sedentary water quality loggers; and
- Monthly vessel based monitoring involving in situ water quality measurements and collection of samples for laboratory analysis of water quality parameters.

The methodology for the baseline water quality monitoring program is described in detail in Appendix J (WQ report) and summarised following.

3.9.2.2 Methodology - Sedentary Water Quality Loggers

Fixed, *in situ* water quality loggers were deployed on the seabed at two locations within the Project Area (Figure 3-50). The deployed loggers were the JCU Mk9 sediment deposition and turbidity sensor, which is a 68HC11 based data logger that can simultaneously measure the deposition of sediment on a flat plate, the turbidity of the water from which the settling is occurring, Photosynthetic Active Radiation (PAR) and water pressure. One logger (WQ2) was deployed at the Ross River mouth (within the project footprint) and a second logger (WQ1) was deployed at the seagrass bed located just offshore from the Ross River mouth. Following review of the first month of monitoring the logger at WQ2 was retained for the remaining period of the monitoring program and monitoring at the Ross River mouth was discontinued. The location of each of the loggers is described in Table 3-38.

Table 3-38 Location of Sedentary Water Quality Loggers

Sites	Location	Approximate Depth (m)	Easting (GDA 94)	Northing (GDA 94)
GHD EIS monitoring site WQ1	In Cleveland Bay, outside of the Ross River mouth, at a known seagrass bed	6	0485287	7872218
GHD EIS monitoring site WQ2	Ross River channel marker, near mouth	3	0482921	7869626

Instruments were calibrated in the field prior to deployment. Loggers were deployed on 2 September 2008 and then serviced on a monthly basis. Each parameter (turbidity, PAR, water pressure and sediment deposition) was measured and recorded by the logger every 10 minutes. Logging units were attached to solid metal stands (30 – 40 kg), submerged and marked with a weighted rope to aid in relocating the loggers during the monthly download and maintenance events (Figure 3-51). The submerged logger setup was utilised to minimise the likelihood of vessel fouling and/or tampering as the loggers were deployed in locations with heavy commercial and recreational vessel activity.

During the 6-month sampling period attempts were made to retrieve the data logger monthly for data download and maintenance. This monthly period of deployment and maintenance has been shown through previous studies to provide the maximum level of confidence in data, with the logger being thoroughly cleaned of bio-fouling during each maintenance event before being redeployed. Weather conditions hampered monthly retrieval on a number of occasions. Table 3-39 summarises the field activities for the download and maintenance throughout the monitoring program.

During the program the long term logger data captured all types of conditions, including a large flood event, high seas without a flood event and calm periods. Obtaining a range of conditions for the area was the intent of the program and it is believed that the data collected adequately represents the conditions at the Precinct site (Prof. P. Ridd, pers. comm.). The sedentary water quality logger results are summarised in the following sections.

Table 3-39   Sedentary Logger Data Collection

Date	Logger 1 – Seagrass meadow	Logger 2 – Ross River mouth
2/09/2008 – 3/10/2008	Data retrieved	Data retrieved
3/10/2008 – 9/11/2008	Data retrieved	
9/11/2008 – 16/12/2008	Data retrieved	
20/12/2008 – 16/01/2008	Data retrieved	
16/01/2009 – 9/02/2009	Data retrieved	

Figure 3-51 Sedentary Water Quality Logger Prior to Deployment

3.9.2.3 Methodology – Vessel-based Water Quality Monitoring

Vessel-based monitoring was conducted to coincide with the maintenance and data download regime for the sedentary loggers. Two forms of data were collected during vessel-based monitoring; *in situ* physio-chemical parameters and water samples for laboratory analysis (Figure 3-52). Samples were collected from 12 monitoring sites located throughout the tidal section of Ross River. The sites are summarised in Table 3-40 and shown in Figure 3-50. Sampling dates are provided inTable 3-41.

Table 3-40 Water and Sediment Quality Monitoring Site Locations

Survey Site	Survey Location	Easting (GDA 94)	Northing (GDA 94)
WQ1 (nephelometer site)	Deepwater Seagrass Meadow	0485287	7872218
WQ2 (nephelometer site)		0482921	7869626
WQ3		0484376	7871106
WQ4		0483434	7870476
WQ5		0483867	7870436
WQ6		0483076	7869945
WQ7		0483679	7870025
WQ8		0484378	7869947
WQ9		0483099	7869665
WQ10		0482625	7869331
WQ11	Eastern Side of the Moored boats in Ross River	0482584	7869025
WQ12	Western Side of the Moored boats in Ross River	0482330	7868620

Table 3-41 Vessel-based Water Quality Monitoring Dates

Sampling Event	Date	Sampling Conducted
1	2nd September 2008	Water and Sediment
2	2nd October 2008	Water
3	4th November 2008	Water
4	1st December 2008	Water
5	22nd January 2009*	Water
6	9th February 2009	Water

* Delayed due to weather constraints: discussed further below

Water quality sampling was undertaken in accordance with the following guidelines and standards:

- Queensland EPA Water Quality Sampling Manual (1999);
- ANZECC and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) October 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines (Chapters 1-7);
- ANZECC/ARMCANZ October 2000 Australian Guidelines for Water Quality Monitoring and Reporting (2000), Chapters 1-7 (ANZECC 2000a);
- Australian Standard Number 5667.1.1998 – Water Quality – Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples;
- Australian Standard Number 5667.6:1998 – Water Quality – Sampling – Guidance on sampling of rivers and streams;
- Australian Standard Number 5667.9:1998 – Water Quality – Sampling – Guidance on sampling of marine waters; and
- Environmental Protection (Water) Policy 1997.

The *in situ* physio-chemical water quality parameters were collected using a hand-held electronic multi-parameter water quality meter with logging capability for turbidity, dissolved oxygen, pH, salinity, redox and temperature (Figure 3-52). The data was stored on the logger and downloaded at the end of each field day. The *in situ* physio-chemical water quality values for each of the twelve locations had 10 replicates recorded at three depths (surface, middle and bottom).

Water samples were collected in laboratory supplied containers at each of the twelve monitoring locations and two sites were randomly sampled to provide quality assurance samples (Figure 3-53). Water samples were collected from approximately 0.2m below the surface of the water column at all sites for analysis of the following parameters:

- Total Suspended Solids (TSS);
- Chlorophyll a;
- Dissolved and total heavy metals (Arsenic, Barium, Beryllium, Cadmium, Chromium, Cobalt, Copper, Manganese, Nickel, Lead, Vanadium, Zinc, Mercury);
- Oil in water; and
- Nutrients (Total Nitrogen, nitrate, nitrite, ammonia, Total Kjeldahl Nitrogen (TKN), Total Phosphorus and Reactive Phosphorus).

Additionally, the first sampling event also included analysis of pesticides, herbicides, polyaromatic hydrocarbons (PAHs), organotins, organochlorine pesticides (OCP), organophosphorus pesticides (OPP), Total Petroleum Hydrocarbons (TPHs) and BTEX. As these potential contaminants were not present at concentrations exceeding the adopted water quality guidelines, they were excluded from ongoing monthly sampling.

Water samples were stored on ice and couriered overnight to the NATA accredited ALS Laboratory Group for analysis under Chain of Custody documentation (Appendix J).

Figure 3-52 In-situ Water Quality Monitoring

Figure 3-53 Collection of Water Samples for Laboratory Analysis

3.9.2.4 Results of Baseline Water Quality Monitoring

This section summarises the results of the baseline water quality monitoring program, including comparison to adopted water quality guidelines.

Rainfall

The tidally influenced section of the Ross River receives freshwater inflows from the catchment during some rainfall events. There was a substantial amount of rainfall received in January and February of 2009, which influenced the results of the water quality monitoring program (Table

3-42).

Table 3-42 Comparison of the Average Rainfall Statistic to Total Rainfall During the Monitoring Program

Townsville Rainfall (mm)		
Month	**Rainfall average statistic**	**Monthly rainfall during the water quality monitoring period**
September	10	0.8
October	24.8	4.2
November	58.9	113.4
December	125.7	178.8
January	268.5	664
February	296.6	989

3.9.2.5 Summary of Water Quality in the Project Area

Based on information collected during the monitoring program and using previous data from the Project Area this section provides a summary of water quality in the vicinity of the TMPP and surrounds and seeks to describe the likely anthropogenic and environmental influences on water quality and temporal and spatial variation in water quality. Full details of the data collected are provided in Appendix J.

Turbidity

The monthly boat based monitoring at multiple sites and the successful collection of continuous data at the deepwater seagrass monitoring site (WQ1) are considered adequate to inform the discussion and management of water quality impacts (Prof. P. Ridd, pers. comm.).

Results for turbidity (monthly and continuous data) and suspended solids indicate that the Ross River estuary and the area immediately offshore from the river mouth is a naturally turbid system and that turbidity is fairly uniform across the water column. The spatial trend shows that turbidity is generally higher in the Ross River sites than the offshore sites and the seasonal trend shows slowly decreasing turbidity leading up to December with a rapid increase post December during the heavy rain period.

The continuous logger data indicated that turbidity was regularly elevated above the QWQG (2006) and ANZECC (2000) guidelines, which is consistent with the POTL long term monitoring data. The continuous logger data showed a correlation between increased wave action and increased suspended solids concentrations and turbidity within the water column (Figure 3-54). This is supported by the study by Sinclair Knight (SK 1991), which suggests that wind and wave induced resuspension are primarily responsible for elevated suspended solids, and therefore turbidity, in the Cleveland Bay area. This has also been confirmed by a number of other studies on sediment transport and hydrodynamics in Cleveland Bay and the Port surrounds as referenced in and determined by GHD (2004a) in their hydrodynamic modelling study of the Port of Townsville Outer Harbour. During monthly vessel based monitoring, it was also observed that increased turbidity at shallow monitoring sites resulted from wind and wave induced resuspension of fine sediments from the seafloor.

There does not appear to be a strong correlation between tidal state (neap/spring), as shown by water depth recorded by the continuous loggers, and turbidity or suspended sediment concentration (Figure 3-55). This indicates that tidal currents may not be a driving factor for turbidity in the vicinity of the Project Area. However, it is possible that on a low spring tide, when water depth is substantially reduced, tidal currents out of the Ross River mouth will also result in resuspension of bottom sediments.

The vessel based monitoring program also recorded elevated turbidity throughout the water column at all sites during the February 2009 monitoring event, which is thought to be a result of inputs of sediment laden runoff from the Ross River catchment. The elevated turbidity and suspended sediment concentrations recorded at WQ1 during January/February 2009 were similar to the elevations seen in mid-late October 2008, when there was no significant rainfall (Table 3-42). However, much higher sediment deposition was recorded at WQ1 during January/February 2009 compared to October 2008, indicating that the freshwater inflow from the Ross River catchment resulted in the mobilisation of sediments from the estuary into the marine environment.

Therefore, two environmental variables appear to influence sediment concentrations in the water column in the Project Area; wave induced resuspension of bottom sediments and the inflow of sediments from the Ross River estuary during rainfall events. Both of these are natural events, although clearing for agriculture and housing estates in the catchment will have increased the input of sediment in runoff into the estuary from rainfall since development of the catchment began.

As expected, elevated turbidity was linked to reduced light availability (measured as PAR) at the deepwater seagrass community (WQ1). This indicates that the seagrass and other subtidal and intertidal benthic communities in the vicinity of the Project Area regularly experience elevated turbidity and consequent low light levels. There were occasions where turbidity at the deepwater seagrass community was elevated above 50 NTU for sustained periods (hours and days), resulting in very low or no PAR levels. During periods of lower wave action, deposition of sediments increased at the continuous logger site WQ1.

A comparison of the continuous logger site data for September 2008 at the estuarine site WQ2 and offshore site WQ1 indicated that mean turbidity was higher at WQ1 (33.7 NTU at WQ1 compared to 9 NTU at WQ2). The maximum values for September were however similar at both sites (178.6 NTU at WQ1 and 152.2 NTU at WQ2). Vessel based monitoring in September was undertaken on a low tide during windy conditions. The elevated turbidity recorded at all monitoring sites during this event was a result of wind and wave induced resuspension.

Figure 3-54 Turbidity (NTU) at WQ1 and Wind Speed (m/s) from September 2008 – February 2009

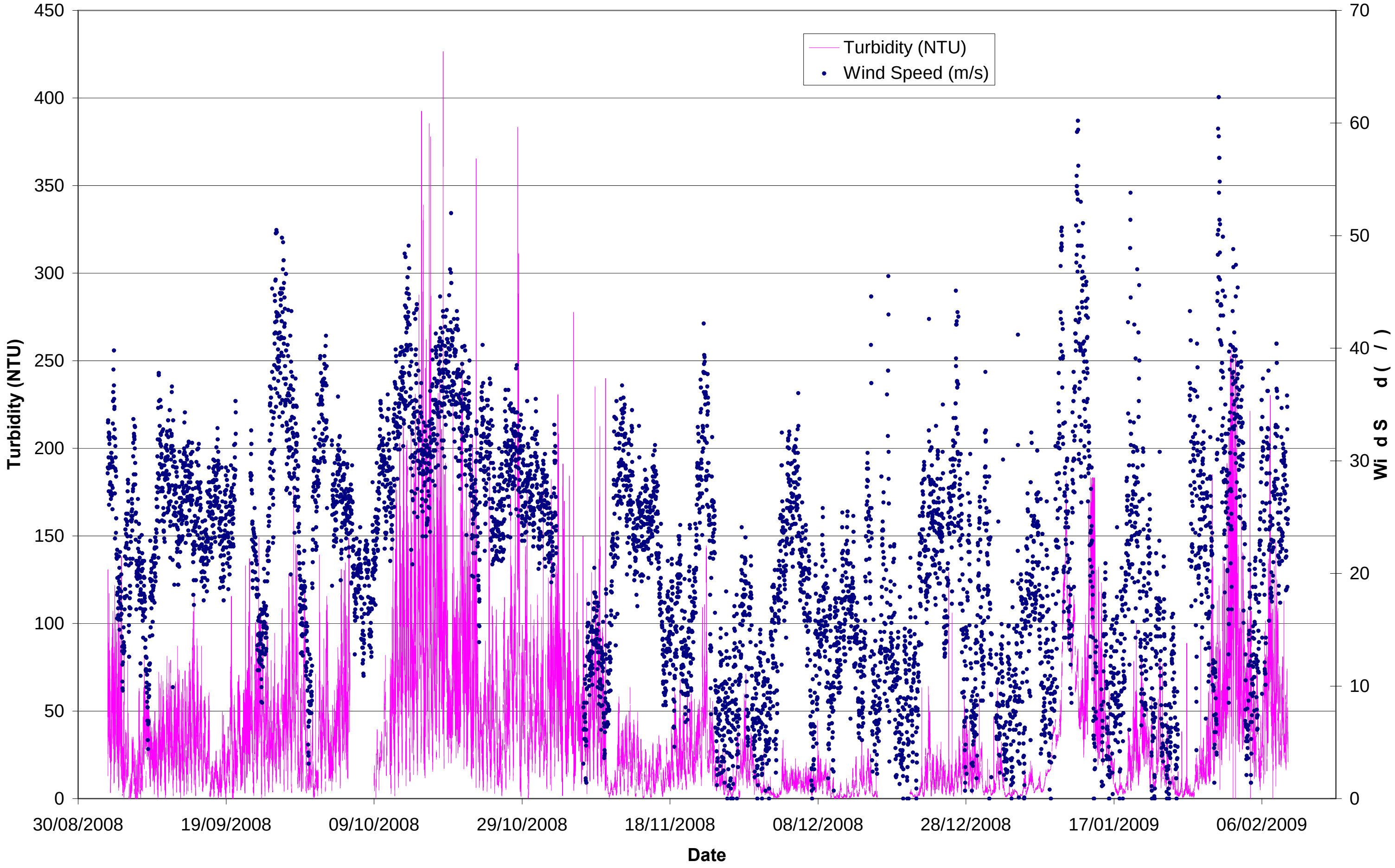
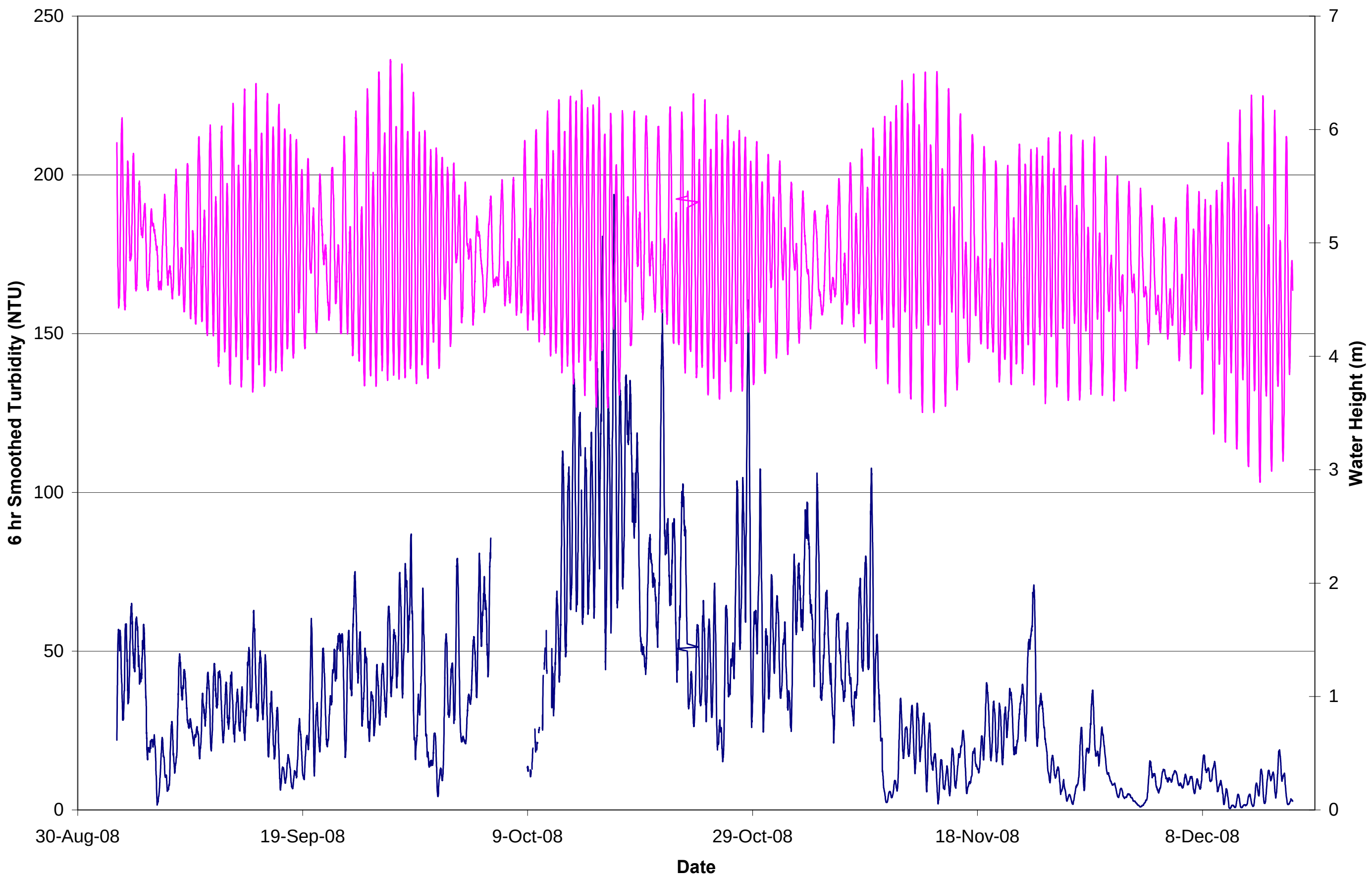


Figure 3-55 Turbidity (NTU) and Water Height (m) at WQ1 from September – December 2008



Nutrients and Inorganics

Generally the water quality at all twelve monitoring sites examined during this study exceeded the QWQG (2006) over the six sampling events for:

- Total Suspended Solids (with the exception of November WQ5, WQ9 and WQ12; December WQ1-8, WQ11-12; and January WQ1, which were all below the guideline level of 15 mg/L);
- Ammonia (guideline level of 8 g/L);
- Total Nitrogen (with the exception of November WQ 4, WQ5; and February WQ1-4, WQ6-12, which were all below the guideline level of 200 g/L); and
- Total Phosphorus (with the exception of January WQ2, WQ3, WQ4, WQ6 and WQ7; and February WQ1-4, WQ6, WQ7 and WQ8 which were all below the guideline of 20 g/L).

Twenty-two of the 60 samples collected during the monitoring program exceeded the QWQG (2006) for Total Oxidised Nitrogen of 3 μg/L and 10 of the 60 samples exceeded the QWQG for Reactive Phosphorous of 6 μg/L. Concentrations of ammonia did not exceed the ANZECC 95% trigger value of 0.91 mg/L, with the highest value being 0.17 mg/L, however, all sites were generally over the ANZECC general recreational guideline value for ammonia of 0.01 mg/L.

This demonstrates that both the long term POTL monitoring data and the EIS vessel based monitoring data showed elevations of nutrients above the QWQG (2006) guidelines in many of the samples collected. This indicates an anthropogenic input of nutrients, such as sewage effluent and fertilisers from urban and agricultural sources.

Results from the vessel based water quality monitoring program showed substantially higher nutrient concentrations at sites WQ10, WQ11 and WQ12, which are located in the vicinity of the existing boat moorings in Ross River (Figure 3-50). This suggests the presence of these moorings is influencing the water quality in that section of Ross River.

Chlorophyll a

The QWQG guideline for Chlorophyll *a* is 2.0 µg/L or mg/m^3. The highest Chlorophyll *a* value recorded during the monitoring program was 29 mg/m^3 at WQ6 in February 2009. This high value is believed to be from the detritus and weed observed in the area during the period of high flow from the Ross River.

With the exception of four sites that recorded values equal to the QWQG (WQ2 – December, WQ5 – January, WQ9 – November, and WQ10 – December), the chlorophyll *a* concentrations for the remainder of the program were below the QWQG.

Anthropogenic Contaminants

There appear to be only very minor inputs of pesticides into the lower estuary of the Ross River, with one compound present above laboratory limits of reporting in the first monitoring event. Pesticides are likely to be sourced from the upstream rural and urban catchment. Inputs of other anthropogenic contaminants from urban areas and the Port operations also appear to be low, with the exception of some localised, minor elevations in oil and grease surrounding the existing boat moorings in the upper estuary.

The POTL long term water quality monitoring program has not recorded concentrations of metals exceeding the ANZECC (2000) 95% trigger values for toxicants, however, the six month vessel based monitoring program recorded the concentration of a number of metals in exceedance of the ANZECC (2000) 95% trigger values. These included concentrations of chromium, copper, cobalt, lead and manganese. Exceedances occurred at various times through the program and were not restricted to any particular site or sampling event.

Locations upstream in Ross River have a long history of marine infrastructure construction and maintenance, including vessel maintenance. Further, a land fill area for domestic waste was previously located adjacent to Ross River upstream from the existing Precinct site. The recorded exceedances in metal contaminants are likely related to upstream industrial uses of the Ross River. Contamination from existing port activities on Ross Creek is not likely as the current and prevailing wind directions are to the north-east.

The different recordings between the POTL long term monitoring program and this program may be a result of different laboratory analysis techniques, with the EIS monitoring program achieving lower limits of reporting and being more sensitive. It did not appear that the concentrations of metals recorded in the vessel based monitoring program were correlated to the turbidity levels recorded at the time of monitoring, nor did the elevated readings persist on all sampling occasions. This indicates these findings are a transient occurrence for the area and not necessarily related to sediment disturbances. Rehabilitation of upstream lands from where contamination may be occurring would assist in reducing potential for water quality degradation in the Precinct area.

Environmental Variables

The influence of environmental variables on turbidity in the Project Area was discussed in an earlier section. The six month monitoring program also captured a significant rainfall period in January and February of 2009 when Townsville received greater than the annual average rainfall in a period of two months (Table 3-42). The vessel based monitoring identified a halocline following the significant rainfall in January/February 2009, with many of the surface samples collected for laboratory analysis being classed as freshwater samples based on their low salinity.

Other water quality parameters also varied with environmental conditions. For example, the concentrations of dissolved oxygen and nutrients (total nitrogen and total phosphorus) decreased with the inflow of freshwater from the catchment in January/February 2009. The exception was WQ10 – 12, where the concentration of total nitrogen and total phosphorus did not vary greatly from the first few months of sampling. Interestingly, the concentrations of oxidised nitrogen (a more bioavailable form of nutrient) exceeded the QWQG (2006) in January/February 2009 at most sites, indicating the influence of the freshwater inflows on nutrient forms and availability in the marine environment. The potential impact of this on cyanobacterial blooms is discussed below in Section 3.9.7.2.

3.9.3 Potential Impacts and Mitigation Measures

3.9.3.1 Impact Assessment

The potential impacts of construction and operation of the Precinct on water quality are:

- The generation and migration of turbid plumes from capital and maintenance dredging;
- The mobilisation of contaminants into the water column (including nutrients and acid sulfate soils) during capital and maintenance dredging; and
- The discharge of contaminants from various marine industries into Ross River.

3.9.3.2 Construction

The Precinct will be constructed in stages, as described under Section 1.2.2, with the second stage potentially including the construction of an offshore breakwater on the southern side of the Ross River mouth and a short section on the northern corner of the river mouth. The key construction processes that have the potential to impact on water quality within the receiving environment include:

- Dredging to remove unsuitable foundation material and create access channel, swing basin and harbour basin;
- Placement of rock to construct revetments and offshore breakwater; and
- Placement of material behind revetments to create a land reserve.

A separate, detailed construction methodology report has been prepared for this project and the outcomes of this report are summarised in Section 2.4. Other sections of the EIS also summarise the results of the geotechnical and acid sulfate soil investigations (refer Section 3.2), which provided a characterisation of the materials to be dredged to construct the Precinct. The general outcome of these investigations were that there is a large amount of material that is not suitable for use in construction of the Marine Precinct, both from a geotechnical and acid generating potential, without substantial treatment and management. It is therefore likely that this material will be dredged and disposed offshore. The environmental investigations and approvals for the offshore disposal component of this work are being addressed by POTL under a separate investigation and approvals process, therefore, this EIS focuses on the impacts of dredging, marine construction and dredged material disposal within the Marine Precinct revetment and does not consider the offshore disposal site in detail. For completeness, a summary of the potential impacts of disposal of dredged material at the offshore disposal site has been prepared from a desktop review of previous studies and monitoring programs.

The potential impacts and mitigation measures for each of the construction processes is outlined in Table 3-43, and a summary of potential impacts from offshore disposal are provided following.

Potential Impacts of Offshore Disposal

A number of studies have been conducted dating back to 1978 examining potential impacts of ocean disposal at the PoT ocean disposal ground. These cover a comprehensive scope including impacts on benthic communities and modelling of onsite/offsite effects of disposal. This includes work conducted by Maunsell in 2008 underpinning preliminary studies for the Port Expansion project. Given the comprehensive work conducted previously, including very recently, it was not deemed necessary to repeat any studies. To develop understanding of the potential impacts of offshore disposal for the TMPP these previous studies and their findings have been reviewed. Technical review comments relating to the behaviour of sea bed material deposited at the offshore spoil ground is provided in Appendix J. A summary of this information in combination with an understanding of proposed dredging/construction activities for the TMPP (as provided under Section 2 of this report) and potential for impacts on the ecology of the area is provided here.

It has been demonstrated that dredged material placed at the offshore disposal site settles rapidly and has little offsite influence (Mud Dynamics Group 1989, TPA 1995 Part 1, Cruz 2000). Information reviewed (refer Appendix J) indicates that during placement operations near-bed suspended sediment concentrations elevate but that any impacts remain close to the dump site. Dredge plumes have little impact upon the background water quality, which is naturally turbid, and also rapidly dissipate (within hours) following cessation of dredging under most conditions.

For the fraction of material that is remobilised, sediment redistribution from the offshore spoil ground occurs naturally and is directed towards southern Cleveland Bay mainly under relatively large swell conditions (Benson *et al.* 1994 and Maunsell 2009). According to Benson *et al.* (1994) impacts from the remobilisation of dumped material from the dump site may take place either as long term dispersion under low to medium level hydrodynamic conditions, or as events under major storms or cyclones. Some resuspended material may be flushed from the bay but some may be deposited in sub-tidal flats containing seagrass and in mangrove swamps.

TPA (1995, part 1) and Maunsell (2009) confirm this finding noting that while, in general, the disposal site is considered stable, redistribution of dumped sediments is likely to occur during periods of high wave energy. Redistributed material under typical hydrodynamic influences comprises primarily the fine silt fractions. Heavier sand fractions mix down through the sediment profile (TPA 1995, Dump Site Characterisation). Exceptions to this may occur during severe storm disturbances such as cyclones.

WBM (2009, Draft) concludes that no impacts from the disposal operations have been found at the ocean disposal ground. This reaffirms an ecological study finding from Cruz (2000) that determined that the benthic fauna of the ocean disposal ground is adapted to regular disposal activity and that offsite impacts decay rapidly in space and time with little influence on the benthic ecology of the area.

Based on the reconciliation of the above findings and considering the volume of material expected to be dredged for construction and operation of the Precinct (refer Section 2) it is predicted that:

- Most of the material dredge for the TMPP will remain at the disposal site during the disposal operations subject to the following conditions:
  - placement of material in depths in excess of 12 m;
  - placement operation undertaken under environmental conditions consistent with the operation constraints of the likely dredging plant;
- The soft clay and sand fractions of the material are expected to remain on site; and

- Subject to these conditions, the plumes generated during the proposed placement operations will have little offsite impact and decay rapidly following cessation of disposal activities.

It is noted that based on studies to support the water and sediment quality investigations of this EIS that a proportion of the material that is proposed to be disposed offshore contains silt and mud fractions. This finer material may disperse from the disposal site over a relatively long period of time depending on the frequency of occurrence of high energy wave conditions, however, offsite ecological impacts are not considered to occur given the demonstrated resilience of the existing system to repeated disposal activities.

Further comment regarding the ecological significance of any potential offsite impacts from ocean disposal is addressed under Section 3.9.3.4 below.

Table 3-43 Summary of Potential Impacts of Precinct Construction on Water Quality

Construction Aspect	Construction Process	Potential Impacts	Mitigation Measures
Dredging to: 1. remove unsuitable foundation material from beneath offshore breakwater 2. create a swing basin, access channel and harbour basin Backfilling of trench dredged beneath offshore breakwater	Material removed from seafloor by a backhoe dredge into a split hopper barge (offshore disposal) Dredged trench for offshore breakwater replaced by sand from land or marine source If marine source of sand utilised, cutter suction dredge used to pump and fill the trench; if a land based source of sand used, spreader barge used to fill the trench	Increased turbidity in the vicinity of the backhoe dredge and from hopper barge overflow Migration of turbid water into Cleveland Bay on an ebb tide and upstream Ross River on a flood tide Mobilisation of contaminants into the water column Disturbance of acid generating material	Use of silt curtains around construction site where practical to prevent migration of turbid plumes over sensitive habitats. This is likely to be most relevant for the dredging of the harbour basin in Stage 2 Monitoring of water quality during dredging and comparison of results to site specific water quality objectives for turbidity Sediment sampling undertaken for the EIS determined that surface and some below surface sediments are considered suitable for unconfined ocean disposal and are compliant to the EILs for contaminated land, therefore the risk of contaminants being mobilised into the water column is considered low Disposal of potential acid sulfate soil material offshore, which limits the potential for oxidation and acid generation A separate, detailed sampling is being undertaken by POTL for the assessment of all the sediment that is to be disposed offshore
Placement of rock to construct revetments and breakwater	Rock sourced from land based quarry Rock tipped from trucks off existing shoreline or end of revetment wall Rock barged to offshore breakwater and placed by	Turbidity generated by resuspension of fine sediments when rock is tipped from trucks Introduction of contaminants into waterway from rock Mobilisation of contaminants	Removal of soft material from foundation prior to construction of revetment/breakwater will reduce the potential for placement of rock to stir up bottom sediments A clean source of rock will be utilised to provide the material for the revetment and breakwater walls Analysis of the rock material will be undertaken to determine that it is clean (i.e. meets Queensland Draft

Construction Aspect	Construction Process	Potential Impacts	Mitigation Measures
	barge mounted grab dredge	into the water column Spills or leaks of hydrocarbons from construction equipment into Ross River	Guidelines for the Assessment and Management of Contaminated Land Environmental Investigation Levels, 1998) Use of silt curtains around construction site where practical to prevent migration of turbid plumes over sensitive habitats Monitor water quality at sensitive habitats for compliance to site specific water quality objectives. Undertake dredge management responses to any observed deviations from water quality objectives, including potential for cessation of dredging works Regular maintenance of construction equipment Spill kits to be carried on all land and marine based equipment Emergency procedures to be in place All personnel to be trained in the use of spill equipment and emergency response procedures
Placement of material behind revetments to create a land reserve 1. land based source 2. marine based source	Hydraulic (cutter suction) or mechanical (backhoe) dredging to relocate suitable dredged material into bunded reclamation. Material to be dredged is PASS and should be handled accordingly. Decant waters containing residual silts and clays discharged into receiving	Some increased turbidity at dredging plant as a result of agitation of seabed material during dredging activity. Increased turbidity as a result of the decant of tailwaters if a marine based source of fill is used to fill revetment. No significant turbidity impacts predicted given high background levels of TSS.	Sediment sampling undertaken for the EIS determined that surface and some below surface sediments are considered suitable for unconfined ocean disposal and are compliant to the EILs for contaminated land, therefore the risk of contaminants being mobilised into the water column is considered low Monitor water quality at sensitive habitats for compliance to site specific water quality objectives. Undertake construction management responses to any observed deviations from water quality objectives. If turbidity levels exceed allowable thresholds for

Construction Aspect	Construction Process	Potential Impacts	Mitigation Measures
	environment. or Dry fill tipped from trucks off existing shoreline or bund wall into area behind the bund wall to create the reclamation. Swamp dozers used to spread fill as required.	Mobilisation of contaminants into the water column Spills or leaks of hydrocarbons from construction equipment into Ross River.	receiving environment due to dredging effects consider use of silt curtains to contain impacts or adoption of different dredge activity profiles (duration/frequency). Provide adequate spoil settlement times to allow settlement of TSS to acceptable discharge standards. Consider potential to discharge into inner harbour of Precinct and use silt curtains across this water body to further mitigate any detected impacts. Regular maintenance of construction equipment Spill kits to be carried on all land and marine based equipment. Emergency procedures to be in place. All personnel to be trained in the use of spill equipment and emergency response procedures.

3.9.3.3 Operation

There are two main activities that will potentially result in impacts from the operation of the Precinct:

- Construction and operation of businesses related to the marine industry; and
- Maintenance dredging to maintain the declared depths of the harbour basin, access channel and swing basin.

The assessment of potential impacts from operation of the Precinct facility has been undertaken on the Precinct Reference Design and industries likely to be housed within the Precinct, as defined by that design. The Reference Design is described in detail under Section 1.1 and Section 2 of this document. In brief, the expected operational industries include:

- Marine industry allotments including maritime infrastructure and vessel fabrication;
- Berth facilities including for trawlers, scientific and tourism vessels, provisioning activities, refuelling and for commercial and recreational users;
- Commercial and recreational chandlery;
- Defence force marine activities, including vessel maintenance
- Seafood industry cold storage and distribution facility;
- Small scale eateries to service industry within Precinct;
- Marine industry training facilities;
- Public and recreational use facilities including provision for 40 pile moorings; and
- A recreational marina.

The existing boats moored in Ross River appear to have impacted on water quality in the immediate vicinity of the moorings, with elevated concentrations of nutrients and minor inputs of hydrocarbons. Water quality in the Precinct basin and Ross River has the potential to be impacted if adequate controls on discharges from berths and moorings as well as the industries and activities that establish at the Precinct are not implemented.

General measures for the management of water quality impacts from the operation of the Precinct include:

- A condition of development on the Precinct will be that industries gain the appropriate environmental approvals and comply with the permit conditions and other relevant guidelines, standards and codes of practice for their industry;
- All owners/operators of activities and industries that establish at the Precinct will be required to prepare and implement an EMP for their activities; and
- Mooring leases will contain guidelines for boat owners in terms of waste disposal in particular and appropriate disposal facilities will be provided. Waste management impacts and mitigation measures appropriate for the Precinct facility have been considered under a separate report for the EIS studies.

Table 3-44 summarises the potential impacts on water quality, likely sources of these contaminants and proposed mitigation measures from operation of the Precinct facility.

Table 3-44 Potential Water Quality Contaminants from the Operation of the Precinct

Potential Contaminants	Likely Source	Mitigation Measures
◗ Nutrients	◗ Fertilisers on gardens ◗ Sewage from moored boats	Provision of appropriate waste disposal facilities for moored boats Compliance with the requirements of the Transport Operations (Marine Pollution) Act 2005 and Transport Operations (Marine Pollution) Regulation 2008
◗ Hydrocarbons	◗ Oil and grease from workshops ◗ Spills and leaks from construction equipment as marine industries are introduced ◗ Spills and leaks from mobile equipment and cars	Provision of appropriate waste disposal facilities for moored boats Installation of oil and grease traps in all workshops Adequate storage and bunding of fuels and oils Use of licensed waste disposal contractors and tracking of wastes where required
◗ Polyaromatic Hydrocarbons	◗ Runoff from hardstand areas due to deposition from incomplete combustion of fuels from cars, trucks and other mobile equipment	Only minor concentrations expected Install appropriate stormwater management measures
◗ Heavy metals	◗ Runoff from hardstand areas due to deposition from cars, trucks and other mobile equipment	Only minor concentrations expected Install appropriate stormwater management measures
◗ Antifoulants	◗ Waste from abrasive blasting and boat painting activities ◗ Leaching from moored and berthed vessels	All facilities to be licensed and comply with relevant standards, guidelines and codes of practice Adequate storage and bunding of chemicals and paints
◗ Sediments	◗ Runoff from exposed soil ◗ Dust creation during construction of marine industries	Protection of exposed ground surfaces with grasses or hydromulch prior to development Use dust suppression where required during construction of marine industries

Potential Contaminants	Likely Source	Mitigation Measures
◗ Hazardous chemicals	◗ Spills to ground or water from workshops and marine fabrication industries	Adequate storage and bunding of chemicals Use of licensed waste disposal contractors and tracking of wastes where required Appropriate emergency response equipment to be available at all businesses and at the moorings and berths Defined emergency response procedures for the Precinct
◗ Gross pollutants	◗ Inappropriate storage of wastes by individual industries and activities within the Precinct	Provision of adequate bins, including allowance for separation of recyclables Installation of gross pollutant traps on stormwater outlets Requirement for an EMP for each industry and activity that establishes at the Precinct

Legislation, Codes of Practice, Standards and Guidelines that should be applied to the operation of the Precinct include, but are not limited to:

- Transport Operations (Marine Pollution) Act 1995;
- Transport Operations (Marine Pollution) Regulation 2008;
- Environmental Protection Act 1994;
- Environmental Protection (Air) Policy 2008;
- Environmental Protection (Noise) Policy 2008;
- Environmental Protection Regulation 2008;
- Environmental Protection (Waste Management) Policy 2000;
- Environmental Protection (Waste Management) Regulation 2000;
- Environmental Protection (Water) Policy 1997;
- Abrasive Blasting Code of Practice 2004;
- Hazardous Substances Code of Practice 2003;
- Brisbane City Council – Operator's Environmental Guide – Pollution Solutions for Abrasive Blasters;
- ANZECC (2000) Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance; and
- Relevant Australian Standards (e.g. for storage and bunding of hazardous chemicals).

Maintenance Dredging

Maintenance dredging will be required on occasion to maintain the access channel, swing basin and harbour basin to their declared depths and to maintain shipping safety. Based on current maintenance dredging for the Ross River, it is likely that dredging will be required biannually and will be undertaken by a trailer suction dredger. Dredging in the harbour basin (Stage 2) should not be required as frequently and is likely to be undertaken by a cutter suction dredger.

The impacts of maintenance dredging will be similar to those of capital dredging, although the duration of the maintenance dredging programs will be less than the capital dredging programs. Sediment quality will be analysed prior to any dredging and appropriate disposal locations identified based on the physical and chemical properties of the material to be dredged. POTL will obtain all required permits for maintenance dredging and will implement mitigation measures and monitoring programs to minimise impacts on the receiving environment, in particular water quality.

3.9.3.4 Impacts on Sensitive Habitats

Potential Impacts of Turbidity and Sedimentation on Ramsar wetlands

The Bowling Green Bay Ramsar wetland area in the Townsville region is located approximately 10 km southeast of Townsville (by line of sight). Because of the considerable distance from the Ramsar wetland to the project area and the very localised nature of potential impacts from the TMPP it is not considered possible that any impacts on water or sediment quality from the TMPP will impact the Ramsar area. This is supported by coastal processes assessments (refer Section 3.8.2) that demonstrate longshore coastal transport occurs from the east to the west indicating any drift from the Precinct will move to the north west away from the wetland coastal area.

Potential Impacts of Turbidity and Sedimentation on Avifauna Protected by International Treaty Agreements

No removal of seabed or disturbance of marine habitats is proposed for the eastern bank area of the Ross River, across from the Lot 773 footprint. The area is heavily utilised by marine wading and migratory birds, which is reported under the Marine and Migratory Avifauna assessment for this EIS. Modelling indicates less than a 1mm change in sedimentation in the areas occupied by these species after two months of dredging and impacts to these species are not predicted from turbidity or sedimentation resulting from construction works. The identified populations currently persist under an existing regime of commercial activities, including dredging. Measures that should be considered to minimise potential to impact upon roosting birds are described addressed under Section 3.10.5.4. Under these measures the TMPP is not expected to impact upon international treaty obligations.

Potential Impacts of Turbidity and Sedimentation on Seagrasses

Seagrass meadows form an important component of coastal ecosystems and perform important functions such as nutrient trapping and recycling, providing food and shelter for many marine organisms, and assist sediment stabilisation (Roelofs *et al.* 2003).

The distribution of seagrass within the vicinity of the Project Area, described in detail under Section 3.10.5 includes a seagrass meadow in the subtidal area directly offshore from the Ross River mouth and low cover within the mangrove communities at East Bank on the southern side of the river mouth. The deepwater seagrass meadows seaward from the Project Area were described by Rasheed and Taylor (2008) as extensive but very patchy, low biomass seagrass. In the wet season, the majority of this meadow is *Cymodocea serrulata* with a mix of *Halophila* and *Halodule* species and in the dry season the seagrass species composition changed to form a monospecific *Halophila decipiens* meadow. This was supported by marine ecological investigations undertaken as part of the this EIS study and described under Section 3.10.5. This study also noted that the East Bank across from the Precinct facility site supported two seagrass species; *Zostera capricorni* and *Halodule uninervis* and two types of mangroves: red mangrove (*Rhizophora stylosa*) and grey mangrove (*Avicennia marina*) on the seaward margin of the mud flat.

Key potential impacts on these communities related to the proposed dredge works are elevated turbidity and sediment deposition or burial.

Seagrass communities are an important part of coastal ecosystems. Seagrass beds slow water movement, causing suspended sediment to fall out of the water column and trapping nutrients that would otherwise disperse into the surrounding ocean (McKenzie and Campbell, 2002). Several key functions of seagrass communities are summarised as follows:

- Seagrasses are the primary producers that contribute to the large quantities of fixed carbons, the basis of all food chains to coastal ecosystems;
- Seagrasses are important in stabilising bottom sediment as they slow water movement, promoting the sedimentation of particulate matter;
- Seagrasses are a part of the nutrient cycle in the aquatic system;
- Seagrasses supply shelter and refuge for both adult and juvenile animals; they also contribute large amounts of substrate for encrusting animals and plants; and
- Seagrasses are essential food for dugongs and also green turtles.

The distribution and growth of seagrasses is regulated by a variety of water quality characteristics such as temperature, salinity, nutrient availability, turbidity, and submarine irradiance (Dennison and Kirkman 1996; Abal and Dennison 1996). For example, it is well documented that the availability of nutrient resources affects the growth, distribution, morphology and seasonal cycling of seagrass communities (Short *et al.* 1995). In addition, seagrasses depend on an adequate degree of water clarity to sustain productivity in their submerged environment (Short and Wyllie-Echeverria 1996). Increased turbidity and sedimentation reduce water clarity, which can affect the health and productivity of seagrass communities (Abal and Dennison 1996).

The following details the likely impacts on seagrass communities associated with elevated turbidity and sediment deposition. There will be no physical removal of seagrasses as a result of the construction of the Precinct.

Elevated Turbidity

The level of impact that elevated turbidity during dredging and the disposal of dredged material will have on the seagrass will depend on the type of community that is present. Some seagrass species may be better adapted to variable light regimes and therefore tolerate high levels of suspended sediment and turbidity.

Variable turbidity regimes in the Project Area, including in relation to existing channel maintenance dredging activities, suggest that existing seagrass species distributions are adapted to temporal changes in turbidity. Rasheed and Taylor (2008) note that seagrasses in the vicinity of the Townsville port are likely adapted to high levels of turbidity both as a result of naturally occurring high turbidity for the area and also in response to existing levels of maintenance dredging and shipping activities. These compounding influences on turbidity are, however, recognised to be short-lived to which the meadows have resilience. Significant impacts may occur to the presence, taxonomic composition or biomass of meadows when the severity or duration of any particular impact exceeds levels of natural variation (Carruthers *et al.,* 2002, Erftemeijer and Lewis, 2006 and Orpin *et al*. 2004). Rasheed and Taylor (2008) and Collier and Waycott (2009) both note considerable risk of impact to seagrass meadow prevalence in the Townsville region from prolonged periods of reduced water quality resulting from compounding influences.

High levels of turbidity for long periods can place a major stress on primary producers such as algae, phytoplankton, and seagrasses. Seagrass has a relatively high light requirement, with most species requiring between 15 and 25% of surface irradiance to maintain key physiological processes (Biber *et al.* 2005, Cheshire *et al.* 2002). The reduction in light due to turbidity plumes from dredging has been previously documented as a key factor in seagrass mortality in Australia (Shepherd *et al.* 1989). Issues related to the maintenance of light availability are paramount to managing seagrass habitats (Deocadiz and Montano 1999). Prolonged turbidity such as that generated from extended dredging programs can lead to the attenuation of light, limiting photosynthesis and subsequently elevate the stress experienced by seagrass meadows.

Sedimentation

Seagrass may suffer impacts resulting in the smothering of existing substrates by sediments settling from the water column during the dredging process. Smothering of seagrass can weigh down leaves, restrict light penetration and cause stress on the plants.

The seagrass communities in the vicinity of the Project Area may experience an increase in sedimentation during dredging and marine construction activities (including ocean disposal of dredged material). Modelling undertaken for the Project indicates that when the dredge is positioned in the mouth of Ross River, sedimentation should not exceed ~1mm at the deepwater seagrass bed located offshore of the Ross River mouth over two months of dredging (Figure 3-56). Given the likelihood that these sediments will be resuspended by storm events or strong winds, it is not anticipated that the predicted level of sedimentation will have a significant negative impact on the seagrass beds in the vicinity of the Project Area.

Desktop assessment of ocean disposal also notes that seagrasses and other benthic communities within the area of potential impact (at the disposal site and up to 2 km from this site) have persisted through time with regular ocean disposal occurring at the spoil ground (Cruz 2000, Rasheed and Taylor, 2008 and refer Section 0). This demonstrates the ecological resilience of these communities to this activity and it not anticipated that the predicted level of ocean disposal will have a significant impact on the seagrass communities within the vicinity of the disposal ground.

Recovery of Seagrass Communities from Sedimentation

Despite the physical impact of sedimentation, seagrass communities maintain a natural resilience to the mobilisation and deposition of sediments (Figure 3-57). Physical disturbance is considered one of most important factors affecting the spatial structure and species diversity of seagrass communities (Fonseca and Kenworthy 1987, Clarke and Kirkman 1989). While disturbance is considered a significant factor in the distribution of species, tolerances to disturbance and sediment deposition vary between species. For example, large seagrass species such as *H. decipiens*, can maintain substantial photosynthetic surface even after large-scale burial. Small species such as *Halodule sp*. or *Halophila sp.* are often completely removed after very small sedimentation events. However these species tend to grow very quickly and recover to pre-event abundances in a short period of time (Duarte *et al.* 1997).

In a study undertaken by Sheridan (2004), the impact of sediment disposal from maintenance dredging on adjacent benthic habitats was measured. The study showed that seagrass populations in the area of disturbance were well established three years after dredging.

Figure 3-56 Plot of Indicative Sediment Depths (m) after Two Months of Dredging in the Ross River mouth (seaward corner of current reclamation). Yellow >2mm, dark blue <1mm

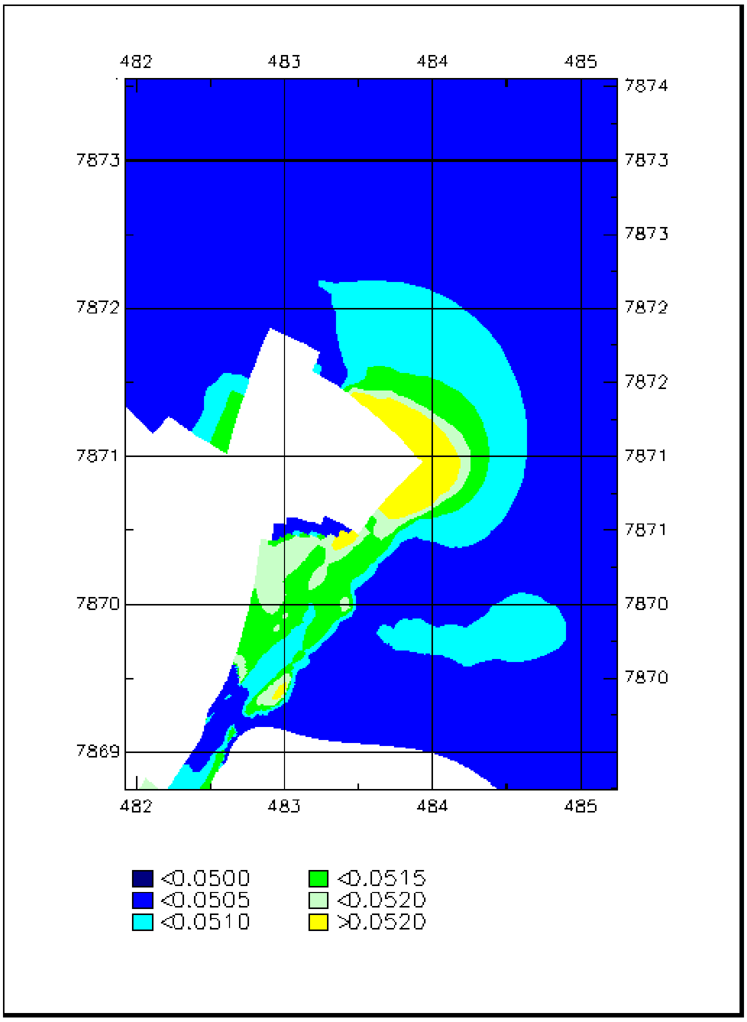
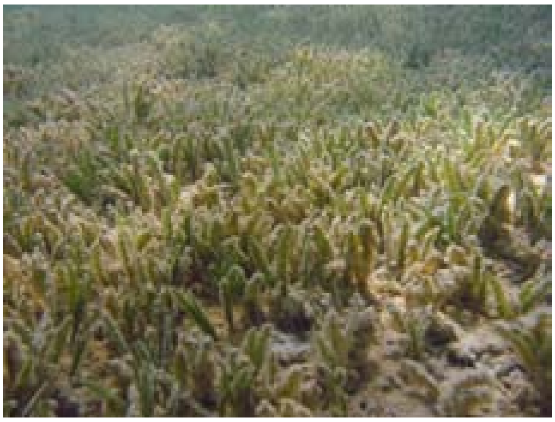


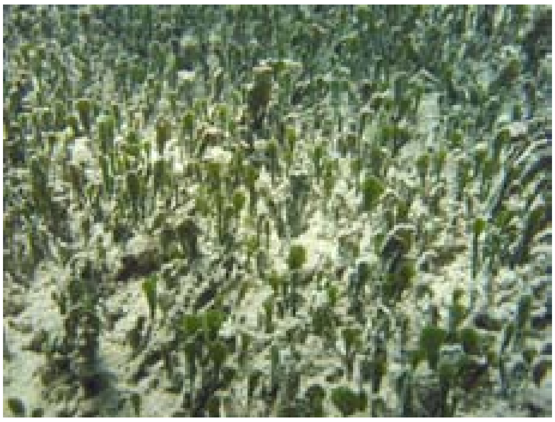
Figure 3-57 Seagrass and algal tolerance to sediment deposition events

Fine sediment deposition following suction dredge disposal (30 mm – 50 mm) (GHD 2002)



Natural deposition over near-shore seagrass beds (GHD 2004b)

Natural deposition over near-shore seagrass beds (GHD 2004b)



Natural deposition over near-shore algal bed (*Codium* sp.) (GHD 2004b)

Conclusions

Seagrasses established within the near-shore coastal waters surrounding the Project Area experience fluctuations in physical extremes, including variable salinity, light penetration, turbidity and sediment deposition regimes. Significant episodic elevations in turbidity occur naturally during wet season storm events and the passage of catastrophic events such as tropical cyclones. Despite these factors, and the history of dredging, ocean disposal and reclamation at the Port, seagrass communities continue to be present within 1 km of the Port and adjacent to the disposal ground.

Short term increases in turbidity associated with dredging, any required disposal and marine construction are considered unlikely to impact significantly on the broader distribution of seagrass within the Project Area for the following reasons:

- The documented survivorship of seagrasses in reduced light environments;
- The pulsed nature of turbidity impact over the dredging period resulting from broken cycles

of dredging and disposal and the physical influence of wave and tidal action on predicted/observed turbidity;

- The documented persistence of established meadows under existing, similar, levels of dredging and disposal; and
- Natural variability of the existing turbidity regime within the near-shore waters surrounding the Project Area.

Potential Impacts of Dredging and Sedimentation on Mangroves and Intertidal Communities

Impacts on mangrove and intertidal communities resulting from dredging and marine construction potentially include physical removal and elevated turbidity and sedimentation. The impacts of physical removal are summarised in Section 3.10.5.

Mangrove communities in the vicinity of the Precinct are adapted to the turbid near shore environments. These communities are adapted to estuarine environments that are typically turbid and generally act as traps for fine sediments in near-shore environments.

Modelling undertaken for the Project indicates that when the dredge is positioned in the mouth of Ross River, sedimentation should not exceed ~1mm around the mangrove communities in the vicinity of the Marine Precinct over two months of dredging (Figure 3-56). The intertidal and subtidal areas of the Ross River estuary generally consist of muddy bottom sediments (described in detail in Section 3.9.4). However, as the continuous water logger monitoring has demonstrated that resuspension of deposited sediments regularly occurs as a result of wind induced wave action, it is not anticipated that dredging will have a detrimental impact on the mangrove communities of the Project Area.

3.9.3.5 Site Specific Water Quality Objectives

The ANZECC (2000) guidelines favour the development of site specific water quality objectives, based on natural conditions and known tolerances of key sensitive species and habitats. The natural turbidity conditions recorded in the Ross River and offshore deepwater seagrass meadow are higher than the QWQG (2006), therefore it is appropriate to consider the development of site specific water quality objectives for turbidity for the construction phase of the Precinct. Turbidity is also the water quality parameter for which there is a large enough dataset across a range of environmental conditions at the sensitive habitat (WQ1, seagrass bed) to utilise in preparing site specific water quality objectives.

No site specific information is available on the physiological tolerance of the seagrass communities of the study area to increased intensities, frequencies and durations of turbidity. However, indirect information can be obtained by examining the natural fluctuations in ambient conditions under which the seagrass community is presently maintained. According to McArthur *et al.* (2004), the 95th percentile turbidity value represents a suitable tolerance threshold for a marine community in the absence of direct physiological response data. For WQ1, the 95th percentile turbidity value for the six months of continuous monitoring was 109 NTU. The approach of McArthur *et al.* (2004) recognises that sediment concentrations below this threshold are not of ecological significance, as the marine community has adapted to deal with the more frequent intensities and durations of turbidity to which they are exposed, including accompanying regimes of light attenuation and sediment deposition. The McArthur *et al.* (2004)

approach also considers intensities and durations to which the 95th percentile is exceeded and provides for these elevations as a set of allowable additional tolerance levels to which a duration of exposure is designated. This method has been used to develop indicative tolerances for this marine community, which are described in detail in Appendix J.

Data analysis indicates that the seagrass community at WQ1 regularly experiences turbidity levels of 109 NTU or greater for periods of 10 or 20 minutes. Occasionally, this community also experiences turbidity levels of 109 NTU or greater for extended periods, including one event of 13 hours in the six month monitoring program.

It is anticipated that the dredging program proposed for the Precinct will be undertaken in two separate stages:

- Stage 1: 38 weeks (8 weeks backhoe and 30 weeks cutter suction dredge)
- Stage 2: 30 weeks (8 weeks cutter suction and 22 weeks backhoe)

The dredging programs will extend for a similar length of time to the baseline monitoring program.

Based on the baseline turbidity data and likely length of the dredging program, Table 3-45 summarises the proposed water quality guidelines for turbidity during dredging to construct the Precinct. Compliance with these guidelines could be monitored via installation of continuous water quality loggers with remote download capability. Data would be downloaded regularly, with the frequency of download being relevant to onsite conditions and reviewed based on whether impacts were being observed at the sensitive habitats. Regular reports would be provided to the regulator, with exceedances of the durations and frequencies specified resulting in management actions, such as cessation of dredging to allow respite in elevated turbidity levels should these occur. The results of turbidity modelling outlined in this report suggest that it is unlikely that dredging will result in increases in turbidity above background levels at the sensitive sites that are of ecological significance and that any increase is likely to be over one tidal cycle only.

Table 3-45 Proposed Water Quality Guidelines for Dredging of Precinct

Duration (consecutive minutes in excess of 109 NTU)	**Frequency (number of incidences during dredging program)**
10	2 times per week
20	1 time per week
>30 minutes	14
>1 hour	10
>2 hours	10
>3 hours	7
>12 hours	1

3.9.4 Sediment quality and dredging – background

As previously summarised, the outcomes of geotechnical and acid sulfate soils investigations undertaken for the TMPP were that there is a large amount of material that is not suitable for use in construction of the Precinct, both from a geotechnical and acid generating potential, without substantial treatment and management and this material is likely to be dredged and disposed offshore. There is, however, potential for material reclamation to be considered during the detailed design process associated with finalisation of the Precinct configuration. For the purposes of this environmental impact assessment offshore disposal of the majority of material is considered as potentially more impactive than proportional reclaim of some material and, adopting a conservative approach, assessment against primarily disposing of material offshore has been conducted. Ability to reclaim material will reduce the level of impact described here.

The existing dredge spoil disposal permit for POTL is for five years from November 2007. This permit allows for disposal of a total of 2,750,000 cubic meters of material to the established offshore disposal ground within Cleveland Bay. The maintenance dredge spoil that is currently removed from the Ross River as required (currently every 2-3years) is a very minor component of the allowed total with an average of around 25,000 m^3/annum. Dredging assessments conducted under Section 2.4 indicate that volume of dredging required for construction of the Precinct that will require disposal to spoil is in the order of 866,000 m^3. The existing spoil ground has sufficient capacity to receive this material. Ongoing maintenance dredging volumes are not expected to increase following construction of the Precinct but may decrease as a result of the breakwater stopping longshore drift of material into the channel. Accordingly, existing permit disposal conditions are expected to be met following construction of the Precinct.

The environmental investigations and approvals for the offshore disposal component of this work are being addressed by POTL under a separate investigation and approvals process. The acid sulfate material in the sediments, their influence upon the construction scenarios and their potential management options are discussed in greater detail under Section 2.4 and Section 3.2 of this report.

3.9.5 Sediment Quality Guidelines

The National Assessment Guidelines for Dredging (NAGD) are a regulatory framework which is applied to ensure the impacts of dredged material loading and disposal are adequately assessed and, when ocean disposal is permitted, that impacts are managed responsibly and effectively (Australian Government, 2009). Sediment quality in the Precinct has been compared to the NAGD (2009) as these guidelines are most stringent guidelines under the National framework for marine sediments. A separate investigation and approvals process is being undertaken to fully characterise the sediments that may require offshore disposal as part of the construction of the Precinct in accordance with the NAGD (2009), therefore this is not dealt with in detail in this EIS.

The DERM Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland, were developed to provide best practice for managing land contamination through planning and development control process. The Environmental Investigation Levels (EILs) contained in these guidelines have been adopted to compare sediment concentrations against. The sediment contaminant concentrations have been assessed against these guidelines to inform any future placement in onshore reclamation areas of sediment from Ross River and as a preliminary overview of potential acceptability for ocean disposal under the NAGD (2009).

Comparison of sediment quality in the Ross River to various guidelines also provides an indication of whether the long term inputs of contaminants from the catchment have impacted on sediment quality in the vicinity of the Precinct. This will also provide a baseline against which future sampling can be compared.

In summary, the adopted guidelines for sediment quality are:

- National Assessment Guidelines for Dredging 2009
  - Interim Sediment Quality Guidelines - Maximum level (ISQG – High)
  - Interim Sediment Quality Guidelines - Screening level (ISQG – Trigger Value); and
- EPA Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998 - Environmental Investigation Levels (EIL).

The guideline values are provided in Table 3-46.

Table 3-46 Sediment Quality Guidelines adopted for Precinct EIS

Chemical	**Trigger Values/Guidelines (mg/kg)**		
	Draft – Contaminated Land QLD - EIL	**NAGD (2009) – ISQG Trigger Value**	**NAGD (2009) – ISQG-High**
Metals			
Arsenic	20	20	70
Antimony	20	2	25
Cadmium	3	1.5	10
Chromium (III +IV)		80	370
Copper	60	65	270
Lead	300	50	220
Manganese	500		
Mercury	1	0.15	1
Nickel	60	21	52
Silver		1	3.7
Zinc	200	200	410
Total Petroleum Hydrocarbons			
C 6 – C9 Fraction	100		
C 10 – C14 Fraction	100		
C 15 – C28 Fraction	1000		

Chemical	Trigger Values/Guidelines (mg/kg)		
	Draft – Contaminated Land QLD - EIL	**NAGD (2009) – ISQG Trigger Value**	**NAGD (2009) – ISQG-High**
C 29 – C36 Fraction	1000		
Monocyclic Aromatic Hydrocarbons			
Benzene			
Polycyclic Aromatic Hydrocarbons			
Benz(a)pyrene	1		
PAHs (Sum of total)	20	10	50
Polychlorinated Biphenyls			
PCBs (sum of total)	1	0.023	
Organochlorine Pesticides			
4,4-DDE		0.0022	0.027
Aldrin + Dieldrin	0.2		
Chlordane		0.0005	0.006
DDD		0.002	0.02
DDT		0.0016	0.046
DDT+DDE+DDD	0.2		
Dieldrin		0.28	0.27 e / 0.62 f
Endrin		0.01	0.12 e / 0.22 f
g-BHC (Lindane)		0.00032	0.001
Organotins			
Tributyltin		9 μgSn/kg	70 μgSn/kg

3.9.6 Description of environmental values

3.9.6.1 Previous sediment quality studies

There is a substantial amount of literature and information available on the existing sediment quality environment, both in the study area and throughout Cleveland Bay. The following reports on sediment quality are applicable to the Precinct:

- Townsville Port Authority (1998). Sediment Monitoring Program Annual Report, July 1997 – June 1998; and
- POTL Sediment Quality Monitoring 1995 – 2008.

Mean heavy metal concentrations recorded from July 1997 to July 1998 for arsenic, barium, cadmium, cobalt, chromium, copper, manganese, molybdenum, nickel, lead and zinc at sites in Ross River did not exceed the ANZECC Soil Investigation Threshold, ANZECC Soil Clean – Up Threshold (TPA 1998).

Sediment quality is monitored as part of the POTL long term sediment monitoring program. This program encompasses a number of different locations throughout the Port of Townsville, but the only sites of interest to this report are the sites in Ross River (RR3, RR4, RR5, RR6, RR7, RR8 and RR9). An indication of which POTL long term monitoring sites correspond to which EIS monitoring sites is provided in Table 3-47.

Table 3-47 Comparison of POTL and GHD Sediment Quality Monitoring Sites in Ross River

POTL Long-term Monitoring Sites	POTL Monitoring at this Site	GHD EIS Monitoring Sites
RR9	Water quality and sediment quality	Near WQ3
RR8	Sediment quality	Near WQ5
RR7	Water quality and sediment quality	Near WQ7
RR6	Sediment quality	In between WQ2 and WQ10
RR5	Water quality and sediment quality	Just upstream of WQ10
RR4	Sediment quality	Near WQ12
RR3	Water quality and sediment quality	Upstream of WQ12

Samples have been collected at these locations quarterly since 1995. Sediment samples were analysed for arsenic, barium, cadmium, cobalt, chromium, copper, manganese, molybdenum, nickel, lead antimony, tin, silver and zinc.

Generally all sites over the POTL monitoring period were below the NAGD (2009) screening levels and the DERM EIL guidelines except for the following:

- In June 1998, all sites except RR3 had concentrations above the Screening level for Copper, Lead and Zinc, with two sites exceeding the high level. Chromium also exceeded the EIL at these sites;
- In January 2002, all sites except RR3 had concentrations above the Screening level for Copper, Lead, and Zinc, while two sites exceeded the Screening level for nickel. Four sites (RR4 – RR7) exceeded the ISQG-high level for zinc;
- Concentrations of nickel exceeded the ISQG trigger value at several sites over the course of the monitoring program and zinc and chromium both exceeded the ISQG trigger value at one site on one sampling event; and
- 56 out of the 164 samples collected for manganese exceeded the EIL of 500 mg/L. Manganese was no longer analysed after April 2002.

3.9.6.2 Baseline sediment quality monitoring

Surface Grab Samples

Sediment samples were collected at the 12 water quality monitoring locations during the first sampling event in September 2008 (Figure 3-50). Two additional samples were collected from randomly chosen sites as quality assurance samples. Samples were collected using a Van Veen benthic sediment grab sampler. The Van Veen sampler was decontaminated between the collection of samples at each site. Sediments were placed in laboratory supplied glass jars with Teflon lined lids, stored on ice and couriered overnight to the NATA accredited ALS Laboratory Group for analysis at the end of each day. Chain of Custody forms are provided in Appendix J.

Sediment samples were analysed for the following parameters:

- Particle size;
- Moisture content;
- Total organic carbon;
- Total heavy metals (arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, manganese, nickel, lead, vanadium, zinc, mercury);
- Nutrients (Total Nitrogen, nitrate, nitrite, ammonia, Total Kjeldahl Nitrogen, Total Phosphorus and Reactive Phosphorus);
- Herbicides;
- Organochlorine Pesticides (OCP);
- Organophosphorus Pesticides (OPP);
- Phenols
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Organotins; and
- Total Petroleum Hydrocarbons (TPHs) and BTEX.

As sediment quality does not tend to change rapidly over time and the concentrations of the potential contaminants were generally not present at concentrations exceeding the adopted sediment quality guidelines, further sediment sampling was not undertaken on a monthly basis. Low concentrations of some contaminants of concern were present at one or more sites, however it was considered that one round of sampling provided an adequate baseline dataset for sediments.

Additional Sediment Sampling

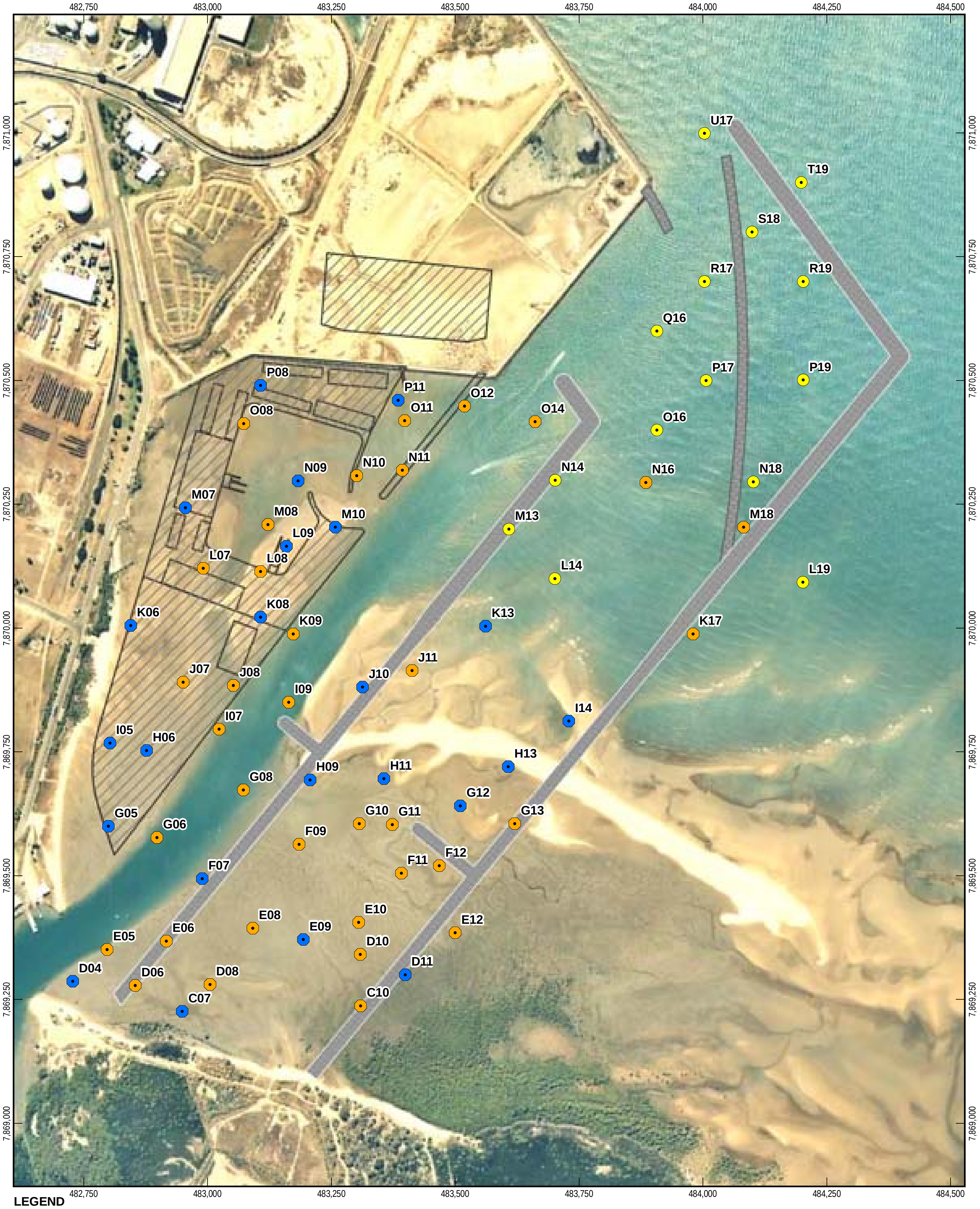
Additional sediment contamination analysis was conducted at various locations during the two acid sulfate soil sampling events. This was an opportunistic assessment as the acid sulfate soil sampling was conducted at different sites to the 12 sediment sampling sites. Contamination analyses were conducted at three of the acid sulfate soil sampling sites, at the following boreholes and depths (Figure 3-58):

- L19_4: 1.5 – 2m;
- L19_7: 0 – 0.5m;
- N14_3: 1.5 – 2.0m;
- N14_6: 0 – 0.5m;
- R17_1: 1.2 – 1.6m; and
- R17_4: 0 – 0.3m.

The samples were collected using a vibrocorer. Sediments were placed in laboratory supplied glass jars with Teflon lined lids, stored on ice and couriered overnight to the NATA accredited ALS Laboratory Group for analysis at the end of each day.

The samples were analysis of the following parameters:

- Moisture content;
- Total Petroleum Hydrocarbons (TPH);
- Organochlorine Pesticides (OCP);
- Organophosphorus Pesticides (OPP);
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Phenols;
- Semi-Volatile Organic Compounds (SVOC);
- Polychlorinated Biphenyls (PCB); and
- Metals (aluminium, antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, vanadium and zinc).



LEGEND

- Vibra-Core Sample Locations - Phase 1
- Vibra-Core Sample Locations - Phase 2
- Vibra-Core Sample Locations - Phase 3
- Proposed Marine Precinct
- Min and Max Options
- Breakwater Option C (Preferred)

1:10,000

0 50 100 150 200 250

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

GHD

PORT of TOWNSVILLE

Port of Townsville
Marine Precinct EIS

Acid Sulphate Soil
Sample Locations

Job Number	42-15399
Revision	B
Date	01 July 2009

Figure 3-58

G:\42\15399\GIS\Projects\EIS\42-15399_407_rev_b.mxd

Level 4 201 Charlotte Street Brisbane QLD 4000 Australia **T** +61 7 3316 4496 **F** +61 7 3316 333 **E** bnemail@ghd.com.au **W** www.ghd.com.au

Data source: Marine Precinct - ©The State of QLD (Port of Townsville LTD) 2009; Monitoring Locations - GHD 2009; Aerial (flown 2004) - ©The State of Queensland (Department of Environment and Resource Management). Created by: TH

3.9.6.3 Results of baseline sediment quality monitoring

The results of the sediment sampling conducted for the EIS are presented in detail in Appendix J. Following is a summary of key findings as they relate to environmental conditions.

The sediment sampling undertaken for this EIS demonstrated the presence of minor concentrations a number of anthropogenic contaminants. PAHs were identified in low concentrations in the vicinity of WQ10 – 12. PAHs are commonly associated with incomplete combustion of fuels and oils and are likely to be present in the Ross River estuary as a result of the presence of boat traffic and moorings, particularly in the vicinity of WQ10 - 12. Nutrient concentrations in sediments (as for water quality findings) were also higher in the vicinity of the boat moorings, indicating an input from this source or other land based anthropogenic activities in this area.

Minor concentrations of tributlytin (TBT) were identified in two sediment samples. TBT is an antifouling agent that was previously used on ships and boats to prevent growth of marine organisms on their hulls. The likely sources of TBT are boat maintenance activities that are currently based on the northern bank of the Ross River, west of the proposed Port Access Road and from boats and ships in both Ross River and the adjacent Port facilities. TBT is usually present in marine sediments heterogeneously.

Minor concentrations of herbicides were also identified in the sediments of the study area. As was the case with water quality, this indicates minor inputs of these anthropogenic contaminants from the Ross River catchment, but no long term build up of these contaminants was evident from this monitoring program.

Overall, the quality of sediments in the Project Area is compliant to the NADG (2009) and the EIL of the Draft Guidelines for the Assessment and Management of Contaminated Land.

3.9.7 Potential impacts and mitigation measures

3.9.7.1 Management of Sediment Quality

As summarised in the discussion of potential impacts on water quality, as a result of the construction and operation of the Precinct a number of marine related industries and activities are planned for the Precinct. Many of these are likely to relocate from the area upstream of the proposed Port Access Road. While significant contamination of the sediments in the Project Area has not been identified there is the potential for the construction and operation of the Precinct to introduce contaminants into the receiving environment and for this to impact on sediment quality. If sediment quality is impacted, this can impact on marine communities in the vicinity of the Project Area and can also impact on the ability to dredge and dispose of the sediments to maintain the declared depths of access channels and basins.

The potential impacts of the construction and operation of the Precinct on sediment quality are similar to those for water quality, as contaminants are often introduced into sediments through the water column. Contaminated sediments can also be introduced directly into the marine environment through runoff of contaminated soils. The potential impacts and mitigation measures are summarised in Table 3-44 of the water quality section.

3.9.7.2 Dredging and Disposal of Sediments

As discussed previously, a large proportion of the material to be dredged for the construction of the Precinct is unsuitable from both a geotechnical and acid generating potential perspective for use as fill in the Precinct without substantial treatment and management. POTL is undertaking a separate process to fully characterise and, if required, will apply for offshore disposal of these sediments. Studies indicate that approximately 25% of the material to be dredged for Stage 2 of the Precinct will be sand that is suitable for reuse as fill within the Precinct. This sand will be dredged using a small cutter suction dredger, be pumped into the Stage 2 reclamation and be placed below the water level.

Therefore, this impact assessment focuses on the potential impacts of dredging of sediments. The impact of dredging on coastal processes and sediment budgets is addressed in Section 3.8 of this EIS and the impacts of increased turbidity resulting from dredging of sediments was discussed in the water quality section of this report above.

The potential impacts of sediment quality on the marine environment have taken into consideration the guidelines for toxicants in sediments provided in the NADG (2009) and DERM Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland 1998 - Environmental Investigation Levels (EIL).

Potential Impacts

Mobilisation of seabed sediments into the water column during dredging and marine construction may increase the bioavailability of toxicants to marine organisms. The principle parameters that affect mobilisation of contaminants from sediment to water are clay type and content, organic matter content, cation exchange and capacity, reactive iron and manganese, oxidation reduction potential (redox), pH and salinity. Of these parameters clay type, organic matter, pH and redox conditions are considered the most important (Burt and Hayes 2005).

The process of dredging results in changes in physiochemical sediment conditions, favouring the mobilisation of contaminants into the environment. Potential contaminant pathways include release of contaminants from mobilised sediments into the water column (USACE and US EPA 2004). Water column impacts are usually water quality (chemical) and toxicity (biological). Primary contaminant groups that may impact the marine environment include heavy metals, hydrocarbons and persistent organic compounds (Burt and Hayes 2005).

Contaminants in Precinct Sediments

As there are only low levels of selected contaminants present in sediments analysed for this EIS, it is not anticipated that the process of dredging will introduce significant concentrations of contaminants into the water column. It is proposed to dispose potential acid sulfate material offshore, preventing oxidation and acid generation. Table 3-43 of the water quality section discusses the potential impacts and mitigation measures for dredging, including introduction of contaminants into the water column. Acid sulfate soils, including potential opportunities and approaches for treatment to enable reclamation, are discussed under Section 3.2.1.3 of this EIS.

One area of risk is the introduction of nutrients into the water column. This is discussed following.

Cyanobacterial Blooms

Cyanobacteria (*Trichodesmium sp.*) often bloom in Cleveland Bay as they do along other parts of the Queensland coast. The planktonic *Trichodesmium* sometimes forms blooms in tropical waters, and after the blooms die *Trichodesmium* is visible as a reddish slick on the surface of the water (www.reef.crc.org.au). Cyanobacteria are important to marine ecosystems because they fix atmospheric nitrogen and are considered an important factor for bloom initiation in oligotrophic tropical and sub-tropical waters (Sparrow and Heimann, 2007).

Conditions that favour cyanobacterial blooms include warm, still water conditions during the late dry season and early wet season. Sediment and nutrient loss from rural industries and the consequent effects upon terrestrial runoff quality have been identified as contributing factors for blooms as they introduce nutrients into the marine environment.

Studies in the Cleveland Bay area have determined that periods of strong winds and wave action and turbulence within shallow areas of the Bay cause the resuspension of bottom sediment, and when calmer conditions prevail, the sediment resettles and leaves nutrient enriched, comparatively clear sea water with good light penetration, which promotes phytoplankton growth (Stark *et al.* 1975). In the tropics a strong south-easterly wind blows almost continuously throughout the winter months, therefore the most of the productive periods are most likely to be during spring and summer, when the strong winds become intermittent. Phytoplankton blooms in the Bay are frequently accompanied by the production of vast orange to brown windrows, which can extend for many kilometres (Stark *et al*. 1975). *Trichodesmium* blooms seem to occur regularly after turbulent water conditions, and are apparently independent of water temperature, which shows a range varying from 20 – 33°C over the period when such blooms occur.

It has been established that during *Trichodesmium* blooms, labile forms of cadmium and dissolved and particulate forms of iron markedly increase, and that these increases occurred along with high concentrations of ‘marine humic acid’, associated with the presence of *Trichodesmium* (Jones *et al*, 1986).

During the six month water quality investigation conducted for this EIS, there was no visual evidence of any *Trichodesmium* bloom, nor were elevated concentrations of chlorophyll a recorded, suggesting that no blooms occurred in the vicinity of Ross River during the monitoring program. However, during the marine ecology surveys, a evidence of a bloom was observed as a red slick on the surface of sediments in the Precinct area during low tide.

It is possible that dredging to construct the Precinct will result in the introduction of nutrients into the water column. The reduction in turbidity that will occur when dredging ceases may also result in conditions that are conducive to algal blooms (i.e. clearer waters with good light penetration). However, the main forms of nutrients found in sediments were not biologically available forms and nutrients are already present in the water column in concentrations above the QWQG (2006). Existing observations of algal blooms in the Townsville region have not, to date, been correlated with previous dredging events. It is therefore considered unlikely that dredging activities to be undertaken during construction or operation of the Precinct facility would promote conditions conducive to algal blooms.

3.10 Nature conservation

3.10.1 Overview

This section details the existing nature conservation values of the project area. The environmental values of nature conservation for the affected area are described in terms of:

- Integrity of ecological processes, including habitats of rare and threatened species
- Conservation of resources
- Biological diversity, including habitats of rare and threatened species
- Integrity of landscapes and places including wilderness and similar natural places
- Aquatic and terrestrial ecosystems.

Terrestrial flora and fauna, avifauna and marine flora and fauna (including megafauna) are described in the following sections. Sensitive environmental areas and the biodiversity they support are described where appropriate. The presence and influence of pest and weed species is addressed under each ecological system section. Desktop literature reviews and field baseline assessments have been used to describe the communities and potential impacts from the project on these communities.

Reference is made, where appropriate, to relevant Queensland and Australian Government legislation and policies on threatened species and ecological communities including recovery plans and offsets of impacts.

Potential adverse and beneficial impacts associated with the project are described, as are the objectives for protecting or enhancing nature conservation environmental values.

Impacts during construction and operation of the project are assessed. Strategies for protecting any rare or threatened species are described, and any obligations imposed by state or commonwealth endangered species legislation or policy or international treaty obligations (i.e. JAMBA, CAMBA, ROKAMBA) are discussed. Measures to mitigate any impacts identified for the project are identified as are strategies to offset any impacts that are not able to be mitigated. The presence of any pest species is noted and strategies to reduce impacts through the project discussed.

3.10.2 Risk Assessment Approach

An assessment has been undertaken to identify any actions of the project or likely impacts that require an authority under the Nature Conservation Act 1992, and/or those that may be assessable development for the purposes of the Vegetation Management Act 1999 and the Fisheries Act 1994. A risk and impact assessment process was used in conducting this assessment and developing management and mitigation strategies for each identified impact.

This risk assessment addresses the construction and operational aspects of development of the Precinct. It has been developed in order to assess the risk posed to the terrestrial and marine environments by activities undertaken as part of the proposed project. The assessment identifies aspects of the works that pose an environmental risk, and classes these risks into one of four categories (Extreme, High, Medium and Low). The classification then allows priorities to be set for addressing and mitigating these risks.

3.10.3 Risk Assessment Methodology

No international standard exists for risk management and as a result the risk assessment methodology employed here is based on the Australian Standard AS/NZS 4360: 1999 *Risk Management* (the Standard) and HB 203: 2000 *Environmental Risk Management – Principles and Process* (the Guidelines). The Standard and Guidelines set out a generic framework for establishing the context, identifying, analysing, evaluating, treating, monitoring and communicating risks. The Best Practice Environmental Management in Mining, Environmental Risk Assessment (EA 1999) also adopts this standard though different definitions have been adopted by EA.

The objective of a risk assessment is to filter the minor acceptable risks from the major non-acceptable risks. It involves consideration of the sources of risk, the consequences and the likelihood that those consequences may occur.

Risk analysis may be undertaken to various degrees of refinement depending upon the risk information and data available. Analysis techniques include:

- Qualitative assessment;
- Semi-Quantitative assessment; and
- Quantitative assessment.

In practice, a qualitative analysis is often used to first obtain a general indication of the level of risk and then a more quantitative analysis is applied to refine the risk.

A quantitative risk assessment can be undertaken based on statistical analysis for various consequences and probabilities. In the absence of statistical data, an estimate may be made of the degree of the consequence and frequency (refer to section 4.3 of the Standard).

The risk assessment methodology for this EIS uses a semi-quantitative process for determining risk. The semi-quantitative process estimates the degree of the consequence and probability and assigns a score to each. The score allocated "does not have to bear an accurate relationship to the actual magnitude of consequences or likelihood" (refer to section 4.3.4 of the Standard). The risk and impact assessment process used here to assess and weight potential project risks was undertaken using an Environmental Risk and Likely Impact ("ERLI") approach. For each possible impact aspect, two key areas were addressed:

Environmental Risk

This essentially considers the risk of irreversible change to natural ecological processes and community interaction. Assessment addresses:

- Conservation significance of environmental, social and cultural values and regional context of these values;
- Current level of integrity of natural ecosystem processes;
- Known sensitivity of ecosystem processes/natural values to human induced change;
- Natural change and resilience of relevant ecosystem processes/natural values;
- Potential for cumulative social and environmental impacts; and
- Level of scientific certainty of the above factors.

Likely Impact

This considered the likely impact of the project, as modified and undertaken in accordance with mitigation strategies (including any environmental management plans or conditions from licensing/approval agencies) and includes:

- Geographic extent of the activities;
- Duration of the activities;
- Magnitude of potential environmental change;
- Confidence in prediction of impact;
- Confidence in mitigation strategies to minimise ecological and social risks; and
- Ability to monitor the impacts and detect change before irreversible change to system processes occurs.

The approach considered direct and indirect impacts, short and long term, cumulative, temporary and irreversible, and adverse and beneficial impacts.

The significance of the impacts was placed in an appropriate context in which to justifiably determine the impact's significance. In particular, the duration of the impact (temporary v permanent) and reversibility were considered. The ability of natural systems (including population, communities and ecosystems) to accept or assimilate impacts was also considered.

The above approach is used to provide the essential information that is used in the formal Risk Assessment as based on the Australian/New Zealand Standard 4360:2004. This methodology is outlined below.

Stage 1: Identification of Risk

This included identification of all relevant risks, addresses all known activities and related environmental aspects of the project.

Stage 2: Risk Analysis

An important feature is recognition of the fact that an event's consequence extends beyond the immediate impact. This methodology ensures that the full consequences of events are visible to risk owners and managers and that the effects on the project are all understood and treated. Each class of consequence is rated a score of 0 - 5, where "0" is nil consequence to "5" is catastrophic.

An analysis of each risk is undertaken to determine an environmental event's likelihood of occurrence and its consequences. A five-level qualitative description of the likelihood and consequences for each risk enables a semi-quantitative method to be used to calculate a 'score' for each risk.

Definitions and scales for Consequences are shown in Table 3-48 and definitions and scales for Likelihood are shown in Table 3-49.

Stage 3: Calculation of Risk Level

Two levels of risk are used:

The **Primary Risk Level (PRL)** is a conservative measure of risk, based on the most severe consequences across all the relevant criteria. PRL is calculated according to the equation:

Primary Risk Level (PRL) = Likelihood Rating X Maximum Consequence Rating

The **Secondary Risk Level (SRL)** is a less conservative measure of risk, which incorporates all relevant criteria, not just the most severe ones. SRL is calculated according to the equation:

Secondary Risk Level (SRL) = Likelihood Rating X Average Consequence Rating

In most circumstances PRL should be the preferred measure, as it is more conservative. Risk scores are banded into risk levels which provide a "plain English" view of the risk. Scores will always be visible to enable prioritisation within bands.

Table 3-50 and Table 3-51 show the bands, their threshold values and indicative management action.

Stage 4: Determination of Options for Treatment of Risks

Following the analysis of a risk it is necessary to investigate the options available for risk treatment and then determine the option or options that provide the greatest cost benefit.

Risks may be treated in one or a combination of ways[5]:

- Avoiding a risk by preventing the activity that leads to the risk eventuating;
- Reducing the likelihood of the risk eventuating;
- Reducing the consequences if the risk does eventuate;
- Transfer the risk; and
- Retaining the risk.

Table 3-48 Threat Criteria and Consequence Scales

Rating	Project Delivery Impacts	Environment	Community & Sustainability	Financial
0 **Nil**	No impact on schedules.	No environmental impact.	No social impact, damage to valued structures or locations of cultural significance or sacred value or loss of environmental resources.	No cost impact.
1 **Insignificant**	Some minor modification to planned activities may be necessary. Insignificant delays. Negligible performance impact.	Negligible release or damage that is contained on-site and is non-reportable. The damage is fully recoverable with no permanent impact on the environment.	Negligible social impact. Negligible damage to valued structures or locations of cultural significance or sacred value. Negligible loss of environmental resources.	Insignificant financial loss to remedy.

[5] After AS/NZS 4360:2004

Rating	Project Delivery Impacts	Environment	Community & Sustainability	Financial
2 **Minor**	Modification to planned activities can be expected. Minor delays. Minor performance degradation.	Minor violation of regulation or guideline with minimal damage to the environment and small clean up. Immediately contained on-site.	Minor impact on the community or public health. Minor damage to valued structures or locations of cultural significance or sacred value. Minor loss of environmental resources.	Minor financial loss to remedy.
3 **Moderate**	Most activities affected. No resumption of normal activities for up to 6 months. Significant delays resulting in some reduction in performance.	Moderate violation of regulation or guideline with moderate damage to the environment and significant clean-up cost.	Detrimental impacts on the community or public health. Damage to valued structures or locations of cultural significance or sacred value. Loss of scarce environmental resources.	Moderate financial loss to remedy.
4 **Major**	All normal activities curtailed. No resumption of normal activities for between 6 and 12 months. Major delays of capability delivery but at non-critical times. Failure to achieve some performance targets.	Significant environmental damage with widespread impacts. Damage may be permanent.	Significant detrimental impacts on the community. Major damage to highly valued structures or locations of cultural significance or sacred value. Significant loss of scarce environmental resources.	Major financial loss to remedy.
5 **Catastrophic**	All activities cease. No resumption for at least 12 months. Major unacceptable delays in delivery of capability occurring at critical times. Failure to achieve critical performance goals.	Long-term environmental harm. Permanent irreparable damage is caused to the environment. For example, acid sulfate soil generated into the estuary environment.	Significant, extensive, detrimental long-term impacts on the community or public health. Irreparable damage to highly valued structures or locations of cultural significance or sacred value. Permanent and significant loss of scarce environmental resources.	Extreme financial loss to remedy.

Table 3-49 Likelihood Rating

Rating	LIKELIHOOD The potential for risks to occur and lead to the assessed consequences			
1	Rare	Very low, very unlikely during the next twenty-five years	Probability less than 0.04	A similar outcome has arisen on a regional, state, national or international level and not unique to the project.
2	Unlikely	Not impossible, likely to occur during the next ten to twenty-five years	Probability 0.04 - 0.1	A similar outcome has arisen at some time previously but action has been taken to reduce the chance of recurrence.
3	Possible	Possible, may arise about once in a one to ten year period	Probability 0.1 - 0.5	A similar outcome has arisen at some time previously.
4	Likely	High, may arise about once per year	Probability 0.5 - 0.8	A similar outcome has arisen several times per year.
5	Almost certain	Very high, may occur at least several times per year	Probability over 0.8	A similar outcome has arisen several times per year in the same location, operation or activity

Table 3-50 Risk Assessment Matrix

Likelihood	Consequences				
	1 – Negligible	2 – Minor	3 – Moderate	4 – Major	5 – Extreme
1 – Rare	1	2	3	4	5
2 – Unlikely	2	4	6	8	10
3 – Likely	3	6	9	12	15
4 – Almost Certain	4	8	12	16	20
5 – Certain	5	10	15	20	25

Table 3-51 Risk levels and Management Action (example)

Risk Level (PRL or SRL)	Descriptor	Indicative management action
1-4	Low	Manage by routine procedures, unlikely to need specific application of resources
5-10	Medium	Manage by specific monitoring or response procedures, develop more detailed actions as resources allow
10-16	High	Senior management attention needed and management responsibilities specified for further action
17-25	Extreme	Immediate action required, senior management will be involved

Limitations

As with any model, the relevance and applicability of the risk model revolves around a number of basic assumptions and limitations. The application of the risk model has been based on subjective ranges of consequences and probabilities.

Limitations of the application of the risk methodology for this study include:

- The assessment is based on the professional judgement of a limited number of experienced GHD staff and does not incorporate the collective experience of all parties involved with the project. The full range of risks and the most appropriate consequence and likelihood rating would be best completed in a workshop involving key stakeholders; and
- The assessment has been limited to a selected number of primary risks and the assessment of cumulative risk to the environment from multiple pollution sources or sources of environmental degradation has not been addressed. Cumulative risks are approached for

this study in a qualitative manner only.

Although a semi-quantitative methodology was used to conduct the risk assessment, the resultant risk estimation is purely relative. The risk estimations do not imply an absolute scale of risk that can be applied to any other situation or assessment.

3.10.4 Terrestrial ecology

3.10.4.1 Overview of terrestrial studies

The terrestrial footprint of the study area includes two parcels of land either side of the Ross River estuary. The largest parcel, for consideration of the largest breakwater footprint, comprises approximately 58 hectares on the southern bank of the estuary (often referred to as the south bank), and includes a portion of the foreshore/littoral zone. The second parcel of land (approximately 34 ha) on the north bank of the Ross River (often referred to as the north bank) includes a narrow strip of heavily modified vegetation. This small area (approximately 1.5 ha) is dominated by marine plants that have recruited at the base of the seawall on the north side of Ross River. This was the only natural habitat remnant in the northern footprint and was the only portion of that area examined.

The study area is located within the Brigalow Belt (northern) Bioregion as defined by the *Interim Biogeographic Regionalisation for Australia*. Specifically, the study area is within an area described as “Province 1 – Townsville Plains” under this biogeographic classification. Typically much of this province includes Quaternary coastal dunes and beaches, typically degrade dunes, sandplains, swales, dune lakes and swamps. Soils are predominantly siliceous/calcareous sands, with groundwater podzols or peats in some areas.

Information regarding the terrestrial ecology of the project area has been collated from a focussed desktop assessment of available information (including Government agencies databases and previous EIS and Environmental Management Plans commissioned for the site and adjacent areas) and from the results of a terrestrial fauna/flora baseline study. Full details of the assessments undertaken for this component of work, including the literature and database reviews, are provided under Appendix S. Information on avifauna was collected during both the terrestrial ecology study and also through a targeted wading and migratory bird assessment The terrestrial ecology study is reported following and the additional avifauna assessments are reported under Section 3.10.5.

3.10.4.2 Objectives and methodologies - terrestrial ecology

Field work for the baseline investigation was conducted in September 2008. Further information to reflect seasonal variations in detectable species composition (i.e. to locate species that may not be apparent in the dry season) was gleaned from three previous ecological studies conducted in the area in association with other infrastructure projects.

The objective of the terrestrial ecology baseline survey was to characterise the floral and faunal community assemblages of the foreshore, dune and mangrove systems within the immediate development area of the Precinct and adjacent Ross River banks using a combination of aerial photograph and on ground assessments. It is considered that if the connected, larger breakwater is to be built, the habitats on the banks in the mouth of the Ross River and to the east of the proposed Precinct area are at greatest risk. These areas include the greatest biodiversity values. By comparison the small area of the northern bank (1.5 hectares) represents reclaimed area and has limited vegetation and fauna habitat value. No formal fauna trapping was done in this area; incidental observation methods were employed.

The mangrove and dune communities adjacent to the south bank in the vicinity of the proposed Precinct development are readily delineated, as they are relatively homogenous, with limited to no ecotone between the communities. Given this homogeneity, and the limited terrestrial habitats present in the mangrove communities, fauna sampling was limited to the sclerophyll woodland on low dune and swale terrain, and the samphire mudflats, to the far east of the Precinct area.

In particular, field surveys had the following scope of activities:

- Vegetation community identification, using Queensland Herbarium regional ecosystem (RE) ground truthing procedures as outlined in Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Nelder *et al*., 2005);
- Identifying flora and fauna species diversity and abundance, and in particular species of conservation significance under State and Commonwealth legislation. Standard biodiversity assessment methodologies ratified by the Environmental Protection Agency were employed;
- Assessment of the regional significance of the project area in terms of the species known to utilise the site;
- Identifying presence of habitat resources such as hollows, fruiting trees, permanent water or streams etc, and the condition and integrity of habitats on the site; and
- Verifying presence of exotic species, in particular those listed as pest species.

Field surveys also noted whether any species of cultural, commercial or recreational significance were present in the footprint of Lot 773.

3.10.4.3 Description of environmental values - flora

Detailed description of the survey findings are provided under Appendix S. These findings are summarised here.

The survey found that there are four main terrestrial vegetation communities in the project area:

- Mangrove shrubland and tall shrubland;
- Mudflats in the upper reaches of the intertidal zone dominated by chenopodaceous plants, sedges and salt couch;
- Sclerophyll woodland on relict sand dunes dominated by Moreton Bay ash and grey paperbark, and with Burdekin plum and Acacia spp. sub-dominant. This community has a high degree of incursion by declared weeds such as chinee apple, rubber vine and lantana; and
- Closed shrubland of chinee apple on relict sand dunes.

A total of 127 flora species were detected, none of which are of conservation significance. None of the flora species of conservation significance previously found in the area, or that are predicted to occur here, have habitat requirements met on the site.

None of the Regional Ecosystems identified in the project area are considered to be of concern. A map of the terrestrial ecology site with regional ecosystems identified is provided as Figure

3-59.

No species of cultural, commercial or recreational species were detected in Lot 773. Landscape scale stands of mangroves are recognised to be culturally important for Indigenous people. They also can have commercial and recreational value providing habitat for fishery species. However, the mangroves detected fringing the edge of Lot 773 are highly fragmented and do not form a landscape stand community. These are not considered to provide significant commercial, cultural or recreational benefit.

3.10.4.4 Description of environmental values - fauna

The faunal survey program identified 44 bird, eight mammal, nine reptile, three amphibian and one crustacean species on the site, and it is likely that a number of other fauna species occur in the immediate vicinity. None of these species are of conservation significance, although some of the bird species are listed under the EPBCA as marine and marine migratory species. However, there at least seven species of wildlife not detected in the field survey but that are known to occur in the area, and that have habitat requirements met on the site. These species are:

- Radjah shelduck (*Tadorna radjah*) (rare under the NCA);
- Beach stone curlew (*Esacus magnirostris*) (vulnerable under the NCA);
- Black-necked stork (*Ephippiorhynchus asiaticus*) (rare under the NCA);
- White-rumped swiftlet (*Collocalia spodiopygius*) (rare under the NCA);
- Coastal sheathtail bat (*Taphozous australis*) (vulnerable under the NCA);
- Estuarine crocodile (*Crocodylus porosus*) (vulnerable, marine and marine migratory under the EPBCA and vulnerable under the NCA); and,
- Rusty monitor (*Varanus semiremex*) (rare under the NCA).

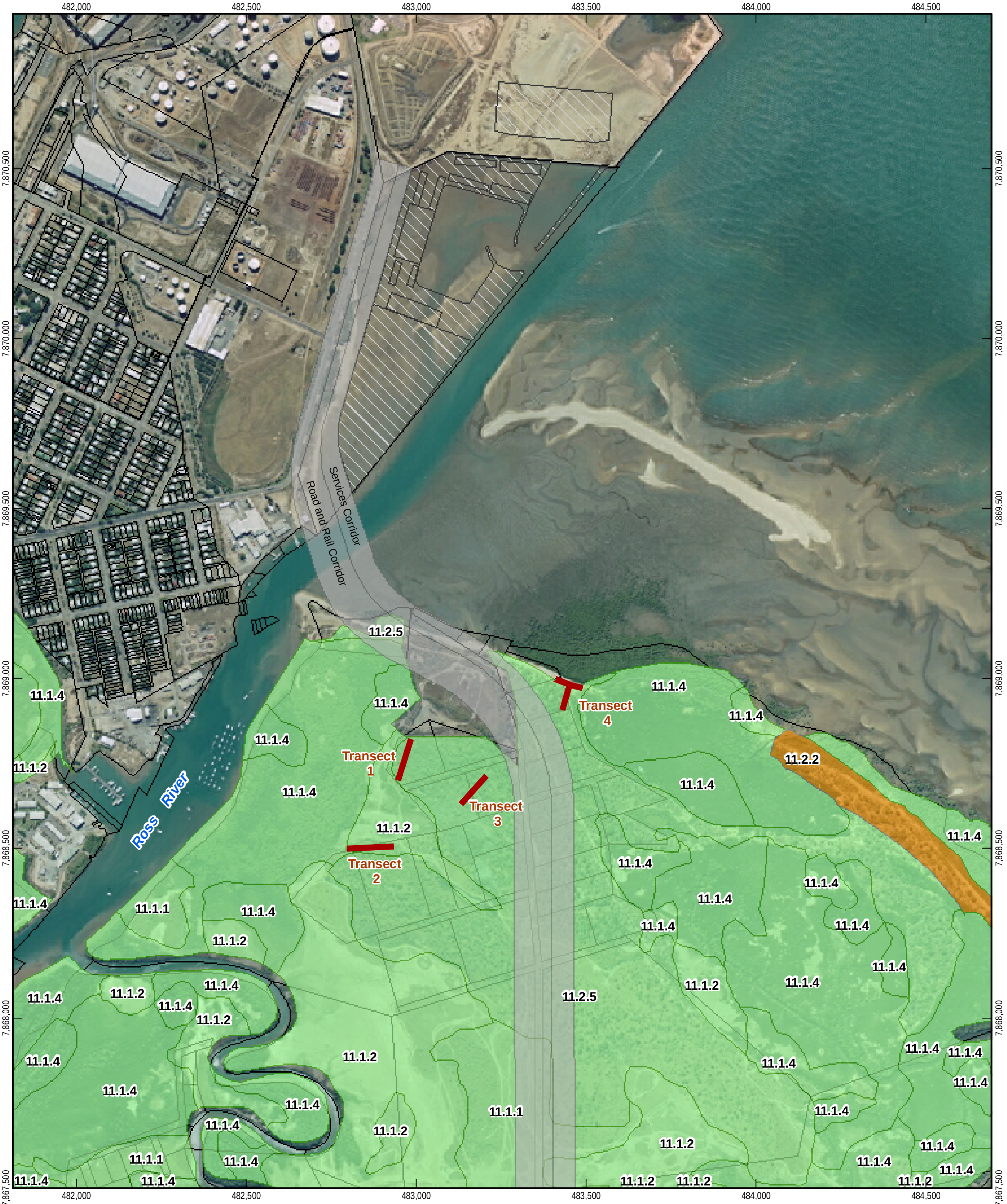
Two invasive species were detected during the survey:

- Feral pig (*Sus scrofa*); and
- Cane toad (*Rhinella marinus*).

Both of these species were detected on the Eastern bank of the Ross River and were not found within the Lot 773 footprint. It is possible that feral cats may occur within both areas, however, no evidence of this was detected.

No terrestrial fauna species of cultural, recreational or commercial significance were detected within the footprint of Lot 773. A number of culturally and recreationally important species (eg birds and bats) were, however, detected on the Eastern bank of the Ross River. In recognition of the areas importance for avifauna an additional study focussed on wading and migratory bird species, particularly CAMBA, JAMBA and ROKAMBA listed species, was undertaken. That is described in Section 3.10.5.

Impacts on terrestrial species identified during the October baseline assessment are discussed in the following section.



LEGEND

- Transect Lines
- Proposed Marine Precinct
- Proposed Transport and Services Corridor
- Cadastre

Regional Ecosystem

- Of Concern - Dominant
- Not Of Concern

Regional ecosystem linework reproduced at scale greater than 1:100,000, except in designated areas, should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100,000 is 100 metres. Regional ecosystem mapping reproduced with permission of Environmental Protection Agency [2006]. While every care is taken to ensure the accuracy of the Information Product, the Environmental Protection Agency makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason. Data must not be used for direct marketing or be used in breach of the privacy laws.

1:15,000 (at A4)

0 100 200 300 400 500

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Port of Townsville
Marine Precinct EIS

Job Number 42-15399
Revision A
Date 01 July 2009

Terrestrial Ecology Site
with Regional Ecosystem Mapping

Figure 3-59

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Data source: Marine Precinct - ©The State of QLD (Port of Townsville LTD) 2009; Aerial (flown 2004), RE Data, DCDB - ©The State of Queensland (Department of Environment and Resource Management). Created by: TH

3.10.4.5 Potential impacts and mitigation measures – terrestrial ecology

The Townsville Marine Precinct Project (TMPP) is expected to have very limited impacts on the terrestrial ecological values of the area in which it is located. The majority of the impacts comprise the removal of a small area (approximately 1.5 ha) of low integrity marine vegetation on the northern precinct site (Lot 773).

No removal of vegetation or disturbance of fauna habitats is proposed for the south section of the precinct. The Port Authority has given the land studied in this survey to the State, and it is now reserved for conservation purposes.

3.10.4.6 Cumulative impacts and mitigation strategies – terrestrial ecology

Prior to the construction of the Precinct a road and rail link to the proposed port site will be constructed. This road and rail corridor will enter the port site from the east, passing through the land on the south side of the Ross River mouth studied in this terrestrial ecology survey. The corridor will follow the recently cleared high voltage power transmission line, and any impacts from the TMPP on this land will be largely cumulative impacts coming on top of the construction of this infrastructure. The actual design and construction of this infrastructure is the subject of another EIS by the Department of Main Roads. Cumulative impacts will mostly be in the order of increases in the intensity of use.

To address the potential for impact on terrestrial ecology values an assessment of the risk of each impact and mitigation measure is provided in Table 3-52. This assessment followed methodology described in Section 3.10.2.

Table 3-52 Risk assessment for terrestrial ecological values

Activity	Expected impact	Preliminary risk assessment (L,C) Score	Standard Mitigation Measures	Residual Risk with Precautionary Measures Adopted (L,C) Score
Works in Ross River				
Pile driving and general construction in water	Increased sedimentation in the Ross River	(3, 4) 12 High	Sediment/silt traps and fences must be in place before any clearing occurs	(2, 3) 6 Medium
Permanent location of Port facilities				
Permanent location of traffic corridor	Permanent loss of small area of vegetation (1.5ha on Lot 773) on the northern bank.	(3, 4) 12 High	Vegetation is of low value, and loss of vegetation will be compensated by retention of land in the south precinct and revegetation activities in this area.	(2, 3) 6 Medium
Loss of ~ 1.5 ha of shoreline and terrestrial habitat on west bank	Loss of habitat for birds and small reptiles	(1, 5) 5 High	Offset by offering of >200 ha of remnant not of concern vegetation on east bank as environmental reserve.	(1, 2) 2 Low
	Loss of small area (<400 m^2) of poorly developed mangrove shrubland	(1,5) 5 High	Mangrove offset to be offered in accordance with Department of Primary Industries and Fisheries Offset Policy	(1, 2) 2 Low
Construction activities				
Use of earth moving machinery	Weeds spread from other sites to the Port site	(3, 4) 12 High	All machinery must be thoroughly washed down before moving to the site according to accepted industry standards	(3, 2) 6 Medium

Activity	Expected impact	Preliminary risk assessment (L,C) Score	Standard Mitigation Measures	Residual Risk with Precautionary Measures Adopted (L,C) Score
	Weeds spread from Port site to other sites	(3, 4) 12 High	All machinery must be thoroughly washed down according to accepted industry standards as soon as possible after leaving the site and before moving to another job	(3, 2) 6 Medium
Construction and use of haul road on west bank for access to proposed breakwater	Dust contamination of air and water surface	(1, 4) 4 Medium	Haul roads must be watered regularly to hold dust down	(1, 2) 2 Low

Expected impacts on terrestrial fauna and flora values from this project are minimal, as the area studied will be largely left intact. The values identified for the site largely centre on the mosaic of coastal communities present (mangrove shrublands, sedge/chenopod dominated mudflats, sandy foreshore vegetation and sclerophyll woodland on relict dunes) in a relatively small area, and the likely presence of up to seven species of conservation significance recorded in the area previously. However, these values have been compromised in part by a thorough invasion of several declared and serious environmental weeds.

The proposal to construct a traffic corridor through this area has the potential to further compromise the value of this land as habitat for both least concern and conservation significant species. That proposal and its impacts are considered in another EIS by the Department of Main Roads, however cumulative impacts resulting from the port construction were considered above.

These impacts were:

- Dedication of 200 ha of land owned by the Port as conservation reserve (a positive benefit that has already taken place);
- Temporary dust and sedimentation impacts from construction activities;
- Loss of a small area of poorly developed non-remnant mangrove shrubland on the northern bank (approximately 1.5 ha); and
- Loss of 1.5 ha of weed infested shoreline and terrestrial habitat on the northern bank.

An assessment of the risk level associated with these impacts was completed and presented in Table 3-52.

Recommended mitigation strategies for the project, based on the known values of the area, are:

- A sediment/silt trapping fence must be erected in the water before any mangroves are cleared to catch sediment clouds;
- All machinery must be thoroughly washed down to accepted industry standards before movement onto the site, and before being moved to another site (using the nearest washdown facility);
- Haul roads must be regularly watered to prevent dust contamination of air and water surface; and
- Loss of habitat (mangroves and terrestrial) may be offset by the prawn farm restoration and the dedication of an Environmental Reserve on Port land on the south bank. Additional discussion on offsets of relevance to this project is provided under Section 3.10.8 below.

Recommended monitoring approaches for the project, based on the known values of the area, are a post construction phase inspection for possible pest species. The primary species of concern will be the terrestrial weed *Sphageneticola triloba* (Singapore Daisy). This species is an aggressive coloniser of disturbed areas on the intertidal margin, and has the proven ability to displace native intertidal grasses (notably *Sporobolus virgini*cus) and smaller mangrove species (*Ceriops*, *Lumnitzera*) on the landward side of the intertidal area. Singapore Daisy is a prominent species, easily identified, and monitoring should consist of a weekly post construction observational program for up to two months after works have ceased, or until landscaping and rehabilitation efforts have become established. Other potential weed species (such as the grass Mossman burr - *Cenchrus echinatus*) may also be problematic and similarly can be monitored on an observational basis post construction.

3.10.4.7 Conclusion – terrestrial ecology

The TMPP is not expected to represent a significant impact on any of these species. However, in order to avoid impacting on these species, the following guidelines should be adopted:

- Impacts to the foreshore and mangrove communities on the east bank should be avoided. This is a critical area for beach stone curlews, with suitable nesting locations in this area, and also for the water mouse (if present).
- Mudflats and other open areas should be retained and kept weed free. These areas offer suitable habitat for Radjah shelducks, black-necked storks and white-rumped swiftlets.
- Sedimentation from Port works should be carefully managed and contained to avoid impacting on crocodile habitat.
- Sclerophyll vegetation on the east bank should be retained. Standing stags and dead timber on the ground should be retained – if woody weeds are cut down the wood should be left in situ (with seeds and reproductive material removed). These areas offer important habitat resources for the rusty monitor, and the coastal sheathtail bat and the white-rumped swiftlet will utilise flyways over canopies to hawk for insects.

3.10.5 Wading and migratory bird studies

3.10.5.1 Overview of bird studies

Shorebirds, which are alternatively known as waders, include a large collection of long range, international migratory species that migrate to and from Australia every year. They also include a smaller grouping of resident species that breed and live within Australia. Over 65% of the 55 species of shorebird that regularly occur in Australia are migratory and subject to international conservation agreements. Also, some of the resident, or non-migratory shorebirds, appear on one or another list of species with conservation concerns (Appendix V).

The two main habitat requirements for shorebirds that migrate to Australia are sites for feeding and roosting. The birds' needs revolve around feeding on intertidal flats at low tide and roosting while the tide is high. The use of feeding grounds may be affected by their proximity to roost sites and vice versa because minimising the flight distance between feeding and roosting sites conserves important energy reserves (Appendix V). Shorebirds regularly congregate and roost in large mixed species flocks on high tide where they can be counted. The sites used for roosting are used habitually by the birds, have particular characteristics and serve as a safe haven for the birds to rest.

The Precinct, located in the mouth of the Ross River, will be adjacent to mangrove systems, mud and sand banks that support a diverse bird life community. Construction of the Precinct will remove an area of intertidal habitat. Construction and operation of the Precinct, therefore, has potential to impact upon birdlife and bird habitats in the vicinity of the mouth of the Ross River.

3.10.5.2 Objectives and methodology – bird studies

Specific studies were undertaken to determine the importance of the bird communities that may be affected by the planned development and to propose management strategies to help ameliorate any potential threats to important birdlife. Emphasis was given to migratory shorebirds, which are particularly prevalent within the environs of the river mouth, although other bird groups were also investigated. A full description of those studies is provided in Appendix V. A summary of findings is provided here.

The Environment Protection and Biodiversity Conservation Act 1999 (Cth) and the Nature Conservation Act (Qld) form the basis for the regulatory framework for assessing possible threats to birdlife and for evaluating management strategies designed to ameliorate any impacts.

Fieldwork at the mouth of the Ross River was undertaken to determine the importance of the area for birdlife and the possible threats to local bird communities from the Port of Townsville Marine Precinct project. Considerable past information on shorebirds is available for the area, which has been incorporated into the assessment of the status of local shorebird communities through comparisons with data from other sites in the same region and with information from other regions in the State.

Shorebirds are of particular importance at the site because they dominate the bird communities that may be impacted by the development, and because there are many migratory species in the area that are subject to international conservation agreements and are of concern to both State and Commonwealth Governments. Most of these migratory shorebirds breed in the arctic taiga and tundra. Other birds have also been considered including both marine and terrestrial species.

Shorebird behaviour is determined by the tide, regardless of the time of day. The birds require intertidal, low tide feeding habitat as well as places at high tide that they can use to rest when they are not feeding. These high tide roost sites are habitually used by shorebirds, have particular features and are an important habitat requirement that allows shorebirds to utilise local food resources at low tide.

Counts of birds were undertaken on intertidal feeding areas and on the main roost site in the area. Also, in order to describe all bird local communities close to the development site, transect counts were undertaken through nearby eucalypt and mangrove woodlands. Brief surveys were also made of the banks of the Ross River upstream of the mouth to better understand the extent of a local egret and ibis rookery and to identify possible movements patterns of birds between the river mouth and further upstream.

3.10.5.3 Description of environmental values – wading and migratory birds

Site significance

Shorebirds and other bird species use the sand bank out from the mouth of the Ross River at high tide for roosting (refer Figure 3-60). Almost the full length (800 m) of the bank remains partially exposed, even on the highest spring tides. The site offers a secure location for over 3000 shorebirds, isolated by water from mammalian predators. The site has all the features of a good high tide roost site. The birds that use the site are those that use the neighbouring intertidal feeding areas but, in addition, birds that feed farther away to the south east, also roost on the site and make up more than a third of the total number of total roosting birds.

Summary data for 29 sites in the region was compiled from datasets belonging to the Australasian Wader Studies Group, the Queensland Wader Study Group and the Townsville Region BOC (Bird Observation and Conservation Australia) and used with data for the Ross

River mouth to highlight regional importance shorebird sites.

The Ross River mouth ranks highest in the region in terms of the maximum shorebird count and the highest average summer count over a period of 25 years (Figure 3-60, Figure 3-61). Of the six highest ranking sites, four are very close to the Ross River mouth and actually represent the same community of shorebirds that utilise the sand bank at the mouth of the river as a high tide roost site.

Shorebirds occurred at markedly different densities on the three low tide feeding areas that were investigated. The highest density of feeding birds was on the flat on the southeast side of the river mouth while the extensive flats along the shoreline farther to the south east was used less intensively. The site of lowest density of feeding birds was Lot 773 on the north west side of the river, which is planned as the site for the Precinct development. The possible reason for the relative lack of shorebirds here is the high level of disturbance by people and their dogs on the site. It is currently a de facto recreational area for the local community.

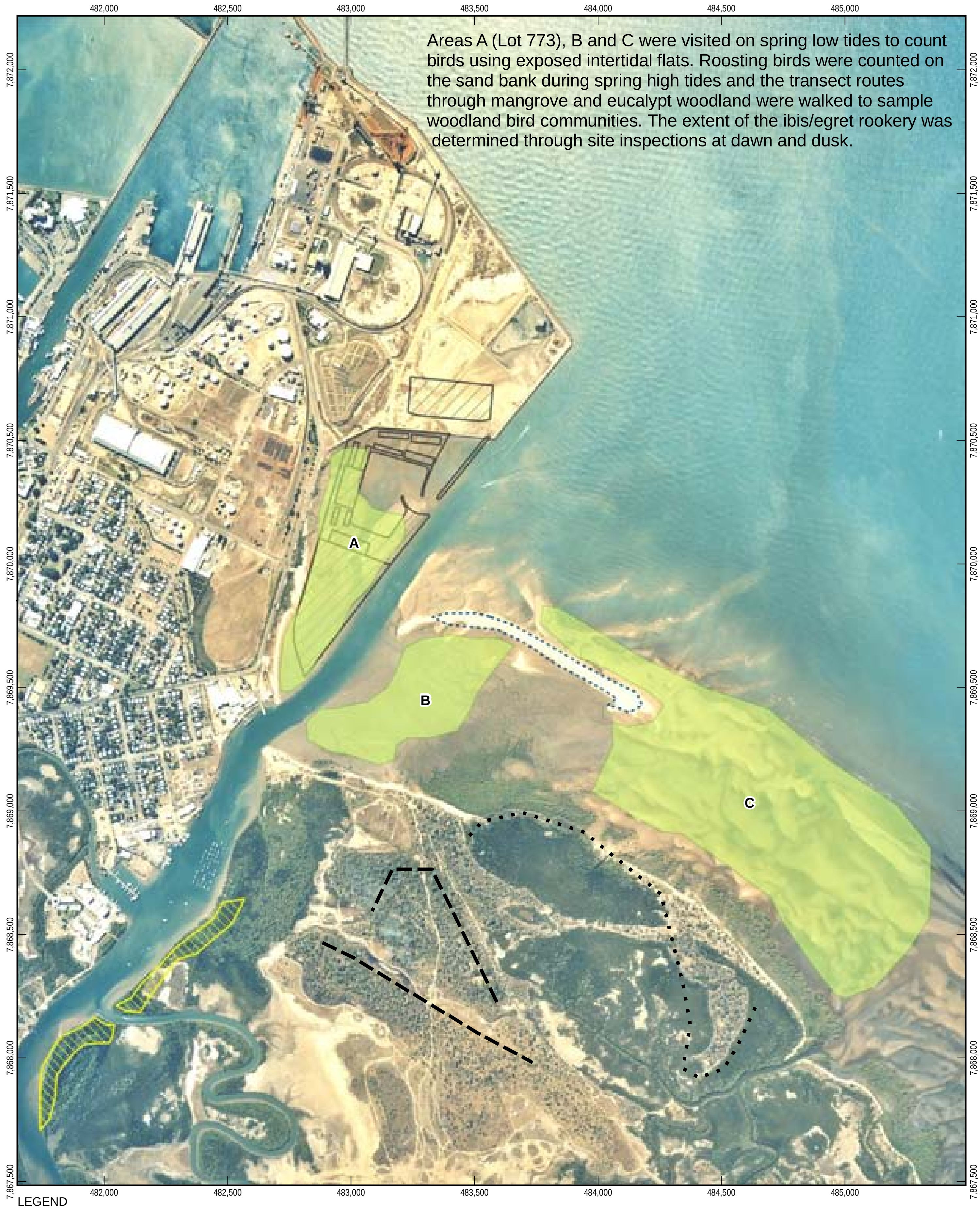
The egret and ibis rookery beside the Ross River, about 1.5 km from the mouth (Figure 3-60), caters for many birds that travel out to neighbouring areas in several directions. From field observations there did not appear to be a strong connection between birds using of the intertidal flats at the mouth of the river and birds that utilise the rookery.

Eucalypt and mangrove woodland transect counts

Thirty nine species were recorded from 223 counts of birds made during transects through eucalypt woodland (Figure 3-60, Appendix V). Fifteen of these species were not recorded elsewhere during the fieldwork. Noteworthy species unique to the habitat included the Red-tailed Black-Cockatoo, Blue-winged Kookaburra, Whitethroated Honeyeater and Fairy Gerygone. The species was found to be breeding in vegetation close to mangroves and is better known as a species of mangroves or rainforest rather than eucalypt woodland. The habitat was degraded with pest weed species and rubbish (refer Section 3.10.4 for a full discussion of this).

Thirty seven species were recorded from 194 counts of birds made during transects through mangrove woodland (Figure 3-60, Appendix V). Nine of these species were not recorded elsewhere during the fieldwork and included the Mangrove Gerygone, Mangrove Honeyeater, Black Butcherbird, Shining Flycatcher and Black-faced Monarch. The first four of these species are characteristic of mangrove woodland and their presence all together suggests that the local mangroves are functioning well as bird habitat. There are few signs of habitat degradation.

Eucalypt and mangrove woodland bird communities are unlikely to suffer from changes caused directly by the TMPP. However, they will be vulnerable to cumulative impacts from the TPAR through habitat destruction of eucalypt woodland and possible indirect impacts on mangroves in the area.



LEGEND

- Eucalypt woodland transect route
- Mangrove woodland transect route
- Extent of ibis/egret rookery
- High tide bird roosting positions
- Survey Area
- Proposed Marine Precinct

1:20,000 (at A4)

0 100 200 300 400 500

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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PORT of TOWNSVILLE

Port of Townsville
Marine Precinct EIS

Job Number | 42-15399
Revision | A
Date | 01 July 2009

Ross River Mouth
Bird Sampling Locations

Figure 3-60

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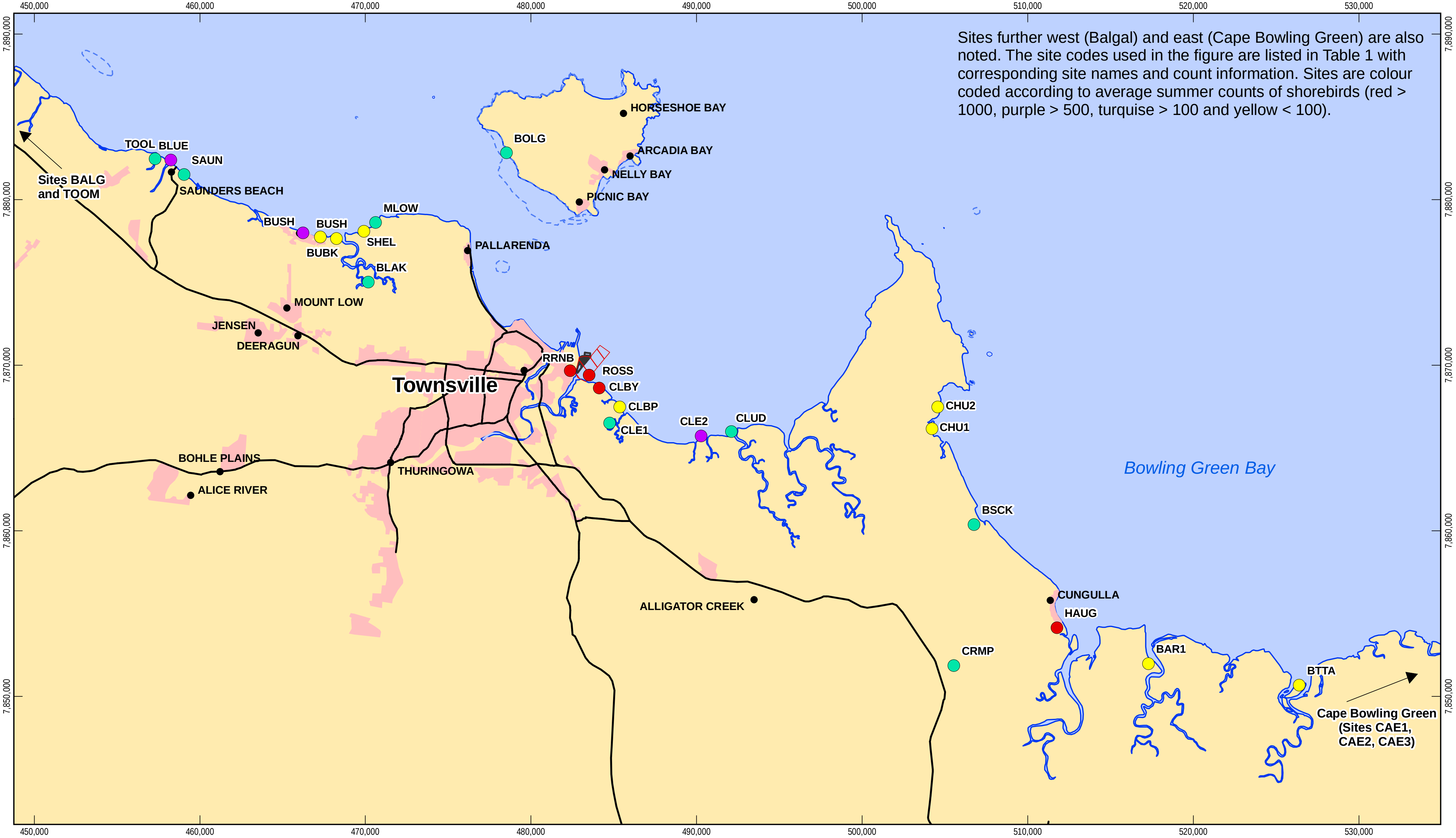
Level 4 201 Charlotte Street Brisbane QLD 4000 Australia T +61 7 3316 4496 F +61 7 3316 333 E bnemail@ghd.com.au W www.ghd.com.au

Data source: Marine Precinct - ©The State of QLD (Port of Townsville LTD) 2009; Aerial (flown 2004) - ©The State of Queensland (Department of Environment and Resource Management). Created by: TH



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0 2 4 6 8 10

Kilometres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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LEGEND

Average Summer Counts of Shorebirds

- > 1000
- > 500
- > 100
- < 100

Project Area of Interest

Builtup Area

Port of Townsville
Marine Precinct EIS

Wetland Bird Sampling Sites in the Vicinity of Townsville from Toolakea to Barratta Creek

Job Number 42-15399
Revision A
Date 01 July 2009

Figure 3-61

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Data Sources: Marine Precinct - ©The State of QLD (Port of Townsville LTD) 2009; GBRMPA Data - ©Commonwealth of Australia (Great Barrier Reef Marine Park Authority); 250k Topo Data - ©Commonwealth of Australia (Geoscience Australia) 2007.

Table 3-53 Summary results for Townsville region shorebird sites

Site name	Site Code	Maximum Count	Average Summer Count	Average Winter Count	Occasions Site Counted
Ross River mouth	ROSS*	6459	1925	622	122
Cleveland Bay nth-Tns	CLBY	3843	1805	601	7
Haughton River	HAUG*	2779	1531	77	11
Cape Bowling Green 1	CAE1	7137	1411	3566	21
Ross River north bank and foreshore	RRNB*	1950	1143	63	7
Cleveland Bay 2	CLE2	921	921	93	1
Busland Beach east to Bohle R.	BUSH*	3970	832	158	84
Bushland Beach west to Black R.	BUBK*	4700	712	30	46
Bluewater Creek	BLUE*	1618	566	217	27
Blakey's Crossing Tns	BLAK	808	271	129	65
Black Soil Ck Bowling green Bay	BSCK	962	247	389	32
Cleveland Bay 1	CLE1*	4040	197	152	49
Cluden Flats	CLUD	280	167		6
Mt Low Beach	MLOW	261	162		2
Saunders Beach	SAUN*	1026	157		7
Cape Bowling Green 2	CAE2	802			2
Cleveland Rd mud flat (AIMS)	CRMF	324	120		26
Bolgers Bay, Magnetic Is	BOLG*	324	110	43	16
Toolakea Beach	TOOL*	374	106	26	28
Cleveland Bay STP	CLBP*	227	79	29	49
Shelly Beach, Cape Pallarenda	SHEL*	228		20	3
Barratta Creek	BTTA	214			2
Cape Bowling Green 3	CAE3	178			1

Site name	Site Code	Maximum Count	Average Summer Count	Average Winter Count	Occasions Site Counted
Bohle River mouth	BOHL*	144			3
Chunda Bay 1	CHU1	140	74	140	2
Balgal Beach	BALG	72	51		6
Toomulla Beach	TOOM*	92	39	31	33
Chunda Bay 2	CHU2	64			1
Barramundi Creek 1	BAR1	54			1

* indicates currently being monitored by Townsville Region Bird Observation and Conservation Australia (TRBOC).

Shorebird counts – low tide

Birds were counted on two low tides on intertidal flats within the study area, and a tabulation of the results for each subarea (A, B and C) is given in Table 3-54. A general assessment of the differences in shorebird counts between subareas A, B and C (Figure 3-60) is given below. Subarea A is intertidal flat on the northwest side of the river, Subarea B lies between the sand banks, the mangroves and the river mouth on the southeast side of the river, and Subarea C is the extent of intertidal flat to the southeast of the mangroves to as far as the first creek entrance. The size of each subarea has been estimated from aerial photographs as 20, 23 and 103 ha respectively.

The average shorebird counts per survey, for subareas A, B and C were 60, 1137 and 1223 birds respectively Table 3-54. The shorebird feeding densities, expressed with respect to the subarea size estimates, were 3, 49 and 12 shorebirds per ha for subareas A, B and C respectively. That is, the data show a sixteen-fold difference in feeding densities of birds between subareas A and B (B higher) and a four fold difference between subareas C and B (B higher). This suggests that the optimal feeding area during the period of the study was out from the river mouth on the southeast side of the river between the mangroves and the sand banks (area B). The second most used feeding area was farther to the south east along the foreshore (area C) and the least used site was area A (Lot 773).

The concentration of birds in subarea B was pronounced and the substrate here was generally very muddy with an obvious proliferation of benthic invertebrates. Also, counts of birds in subarea B have been understated because, unlike subareas A and C, this area was difficult to traverse due to deep, soft mud and feeding flocks were mostly counted from farther away than at the other two sites and birds would have been missed in the counts. The high number of birds here was also apparent on the rising tide when birds began to congregate into flocks ready for moving onto the high tide roost.

Table 3-54 Average counts over two low tides of shorebird species counted on intertidal areas A, B and C

(refer Figure 3-60 for areas, refer Appendix V for scientific names)

Area Label	**A**	**B**	**C**
Area (ha)	20	23	103
Australian Pied Oystercatcher	2		2
Pacific Golden Plover		2	2
Grey Plover	9		3
Red-capped plover	7		7
Lesser Sand Plover		9	33
Greater Sand Plover	24	1	59
Bar-tailed Godwit	10	60	37
Whimbrel	8	1	17
Eastern Curlew		2	20
Terek Sandpiper			1
Grey-tailed Tattler		8	9
Common Greenshank		4	1
Great Knot		750	89
Red Knot		2	2
Red-necked Stint		127	720
Sharp-tailed Sandpiper		172	225
Total	60	1137	1223
Total birds/ha	3	49	12

Shorebird counts – high tide

Birds were concentrated at high tide along the exposed sand bank near the mouth of the Ross River (Figure 3-60) The approximate locations where they were most concentrated is shown but their positioning can vary depending upon the tide height, weather conditions, the current shape of the sand bank and whether the flocks have been disturbed or forced to move by people, boats or natural predators. No other high tide roosts were located in the study area except for the probable use by birds of the eastern reclaim area of the port.

During the fieldwork, four high tide roost counts were undertaken on the sand bank and 31 species were recorded. The high tide counts confirmed the importance of the site for shorebirds and a full appraisal of the latest roost counts is made together with past data in the sections to follow.

Comparison with low tide scan counts

Shorebirds that feed in an area generally roost nearby and there is expected to be a correlation between birds counted roosting at high tide and those counted at low tide feeding. However, this correlation of numbers of birds roosting and feeding is influenced greatly by difficulties of sampling, by the mobility of the birds, by the large areas that can be available for feeding and often by the availability of alternative roost sites. Nevertheless, the link between the numbers of roosting and feeding birds around the mouth of the Ross River is quite reasonable (refer Appendix V) and clearly suggests that birds that forage nearby are using the roost site. Large numbers of birds were also observed moving from the feeding areas to the roost on rising tides.

Of the 35 bird species recorded from either the roost site or from the intertidal flats, 25 species were recorded in both sets of data. Of the species of shorebird, which made up for over 95% of total counts, 14 out of the 16 species were recorded from both roost site counts and from low tide feeding counts.

It is usual for shorebirds to feed and to roost at sites within 8 km of each other. Because the roost counts of shorebirds was higher then the feeding counts (refer Appendix V), data suggest that even more birds were using the roost site than were feeding on the neighbouring flats (higher counts on the roost site). It is most probable that shorebirds that feed even farther away along the shoreline of Cleveland Bay to the southeast return to roost on the sand bank at the Ross River mouth. There are many records of high feeding densities of birds at sites farther to the southeast of the sand bank, that is, at CLE1 (Figure 3-61) 4 km from the roost site.

Most abundant species

Over time, 23 species of migratory shorebird, 8 species of resident shorebird and 34 non shorebird species have been recorded on intertidal areas at the mouth of the Ross River. On any single visit to the site about 12 shorebird (9 migratory and 3 resident) and 4 other species of birds are present. Amongst the non shorebird species, seven species of tern, Little and Great Egrets, cormorants, ibis, and several birds of prey regularly use the site. Of particular note are Little Tern and Beach Stone-curlew. In order of overall abundance at the site the following nine species of migratory shorebird make up 85% of the total number of birds counted there:

- Great Knot;
- Rednecked Stint;
- Bar-tailed Godwit;
- Sharp-tailed Sandpiper;
- Eastern Curlew;
- Whimbrel;
- Lesser and Greater Sandplovers; and
- Grey-tailed Tattler.

Each species displays its own pattern of seasonal abundance at the site because of differences in migration behaviour and distribution within Australia (refer Appendix V).

Species of significance

The mouth of the Ross River was recognised in Watkins (1983) as being internationally significant for the number of Lesser Sandplover and Eastern Curlew that have been recorded there and nationally significant on the basis of the number of Whimbrel. Also, the site arguably has international significance on the basis of numbers of Great Knot and Red-necked Stint. Furthermore, migratory shorebirds generally are subject to international conservation agreements between Australia and three other countries. Species of particular interest on the basis of State Legislation are the Beach Stone Curlew, Eastern Curlew and Little Tern.

Other recent appraisals of shorebirds using the Ross River mouth sand bank and associated feeding flats (NRA 2008, Maunsell 2008) have also highlighted the significance of the area for shorebirds and in particularly the occasional very high counts of Great Knot and Red-necked Stint, which on at least three occasions for Great Knot and one occasion for Red-necked Stint, have been above 1% of the East Asian-Australasian Flyway pollution estimates for these species.

3.10.5.4 Potential Impacts and Mitigation Measures – wading and migratory birds

Loss of feeding habitat Lot 773

The development of Lot 773 as a Marine Precinct would mean the permanent loss of about 20 ha of feeding habitat for shorebirds. There is six times this extent of intertidal feeding habitat within 2 km of the Precinct. Furthermore, the quality of Lot 773 as feeding habitat is already compromised by the regular use of the area at low tide by people traversing, often with their dogs, disturbing feeding birds. Without the prospect of the Precinct, this disturbance could perhaps be minimised through controls on the activity of people on the flat. Nevertheless, preservation of Lot 773 as feeding habitat is not considered critical for maintaining the large numbers of shorebirds that frequent the area in general. On the south east bank of the river though, opposite the Precinct, there are important natural habitat features that are considered critical to local bird communities.

Offsite impact of the development on feeding habitat

The area of soft mud on the south-east side of the river between the sand bank and the inner mouth of the river (Area B, Figure 3-60) can be used intensively by shorebirds and, for the period of this study, carried far more shorebirds per hectare than the feeding flats farther to the east. Alteration, diminution or disturbance that affected shorebird feeding on this section of intertidal flat would represent a significant loss of amenity for shorebirds that frequent the area.

Physical changes to the substrate in this area through the encroachment of man made structures or through changed sedimentation patterns need to be minimised and carefully managed. Direct disturbance by people of shorebirds feeding here also needs to be managed but there is a natural safeguard that already exists in the form of deep, soft muds that form the local substrate, which practically precludes pedestrian access to anywhere other the edge of the site.