ENVIRONMENTAL VALUES AND MANAGEMENT OF IMPACTS - PART 1

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4. ENVIRONMENTAL VALUES AND MANAGEMENT OF IMPACTS

A description of the existing environment in the vicinity of the TOT Project Site and the existing social, economic and ecological values including downstream values that may be affected by construction and operation of the TOT Project is provided in each element of this Section of the EIS, supported relevant background information and studies and from detailed site-specific investigations conducted by the Proponents specialist consultants. The results of investigations reported throughout this Section are provided in Section 7, Appendices to the EIS.

Baseline information has been collected during specialist investigations and is used to describe the environment in sufficient detail to allow assessment of potential impacts on the identified environmental values. Environmental values are described for all elements of the TOT Project such as land, water, coast, air, waste, noise, nature conservation, cultural heritage, social and community, health and safety, economy, hazards and risk, traffic and transport and are defined in accordance with the *Environmental Protection Act 1994*, Environmental Protection Policies and relevant standards and guidelines.

Potential impacts of the TOT Project on environmental values have been identified and described by detailed site investigations including cumulative impacts of the TOT Project in combination with other sources of impacts/contamination. Local, State and Commonwealth legislative and planning requirements that apply to the TOT Project are described and strategies for minimising impacts on significant conservation values are outlined in relevant sub-sections.

Management strategies and monitoring programmes are proposed in each section to ensure mitigation of potential impacts and protection of environmental values identified during site-specific investigations. Environmental objectives are set for protection of environmental values as well as relevant standards and performance indicators to measure achievement of these objectives.

All environmental protection requirements for management and monitoring during the planning, construction, operation, rehabilitation and decommissioning phases of the TOT Project are incorporated into the TOT Project EMP provided in Section 5.

The following issues are considered for each element under investigation by this EIS and are detailed in each of the specialist consultants' reports.

- A description of existing environmental values of the air, land, water, social and economic environments that may be affected by the TOT Project;
- An assessment of potential impacts on all identified values including cumulative impacts on land, air and water environments that may be affected by the TOT Project and other proposals;
- Where relevant, cooperative monitoring and management of cumulative impacts in consultation with other industries are described;
- Objectives are proposed for protection, enhancement and rehabilitation of environmental values including monitoring of measurable indicators that will detect impacts and demonstrate achievement of the objectives;
- Control measures for actions and activities to be taken are provided by specialists and are incorporated into the TOT Project EMP;
- Monitoring and auditing requirements are proposed by specialists to detect changes in environmental values and are incorporated into the TOT Project EMP;

Adoption of the TOT Project EMP including specialists' recommendations will ensure protection of environmental values and implementation of management strategies proposed throughout this Section of the EIS. The EMP outlines a framework for undertaking reporting, monitoring and corrective actions and assigns responsibility to appropriate parties.

4.1 Climate

The Proponent has undertaken an expert review of the existing climatic conditions within the TOT Project Site and its meteorologically relevant surrounding area and investigated the potential impacts of climatic events on construction and operation of the TOT Project Site. The Review of Site Climatic Conditions by Hyder Consulting is presented in Section 7, Appendix 7 and is summarised here.

4.1.1 Existing Environmental Values

The nearest weather recording station to the TOT Project Site is the Townsville Meteorological Office, located at the Townsville Aerodrome (elevation 7.5m) approximately 6km from the Port of Townsville. Data has been collected by the Bureau of Meteorology (BoM) between 1940 and 2007 at the Townsville Aerodrome weather station and is utilised for the purpose of this EIS.

The Townsville area is characterised by a tropical wet and dry climate (savanna climate). During the dry season (May to October), temperatures are mild and humidity is moderate. During the wet season (November to April), temperatures and humidity are high with frequent storm events.

Townsville experiences an average annual rainfall of 1115.8mm with the highest rainfall occurring during the wet season from November to April. During the wet season, the Townsville area experiences frequent heavy rainfall events. The highest annual rainfall on record at the Townsville Aerodrome weather station was 2399.8mm in 2000. In contrast, the following year recorded only 467mm.

In the Townsville area, the highest temperatures occur between November and March and the lowest temperatures occur between April and October. The city has 142.4 mean days per year with temperature in excess of 30ºC, the mean annual maximum temperature is 28.9ºC and the mean annual minimum temperature is 19.8ºC.

Relative humidity is highest in the morning and monthly averages range between 60% in April to 75% in February.

Wind speed is highest in the afternoon and is predominantly onshore, from the northeast during the wet season and the southeast during the dry season. Monthly wind speed averages vary between 18km/hr in June and 23.3km/hr in September.

Review of Townsville wind roses confirms that wind conditions at the Port of Townsville are typically defined by sea breezes. Wind roses for the Townsville Airport meteorological station show that morning winds are generally off-shore with wind speeds varying between 10 – 30 km/hr. It is noted however, that during this period the occurrence of calm wind is high with a greater occurrence of calm conditions during the autumn and winter months (15 % and 33 % respectively). During summer and spring, calm conditions are less prevalent at 7 % and 15 % respectively.

During the day time, winds typically turn on-shore with the afternoon wind roses from the airport site identifying this trend. The occurrence of calm conditions is also low in the afternoons at less than 2 % for all periods of the year.

The above average climatic elements are summarise in Table 4.1.1 below:

Table 4.1.1: Townsville Climate Averages (1940 – 2007)

Month	Mean daily Maximum Temp.(ºC)	Mean daily Minimum Temp. (ºC)	Highest maximum Temp.(ºC)	Mean 9am Relative Humidity (%)	Mean 3pm Relative Humidity (%)	Mean 9am Wind Speed (km/hr)	Mean 3pm Wind Speed (km/hr)	Mean Rainfall (mm)	Mean Daily Evaporation (mm)
Jan	31.4	24.2	44.3	71	65	10.8	19.8	265.3	8.3
Feb	31.1	24.0	42.7	75	67	9.7	18.5	292.6	7.3
Mar	30.7	22.9	37.6	72	64	10.0	19.4	183.4	7.0
Apr	29.6	20.6	35.8	68	60	10.6	20.5	68.0	6.6
May	27.6	17.6	32.2	67	57	8.6	19.2	33.9	5.5
Juniper	25.6	14.6	32.2	66	52	8.1	18.0	21.1	5.0
Jul	25.1	13.6	31.6	66	51	7.7	19.7	13.1	5.3
Aug	26.0	14.7	33.3	63	52	9.7	21.8	16.5	6.2
Sep	27.7	17.3	36.5	60	53	13.6	23.5	10.2	7.7
Oct	29.4	20.7	37.1	61	55	15.4	23.3	25.3	8.8
Nov	30.7	22.9	41.0	63	58	14.9	22.9	57.1	9.2
Dec	31.4	24.0	42.1	67	61	13.4	22.1	124.7	9.0
Annual Value	**28.9**	**19.8**	**44.3**	**66**	**58**	**11.0**	**20.7**	**1115.8**	**7.2**

Source: Bureau of Meteorology; www.bom.gov.au

Extremes of Climate

Tropical cyclones can develop during monsoonal conditions from late December until early April throughout the Northern Australian Coastline and may cause major flooding and beach erosion within the regions they affect.

Tropical cyclone data presented in Table 4.1.2 is based on 11 years of weather data recorded by the Bureau of Meteorology. On average, the North Queensland coast faced around 3.45 cyclones a year during this period.

Table 4.1.2: Frequency of cyclones occurring in the North Queensland region 1996-2006

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Jan	2			3			1			1	1
Feb	1	3	1	2	1	2	1	1	1	1	1
Mar	1		2				1	2		1	2
Apr		1			2						1
Nov	1										
Dec	1	1									

The recently released *Townsville-Thuringowa Storm Tide Study* (GHD 2007) provides specific data on the frequency of occurrence of cyclones that entered within a 500km radius of Townsville from 1959 to 2004. It was estimated that the frequency of cyclones affecting Townsville was an

average of 1.78 cyclones per season during this period. For the purpose of comparison with the frequency of cyclones in North Queensland as presented in Table 2, Table 4.1.3 presents data on tropical cyclone occurrence in Townsville from the GHD Study for the period 1996 to 2004.

Table 4.1.3: Frequency of cyclones occurring within 500km of Townsville 1996-2004

	1996	1997	1998	1999	2000	2001	2002	2003	2004
Jan	2			1					
Feb		2	1		1	1			
Mar		1	2	1	1			1	1
Apr									
Nov									
Dec									

While the data indicates cyclones are a annual occurrence in tropical northern regions including Townsville, the majority cause no significant damage. In the fortunately rare occasions when an extreme event occurs, as can be seen through the following historic weather events, significant potential impacts may occur in coastal areas of Townsville during extreme weather conditions.

Tropical cyclone 'Althea' caused approximately $50 million damage in the Townsville region in December 1971 including extensive damage at the Strand and Cape Pallarenda. A 2.9m storm surge was recorded in Townsville Harbour and 3.6m storm surge was recorded at Toolakea. In March 1988, cyclone 'Charlie' caused beach erosion and tidal inundation within Townsville. Although cyclone 'Justin' did not make landfall in Townsville in March 1997, it caused severe beach erosion and tidal inundation along the Townsville coast.

Cyclones 'Sid' and 'Rona' caused major flooding and extensive damage to private property and local government infrastructure (Sid caused damage in excess of $100 million) in January 1998 and February 1999 respectively. Cyclone 'Tessi', which hit the coast in March 2000, set new weather records for April in Townsville.

As Tables 4.1.2 and 4.1.3 indicates, regular cyclonic events in intervening years caused no significant damage.

Emission of greenhouse gases to the atmosphere is expected to result in changes in climatic conditions such as increased temperatures and decreased rainfall. Predictions of the impact of climate change on sea level rise vary greatly and there is a degree of uncertainty in these predictions. However, the best available data indicates that a global mean sea-level rise of approximately 50cm is expected between 1990 and 2100.

Climate modelling undertaken by CSIRO has predicted that average temperatures will increase overall by 1-2ºC over most of Australia by 2030. Annual average increases in evaporation due to increased temperatures are expected to range from 0 to 8% per degree increase in temperature resulting in decreases in the annual water balance of around 15 to 160mm by 2030.

4.1.2 Potential Impacts and Mitigation Measures

The climatic events described in Section 4.1.1 above may have significant impacts on the Townsville area and the TOT Project Site. Furthermore, climate change is predicted to increase the frequency and severity of such events. Potential impacts associated with extreme climatic events include damage to buildings and property and potential risks to human lives. The potential impacts of extreme climatic events have therefore been taken into consideration in the design of the TOT Project Site. Design parameters of finished land levels and breakwater design are detailed in the Coastal Engineering report and discussed in **Section 4.7** of this EIS.

Tropical Cyclones and Storm Surge

Strong winds associated with tropical cyclones can cause extensive structural damage to buildings. Heavy winds also trigger strong wave action that causes coastal erosion, storm surges or storm tides, that may destroy buildings and infrastructure located on the coast.

As discussed in the Coastal Engineering Study, in Section 7, Appendix 13 by Coastal Engineering Solutions storm surges often occur during the passing of a tropical cyclone, resulting in flooding of low lying coastal areas and severe wave action on coastal structures. If the maximum storm surge coincides with a high spring tide, the impacts on low lying coastal areas can be even greater. The TOT Project Site is located in the area affected by predicted storm surges of 4m AHD (Australian Height Datum) on the Storm Surge Map of Townsville and is therefore prone to such impacts.

Extreme events may cause flooding of low-lying areas and may have impacts on structures in coastal areas. A study has been undertaken by Coastal Engineering Solutions (CES) to assess the potential impacts of extreme events on the TOT Project and is included in Section 7, Appendix 13. The CES report provides requirements for the design of TOT Project infrastructure in order to withstand potential impacts associated with storm surge and storm tides.

Climate Change

If climate changes develop as predicted, the foreshores of the Townsville region will be subjected to potentially greater storm and cyclone activity, higher waves, stronger winds and increased sea levels.

Potential changes due to climate change and sea-level rise include increased coastal erosion, increased storm surge flooding and loss of property, infrastructure and life These potential risks will be taken into account in the development of management strategies to maintain public safety and to protect property and assets.

The Queensland Government currently requires that all design water levels for works within coastal areas include an allowance of 0.3 metres for the predicted rise in sea level. This design level has been allowed for by Coastal Engineering Solutions in the design of the rock armoured breakwaters for the TOT Project and in the finished land levels for the building platforms within the TOT Precinct and the Breakwater Cove Precinct

Hazard Management

The TOT and Breakwater Cove Precincts have been designed and constructed to ensure that the development minimises the potential adverse effects of extreme weather events and does not result in an unacceptable risk to people or property. The floors of all buildings within the TOT Project will be situated above the required design levels to provide flood immunity. All structures have been designed and constructed to withstand hydrostatic and hydrodynamic forces that may occur as a result of tidal inundation. A detailed description of these requirements is provided in Section 4.7 of this EIS.

It is intended that a Disaster Action Plan will be developed for the site to provide prevention and response measures for preservation of life and property in the event of a natural hazard such as a storm, flood or cyclone.

The primary purpose of the Disaster Action Plan will be to inform residents of the characteristics of the site and its environs and the evacuation processes in case of an emergency. The Body Corporate will review this document with Council to ensure its currency, accuracy and compatibility with the Townsville-Thuringowa State Emergency Services (SES) Unit.

Water Management

Rainfall in Townsville is highly variable with more than 75% of average annual rainfall occurring between January and March and 275 days a year on average being rain free. In addition, daily evaporation rates can exceed daily rainfall for most of the year (Bureau of Meteorology 2006). The municipal water supply within Townsville is adequate to meet TOT Projected water demands for the TOT Project Site. However, management of water within the site can assist in reducing demand on high quality potable water supplies.

The management of stormwater within the TOT Project Site is addressed in Section 4.4 of this EIS.

Reduction of household potable water use will be encouraged by provision of information on water saving measures within the Breakwater Cove EMP to be provided to future landowners by the Body Corporate. The Water element of the EMP provides measures to maximise water efficiency through installation of water efficient fixtures and equipment, water efficient landscaping and rainwater re-use.

The TOT Project will also be subject to any State of Local Government general restrictions on water use.

The climatic impacts on air quality, particularly winds, rain humidity and temperature inversions on air quality are addressed in Section 4.8 of this EIS.

4.2 Land

4.2.1 Description of Environmental Values

4.2.1.1 Topography

There are no terrestrial features present at the TOT Project Site as the site is below sea level and inundated by the sea. Reference to the Maritime Safety Queensland's "Tide Tables and Boating Safety Guide 2006" notes the following tidal data for Townsville Port:

- Lowest Astronomical Tide (LAT) is 0.00 m LAT = -1.856 m AHD
- Highest Astronomical Tide (HAT) is 4.01 m LAT = 2.154 m AHD

The geomorphology and bathymetry of the TOT Project is discussed in the Section 4.7.

4.2.1.2 Geology

An assessment of the existing geology of the TOT Project Site was undertaken by Golder Associates in their Geotechnical and Acid Sulphate Soil Investigation Report. The results of this assessment are summarised here and the Report is contained in Section 7, Appendix 8.

Geological properties that may influence ground stability are described in Section 4.2.2.2 and 4.2.2.3.

The site is underlain by Quaternary age alluvium and colluvium sediments which are in turn underlain by Late-Palaeozoic age Granite. The ground conditions encountered during geotechnical investigations are detailed on the borehole record sheets included in the Geotechnical Investigation report contained in Appendix 8.

4.2.1.3 Soils

Geotechnical sampling and analysis was undertaken within the PTOT Project Site by Golder Associates to characterise the physical and chemical properties of surface and subsurface materials and groundwater levels. The Geotechnical Investigation is contained in Appendix 8 and is summarised here.

Surface Materials

Seabed sediments ('ooze') range in depth from 1.3m to 3.1m across the TOT Project Site. These consist of a mixture of organic extremely soft to soft silty clay/ clayey silt with very loose and loose sand/ silty sand/ clayey sand. Clay and silt content represents approximately 70% of the ooze. The ooze materials are highly compressible and settlements are expected to be high where the ooze is not removed.

Subsurface Materials

In general, subsurface materials consist of stiff to hard clay/ sandy clay. Medium dense to very dense sands were encountered at varying depths in boreholes across the Project Site. No soft compressible material was encountered below the surface ooze deposits.

Groundwater levels recorded within the three groundwater monitoring wells are:

- MWTOT-1 ~ -12m AHD
- MWTOT-2 ~ -8.4m AHD
- MWTOT-7 ~ +2.1m AHD (likely associated with perched water table in fill).

4.2.1.4 Land Use

There are no existing terrestrial uses of the project Site as it is entirely inundated by the sea.

Historical and future Planning Policy for the Project Site has been discussed in detail in Section 1. of the EIS.

4.2.1.5 Acid Sulfate Soils

An investigation of acid sulphate soils was also undertaken by Golder Associates and is contained in Appendix 8. Field pH tests were conducted during the site investigation and soil samples collected for laboratory analysis. Following a review of the field pH_F and pH_{FOX} tests and the soil profiles, a total of 43 soil samples were selected for laboratory Chromium Suite Analysis. The results of this investigation are provided in the Geotechnical investigation and are summarised here.

The surface sediment layer of "ooze" material is comprised of recent marine sediments generally consisting of dark grey silty/ clay, clayey silt with some sandy zones. Shell fragments commonly occur within this layer. Materials underlying the ooze are older "stiff to hard" clays and sandy clays and medium dense to very dense clayey sand and sand. These materials are much lighter in colour than the ooze.

The field pH measurements on all soil samples were above 7 and therefore no indications of actual acid sulfate soils (AASS) were detected. Low potential acid sulphate soils (PASS) was indicated in all soil samples from the surface ooze layer. A low PASS potential was also indicated in all soil samples collected from below the ooze layer. The laboratory Chromium Suite tests indicated that existing acidity in all samples analysed were below the laboratory limit of reporting, indicating AASS conditions are not currently present within the depth of investigation at this site.

4.2.1.6 Contaminated Land

The TOT Project Site is entirely submerged by marine waters. No known contaminated sites are expected to exist as there has been no previous land use of the TOT Project Site.

4.2.1.7 Sensitive Environmental Areas

The identification of Sensitive environmental Areas and any potential impacts on the environmental values of such area that may be affected by the TOT Project are assessed and described in Section 4.11.

4.2.2 Potential Impacts and Mitigation Measures

4.2.2.1 Land Use Suitability

There are no existing terrestrial uses of the project Site as it is entirely inundated by the sea.

Historical and future Planning Policy for the Project Site has been discussed in detail in Section 1 of the EIS.

Issues associated with compatibility of the TOT Project with surrounding land uses and impacts on human activities are discussed in Section 2.2 and 3.3.

4.2.2.2 Soil Erosion

Materials that are excavated from TOT Project Site are expected to be geotechnically suitable for re-use as fill provided any organic or oversize (>75 mm) materials are removed and soils are appropriately moisture conditioned on placement. Compaction standards and moisture content of clay and sand material recommended by the Geotechnical Investigation report will be applied to all fill material to be reused within the site. Excavation heights and batter slope angles will also be in accordance with the recommendations of the Geotechnical and Acid Sulphate Soil Investigation report.

The stiff sandy clay encountered below the ooze at the site generally has a low to moderate potential for dispersion. Although erosion/dispersion potential is considered to be low to moderate, erosion and dispersion can still occur through rain-drop impact, rainfall run-off and run-off associated with water/groundwater redirected through the site. To reduce this potential, erosion and sediments generated from slope-wash will be managed and controlled with the following methods:

- Compaction of exposed soils at an appropriate density and moisture content;
- Silt fences at down-slope boundaries of construction works;
- Perimeter diversion drains around earthworks; and
- Paving or re-vegetating exposed soils as soon as possible following completion.

Water Quality modelling was undertaken using the PHREEQC program of the United States Geological Survey. This was coupled with the run off water quality obtained from the MUSIC program for the export of nutrients from the constructed catchment area. Mixing and flushing and mixed water quality models were developed to simulate worst case scenarios for the development. The modelling included first flush scenarios for the total dissolution of the dust falling on the development and/ or the total incorporation of the dust into the bottom sediment of the Project Site.

All data, both raw and modelled indicate that all flushed water exiting the development will be within current ambient range of ANZECC, 95% Species Protection Guidelines or both. All data

indicate that all sediments produced from the TOT Project will be within current ambient levels of Cleveland Bay.

As discussed in Section 3.5, regular annual maintenance dredging of the internal access channel and canals will be undertaken to maintain water and sediment quality.

4.2.2.3 Settlement

Total settlements for the site have been calculated to be in the order of +/-40mm maximum for an additional 10kPa site load (structure and/or filling). Differential settlements should be assessed as up to 50% of total settlements. Swellings is possible within the placed fill material if the reduction of void ratio is not achieved during fill placement allowing greater infiltration of groundwater into the fill material and resultant swelling of the clay.

Significantly higher settlements are anticipated where ooze material is to be stockpiled in the park land areas at the northern end of the site. See Step 7 of the Construction Methodology in Section 3.4 of this EIS. Calculated settlements for these areas are 40-80mm / 1m of fill load/ meter thickness of ooze. Differential settlements should be assessed as up to 50% of total settlements and can be sudden and abrupt. Allowance will be made for topping up the level of this area except where settlements are to be induced prior to the end of construction.

Preload and Wick Drains

Wick drains will be installed within the stockpiled ooze to help accelerate the settlement rate. Additional load will be applied to the stockpiled ooze material in order to achieve accelerated settlements. This preload will be applied for a minimum period of six months.

Consolidation will be accelerated by installation of wick drains, which act to allow rapid vertical drainage of pore water out of the stockpiled ooze. If wick drains are used, provision will be made for the pore water from each vertical wick to escape horizontally from the top of the wick. This will be achieved by using “clean” rock fill for the lowest 300-500mm thickness of preload material and by coupling the tops of the wicks together by “stapled on” horizontal strips of wick material. It is expected that a wick spacing of 1.5m would reduce the consolidation time to about 6-9 months with a 3m high preload surcharge.

Batter slopes on the outside of the placed preload will be a maximum of 1:3 (horizontal: vertical) to help reduce the potential for instability as the preload settles. Some localized instability may still occur depending on the degree of differential settlements induced. In this case half height berms will be required.

Settlement Monitoring

Settlement monitoring will be undertaken to provide information on the degree of settlement achieved and to indicate when the preload can be removed. Settlement monitoring monuments will be installed in a grid pattern throughout the footprint of the preload at 40m grid spacing as recommended in the Geotechnical and Acid Sulphate Soils Investigation Report. This will be undertaken as follows:

- A surveyor will be engaged to take an initial prefill-placement RL to +/-2mm on top of the inner pipe.
- The surveyor will also take readings at regularly-spaced one week intervals while fill is being placed and after it is in place, unless the frequency is reduced or increased, depending on settlement rate.
- At the same time as (b) the surveyor will take an “average” fill RL close to each monument.

- The surveyor will report the RLs to +/-2mm on a regular basis and to 3 decimal places. These will be reported to the geotechnical engineer.

- The geotechnical engineer will plot and manage the settlement data progressively, reporting on progress and any spurious readings (which should be corrected by an additional surveyor's visit as needed).

4.2.2.4 Acid Sulfate Soils

The control measures recommended by Golder Associates relating to management of acid sulphate soils are outlined in the Geotechnical and Acid Sulphate Soils Investigation report in Appendix 8 and will be adopted for the construction phase of development. Management measures contained in this report have been incorporated into the TOT Project EMP and are summarised here.

The field screening of pH indicated no occurrence of AASS. Low potential for PASS was detected in surface ooze and subsurface stiff clay material. Field results were confirmed by laboratory Chromium Suite tests determined that existing acidity in all samples analysed were below the laboratory limit of reporting, indicating AASS conditions are not currently present within the depth of investigation at this site.

Surficial ooze materials generally have concentrations of Chromium Reducible Sulfur exceeding the Action Criteria of 0.03 %S. Laboratory tests indicate that these soils also have sufficient acid neutralising capacity to produce a calculated net acidity below the recommended Action Criteria. This suggests that these soils would be "self neutralising" and additional neutralising treatment would not be required. However, experience with disturbance of large quantities of similar "self neutralising" soil has shown that some acidity is still produced in excavated stockpiles. Therefore management measures will be adopted to prevent "incidental" acid generation where ooze materials are excavated, drained or dewatered for periods of greater than 24 hours.

Limited testing of older deposits of stiff to hard clays and dense sands underlying the ooze layer confirmed that these materials are not PASS. No specific management of these materials is therefore required.

Given the current construction methodology and the inferred zonation of PASS material in and around the development area, it is highly unlikely that there will be any disturbances of this material. Regular field testing pH field/ pH oxidized will be undertaken using standard hydrogen peroxide techniques during initial stages of construction prior to dewatering.

Should any potential acidity be generated during peroxide treatment then the excavated material will be:

- Treated to maximum levels indicated from the Golders Geotechnical and Acid Sulphate Soils Reports

- Immediately replaced into a non-oxidising environment by burial. This is possible as the material will be used immediately to construct the arms of the development.

While the bunded excavation is being undertaken in sequence, systematic acid sulphate assessment will be undertaken on each section of the exposed floor to determine the extent of ASS and PASS. When this excavation has been completed and if it is likely that any PASS will be disturbed then appropriate management measures will be given in an Acid Sulphate Soils Management Plan prepared in accordance with QASSIT Guidelines and the requirements of SPP 2/02

This Management Plan will be prepared in consultation with NR&W and EPA.

4.2.2.5 Contaminated Land

The development area is reclaimed from marine submersion. No registered contaminated sites exist in the Project Site area. Consequently no management plan is necessary as would otherwise be required under the Environmental Protection Act 1994.

Should contamination be encountered during the course of construction, the appropriate procedures as outlined in the Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland will be followed as is anticipated within the Project EMP.

4.3 Traffic and Transport

4.3.1.1 Existing Transport Infrastructure

A Traffic Modeling Report has been prepared by Veitch Lister Consulting (VLC) and a Traffic Impact Study Report has been prepared by Holland Traffic Consulting (HTC). These two (2) reports need to be read together and they detail the current standards of operation and performance indicators of the existing land-based transport infrastructure and allow an assessment of potential impacts to be undertaken.

It is clear from the reports that the only existing land-based transportation infrastructure potentially affected by the TOT during both construction and operational stages are the existing roads feeding the breakwater.

The reports examine the existing road network, including both local government and State-controlled roads, and show that there is already a problem at the Flinders /Denham Street intersection which is close to capacity at times. The performance of this intersection as noted in the HTC report is aggravated by the one-way rotarian system linking the Strand, King Street and Wickham Street, which effectively directs traffic from the Breakwater to Flinders Street, away from the Strand and towards the problematic Flinders/Denham Street intersection. The shortcomings of the intersection are quite noticeable when there are special events at the Townsville Entertainment Centre (TEC) causing higher than normal traffic movements to and from the Breakwater via Denham Street, Flinders Street East, Wickham Street and the Strand.

The HTC report notes that the TOT will not make any difference to this situation and concludes that the main feeder road to the development site – Sir Leslies Thiess Drive - is more than adequate to accommodate the TOT and other planned developments adjacent to the Casino.

The current traffic flows on Sir Leslie Thiess Drive as surveyed in late 2006 are in the order of 6000 vehicles per day with an average evening peak hour high of about 600 vehicles per hour (VPH). During the survey period the traffic flows peaked when a basketball game was held at the TEC at 1068 VPH northbound before the game and 1483 VPH southbound after the game.

The HTC report notes that on completion of the development adjacent to the Casino and TOT, Sir Leslie Thiess Drive is expected to have daily traffic flows in the order of 17,000 vehicles per day – well within the potential of a 4 lane – 2 way road. It concludes that the impact of the TOT on Flinders Street East and the problematic Denham Street/Flinders Street intersection is negligible (less than 5%) even in the 2025 time horizon when the development is expected to be completed.

The existing and future port and waterway transport will not be affected by the TOT. City Pacific thoroughly investigated the existing Port of Townsville infrastructure and marine transport networks, including a description of the existing port traffic, frequency and types of vessels that currently use port infrastructure. Following consultation with the Townsville Port Authority, it can be concluded that the port operations will not be detrimentally affected either by the construction or operational traffic.

These investigations also canvassed the predicted increased use of the port including potential new trades and the likely changes to vessel and rail traffic. The TOT does not affect the existing

non-port maritime infrastructure including marinas, mooring areas, boat ramps, pontoons along with associated land-based infrastructure eg. carparking and hardstand areas.

The existing non-port waterway traffic will not be affected by the TOT during both the construction and operational phase.

The parking situation around the Casino and the TEC was also surveyed in late 2006 and in particular during a Saturday evening basketball game. Excluding the parking available on the Strand it was observed that there were over 1750 spaces available. The only spaces likely to be lost, and this is only during construction, are the 20 spaces in Entertainment Drive. At the conclusion of the development an additional 500 spaces will be readily available in the new car park to be developed adjacent to the TEC.

Road conditions in the area affected by the project are not going to significantly change with or without the project.

The existing pedestrian and cycle networks on the breakwater will be greatly extended and enhanced at the completion of the development. Pedestrians and cyclists will be able to make their way to the northern edge of the project where a new open space will be developed On the western side of the development, pedestrians and cyclists will be able to traverse the western breakwater or the Strand breakwater via Mariners Peninsular.

4.3.1.2 Potential impacts and mitigation measures – land based transport

The HTC report notes that Council's medium to long term traffic planning for the locality recognizes the limitations of the Flinders Street/Denham Street intersection and proposes another bridge across Ross Creek closer to the Breakwater as an extension of the Strand to Ross Street in South Townsville. The timing of this initiative is unknown.

During the construction phase the impact on the road network is more widespread and presents different characteristics.

The construction traffic and in particular the trucks hauling the fill material are proposed to access the development site, via a temporary bridge across Ross Creek (at the same location as the Council bridge) from Ross Street in South Townsville. Construction traffic will disperse as the distance from the development site increases and the HTC report notes that given the volume and type of vehicles involved there should be no detrimental impact at distant locations in the region.

The HTC report notes that the volume of traffic generated by workforce personnel, visitors and service vehicles (excluding the fill material haul trucks) is insignificant.

As noted in the HTC report, the movement of the fill material haul trucks is expected at its peak to be the equivalent of 7 truck loads per hour. The trucks themselves need to be large to reduce the time required to deliver the material and reduce the number of truck movement. It is expected that the haul trucks will operate for up to 10 hours a day six days a week. The largest of the heavy and oversize indivisible loads hauling the fill material will be B Doubles and semi-trailers.

The fill material will be sourced from quarries located on the southern and/or western fringe of the urban area of Townsville/Thuringowa and will travel to the development site via Abbott Street, Railway Avenue (or Woolcock Street), Boundary Street and Archer Street which is a well used heavy vehicle corridor to the Port and the impact of the fill material haul traffic decreases as the distance from the development site increases. The HTC report concludes that with appropriate temporary traffic management measures the impact of the haul traffic should be negligible.

Apart from localized corrective traffic measures to accommodate the haul trucks there are no other requirements for provision of additional transport infrastructure. These localized measures

are limited to the intersection of the Strand and Sir Leslie Thiess Drive and are likely to include temporary traffic signals and alterations to the current on-street layout to accommodate a truck holding area on the approach to the temporary bridge. Similar works in Ross Street South Townsville will be necessary to accommodate access to the temporary bridge.

The impact on road infrastructure, road users and road safety has been considered by the proponent and are as follows:

- The impact on the road network generated by any interim or temporary road works, necessary to service the initial stages of the Project, are limited to either side of the temporary bridge.

- The impact on stakeholders along all haulage routes (for example, noise and vibration) will be insignificant except from the temporary bridge along the Strand and then Sir Leslie Thiess Drive where the impact will be more noticeable.

- Given the proposed insignificant increase in traffic levels the existing pavement condition of affected roads is not going to be affected and the potential for accelerated damage other than in Ross Street, the Strand, Sir Leslie Thiess Drive and Entertainment Drive is nil. These impacted streets will be returned to their normal condition by the developer at completion of the project.

- The impacts on agricultural operations or harvest is nil.

- The potential impacts of the Project on stakeholders including residents of the Breakwater Cove Precinct and local residents as noted above is high but this will be mitigated by limiting the number of hours per day and number of days per week that hauling can occur.

- The peak traffic loads associated with existing uses in the vicinity of Sir Leslie Thiess Drive will nearly treble, but is nevertheless within the capacity of the network and Sir Leslie Thiess Drive. Elsewhere the impact is negligible.

- As indicated above the only corrective measures required to address adverse road impacts relate to the construction phase and the temporary works, the cost of these works will be borne by the proponent.

Where the existing network will not be challenged by the operation of the cruise terminal, given that it is not expected to generate significant amounts of passenger car traffic, the impact of events at the TEC requires further consideration. The potential adverse impacts of special events like basketball games will be reduced by the addition of the new 500 space car park. However the congestion on the roads in and out of the Breakwater will continue to be a problem and the HTC report suggests that temporary traffic control measures would be of assistance. These would be similar to those which occur during football games at Dairy Farmers Stadium.

There is not expected to be any detrimental impact on any current or proposed rail infrastructure which will continue to take priority over road transport.

Given that the development site is located adjacent to the Magnetic Island passenger ferry service and the CBD where public transport services are at their highest in the region, no additional public transport services are needed in terms of existing transport networks and frequency of services and the requirement for provision of additional facilities during either the construction or operational phases of the development. A bus stop has been incorporated into the project design, at the Ocean Terminal. The existing linkages to pedestrian and cycle networks will be maintained.

As the project does not involve the transportation of significant quantities of dangerous liquids it is not necessary to contemplate anything extraordinary in regard to contingency plans and the adequacy of equipment and facilities to deal with possible spills.

The HTC report notes that access in and around the site by emergency vehicles (eg ambulance, fire and rescue) is not expected to be a problem, however an alternative to road access/escape needs to be considered in the future as it is now in case of any congestion or conflict along the one access along Sir Leslie Thiess Drive.

The VLC and HTC reports therefore provide sufficient information of the impacts and proposed measures to make an independent assessment of how the State-controlled and local government road networks will be affected having regard to the Department of Main Roads' *"Guidelines for the Assessment of Road Impacts of Development (2006)"*.

4.3.1.3 Potential Impacts and Mitigation Measures - Marine Transport

Increase in Shipping Traffic as a Result of the TOT

It is expected that visiting naval vessels will increase to around 40 to 50 a year from the existing 30 vessels a year. Currently, 7 to 8 cruise vessels visit the Port each year. This is expected to increase to around 20 vessels a year. The net expected increase because of the operation of the TOT Precinct will therefore be around 20 to 30.

Ship Movements and Port Requirements for Construction and Operation

The Port is closed to through traffic while vessels are entering and leaving the Port area. The 'Port Closed' signal will be activated during this time and must be observed by marine vessels wishing to enter the Port boundaries. Permission must be sought from the Pilot to allow traffic through during this time. Marine traffic will be required to liaise with Port Control to cross the Port access channel.

For the alternative haul option requiring barge transport, it is expected that 2 barges would work on a 90 minute cycles, which would result in a vessel transit across the Port access channel every 22 minutes. In discussions with the Harbour Master, disruptions to Port operations would not be expected from such a low frequency operation on relatively slow vessels. However, all movements will be reported to Port Control.

All vessels required to cross the entrance to Ross Creek will observe established harbour operations protocols including giving way to all shipping traffic and normal application of collision regulations for all other small craft. It is anticipated appropriate notification to mariners and emergency response agencies will be provided where necessary by the Harbour Master.

Construction Programme for Major Marine Works

The construction programme for all key construction elements is provided in the Construction Methodology report (Appendix 5). Once construction vessels and equipment are in place within the construction site, all works will be conducted outside the main Ross Creek navigational channel. It is not anticipated that construction works will impact on Port operations or non-Port vessels. Short-term disruptions may be experienced while mobilising equipment in and out of the works site.

The preferred option for haulage of materials to the TOT Project Site involves construction of a temporary bridge over Ross Creek. This bridge will be openable to maintain navigational access for vessels moored in Ross Creek marinas.

Opportunities for vessels to navigate Ross Creek via the proposed temporary bridge will be for a 10 to 15 minute period occurring at the following times:

- Remains open until 7:00am
- Bridge opens temporarily at 8:00am

- Bridge opens temporarily at 11:00am
- Bridge opens temporarily at 2:00pm
- Bridge opens temporarily at 5:00pm
- Remains open after 7:00pm

During Wednesday night sailing events, the bridge will remain open from 3:00pm.

A temporary mooring pontoon as a vessel hold point will be provided on both up and downstream sides of the temporary bridge to ensure safety of waiting vessels. Emergency vessel access will be provided as required by communication via the Harbour Master to the bridge operator. In the event that no vessels are waiting at the times designated above, the bridge will remain closed.

Required Modifications to Port Infrastructure

Vessels using the TOT wharf will utilise existing navigational channels for access to the Port. It is not expected that additional markers and beacons will be required for this purpose. However, the need for additional infrastructure will be decided in consultation with the Townsville Port Authority and Maritime Safety Queensland. Any additional markers and beacons will be installed as required.

Construction and Operation Activities on Non-Port Waterway Traffic

It is not expected that non-Port traffic will increase within Ross Creek or Ross River as a result of the TOT Project. Recreational vessels within Breakwater Cove would be expected to access directly to Cleveland Bay and will not affect these waterways.

Construction activities are not expected to affect non-Port traffic. For the barge transport option, vessels will cross the Port access channel around every 22 minutes. These vessels will then proceed to a barge landing site that will be located outside navigational channels.

Potential Impacts on Operation of the Volunteer Marine Rescue Service

All vessel movements required for the barge transport option for delivery of materials to the site will be developed in close communication with the Volunteer Marine Rescue (VMR). VMR will be provided with a programme of expected barge movements during construction.

The proposed temporary bridge haul route will be located upstream of the VMR site in Ross Creek.

Constraints to Navigation whilst Military Vessels are Berthed

Naval vessels require a 100m exclusion zone around the vessel whilst berthed at the TOT wharf. This requirement is currently provided by the Port of Townsville when a naval vessel is at berth. This requirement will be provided within the TOT Precinct by construction of security fencing on the landward side and by maintaining moveable exclusion zone transition lights on the seaward side of the vessel.

Constraints to Navigation during Berthing and Departure of Ships using the TOT

As identified in communications with the harbour master, the ‘Port Closed’ signal will be activated during berthing and departure of cruise and naval vessels from the TOT Precinct berth f as is currently practiced for all vessels within the Port area. Permission will be required from the Pilot to allow traffic through during this time and all traffic will be required to liaise with Port Control.

While in berth, the specification required for construction of the TOT Precinct was to ensure that vessels were contained within the berth pocket and did not impact on the shipping channel and

swing basin area. This allows for continued operation of Port facilities without interruption while the TOT Precinct is also in use. The swing basin and main channel width also provide adequate separation distances between ships are adjoining berths.

Impacts on Public Boat Ramps and Car-trailer parking

Access to public boat ramps is not expected to be impeded by construction works or by operation of the TOT Project. Residents of the Breakwater Cove Precinct will have private jetties for mooring of recreational vessels and will not need to utilise public boat ramps.

Measures to Minimise Interference with Vessel Traffic to and from Ross Creek during Construction

All construction works will be conducted outside the main Ross Creek navigational channel. It is therefore not anticipated that construction works will impact on vessel traffic within Ross Creek. Short-term disruptions may be experienced while immobilising equipment in and out of the works site. These works will be advised to the Harbour Master who will advise mariners accordingly. Any expected disruptions in waterways will be publicly advertised.

Siltation and Erosion Effects on Ross Creek Boat Harbour Infrastructure

The Port of Townsville has an existing maintenance dredging programme that includes dredging of Ross Creek. Any effects from manoeuvring of vessels within the TOT Precinct will be addressed as part of this programme.

Potential Increase in Demand for Public Boat Launching Facilities

The operation of the TOT Project is not expected to increase demand on public boat launching facilities. All residential lots will have private jetties for mooring of recreational vessels and purchasers of multiple dwelling units will have access (and in many circumstances priority) to the berths within the commercial marina. There will be little need for residents to use public boat ramps.

Need for a Public Vessel Landing in the Breakwater Cove Precinct

The commercial marina adjacent to the Jupiters Casino and the Entertainment Centre will have a pick-up and set down area that will be available to the public and will be owned and maintained by the marina.

Impact of Increased Shipping

Operation of the TOT is only expected to result in an additional 20 to 30 vessels to the 600 to 700 vessels that currently use the Port each year. This represents an increase in existing shipping traffic of approximately 3.8%. From discussions with the Harbour Master, an increase of this magnitude is not expected to create significant impacts on waste volumes and ship queuing. Waste materials will be managed in accordance with current practices and with the waste management measures outlined in the Waste Report (Appendix 11) and contained in the TOT Project EMP

Impacts on Residences and Businesses from Electromagnetic Radiation

EMC Technologies have undertaken an Electromagnetic Radiation Survey (EMR) at the TOT Project Site A Copy of this survey in located in Section 7, Appendix 18.Precinct

This Survey details the measurements of radiofrequency (RF) Electromagnetic Radiation (EMR)-also known as Electromagnetic Energy (EME), that currently exist in and around the Project Site

The measurements were taken during a visit of US NAVY amphibious command ship "LHD2" in the Port of Townsville.

It was noted that during all measurements front radar antennas appeared to be operating (rotating). None of the ships rear radar antennas appeared to be in operation during tests. Measurements were taken at ground level, at various locations along existing breakwater.

The Australian Communications and Media Authority (ACMA) formerly the Australian Communications Authority (ACA) is the Australian government regulator that grants licences for the use of the RF spectrum. The regulations require that the General Public must not be exposed to RF fields in excess of the limits prescribed by the ARPANSA standard. Reference is made to the EMC Technologies Report for details.

The EMR/RF levels measured during the broadband and narrowband survey, as reported in this test report, are all relatively low compared to the ARPANSA limit.

The levels seen during this EMR survey would not be expected to pose a risk to either residential or business located within the proposed Ocean Terminal Precinct.

While EMR/RF levels higher up from ground level may be higher than measured (on ground level), (in the order of 10's of Volts per meter as a result of being more direct line of sight from ships radars etc), it is not expected that these levels would exceed the General Exposure levels of the ARPANSA standards.

There is a low potential for this energy to cause interference with electronic devices in nearby apartments or units including television and radio transmission. If this was the case, this may be dealt with on a case by case basis with normal solutions such as filtering or moving affected equipment further away from the source or retuning of frequencies.

Disturbances recorded however would not be expected to cause noticeable degradation of TV and Radio reception or other general electronic devices (such as Bluetooth, LAN, radio controlled door openers).

Overall the risk for EMF disturbance from the port of Townsville having adverse negative impact on residential and business activities within the proposed Townsville Ocean Terminal TOT Project is viewed as low.

4.4 Non-Transport Infrastructure

This section of the EIS describes the non-transport infrastructure required to service the TOT Project Site including electrical, telecommunications, stormwater drainage, water supply and sewerage networks. An assessment is made of the capacity of existing infrastructure to provide services for the TOT Project and the requirements for upgrades or relocation of existing infrastructure and the proposed construction of additional infrastructure. All infrastructure assessments have been undertaken in consultation with service providers.

4.4.1 Description of Environmental Values

Location of Existing Infrastructure

Preliminary surveys have been undertaken to establish the location of underground services within adjacent road reserves and open space areas. Surveys and data searches have been undertaken in consultation with the various service providers to establish the relative spatial position and capacity of existing services. The locations of existing infrastructure are illustrated on drawings provided in the Infrastructure Report which is contained in Appendix 10.

Existing infrastructure and services in proximity of the TOT Project Site have been identified as follows.

- The energy supply is a combination of underground and overhead services it falls under the ownership, operation and maintenance of Ergon Energy.
- There is a main feeder line that connects the Townsville Central City area with Magnetic Island.
- Water supply is provided by existing underground services in Sir Leslie Thiess Drive and Entertainment Road. The water supply is provided, operated and maintained by Citiwater Townsville, a business unit of Townsville City Council.
- The sewerage reticulation system within the City is owned, operated and maintained by Citiwater.
- Telecommunications within proximity of the TOT site is provided by Telstra.
- Existing street lighting is contained within the road reserves adjacent to the TOT Project Site.

Environmental Values affected by TOT Project Infrastructure

The Townsville City Plan describes the Desired Environmental Outcomes (DEOs) for the City. The DEO for the Townsville City area relating to infrastructure and services is:

> "*A community with an appropriate level of access to services, where infrastructure is provided efficiently and effectively,contributing to a high standard of living for residents and meeting ESD responsibilities."*

Construction of the TOT Project Site and installation of required infrastructure and services will be undertaken with regard for the values identified by this DEO.

Location and Owner/Custodians of Land Tenure

The TOT Project Site is to be formed by the reclamation of land from State waters pursuant to the terms of development leases between the State and the Proponent. A further and more detailed description of the existing land details and future tenure arrangements is identified in Section 3.7 of the EIS.

In relation to infrastructure services such as water supply, sewerage rising mains, energy supply mains and telecommunication mains, the extension of these services to adequately service the TOT Project Site are proposed to be contained within the existing dedicated road reserve areas. These road areas are currently under the ownership of the State and roadworks and other facilities are maintained by Townsville City Council and other utility supply agencies (for their respective utility service).

4.4.2 Potential Impacts and Mitigation Measures

This section provides an assessment of the potential impacts of the proposed development on existing infrastructure and services.

4.4.2.1 Energy

Energy Requirements of the TOT Project

An Energy Reticulation Master Plan has been developed by Hasthill Consultants detailing the proposed Ergon Energy infrastructure to enable low voltage power reticulation to each dwelling within the Breakwater Cove Precinct and to service the ocean terminal.

A network of 11,000 Volt cables in a ring main is proposed to supply a number of pad mounted transformers strategically located around the site. Transformers will generally be located in open

space areas. Four 415 Volt 50 HZ 50 Amp 3-phase power points will be provided and located at regular spacing on the wharf adjacent to a bollard.

Four 415 Volt 50 HZ 50 Amp 3-phase power points will be provided and located at regular spacing on the ocean terminal wharf adjacent to a bollard.

Existing Network Capacity

Due to the increase in power demand to the area for the proposed development, discussions are continuing with Ergon Energy who are establishing a new zone sub station near The Strand with new underground high voltage lines to be reticulated from this location to the TOT Project Site.

Potential Impacts on Existing Infrastructure and Required Upgrades

Electricity supply to the TOT Project Site will require new 11kV cables to be reticulated along the edge of the existing Sir Leslie Thiess Drive and Entertainment roadway and within the proposed new private roads from the new zone sub station to each of the proposed pad mounted transformers. The Energy Reticulation Master Plan prepared by Hasthill Consulting provides details of the electrical infrastructure required to supply energy requirements for the proposed development (Refer to Drawing No. 6582-TOT:E:01 contained in the Infrastructure Report in Appendix 10).

As other significant development is occurring within the locality, which will also require connection through Sir Leslie Thiess Drive, the Proponent is in discussion with other developers to ensure coordinated infrastructure upgrades along this route.

The proposed works within the TOT Project Site will require the relocation of part of an existing electricity supply cable to Magnetic Island. The final position of the relocated electricity main to Magnetic Island will be positioned accurately by survey. Discussions are continuing with Ergon Energy in relation to this regional trunk supply relocation to ensure there are no delays caused to the TOT Project Site at the time of proposed construction commencement and that it would not disrupt supply to the current end users.

Energy Conservation Measures

Energy efficiency measures would be implemented within each residential dwelling within the Breakwater Cove Precinct to ensure compliance with the current energy provisions of the Building Code of Australia (BCA). The energy efficiency provisions contained in BCA 2005 Part J require consideration of:

- Thermal efficiency of the building fabric;
- Minimisation of external glazing;
- Sealing of building elements;
- Provision of cross-flow air movement;
- Provision of insulation and sealing of building services pipework.

In addition to these provisions, the BCA requires that new houses achieve a minimum 4-Star energy rating. These requirements as well as sustainable housing principles contained in Council's *Sustainable Housing for the Tropics* initiative have been incorporated into the EMP to be provided to future land owners within the Breakwater Cove Precinct

The TOT Precinct is being designed in accordance with State Specifications and final energy efficient design measures in accordance with those Specifications will be undertaken.

4.4.2.2 Water Supply and Storage

Existing Water Supply Network

The existing Townsville Citiwater reticulation mains are contained within the road reserve areas of The Strand, Sir Leslie Thiess Drive and Entertainment Road. The water supply trunk main network in the vicinity of the proposed TOT Project Site is generally as follows:

- 250mm diameter Citiwater water supply main in Sir Leslie Thiess Drive on the northern and western side of this roadway.
- There is an existing 150mm water supply main in Sir Leslie Thiess Drive generally on the eastern and Southern road verge area.

The location of the existing water supply mains are shown on Drawing K038-QL00704-01 (contained in the Infrastructure Report in Appendix 10).

TOT Project Potable Water and Fire Service Demand

The key water supply design criteria will comply with Townsville City Council requirements as follows.

- Townsville City Council's residential maximum hour demand of 0.048 L/s/EP. The design shall also refer to Council's "Water Supply Distribution Planning Report" of March 1995.
- Townsville City Council does not permit dead ends. A "tube" main must be laid back around a cul-de-sac and connected back into the feeder main.
- Minimum service pressure provision shall be 22 metres of pressure at the customer's meter with a minimum flow rate of 30L/minute.
- Property services and water meters shall only be installed by Council upon application.
- Reticulation systems shall be designed to supply peak instantaneous demand by gravity while maintaining a minimum static head of 220kPa.
- Water mains required for fire-fighting purposes in the development shall be designed in accordance with the Fire Services requirements. For the external reticulation system firefighting provisions are detailed in the Guidelines for Planning and Design of Urban Water Supply Schemes Chapter 21A -Fire Fighting
- Each dwelling shall have an individual service tapped from the main and extending 300mm inside the lot boundary unless otherwise permitted by the Water Authority.

Further ongoing discussions are to be held with Townsville City Council in relation to water metering of the community management scheme area.

Construction Demands and Temporary Facilities

Water supply is required for the demountable offices and ablution facilities. A water supply connection will be made from the existing water supply main in Sir Leslie Thiess Drive to service this requirement.

The proposed connection of the TOT Project Site to the existing Townsville Citiwater water supply main is proposed to occur generally at the intersection of Sir Leslie Thiess Drive and Entertainment Drive. There are two water supply mains existing at this position being a 250 diameter water main and a 150 diameter water main. The proposed connection point is indicated on Drawing K038-QL00704 (contained in the Infrastructure Report in Appendix 10).

With regard to upgrading of water supply mains within the City, Townsville City Council has existing headworks contributions that are levied on developments that require a Material Change of Use or Reconfiguration of a Lot development application. The TOT Project Site has been considered in relation to water supply augmentation and it is proposed that the required water supply augmentation will be facilitated by payment of the required headworks contributions to Townsville City Council.

Council has also formulated Priority Infrastructure Plans (PIPs) which will replace the City infrastructure headworks policies in due course and will form part of the Townsville City Plan. Contributions for water supply and sewerage will be levied by Townsville City Council under either its headworks contribution policy or the PIP Charges whichever is applicable at the time of the future relevant development applications associated with the TOT Project Site.

Cruise Vessel Demands and Proposed Facilities

Potable water will be provided through a pipeline connection from the Citiwater reticulation system capable of delivering 200t/hour with 4 discharge points on the wharf equally spaced. Industry standard connections will be provided. Backflow prevention devices will also be included. A fire service will be run from the same water main allowing for 5 hydrants equally spaced along the wharf.

Fire Service

The design parameters for the provisions for Fire Hydrant, Fire Hose and Fire Sprinkler services as required under BCA and Australian Standards 2419, 2118 and 3962 have been made dependent on the individual site requirements. The minimum flow requirements will be provided in accordance with Council requirements of 151/s at 12 metres. The maximum residual pressure provided for under fire fighting flows will be 65-70 metres head.

Design flows for future fire sprinkler requirements have been adopted for reasonable design possibilities. Any site specific flows above this would generally be provided on site by the provision of water storage and fixed in-situ pumps.

TOT Project Potable Water Demand and Rate of Supply

The potable water requirements for operation of the TOT Project Site have been calculated by Steve Paul and Partners and are presented in Table 4.4.1.

Table 4.4.1: Water supply demands and supply rates

Water Supply	Daily Demand (average)	Rate of Supply (peak)
Breakwater Cove Multiple Dwellings (500)	425,000L	57.6L/s
Breakwater Cove Detached Dwellings (200)	750L/lot	0.6L/s
Breakwater Cove Retail (1500m^2)	7,500L	2.96L/s
Breakwater Cove Marina: Commercial berths (360) Superyachts (10)	 25,000L 5,000L	 8L/s 0.75L/s
Ocean Terminal	280,000L	55.0L/s

Water Supply Conservation Measures

The water supply conservation measures proposed to be adopted by the TOT Project Site include the following:

- Provision for individual rainwater tanks to supply water for non-potable uses for detached dwellings within the TOT Project.
- Provision of rainwater tanks to service irrigation needs of landscaping adjoining the ocean terminal building and surrounds.
- Encouraging final developers, builders and residents to follow the principles contained in the Townsville City Council "Sustainable Housing for the Tropics" initiative.

Recycled Water Supply

There is no proposal for recycling of water within the TOT Project Site. All water will be sourced from the Council potable water supply. Harvested rainwater will be used for the purposes of landscape irrigation.

4.4.2.3 Stormwater Drainage

Existing Stormwater Drainage

The TOT Project Site is situated externally to any stormwater drainage catchment that may impact on the existing stormwater drainage in Entertainment Road or Sir Leslie Theiss Drive. The TOT Project Site will not connect into the existing stormwater drainage system currently owned and maintained by the Townsville City Council. Existing stormwater drainage in the vicinity of the site is indicated on Drawing K038-QL00704-01 (contained in the Infrastructure Report in Appendix 10).

Concept Stormwater Drainage and Disposal System

The concept stormwater drainage and disposal system for the TOT Project Site comprises individual catchments of each of the residential peninsulas and the catchment for the open space road reserves and terminal building area. The conceptual stormwater drainage layout is indicated on Drawing K023-QL00704-03 (contained in the Infrastructure Report in Appendix 10).

The key elements of the stormwater drainage system generally provide for the following:

- Detached dwellings will discharge stormwater to a rainwater tank to supply water for non-potable uses. The overflow from the rainwater tank will discharge into a treatment device prior to discharge to the receiving waters;
- Roadway and car park treatment areas stormwater drainage will be collected in kerb and channel gully pits and pipe drainage systems with diversion flows provided to water quality treatment areas prior to discharge to the receiving waters; and
- Stormwater drainage from the access road and car park of the terminal building and facilities is proposed to be collected and treated in a treatment device prior to discharge to receiving waters.

Stormwater Management Plan

A Site-Based Stormwater Management Plan – Water Quality and Quantity Study (SWMP) has been prepared by Hyder Consulting and is contained in the Infrastructure Report in Appendix 10. The SWMP provides strategies to prevent impacts to the existing water quality in receiving waterways during the operational phase of the development. A full hydraulic analysis will be

prepared at the detailed design stage. This analysis will be in accordance with Townsville City Council requirements.

Stormwater Layout Options

Two options were assessed for the Breakwater Cove Precinct to mitigate the effects of stormwater runoff from the site and protect the water quality of receiving environments. These options are described below:

Option A

All residential lots are to be graded to the road where stormwater discharge from minor storm events is collected in the road drainage. The runoff from the lots and roads for the major storm events will be conveyed within the road reserve. The preliminary stormwater layout for Option A is provided in the SWMP (Drawing K023-QL00704-02)

Option B

Option B has the same sub-catchments as per Option A however the lots grade towards the rear of the properties and rear-of-allotment drainage is provided. The preliminary stormwater layout for Option B is provided in the SWMP (Drawing K024-QL00704-01).

Stormwater Quantity Analysis

Preliminary stormwater analysis has been conducted for the two stormwater layout options to predict the discharge rates at each outlet for the subdivision.

Stormwater layout for Option A has fewer outlets as a result of no rear-of-allotment drainage. All runoff from the lots for Option A will drain towards the road drainage. The introduction of rear-of-allotment drainage in Option B will reduce the size of road drainage as the lots and road sub-catchments are separated. Option B has additional outlets to cater for discharge from rear-of-allotment drainage.

A detailed hydraulic assessment will be undertaken at the detailed design stage of the development. This analysis will comply with the Townsville City Council requirements for a conventional operational works application pursuant to the Integrated Planning Act 1997.

Water Quality Objectives

A number of water quality guidelines currently exist for Australian, Queensland and North Queensland receiving waters upon which water quality objectives for receiving environments can be based. The water quality guidelines used in reference to this study are outlined below.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC Guidelines)

Trigger values for physical and chemical indicators of water quality are specified by the ANZECC Guidelines for use in determining water quality objectives for a range of ecosystem types. The ANZECC trigger values for inshore marine ecosystems in tropical northern Queensland are provided in the SWMP.

The ANZECC Guidelines identify the need to develop locally relevant guideline values tailored to particular regions and water types in order to refine the conservative values contained in the national guidelines according to local conditions.

Queensland Water Quality Guidelines (2006)

The Environmental Protection Agency (EPA) has prepared guidelines for water quality in Queensland to be considered in conjunction with the ANZECC Guidelines. EPA guideline values are used for establishing water quality objectives and assessment of development in Queensland. The physico-chemical guideline values for enclosed coastal waters in the Central Coast Queensland region are given the SWMP.

The Guidelines acknowledge the need to consider site-specific conditions in determining appropriate guidelines and alternative levels of protection, particularly in disturbed environments.

Existing Water Quality

Site-specific investigations of water quality have been undertaken by C&R Consulting Pty Ltd in the Report on Impacts of the TOT Project on Water Quality of Cleveland Bay (Appendix 12). This study has also reviewed existing information on the water quality of Cleveland Bay in the vicinity of the TOT Project Site.

The Cleveland Bay area has been assessed by C & R as being slightly to moderately disturbed. Levels of Phosphorous at sampling locations surrounding the TOT Project Site are currently above guideline values ranging from <50µg/L to 19,800µg/L and levels of up to 1,140µg/L were detected at the TOT Project Site. Nitrogen levels in surface waters sampled within the TOT Project Site and surrounding areas were below guideline values ranging from <500µg/L to 700µg/L between all sites sampled.

Site-specific water quality objectives for the TOT Project Site have been recommended based on existing levels of contaminants in surface waters.

Stormwater Quality Improvement Devices

The site has been divided into sub-catchments for the purposes of stormwater treatment. Each sub-catchment will drain by overland flow to a series of stormwater quality improvement devices then to a central discharge location for release.

Rainwater Tanks

The Queensland State Government requires that all new Class 1 homes built after 1 January 2007 will install a minimum 5000L tank to collect rainfall for connection to non-potable water uses including garden irrigation, toilet flushing and washing machine cold water.

Townsville City Council have applied to the Queensland Government for an exemption to this requirement. Rainwater tanks may therefore not be required for the TOT Project Site given Townsville's rainfall and temporal patterns.

Gross Pollutant Trap

Gross pollutant traps (GPTs) remove solids of greater than 5mm in size that are conveyed in stormwater to prevent entry of pollutants to receiving waterways. Gross pollutant loads include rubbish and coarse sediment mostly organic material such as leaves and twigs and also plastic and paper items such as food and drink containers. These devices will be installed to treat stormwater from roadways within the TOT Project Site.

Leaf/Litter Basket

Metal or plastic litter baskets can be installed in gully pits within individual drainage lines to intercept gross pollutants from up to 1 hectare catchments. Litter and organic material is trapped within the basket and some coarse sediment may be removed by filtration through trapped material. These treatment devices will be used to treat stormwater flows within residential lots.

Oil and Grit Separator

Oil and grit separators are structures consisting of one or more chambers that remove sediment, screen debris, and separate oil from stormwater. These devices will be used to treat stormwater runoff from hardstand areas within the TOT Precinct and will also remove gross pollutants.

Stormwater Modelling

A quantitative assessment of stormwater runoff quality was undertaken to assess pollutant export loads from the development site using the Cooperative Research Centre for Catchment Hydrology's (CRCCH) MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model. Details of the MUSIC modelling are contained in the SWMP.

Modelling Results and Conclusions

Comparisons of modelling results have shown that Option B produces higher pollutant reduction efficiency than Option A. This is due to the implementation of leaf/litter baskets within the rear-of-allotment drainage system.

Option B would achieve a greater dispersion of fresh water into the receiving waters due to the increased number of outlets as a result from rear-of-allotment drainage. The introduction of rainwater tanks shows an increase in the pollutant reduction efficiency due to retention and reuse of runoff within the system.

Either Option B without rainwater tanks or with rainwater tanks would be the preferred option with pollutant load reductions of up to 92% of Gross Pollutants, 51% of total suspended solids, 22% of Total Phosphorous and 25% of Total Nitrogen achieved on an annual basis.

Operational Works in the Coastal Management District

The physical TOT Project Site is within the State water of Queensland. In recognition of the State Coastal Policy, measures are proposed to prevent sedimentation and erosion and to ensure coastal values are protected.

The stormwater drainage outlets will be constructed with an outlet to the receiving waters in the new waterway areas situated below highest astronomical tide and mean high water spring tide levels. As a result these structures will be constructed in tidal waters. The detailed design of these structures will be the subject of further operational works development applications to be lodged with various agencies in association with the on-going detailed design and construction of civil engineering works associated with the proposed development.

The effects of stormwater drainage on the water quality of the TOT Project Site have been modelled using a combined MUSIC and PHREEQC approach. Models have related to worst case, first flush scenarios after an extensive period (9 months) of dry weather within a minimal flushing event of 12.5mm. Likely compositions of atmospheric dust were input into this scenario assuming total dissolution of the dust material or total incorporation of the dust material into the bottom sediment.

Providing regular maintenance dredging is undertaken to ensure adequate flushing then all data indicate that flushed water quality exiting the TOT Project Site will be within current ambient range or 95% ANZECC 2000 Species Protection Guidelines or both and that all sediments produced from the development will be within current ambient ranges (HIL-A Compliant).

4.4.2.4 Sewerage

Existing Sewerage Network Capacity

The existing sewerage infrastructure in the Townsville CBD comprises sewer gravity mains collecting from individual properties, being then collected to pump stations and lift stations to be transported from these facilities via rising mains to major pump stations within the City.

There are no existing Citiwater sewerage facilities within the TOT Project Site. Existing sewerage facilities owned and operated by Citiwater are located in Sir Leslie Thiess Drive and Entertainment Road. The existing sewerage pump stations situated near the intersection of Entertainment Road and Sir Leslie Thiess Drive will be the point of discharge of sewer from the TOT Project Site.

TOT Project Sewerage Requirements

The proposed sewage from the TOT Project Site is to be collected internally via a series of gravity sewer mains, vacuum mains and pump station with discharge rising mains to connect to the existing sewer pump station situated at the corner of Sir Leslie Thiess Drive and Entertainment Road.

It is proposed that the sewer reticulation and vacuum pump station system within the TOT Project Site will be privately owned, operated and maintained by the Body Corporate. The sewer facilities external to the TOT Project Site will become assets of Townsville Citiwater. These facilities will ultimately be operated and maintained by Citiwater.

The sewerage network designed for the TOT Project Site will comply with all Townsville Citiwater design and construction criteria as specified in the Infrastructure Report contained in Appendix 10. The design of gravity sewer systems and pump station components will also comply with the Water Services Association of Australia's publication "Sewerage Code of Australia" unless specified otherwise by Townsville City Council.

House / Apartment Sites

The design parameters incorporate the required provisions for sanitary plumbing and house drainage flows and are sized in accordance with AS 3500 requirements and Townsville City Council Guidelines.

It is proposed to utilise a vacuum sewerage system as identified in the Vacuum Code of Australia WSA06 to collect and transport sewage within the TOT Project Site. This system is particularly suited to flat terrain and will be used instead of a gravity system. The configuration of the proposed vacuum sewer reticulation system is indicated on Drawing K030-QL00704-02 (contained in the Infrastructure Report in Appendix 10).

Ocean Terminal Sewage Discharge

A single or multiple storage tank with a combined capacity of 90,000 litres to provide interim storage for approx 10 hours will be provided on site. Off peak discharge will be at 2.5-3 l/s. No provision is made for the pre-treatment of the wastewater before it is discharged into the City wastewater drainage system.

Sewage and Grey Water

Sewage/grey water will be discharged directly into the town sewerage system through a storage tank, pump station and piping system. The minimum pump capacity of the pump station will be 4.5 litres. A typical discharge from the Benchmark ship is 230 litre/capita/day and design discharge is 2.5 litre/s.

The TOT wharf will not cater for receival and/or treatment of ballast water from vessels.

Marina Discharge

Discharge from commercial and private marina berths will be at a centralised collection point via a land based vacuum sewerage and storage facility or similar. This type of system is considered under Townsville City Council discharge guidelines as trade waste and will be collected in an on site holding well of suitable capacity for either transportation off site by a licensed contractor or to be discharged to sewer at a preset discharge rate.

Contingency Measures

The proposed sewerage facilities to be contained within the TOT Project Site are conventional gravity sewer mains and sewer rising mains. There will be a variation to the conventional aspect of the sewer facilities to be constructed within the TOT Project Site; this will be the vacuum sewer components of the proposed network system.

The vacuum sewerage facility will be constructed to be compliant with the Vacuum Sewer Code of Australia WSA06-2004 and relevant amendments. The sewerage configuration will have regard to the requirements to accommodate the vacuum stations. These vacuum stations will be situated in the lowest portion of the residential peninsulas.

It is proposed emergency pumping arrangements will be made in the vacuum pump station for bypass pumping and/or a pump out facility. Arrangements will also be made for a temporary standby generator in case of electrical power failure to the vacuum pump station.

An odour control filter (or bio filter) will be used to remove odours from the vacuum generator exhaust containing odorous compounds which will include biodegradable organic compounds bypassing gases to a natural biological active filter membrane.

The on-site generator will be configured to provide for an auto-start on loss of power and will be properly secured with required safety signage. Noise from the generator will comply with the relevant Townsville City Council and EPA noise guidelines and requirements.

The vacuum sewer will generally be located on the opposite side of the road reserve to the water main construction. The sewer depths in the vacuum sewers will be located at depths to mitigate risk of third party intrusion and will have a minimum depth of 600mm.

Required Infrastructure Upgrades

There are no further required sewerage infrastructure upgrades to be undertaken as part of the TOT Project Site. Any sewerage works external to the site required to be upgraded will be undertaken by Citiwater in accordance with the provisions and forward planning TOT Projections allowed for in the headworks contributions or PIP charges, which ever the case maybe.

4.4.2.5 Telecommunications

Existing Network Capacity

Due to the number of dwellings and provision of telephone lines to the TOT Project Site as well as broadband Internet facilities, negotiations are taking place with Telstra to provide a Remote Integrated Multiplexor (RIM) Unit to be centrally located within the proposed development.

TOT Project Infrastructure Requirements

A Communications Reticulation Master Plan has been prepared by Hasthill Consultants detailing infrastructure required to provide telecommunications services to the TOT Project Site. The

proposed telecommunications reticulation for the site is presented on Hasthill's Drawing No. 6582-TOT:E:02 (contained in the Infrastructure Report in Appendix 10).

Potential Impacts on Existing Infrastructure and Required Upgrades

Fibre Optic cable will be reticulated by Telstra from the nearest existing node via underground conduits in the road reserve of the existing and proposed road infrastructure. Multipair copper cables would then be reticulated via underground conduit and pit network to each dwelling within the Breakwater Cove Precinct and the TOT Precinct.

Roads

The proposed internal road network is illustrated on Drawing K032-QL00704-03. Road cross sections are provided on Drawings K033-QL00704-02, K034-QL00704-02 and K035-QL00704-02 (contained in the Infrastructure Report in Appendix 10).

4.4.2.6 Other Infrastructure

Fuel Supply

An assessment of options for fuel supply to vessels in the TOT Precinct has been undertaken. Three options were considered including:

- Road Tanker;
- Bunkering pipe line facility, and
- Fuel barge

Diesel fuel is currently delivered to vessels in the Port of Townsville by road tanker. The road tanker will be required to park on the discharge apron along the wharf that is designed to capture and prevent any spillage from entering the waterway or land.

The fuel tanker discharge aprons at the TOT will be designed to capture one compartment or 9,000 litres in case of a major leak during the bunkering operation. A typical containment apron is detailed on Drawing 07080-A-0010 (contained in the Infrastructure Report in Appendix 10) which includes a 10,000 litre underground tank that will hold any unwanted spill. The underground tank will only be in operation during bunkering, this will make sure that the capture tank does not fill up with rainwater.

A further option for delivery of fuel to vessels would involve bunkering by barge. A double hulled 1500 DWT bunker barge would be used for this purpose. The barge would berth alongside the vessel during bunkering and would be located within the berth pocket outside the Port navigational channel.

This fuel bunkering service would be provided by a separate commercial entity and any barge berthing facilities and fuel storage would be provided by an independent contractor.

Temporary Structures and Materials

A number of temporary structures used in construction of the TOT and Breakwater Cove Precincts will be established within the TOT Project Site during the construction phase of development. These are outlined below.

Temporary Buildings and Structures

Temporary buildings will be installed on the TOT Project Site within a designated construction compound to provide office, lunch room, first aid area and toilet facilities for construction staff.

This compound will also provide a location for stockpiles and storage of construction materials and equipment. A storage area will be provided within the construction compound for secure storage of civil infrastructure facilities including water supply and sewerage pipeworks, valves and associated fittings.

An equipment maintenance area will be provided within the construction compound for routine maintenance of construction vehicles, plant and equipment. This area will be fully bunded and runoff contained to prevent dispersal of oils and hydrocarbons to receiving environments. Extensive equipment maintenance and/or repairs will be conducted at an off-site facility.

The TOT Project Site will be fully bunded by construction of permanent breakwaters and temporary bunding material to isolate the TOT Project Site from adjacent waterways. Temporary bunds will be constructed of rock material and will be removed at the completion of site reclamation works to allow water to flow into canal and marina areas.

Temporary Stockpile Site – Riverside Marine

Negotiations have been undertaken with the owner of the Riverside Marine site for possible temporary stockpiling of rock and sand fill material for the period of construction as a Transport Option (see Section 3.4.4). Materials delivered by overland truck via Boundary Road will be stored temporarily within this site and removed to the TOT Project Site by barge. The barge landing facility at this site will require upgrade for delivery of construction materials to the TOT Project Site which will be left in place for future use by Riverside Marine.

Removal and Disposal of Temporary Structures

The Construction TOT Project Manager will supervise decommissioning and removal of all temporary structures and materials which will be undertaken within 2 weeks of completion of construction works. Decommissioning and removal of the temporary bridge across Ross Creek will be undertaken within 3 months of completion of construction works.

It is expected that the majority of structures and materials will be either demobilised and returned to suppliers or manufacturers or reused within the site. Any structures or materials that cannot be reused will be removed to an approved recycling facility or landfill site for disposal as described in the Waste Management report.

Temporary Accommodation

It is not proposed to construct temporary accommodation for housing of construction employees. Construction personnel will be sourced predominantly from the local construction workforce. It is expected that specialist personnel required to be sourced from other areas can be housed within existing accommodation facilities in Townsville. This matter is discussed in the Social Impact Report in Appendix 21 and in Section 4.13.

Where a construction caretaker is required to remain on site from time to time for site security purposes, temporary accommodation will be provided within the proposed temporary office and facilities buildings. This is not expected to be a regular use and a separate structure is therefore not required for accommodation purposes.

4.5 Waste

The TOT Project Site will generate waste throughout construction and operation. Waste management measures will be implemented during the construction and operational phases to ensure that impacts on the receiving environment are minimised. Hyder Consulting has conducted an assessment of the types and quantities of waste generated during construction and operation of the TOT Project Site and has identified opportunities for minimisation and management of waste stream elements. The results of this assessment are presented in the Waste Management Report in Appendix 11 and are summarised here.

4.5.1 Characters and quantities of waste materials

Construction waste

Construction activities within the TOT and the Breakwater Cove Precincts will generate a range of wastes requiring various disposal methods. The major waste types likely to be generated during the construction phase include:

- Excess fill and excavated material;
- Concrete, timber, steel/metals, asphalt;
- Cardboard, plastics and packaging materials;
- Plasterboard;
- Landscaping materials.

The volume of fill material required for site reclamation works has been reduced through re-evaluation of the construction methodology. Materials excavated from within the site will be reused as fill to form building platforms to the required levels. This methodology has reduced the requirement for rock and sand fill and has prevented the need for disposal of excavated material.

Civil infrastructure works to be undertaken once land platforms are constructed will be monitored to ensure that accurate material quantities are ordered to prevent excess material requiring disposal. Material that cannot be recycled or reused within the site will be either returned to the supplier or delivered to a recycling facility.

It is expected that waste materials generated during site reclamation works will be minimal and that materials requiring disposal can be accommodated by existing landfill and recycling facilities.

It is estimated that 9.2kg of waste will be generated per $100 of building and construction work undertaken within the TOT Project. This figure may vary by up to 20% either side of the median value of 9.2kg (EPA NSW, 2000). Assuming that a total of $AUS 2.2 million is allocated to the construction of the terminal building, the total amount of waste generated is estimated at 202 tonnes during the construction phase, which is expected to last for two years.

Similarly, if expenditure on buildings and structures in the Breakwater Cove Precinct including the future marina is $AUS 399 million then the total volume of waste is estimated as being between 29,366 and 44,050 tonnes over an estimated four year period.

The waste generated by on site workers is calculated at approximately 0.5kg of waste per day over 300 working days per year, this will generate waste equal to 180 tonnes per annum. Significant amounts of dredged material may also be generated some of which may be unsuitable for building foundations and thus require disposal. Construction waste estimates are summarised in Table 4.5.1.

Table 4.5.1: Total Waste Generation during Construction Phase (per annum)

Waste Source	Waste Generated (tonnes/year)
Townsville Ocean Terminal	101
Breakwater Cove Precinct	9,177
Site workers	180
Total Waste Generated	**9,458 (approximately)**

Operational waste

Townsville Ocean Terminal Precinct

The major waste elements likely to be generated during operation of the TOT Precinct include:

- Food waste;
- Plastics and packaging materials;
- Paper and cardboard;
- Oil, grease and hazardous waste;
- Non-quarantine garbage from vessels (food, paper, glass, metals, plastics and packaging); and
- Quarantine waste from vessels (galley and accommodation refuse; floor sweepings; organic wastes that constitute a health risk; and food subject to quarantine).

Terminal Building

It is expected that around 20 personnel will be employed within the terminal building. It can be estimated that the café would produce approximately 2.54 tonnes of waste per employee each year. Approximately 5 café employees would produce around about 12 tonnes of waste each year. It is noted that the terminal building will only operate whilst a vessel is berthed at the wharf. It is therefore expected that the TOT would operate for approximately one third of the year given that 20 cruise ships and 40 to 50 naval vessels are expected to use the facility each year.

The 15 office employees could be expected to generate around 0.93 tonnes per employee each year, which would amount to 13.95 tonnes of waste. Given that the TOT will operate for only one third of the year, the expected waste generation from café employees would be approximately 3.8 tonnes per year.

The estimated amount of office waste generated per year is around 0.93 tonnes per employee each year, which would amount to 13.95 tonnes of waste for 15 office employees. The expected rate of waste generation given that the facility will be operational for only one third of the year is approximately 4.19 tonnes per year.

The number of visitors to the terminal each year (cruise and naval vessels) is assumed to be around 200,000. A single tourist may be expected to produce around 0.1 to 0.2 kg of waste if required to spend 2 or 3 hours within the terminal. In addition, day-trippers or persons visiting the TOT for recreational purposes may dispose of food packaging and organic waste.

Visiting Ships

Any ship visiting Townsville Ocean Terminal that has sailed in international waters is deemed foreign, and all waste on board will be subject to inspection by the Australian Quarantine and Inspection Service (AQIS). Plastics and metal which have been appropriately segregated may be suitable for recycling. In cases where contamination has occurred (e.g. contact with foodstuffs) the waste must be treated in accordance with AQIS requirements, which is either deep burial or incineration. All quarantine waste in Townsville is buried under AQIS supervision.

It is expected that approximately 20 cruise ships and 40 to 50 military vessels will visit the TOT each year. The type of waste generated by a typical cruise ship includes glass, paper, steel, food scraps, aluminium, cardboard etc. Waste generated by military vessels is of similar composition. Small amounts of hazardous materials are also generated on ships from on-board activities and processes that include photo processing, dry-cleaning, and equipment cleaning.

A typical cruise ship with approximately 1158 passengers that has been sea bound for 9.5 days is estimated to produce around 33 tonnes of domestic waste and 220 kg of hazardous waste. The amount of waste generated by 20 such vessels over a one year would typically be around 660 tonnes of domestic waste and 4.4 tonnes of hazardous waste.

A military ship produces around 750kg of waste each day; hence a ship at sea for 5 days might arrive at shore with 3.8 tonnes of waste. The total amount of domestic waste generated by 45 military vessels is approximately 169 tonnes/year.

Breakwater Cove Precinct

The waste stream elements expected to be generated from the Breakwater Cove Precinct include:

- Domestic garbage;
- Aluminium;
- Glass;
- Steel;
- Plastics (PET and HDPE); and
- Paper and cardboard.

The Breakwater Cove Precinct will provide landform for future construction of approximately 500 apartments and 200 detached dwellings. The Australian Bureau of Statistics Census Data (2001) shows that the average number of residents in Australian dwellings was 2.7 residents in detached dwellings and 1.7 residents in apartments. It is therefore estimated that around 1,390 persons will be accommodated in both apartments and detached dwellings within the site. The predicted volume of waste generated from 1,390 persons is estimated at around 695 tonnes/year (based on an average domestic waste generation rate of 0.5 tonnes/person/year).

Maintenance Dredging

Maintenance dredging will be required to maintain the dimensions of access channels and waterways within the TOT Project Site for navigational purposes. Material dredged from the TOT berth pocket will be disposed of at the Port of Townsville approved disposal site and dredge spoil from other area will be either reused within the project Site or alternative disposal sites utilised as discussed in Section 3.5.

Volumes of material to be dredged and frequency of maintenance dredging is detailed in Section 3.5 of the EIS. Disposal of this material will be in accordance with existing Port of Townsville approvals.

Operational Waste Generation Rates

Estimated quantities of waste from various sources within the TOT Project during its operation are summarised in Table 4.5.2. Of this, a proportion will be recycled, and a proportion will be transported to landfill for disposal.

Table 4.5.2: Total Waste Generation during TOT Project Operational Phase (per annum)

	Waste in tonnes/year
Breakwater Cove Precinct[1]	695
Terminal Building[2]	8
Ships[3]	833
Day Visitors	30
Total	Approximately **1,566**

These figures are based on the following assumptions:
[1] 1,390 residents generating 0.5 tonnes/person/year
[2] 20 Personnel in total – 5 in café and 15 in various offices for one-third of each year
[3] 20 Cruise ships with 33 tonnes each; 45 Military ships with 3.7 tonnes each

Decommissioning

At the completion of site construction works, temporary buildings used as offices and other facilities will be demobilised off site. At the completion of site construction works and once the site is secure for public access, fencing material will be demobilised off site. It is expected that these materials can be reused and will not require disposal.

Rock material removed from temporary bunds and barge landing sites will be reused within the site in final profiling of breakwaters. The barge landing facility at the Riverside Marine stockpile site will require upgrade for delivery of construction materials to the site. This facility will be left in place for future use by Riverside Marine at the completion of site construction works.

Waste-Related Traffic

Most construction truck movements will occur through delivery of materials to the site. There will be some additional traffic transporting waste and recycling materials in the opposite direction. Over the construction period for the TOT and residential Precinct, it is estimated an average of 4 to 15 truck movements per day.

During the operational phase of the terminal and breakwater Precinct, traffic generation will be in the order of one to three truck movements per day for waste collection and recycling from the terminal.

Volume of Product Produced

There are no production processes proposed during operation of the TOT Project Site that will result in generation of process wastes or by-products or that will require input of raw materials.

4.5.1.1 Solid Waste

Existing Waste Facilities

Domestic Waste Disposal

Citiwaste Townsville collects some 45,000 tonnes of domestic waste each year. A total of 71,592 tonnes of waste is deposited each year at the landfill site in Vantassel Street, Townsville. This is the only operating landfill in Townsville and has a TOT Projected lifespan of more than 70 years. This facility is expected to be sufficient to accept domestic waste generated from the Breakwater Cove Precinct.

Commercial Waste Disposal

Adequate waste disposal facilities exist within the Local Government area for disposal of waste generated during construction of the TOT and Breakwater Cove Precincts. The Vantassel Street Townsville Landfill is also licensed to accept construction and demolition wastes.

Future Requirements

The volume of waste produced throughout the construction of the TOT Project is estimated to be around about 38,170 tonnes and the sustained amount created throughout the life of the TOT Project is expected to be in the region of 1,606 tonnes per annum. Existing waste facilities are expected to be of sufficient capacity to receive this volume of waste. It is therefore not proposed to construct additional landfill for the TOT Project.

4.5.1.2 Liquid Waste

Quality and quantity of stormwater, site drainage and runoff from roads and hardstand areas within the site is detailed in the Stormwater Management Plan. A site stormwater analysis, usage of water and water supply for the TOT Project is detailed in the Infrastructure Report in Section 7, Appendix 10. The collection, treatment and disposal of wastewater origination from the TOT Project is described in the Infrastructure Report.

Management of groundwater during site excavations is described in the Impact of the TOT on Water Quality of Cleveland Bay Report by C & R Consulting Appendix 12. An erosion and sediment control plan will be prepared during the detailed design phase to be implemented during construction in accordance with the *Engineering Guidelines for Queensland Construction Sites* (Institute of Engineers Australia) to prevent mobilisation of pollutants in runoff from the site and to protect the water quality of surrounding waterways during construction. Management measures for handling of hazardous substances including liquid waste products is outlined in the TOT Project EMP.

Given the depth of excavations it is highly unlikely any groundwater aquifers will be intersected during the construction or operations of the development. Therefore, no groundwaters will be discharged from the excavations.

Trade Waste

A trade waste approval will be obtained from Townsville City Council to allow discharge of waste water from the proposed oil and grit separators within the TOT Precinct to the sewer. The TOT operator will ensure that all conditions of the approval and Council requirements relating to trade waste are met.

Regular cleaning and removal of accumulated oil and grease from the oil and grit separator will be undertaken by an EPA-licensed contractor who will be responsible for waste tracking requirements. All trade waste will be transported, treated and disposed of in accordance with the *Environmental Protection Regulation 1998* and the *Environmental Protection (Waste Management) Regulation 2000*.

4.5.2 Description of environmental values

The environmental values that may be affected by wastes generated by the TOT Project Site include the values of receiving environments described by site-specific investigations undertaken during preparation of this EIS. Cross-references to sections of the EIS where relevant environmental values are described are provided in Table 4.5.3.

Table 4.5.3: Environmental values potentially affected by TOT Project waste.

Environmental Values	Section of the EIS
Soils, geology and terrestrial land uses	4.2.1
surface water quality, downstream water uses, groundwater resources and coastal environments	4.6.1 and 4.7.1
Local air quality, public amenity and well-being	4.8.1
Visual amenity and landscape character	4.9.1
Terrestrial and aquatic species, communities and habitats	4.11.1
Community facilities, social amenity and well-being	4.13.1
Health and safety of community and workforce	4.14.1

4.5.3 Potential impacts and mitigation measures

Objectives

The objectives for waste minimisation and management at the TOT Project Site during construction and operation are:

- To minimise waste generated at the site to reduce the volume of waste requiring disposal to landfill.
- To prevent dispersal of waste from the site to receiving environments.
- To ensure compliance with the *Environmental Protection Act 1994* and the *Environmental Protection (Waste Management) Policy 2000* (EPP Waste).
- To encourage residents and operators within the TOT Project Site to implement waste reduction management measures.

The *Environment Protection (Waste Management) Policy 2000* (EPP Waste) provides for the preparation of waste management plans to minimise waste generation, promote the efficient use of resources and promote the use of waste as a resource in order to achieve the waste objectives of the *Environment Protection Act 1994*.

The EPP Waste outlines a 'waste hierarchy' to be adopted for waste minimisation and management. This hierarchy lists waste management practices in the preferred order of adoption. These include waste avoidance as a first option, then re-use, recycling, energy recovery and waste disposal as a last option. This waste hierarchy will be adopted in the implementation of impact mitigation strategies for the development.

Potential Impacts

Potential environmental and human health impacts may occur as a result of poor waste management practices. Potential impacts are identified in Table 4.5.6. Mitigation measures are proposed in various sections of the EIS as outlined in Table 4.5.4. Protection measures proposed to mitigate these impacts during construction and operation are outlined in the following section.

Table 4.5.4: Potential waste impacts and proposed mitigation measures

Potential Impacts	Mitigation Measures	Section of the EIS
Excessive resource use leading to depletion of natural resources	Construction waste reduction and recycling measures	Waste 4.5.3
Excessive resource use resulting in greenhouse gas production	Greenhouse gas reduction measures	Air 4.8.2.1
Emission of polluting substances to surrounding waterways resulting in water quality impacts	Sewer and stormwater management measures	Infrastructure 4.4.2.3 and 4.4.2.4
	Hazardous substances management	Construction 3.4.1
Emission of polluting substances to surrounding waterways leading to ecological impacts	Sewer and stormwater management	Infrastructure 4.4.2.3 and 4.4.2.4
	Hazardous substances management	Construction 3.4.1
	Construction and operational waste management measures	Waste 4.5.3
Emission of polluting substances to air leading to human health impacts	Air quality control measures	Air 4.8.2
Emission of polluting substances to air leading to odour impacts	Air quality control measures	Air 4.8.2
Emission of polluting substances to land resulting in recreational and visual impacts	Construction and operational waste management measures	Waste 4.5.3

Waste minimisation and management measures

The volume of waste produced throughout the construction of the TOT Project is estimated to be around about 38,170 tonnes and the sustained amount created throughout the life of the TOT Project is expected to be in the region of 1,606 tonnes per annum. This should have minimal impact on the current landfill space found at Vantassel St in Townsville; hence no further landfill infrastructure will be required to support this TOT Project.

A proportion of the domestic waste generated at the TOT will be recycled. It is assumed that a recycling rate of 20% can be achieved if the suggestions provided in the Waste Management Plan (Chapter 5) are implemented. It is assumed that a construction waste recycling rate of approximately 76% or 7,051 tonnes of construction waste recovery of the 9,278 tonnes generated can be achieved for each year of construction.

Construction waste management measures

The TOT Project construction phase contractors are to adopt a policy of waste management that ensures protection of natural resources through minimisation of construction materials and reduction of environmental impacts by ensuring appropriate recycling, reuse and disposal methods.

Separation of waste materials for recycling will be undertaken within the TOT Project Site. In addition, opportunities may be identified at a later stage for separation and re-use/recycling of certain materials at businesses off site. Waste avoidance may be achieved during construction by avoiding over-estimation of material supplies or by using alternative materials and processes to

minimise the amount of material requiring disposal. The contractor will ensure that separate waste receptacles are provided within the construction site for reuse of waste materials. Construction waste materials requiring disposal will be collected for disposal at Vantassel St landfill facility.

Opportunities for reuse and recycling of construction wastes may include the following:

- Clean plasterboard may be recycled for manufacture of new plasterboard or shredded and used in the remediation of soils.
- Wood waste can be reprocessed for uses such as compost for soil improvement, mulch to control weeds and reduce evaporation, as wood chips for landscaping.
- Metals, glass, plastics, paper and cardboard may be separated and stored for collection by Council's recycling service and treated at Visy's MRF.
- Crushed concrete can potentially be used as aggregate for road bases, pipe bedding material, for kerb and guttering.
- Asphalt can be recycled in new hot mix asphalt, hot-in-place or cold.

Additional measures are provided in the EMP in Section 5.

Operational waste management measures

Access and parking for waste collection vehicles will be provided in a designated secure location ensuring the amenity of adjacent residential areas is protected and that port operations are not affected. A storage tank will be provided within the TOT Precinct to provide interim storage of sewage from vessels at berth in accordance with the requirements of the TOT Project Brief. Sewage will be discharged from this tank by means of pump station and pipework for treatment at the Townsville City sewerage treatment plan (sewage infrastructure is described in the Infrastructure Report in Appendix 10).

It is anticipated that waste removal contractors similar to those used by the Port of Townsville will provide services for collection of oily waste and garbage from the cruise ship terminal. Waste oil and oily mixtures are currently collected by North Queensland Resource Recovery and transported from the site for recycling. Garbage from Australian vessels is currently collected by specialist waste contractors J.J. Richards and removed to a waste disposal facility. J.J. Richards ensure all waste tracking is undertaken in accordance with EPA requirements.

Where waste is proposed to be removed from vessels, best practice standards will apply in accordance with the Australian Quarantine Guidelines for Cruise Vessel Agents and Operators (AQIS 2006). These guidelines outline procedures for all vessels arriving in Australia from international waters. Vessels will be required to manage waste onboard the vessel in accordance with the Convention for the Prevention of Pollution from Ships (MARPOL 73/78) regulations.

All quarantine waste is to be removed by an authorised contractor to be treated by autoclave. Quarantine waste products include:

- Organic galley and accommodation refuse;
- Packing material and floor sweepings;
- Other organic wastes that constitute a health risk; and
- Interstate food subject to quarantine.

Ship masters will be required to contact the relevant waste contractors not less than 24 hours prior to expected discharge of waste from the ship. Information will be provided at that time on the

type and volume of waste to be discharged and the time and location of transfer of waste from the ship. The ship's master will be required to ensure that wastes have been adequately separated and contained on-board and that quarantine waste is segregated from other wastes and contained in an authorised manner. Any waste that was separated for recycling on the vessel will be transferred to recycling receptacles upon arrival. Waste for disposal will be collected by an approved waste disposal contractor and transported for disposal off-site.

Best practice standards will be adopted for the implementation of waste receptacles on site. Separate bins will be provided within the TOT site for general waste and recyclable waste within the terminal and associated facilities. Signage will be displayed around terminal buildings to inform building users of the requirements for waste management within the site.

The Body Corporate will be responsible for maintenance of the central waste storage area and for on-street placement of bins for collection by waste contractor vehicles. The waste collection area will be located to enable easy access and manoeuvring of collection vehicles.

Residents of Breakwater Cove will be encouraged to separate household rubbish and recyclables by provision of services for collection of separated wastes. It is proposed arrangements will be made with Townsville City Council to enable services to be provided by Council's existing waste contractors for weekly kerbside collection of domestic waste and fortnightly collection of recyclables.

The waste stream elements and proposed treatment and disposal measures for the construction and operational phases are illustrated in Schematic Waste Diagrams provided in the Waste Management report in Appendix 11.

Waste minimisation and cleaner production

Cleaner production technology is applied to production processes to reduce generation of industrial waste, greenhouse gas emissions and consumption of raw materials. There are no production processes proposed during operation of the TOT Project Site that will result in generation of by-products or input of raw materials. Additionally there is no proposal for integrated process design, cogeneration of power or by-product re-use.

However, waste minimisation principles have been applied to the construction and operational phases of the TOT Project to ensure reduction of energy and water consumption and to ensure efficient use of material resources. Additional measures for reducing greenhouse gas emissions and minimising energy consumption are dealt with in other studies being undertaken for the EIS.

Open space areas and public places

Each visitor to public places generates some 140 grams of waste in total, including 35 grams of potentially recyclable material. The total amount of waste generated from open spaces within the TOT Project Site can be estimated to be 42 tonnes per annum. With provision of appropriate recycling bins, around 25% or 10.5 tonnes can potentially be recycled. The recovery rate can be substantially improved where an appropriate Public Place Recycling Program is in place. An example of such a program is provided in the Waste Management report in Appendix 11.

Open space areas within the TOT Project Site will require approximately 8 waste bins and 12 recycling bins to achieve waste management targets. The appropriate positioning of the bins should be determined so as to prevent littering.

4.6 Water Resources

This section describes the existing environment for water resources which may be affected by the TOT Project Site. An investigation of water and sediments within the TOT Project Site was conducted by C&R Consulting Pty Ltd (C&R) to identify environmental values and determine the quality and quantity of surface water, groundwater and sediment. The results of this investigation

are presented in the C & R Impact of the TOT on Water Quality of Cleveland Bay Report contained in Appendix 12 and are summarised here.

4.6.1 Description of Environmental Values

The environmental values of Cleveland Bay include the good chemical properties of the ambient waters and sediments. Existing water quality is generally compliant with the ANZECC Guidelines. However, at times, lead in these waters is inconsistent with these Guidelines. Given the flushing and chemical modelling undertaken during water quality investigations, it is expected that all waters discharged from the TOT Project Site will be consistent with ambient conditions. Therefore, water quality from the TOT Project Site will not impact on water resources and existing environmental values of Cleveland Bay.

4.6.1.1 Surface Waterways

As the site is located entirely in a marine environment, there are no surface watercourses with downstream water uses that will be affected by the TOT Project. Marine surface waters and coastal water quality within Cleveland Bay is described in Section 4.7.1.1 of this EIS.

4.6.1.2 Groundwater

A survey of groundwater within the TOT Project Site was conducted by C&R including sampling and analysis of water from three monitoring bores. The TOT Project Site is currently submerged beneath approximately 1 to 2m of sea water and groundwaters beneath this site are not used as water resources. Saline waters are present beneath the subsurface of the TOT Project Site and are too saline for any agricultural, stock waters or potable water uses. Neighbouring areas are either sea-bed or existing reclaimed areas and no use of groundwater occurs in these areas

Groundwater characteristics

The groundwater levels within the TOT Project Site fluctuate in response to daily tidal cycles, from a depth of -4 to 5m below current surface to -7 to 8m below this level. These levels are beyond those envisaged for excavation during the development and groundwater is therefore not expected to be disturbed during construction works. Groundwater recharge is almost exclusively from marine sources and the flow is generally south to north during outgoing tides with north to south flow during incoming tides.

Monitoring bores installed during this investigation will be regularly monitored for salinity, pH and turbidity during construction and operations to ensure existing water quality conditions are maintained. Monitoring will be undertaken on a weekly basis during construction, and a seasonal monitoring programme is proposed during operations. Monitoring data obtained from the groundwater survey indicates that the groundwater has marine characteristics and its composition will be similar to the average composition of marine bottom waters.

There is no existing use of these groundwaters and the sustainability of both quality and quantity are not an issue. Since excavation works will not intercept known groundwater aquifers, the physical integrity, morphology of subsurface flow paths and processes will not be compromised.

Pollution of the groundwater flow paths is highly unlikely as excavation will not intersect the shallow aquifers. During construction, any contamination to groundwater aquifers will be protected by control measures contained in the TOT Project EMP and the Construction Site-based Management Plan to be developed by the construction contractor. During operations, maintenance of efficient water flushing and annual dredging will ensure maintenance of good water and sediment quality. This will minimise the risk of groundwater pollution from water and sediment sources.

4.6.2 Potential Impacts and Mitigation Measures

There are no water resource uses indicated or planned for the marine waters of the Bay or the marine related groundwater system. The quality and quantity of surface waters will be maintained to ensure protection of downstream uses, marine biota and the littoral zone.

Investigations of water chemical properties and stormwater modelling indicate that even under worst case scenarios the water and sediment quality of the development will be consistent with ANZECC 2000 Water Quality and HIL-A Soil and Sediment Standards.

If water quality is maintained, then it is considered that all other environmental values will be protected. Thus, preservation of water quality by adequate flushing and maintenance dredging are vital to the viability of the TOT Project. Monitoring strategies involving continuous water monitoring during the construction phase is proposed. A mixture of continuous seasonal and event-based monitoring for water quality and annual monitoring for sediment quality, in association with the annual maintenance dredging is also proposed.

4.6.2.1 Surface Water and Water Courses

There are no watercourse implications for this TOT Project relating to water resources. Marine water within the TOT Project Site and that discharged from the site will be within ambient water quality ranges.

During construction, the waters discharged from the site will be continuously monitored for pH, salinity and turbidity. This will provide an indication of the potential impacts on seagrass areas adjacent to the TOT Project Site.

Studies of water chemical properties and stormwater modelling indicate that water and sediment quality will be maintained under worst case scenarios.

Water quality modelling results indicate:

- Water quality meets ANZECC 2000, 95% Species and Protection Guidelines of ambient ranges within the Bay or both
- Sediment quality meets Queensland HIL-A Guidelines.

As it is no longer proposed to undertake sand extraction within adjacent watercourses, there will be no hydrological impacts such as diversion of streams, scouring and erosion, changes in flooding regimes or modification of existing habitats. In addition, there are no fresh groundwater uses in the TOT Project Site as described above.

4.6.2.2 Groundwater

The potential of the TOT Project to contaminate the groundwaters is regarded as highly unlikely. Since it is also highly unlikely that any use will be made of the groundwater resource, the proposed TOT Project is also highly unlikely to have any impacts of groundwater sustainability, depletion or recharge. Regular weekly monitoring of groundwater bores for pH, salinity and turbidity will ensure that groundwater quality is maintained.

Given the nature of the development, the shallow depths of any excavation and that no extractive activities relating to groundwater will occur, it is highly unlikely that land disturbance will impact on local groundwater regimes by changing subsurface porosity and permeability conditions.

4.7 Coastal Environment

4.7.1 Description of Environmental Values

The value of coastal resources is determined by the quality of surface waters, sediments and groundwaters. Generally, water quality existing in and discharging from the TOT Project Site will be better than that required by the 95% ANZECC 2000 Species Protection Guidelines or will be consistent with current ambient water quality in Cleveland Bay or both.

4.7.1.1 Water Quality

Water quality data collected for this baseline study revealed a number of existing levels outside ANZECC Guidelines. Impact sites and control sites to the west of the Port Western Breakwater show very high levels of total Phosphorous often associated with above average metals levels in the waters.

Despite this, all water samples analysed were better than 95% ANZECC 2000 Guidelines or within currently existing ambient ranges or both. These results may be as a result of background processes such as variations in wind strength and direction. The existing water quality of surround marine waters and of the development area are given in the Water and Sediment Quality Report. In terms of physical and chemical characteristics:

- Water quality in the surrounding areas and within the development are consistent with either existing ambient water quality or 95% ANZECC Guidelines with respect to physical parameters, heavy metals, acidity and TPH/BTEX.

- Sediment quality within the waters of the TOT Project Area is consistent with the current ambient waters and Queensland HIL-A Soil Guidelines Criteria.

- Potential pollutants generally found in the area are those related to the operations of the Port of Townsville and those coming from the widespread activities of Townsville City itself. It is these sources that have combined to define the current ambient qualities of both waters and sediments in the Bay. Water and sediment quality within the TOT Project Site and into the Bay, have been modelled using PHREEQC (for metals and metalloids in waters and sediments) and MUSIC (for nutrients). These models have examined a range of first flush, stormwaters – marine water, mixes. Models included:

    - Total dissolution of dust settled after a nine month dry and minimal flush volume and

    - Total sedimentation, no dissolution, of this dust after a nine-month period.

In all cases, since the dust survey for the TOT Project only included particle size information, chemical species present in the dust were obtained from other studies undertaken outside this current TOT Project.

When modelled, even under worst case scenarios, contaminants and pollutants present in the flows from the TOT Project Site after a minimal first flush will, assuming adequate annual maintenance dredging:

- For water quality, meet ANZECC, 2000 95% Species Protection Guidelines or be within current ambient ranges or both

- For sediment quality, meet Queensland HIL-A Soil Guidelines

4.7.1.2 Coastal Processes

A Coastal engineering assessment has been conducted by Coastal Engineering Solutions to determine the coastal process relevant to the TOT Project Site. The Coastal Engineering Report is provided in Appendix 13 and is summarised here.

Hydrodynamics

Bathymetry

Cleveland Bay is approximately 15km wide and 15km long and faces northeast. Cape Cleveland forms the eastern boundary of the Bay and Magnetic Island forms its western boundary. Both of these topographical features play an important role in defining the wave climate, tidal hydrodynamics and ocean water levels on the foreshores and nearshore regions of Cleveland Bay. The Great Barrier Reef (GBR), which lies some 70km offshore, considerably attenuates the passage of ocean swell wave energy into the Bay.

At its seaward limit, Cleveland Bay is only some 12 metres deep and seabed approach slopes through the Bay to local foreshores are very flat. These flat approach slopes, in conjunction with the surrounding land features of Magnetic Island and Cape Cleveland, provide natural protection and wave energy attenuation for the TOT Project Site, particularly during cyclones. However, large waves can propagate into Cleveland Bay across the long, open northeast fetches. The amount of wave energy that reaches the shoreline is determined largely by the depth of water over the seabed approaches.

Ocean Water Levels

Astronomical Tides

The maximum possible astronomical tidal range at Townsville is 4.01 metres, with an average range during “spring tides” of 2.34 metres and 0.63 metres during “neap tides”. Spring tides tend to be higher than normal around the time of the Christmas / New Year period and also mid-year. These occurrences are often referred to in lay terms as “king tides”.

Variations in predicted astronomical tidal heights are primarily caused by strong or prolonged winds, and/or by uncharacteristically high or low barometric pressures. The occurrence of storm surges associated with tropical cyclones can also strongly influence ocean water levels.

Data on the frequency of occurrence of variations in ocean water levels has been used in design of physical infrastructure associated with the TOT Project Site to allow maximum utilisation under most operating conditions.

Storm Tide

The combination of astronomical tide and storm surge is known as storm tide. If the maximum surge coincides with a high spring tide, severe flooding of low lying coastal areas can occur and the upper sections of coastal structures can be subjected to severe wave action. The storm tide return periods determined for Townsville indicate the following ocean water levels associated with tropical cyclone occurrences (Refer Table 4.7.1).

Table 4.7.1: Water levels associated with tropical cyclones

Average Recurrence Interval (ARI)	RL to AHD without Climate Change	RL to AHD with Climate Change
20 years	2.25	2.55
50 years	2.40	2.70
100 years	2.50	2.84
500 years	3.07	3.51

Storm Tide Levels at Townsville (to AHD datum)

The *Townsville – Thuringowa Storm Tide Study* prepared by GHD Pty Ltd presents the estimated increase in total storm tide levels for selected return periods under an enhanced greenhouse scenario. At the Breakwater Casino site, the predicted increase is 0.4m.

Therefore, the 100 year ARI storm tide level applicable around the perimeter of the surplus casino land is RL+2.8m AHD under present day conditions; and RL+3.2m AHD in the year 2050 as a consequence of a sea level rise caused by future climate change. It is this later storm tide level of RL+3.2m AHD that is used for this assessment of inundation and overtopping of the proposed Resort Corp development by storm tide events. The 50 year ARI storm tide level around the perimeter of the surplus casino land is estimated as RL+2.6m AHD under present day conditions and RL+3.0m AHD in the year 2050.

Climate Change

Climate change as a consequence of greenhouse gas emissions is expected to cause changes to water temperatures, rainfall, sea levels, wind speeds and storm systems. If climate changes occur as predicted, the foreshores of the Townsville region will be subjected to potentially greater storm and cyclone activity, higher waves, stronger winds and increased water levels. There are significant uncertainties regarding predictions of the impact of climate change on sea level rise.

At the present time, the best analytical data seems to suggest that the global mean sea-level could rise by about 48cm (plus or minus approximately 40cm) between 1990 and 2100 (IPCC; 2001 and CSIRO; 2001 and NCCOE; 2004). The policy adopted by the Queensland Government with respect to building and engineering standards for maritime works requires an allowance for greenhouse induced sea level rise of 0.3 metres.

Wave Climate

Waves arrive in the nearshore waters around the TOT Project Site as a consequence of two phenomena, namely:

- distant sea waves generated by winds blowing across the open water fetches between the mainland and the outer GBR system; and
- local sea waves generated by winds blowing across the open waters of Cleveland Bay and the West Channel between Magnetic Island and The Strand/Rowes Bay foreshores.

Distant Seas

The GBR inhibits the open ocean swell generated by weather systems in the Coral Sea as this swell propagates to the mainland. Nevertheless, the significant distances between the mainland and the GBR means that sizeable waves can be generated by winds blowing across these fetches, particularly during cyclones.

To the northeast of Townsville there are very long open water fetches across which winds can generate significant wave energy. Waves from the southeast quadrant can diffract and refract around the northern tip of Cape Cleveland and propagate to the TOT Project Site.

Local Seas

Whilst the northerly and north-westerly fetches within the Bay are relatively short and shallow, they still enable substantial wave energy to be generated and propagate to the Port region, particularly during local cyclone events.

These waves will be critical to the design of the proposed new Strand Breakwater since it will be aligned almost perpendicular to these local sea waves as they approach and impinge on the structure. They will also play an important role in determining operational aspects of the entrance into the Breakwater Cove waterways, since this entrance also faces these local seas.

Geomorphodynamics

Littoral Processes & Historical Changes to Foreshores

There have been many changes to the physical environment of Townsville since European settlement, which have initiated changes to the local littoral transport regime. Original sediment yield from the Ross River has been variously estimated as being between 68,000 tonnes/year (Sinclair Knight Merz, 1996) and 330,000 tonnes/year (Belpario, 1978).

The subsequent development of the Townsville region has resulted in this natural supply of sand onto local foreshores being severely restricted. Sand that was previously within the active beach system began to redistribute itself, creating a pocket beach adjacent to the Port Western Breakwater. It is clear from an inspection of aerial photographs that this beach had reached a state of equilibrium by 1941.

The sand to create this pocket beach would have come from the central part of The Strand foreshore. Waves arriving from the north-easterly sector would have transported the sand alongshore to the southern end of The Strand beach compartment. However the new Port breakwaters created a “wave shadow” during south-easterly waves that prevented this sand being returned northwards to maintain a dynamic equilibrium in the planform of the beach.

The subsequent construction of the Kissing Point Pool effectively created a barrier to longshore sand transport around Kissing Point. A small amount of sand had accumulated to the southeast of the pool as a consequence of ambient wave conditions. However, the wave shadow cast by the Kissing Point Pool reclamation prevented sand being transported from this northern end of The Strand Precinct back towards the central and southern areas.

In other words, seasonal wave processes were transporting sand from the central portion of The Strand foreshore towards either end, from where it could not be transported back during subsequent seasons. This one-way feed of sand, in conjunction with the diminished supply from the Ross River entrance, resulted in the gradual erosion of the central sections of The Strand foreshore.

Foreshore protection works undertaken along The Strand achieved the objective of minimising sand loss. However, there are seasonal variations to shoreline orientation, which manifests itself as local erosion of sand in some locations that are balanced by local accretion at other locations.

Sedimentation and Turbidity from Dredging

Sedimentation rates within the Breakwater Cove waterways and the TOT berth pocket have been determined by modelling undertaken by Global Environment Modelling Systems (GEMS) and are described in Section 3.5. Impacts on receiving environments that may arise as a result of maintenance dredging and increased turbidity are described in Section 4.11. Strategies proposed

to mitigate these impacts are described in Section 4.11 and have been incorporated into the TOT Project EMP.

Dredge Material Disposal

Proposed methods for disposal of dredge spoil are described in Sections 3.4 (capital dredge spoil) and Section 3.5 (maintenance dredge spoil)

Sedimentation Rates

Sedimentation rates have been determined by modelling undertaken by GEMS to determine the requirements for maintenance dredging frequency and volumes. These results are outlined in Section 3.5.

Coastal Resource Values

The values of coastal resources are determined by water quality and sediment quality and have been investigated by C&R. The results of this investigation are reported in Section 4.6 and 4.7.1.

Marine Sediments and Sediment Quality

The quality of sediments within the TOT Project Site has been investigated by C&R and is reported in the Water and Sediment Quality Report. The results of this investigation are summarised in Section 4.6 and 4.7.1.

Local and Regional Coastal Processes

Mathematical modelling was undertaken to generate an understanding of the local wave climate in the vicinity of the TOT Project Site, both in terms of the ambient waves and extreme waves associated with cyclones and severe storms. Model predictions were verified by comparing them to actual measurements. The wave study is also being undertaken as input to a subsequent Sediment Transport module of the modelling process to determine potential implications to the orientation of existing beaches adjacent to the proposed development.

A suite of computer programs has been used to mathematically model the waves affecting the TOT Project Site including waves at inshore and offshore locations. Modelling of wave generation and transformation has been undertaken to determine offshore wave characteristics and the transformation of these waves through refraction, diffraction, shoaling, breaking and attenuation as they propagate towards the shoreline

The Design Storm Event

Townsville City Council requires that all foreshore developments must accommodate the 100 year Average Recurrence Interval (ARI) storm tide and associated wave effects. This is the storm tide level adopted by Council for managing development in this location, and therefore constitutes the Designated Storm Tide Event (DSTE) under the *State Coastal Management Plan - Queensland's Coastal Policy* (State Coastal Plan) policy 2.2.4. Furthermore, the requirements of the Environmental Protection Agency's (EPA) operational policy "*Building and engineering standards for tidal works - Version 1.2*" have been incorporated into the design of marine structures for the TOT Project Site.

The minimum acceptable standards for seawalls presented under Clause G of the EPA policy, states that seawalls must be designed to withstand wave and water level conditions associated with the 50 year Average Recurrence Interval (ARI) event. However, marine infrastructure associated with the TOT Project Site will be designed to accommodate the more severe 100 year ARI design storm event, which is the storm event to be used for storm tide hazard mitigation under State Coastal Plan policy 2.2.4.

When designing coastal defences it is necessary to consider the likelihood of both severe waves and extreme water levels occurring simultaneously. The assumption of complete dependence between waves and water levels in an analysis of joint occurrence would lead to a very conservative design since the 100 year ARI event would have to comprise a 100 year ARI storm tide level and a 100 year ARI wave height.

The approach adopted when developing structural concepts for the various perimeter seawalls and breakwaters of the TOT Project Site has been to consider the following scenarios as potentially constituting the 100 year ARI event, and to then select the one having the most adverse effect on structural performance:

- Scenario 1: 100 year ARI storm tide level occurring simultaneously with the 50 year ARI wave characteristics; or

- Scenario 2: 50 year ARI storm tide level occurring simultaneously with the 100 year ARI wave characteristics.

Offshore Wave Climate

Distant Seas - Ambient Conditions

In July 1975 the (then) Beach Protection Authority installed a wave recording station in the waters offshore of the Townsville region. This station is currently maintained and operated by the *Coastal Services Unit* of the EPA. This data provides important information on wave height and period offshore of Cleveland Bay.

Given the importance of wave direction to the subsequent transformation of offshore waves to inshore sites in the vicinity of the TOT Project Site, the data recorded during the deployment of the directional Waverider buoy has been used by the mathematical modelling process to investigate the ambient Distant Sea waves. During the four year dataset there were a number of significant weather events that resulted in offshore significant wave heights of 1.5m to 2m.

Distant Seas - Extreme / Cyclone Conditions

Cyclone wave information in the deep waters offshore of Townsville has been extracted from the data generated for the *Atlas of Tropical Cyclone Waves in the Great Barrier Reef* compiled by the Marine Modelling Unit (MMU) in the School of Engineering at James Cook University.

The resolution of the computational grid used for the simulation of tropical cyclones was 1,500m and a location in the deep water offshore of Cleveland Bay was investigated to provide the extreme offshore wave climate for this TOT Project.

A summary of the cyclone wave climate for the TOT Project Site is presented in Figure 3.1 in the Coastal Engineering Studies Report contained in Appendix 13. This figure demonstrates that significant wave heights of approximately 7.1 metres (or greater) occur on a long-term average once every 50 years. If a TOT Project life of 50 years were assumed, there is an 85% chance of encountering waves in the waters offshore of Cleveland Bay which are equal to or greater than 6.0 metres at least once during any 50 year period.

The extreme wave climate in the deep waters offshore of Cleveland Bay is summarised in Table 4.7.2.

Table 4.7.2: Extreme wave conditions for distant seas offshore of Cleveland Bay

Wave Parameter	50 year ARI	100 year ARI
Significant Wave Height (H_s)	7.1 metres	8.0 metres
Peak Period (T_p)	9.5 secs – 11.5 secs	10.5 secs – 12 secs
Mean Wave Direction (θm)	All between bearings of 30º to 120º	

Local Seas Ambient Conditions

Hindcasts for waves generated by winds blowing across local Cleveland Bay fetches have been produced using standard mathematical techniques. This requires the use of directional wind data - as measured by the Bureau of Meteorology (BOM) at anemometer sites. The wind data selected as being most representative of the conditions for wave hindcasting across Cleveland Bay fetches was that recorded at the BOM's Lucinda AWS station.

It is acknowledged that the location of the Lucinda instrument is some 90kms north-west of Townsville, however the shoreline is similarly orientated and a reasonable representation of sea breeze effects is expected. The scale of the synoptic systems that generate the winds that arrive at the Lucinda site and at Cleveland Bay is such that the wind fields are expected to be similar at both coastal locations. The fetches across which Local Seas are generated are presented in Table 3.2 in the Coastal Engineering Studies Report contained in Appendix 13

Because the Local Seas generated by ambient winds can occur in conjunction with Distant Seas, the wind speeds and directions recorded three-hourly by the anemometer at Lucinda over the same timeframe as the Waverider measurements of Distant Seas have been used to establish a wave database over this same 4 year timeframe. Some 10,730 sequential wave records (each consisting of the offshore wave height, wave period and wave direction) therefore make up the complete time series of hindcast Local Sea wave events.

Local Seas - Extreme / Cyclone Conditions

Determination of the winds associated with cyclone events having 50 year and 100 year ARI occurrences has been used in determining the extreme wave conditions associated with Local Seas.

The 10 minute-averaged wind speeds of 42 m/sec and 45 m/sec stated in a study of cyclone intensity by Blain Bremner and Williams (1984) have been used to hindcast the extreme waves for Local Seas in the vicinity of the TOT Project Site by applying them across each of the local fetches of Cleveland Bay. The resulting extreme waves associated with Local Seas are summarised in Table 4.7.3.

Table 4.7.3: Extreme wave conditions for local seas offshore of Cleveland Bay

	50 year ARI		100 year ARI	
Direction (degrees True North)	H_s (metres)	T_p (seconds)	H_s (metres)	T_p (seconds)
330	1.78	6	1.86	6
340	1.78	6	1.86	6
350	1.49	5	1.56	5
360	1.48	5	1.55	5
10	1.46	5	1.54	5
20	1.50	5	1.57	5
30	2.05	7	2.14	7
40	2.83	7	2.98	7
50	2.85	7	3.00	7
60	2.29	7	2.40	7
70	2.28	7	2.38	7
80	1.80	6	1.88	6
90	1.24	6	1.29	6
100	0.92	5	0.95	5
110	0.92	5	0.95	5

Nearshore Wave Climate

When considering how Local and Distant Seas are affected as they propagate shoreward, it is necessary to consider the processes of wave refraction, diffraction, seabed friction, shoaling and wave breaking. These wave transformation processes are replicated by application of the various mathematical modelling techniques.

The wave climate in the nearshore waters around the TOT Project Site has been determined for the pre-development and post-development scenarios to identify any impacts that the proposed development may have on the wave climate of adjacent foreshores and to provide wave information to assist in the design of marine/foreshore infrastructure associated with the TOT Project.

Methodology for Modelling Wave Transformation to Nearshore Areas

The program *CES350* is used to determine the wave refraction and wave shoaling effects as waves propagate shoreward from the deep waters beyond Cleveland Bay into the nearshore waters surrounding the TOT Project Site.

An extensive computational grid arrangement has therefore been established to schematise the form of the seabed over which waves can propagate. The spacing within adjoining grids is variable with a fine spacing used in areas of complex or rapidly changing bathymetry and a wider spacing where the seabed is relatively flat and unchanging.

The grid systems established for this study cover the entire nearshore waters of Cleveland Bay from northwest of Magnetic Island, to near Cape Ferguson in Bowling Green Bay to the southeast. They extended out into the deep waters between the mainland and the Great Barrier Reef (refer to Figure 3.2 in the Coastal Engineering Studies Report in Appendix 13).

The wave transformation program CES350 tracks wave orthogonals across the computational grid from selected nearshore locations out into deep water. A wave orthogonal is basically a "ray" drawn perpendicular to the alignment of the wave crests which defines the approaching path of the wave. Each ray depicts the reverse path that a wave orthogonal takes between deepwater (the generation area) into each selected nearshore site.

The reverse rays from sites in the vicinity of the TOT Project Site tracked out across the approaches to the Port area through Cleveland Bay across the open water fetches of the northeast and the east/southeast sectors into the deep water where the offshore wave climate was determined by the Wave Transformation Module.

Ambient Conditions

The ambient wave climate in the Townsville region consists of Distant Seas and Local Seas, which can co-exist at any particular time.

Distant Seas

The Distant Sea hindcast data for modelling ambient wave conditions were recorded by the EPA's directional Waverider off Cape Cleveland. Offshore wave conditions for the Waverider records are modified by the Wave Transformation Model in accordance with the relationships determined by the reverse ray modelling. This has been undertaken for various nearshore sites under investigation. The outputs for each nearshore site consist of wave data files for Distant Seas, each containing the four year long wave data set (of 53,777 records).

Local Seas

The Local Sea hindcast data for modelling ambient wave conditions also consists of a time series of offshore wave conditions over the same period from 12 October 2000 to 28 September 2004 as that determined for the Distant Sea database. The offshore wave conditions have been modified by the Wave Transformation Model in accordance to the relationships determined by the reverse ray modelling. This has been undertaken for various nearshore sites under investigation. The outputs for each nearshore site therefore consist of wave data files for Local Seas, each containing the approximate four year long wave data set (of 10,730 records).

Extreme / Cyclone Conditions

The extreme wave climate in the Townsville region also consists of waves generated as either Distant Seas or Local Seas. These large waves typically occur as a consequence of an extreme synoptic event such as a cyclone. Therefore, unlike ambient conditions, extreme wave conditions will occur as either Distant Seas or as Local Seas that is their most adverse wave conditions will not co-exist. This is because the maximum winds associated with the particular cyclone event will be such that they will affect open water fetches that result in either Distant Seas or Local Seas being the dominant wave source at any particular time.

Table 4.7.4 presents the extreme wave characteristics at locations around the perimeter of the TOT Project Site for the two designated storm tide scenarios described under Design Storm Event.

Table 4.7.4: 100 year ARI design wave conditions for the TOT Project Site

Structure	Design Parameter	Scenario 1	Scenario 2
Northern Breakwater	Significant Wave Height (H_s)	2.35 metres	1.84 metres
	Peak Period (T_p)	10 to 11 secs	11 to 12 secs
	Storm Tide Level (to AHD)	RL+2.84m	RL+2.70m
Strand Breakwater	Significant Wave Height (H_s)	1.7 metres	1.8 metres
	Peak Period (T_p)	6 secs	6 secs
	Storm Tide Level (to AHD)	RL+2.84m	RL+ 2.70m

4.7.2 Potential Impacts and Mitigation Measures

The BICA Act has determined that the issuance of the Term Leases required for the reclamation and freehold of the Project Site (as discussed in Section 3.7 of this EIS) are the most appropriate tenure and use of the land to facilitate the TOT Project uses under the *Coastal Protection and Management Act 1995*. At the time of drafting this EIS, no Regional Coastal Management Plan exists for the greater Townsville coastal area under the *Coastal Protection and Management act 1995*. However, the Proponent has considered the relevant policies of the State Coastal Management Plan 2001.

The purpose of the State Coastal Management Plan is for the protection and management of Queensland's coastal resources in relation to their ecological, economic and social values. The Plan however acknowledges that urban areas such as the highly modified surrounding environment to the Project Site mean that the principles of the State Coastal Management Plan have lesser application to those areas of coastline predominantly in their natural state.

The State Coastal Management Plan identifies 10 coastal management issues and proposed principles and policies for their management, all of which have been considered within this EIS process.

State Coastal Management Plan Issue	EIS Response to Principles and Policy
Coastal Use and Development	**Areas of State Significance (Social and Economic):** As the TOT Precinct is intended to be Strategic Port Land, it falls within the policy requirements to identify and protect the integrity and function of the TOT Precinct as an area of State significance (social and economic) for the purpose of coastal management. **Settlement Pattern and Design:** The provision of new infrastructure pursuant to the policy promotes consolidation of urban areas. The overall TOT Project is sited within the conjunction of existing Port and the major CBD urban area of Townsville and consolidates the existing urban footprint. **Coastal-dependent land uses:** As identified in Section 1.6 of this EIS, the Project Site has long been identified for development of a Coastal dependant land use. The TOT Project provides economic and social opportunities with benefits to the community (see Sections 4.13 and 15 of this EIS)

	Canals and Dry Land Marinas: In accordance with the policy that further development of canals should not proceed unless effects on coastal resources and values are assessed, this EIS process fully discusses and identifies all potential impacts and mitigation measures for assessment. **Maritime Infrastructure:** This policy fully supports the provision of the TOT Precinct as a public facility with significant economic benefits to the State being located in this coastal environment. The State Cruise Shipping Plan demonstrates the public need for the TOT Project and the integrated residential development provides the economic consideration to allow this major piece of maritime infrastructure to occur with no net loss of public access to the coast or significant adverse impacts on coastal resources or their values. **Dredging:** As discussed in Section 3.5, 4.6 and 4.7 of this EIS, the capital and maintenance dredging activities proposed maintain the ability for use of the TOT Project, maintain water quality objectives for the proposed development and do not have any significant adverse impacts on coastal processes, fisheries or coastal habitats. **Reclamation:** As identified in Section 2.3 of this EIS and due to the specific coastal dependent nature of the Project, this EIS demonstrates that there is no alternative site available to create the TOT Precinct. The reclamation can be undertaken in a co-ordinated manner without significant adverse impacts on coastal resources and their values. **Tourism and Recreational Activities:** The TOT Project increases the diversity and quality of recreational and tourism facilities within Queensland particularly in relation to the significant Cruise Shipping infrastructure being created, while ensuring that the coastal resources and their values, upon which these experiences rely, are protected. The TOT Ptoject supports the overall State Cruise Shipping Plan in terms of the economic benefits of this tourism facility.
Physical Coastal Processes	As identified in Sections 3.4, 4.1 and 4.7 of this EIS, the proposed development specifications and construction methodology has taken into account climate change, extreme climatic events such as cyclones and storm surge and all other relevant matters to ensure that changes to coastal processes are taken into account for the

	future.
Public Access to the Coast	The TOT Project replaces by the Strand Breakwater, public access lost from the existing Western Breakwater. The Project provides a significant waterside parkland area and improves the availability of the public to access commercial and restaurant facilities adjoining the Marina environment.
Water Quality	Section 4.6, 4.7 and 4.2 of this EIS and the attached technical reports identify that all potential impacts in relation to water quality management, waste water discharges, stormwater management, groundwater, acid sulphate soils and waste disposal can be adequately mitigated to satisfy this issue.
Indigenous Traditional Owner Cultural Resources	All matters of indigenous cultural heritage have been resolved with the traditional owners as discussed in Section 4.12.
Cultural Heritage	The project site does not hold any cultural heritage significance as discussed in Section 4.12.
Coastal Landscapes	Visual Amenity impacts of the Project on the existing Project Site area which is adjacent to an active industrial port environment and the Townsville urban area have been discussed in detail in Section 4.11 of this EIS.
Conserving Nature	The detailed Nature Conservation study contained in Appendix 19 and summarised in Section 4.11 of this EIS indicates that the overall TOT Project can be undertaken with appropriate mitigating measures to ensure no significant adverse impacts on the surrounding natural environment.
Coordinated Management	Development of this Project has been undertaken with detailed consultation at both Local Government, State and Federal level as discussed in Section 1.5 and 1.6 of this EIS.
Research and Information	Throughout the EIS process the Proponent and its technical consultant team have both utilised existing research and data and undertaken independent and site specific investigations for the collection of specific information to support this EIS. The EIS has specifically investigated coastal processes, environmental values and other matters that may be of relevance to the wider scientific community and increase local knowledge of the surrounding environment.

The TOT Project is therefore consistent with the principles and policies outlined for the major issues discussed within the State Coastal Management Plan 2001 to the extent required by the provisions of BICA Act.

4.7.2.1 Water Quality

Water and sediment quality within the development will be maintained and achieved by adequate flushing and annual maintenance dredging. Standards of the water quality will be consistent with existing ambient water quality or ANZECC, 2000 95%, Species Protection Guidelines or both. Water quality parameters will be:

- Monitored during construction by five continuous water quality monitoring station sited strategically around the perimeter of the site. In the event that turbidity, pH or salinity exceeds Investigation levels, investigations shall be carried out to ascertain and rectify causes of the non-compliance.

- Intervention levels will be set as listed in the Water Quality Report and Table 4.4.2.3. In the event that intervention levels are exceeded, all work on the site will cease until the causes of the non-compliance are rectified.

- During construction auditing will be carried out by full, real-time observations of the outputs from the continuous monitoring stations. Levels will be assessed against recommended guidelines.

- Management of water and sediment quality issues during the construction phase will be fully documented in the Construction Site-based Management Plan to be prepared by the construction contractor. Management decisions during construction will be on the basis of real-time monitoring data, audited against the recommended investigations and intervention levels

- During operations, monitoring will be undertaken for water quality parameters from three continuous monitoring stations strategically sited. Parameters measured and assessment levels used will be as for the construction phase.

- As during construction, auditing during operations will be carried out by real-time observations against recommended Guidelines levels.

- For water and sediment quality to be maintained, annual maintenance dredging will be undertaken to ensure adequate flushing is achieved. At the time of this annual maintenance dredging full, multi-element chemical analysis will be undertaken on a number of sediment samples together with comprehensive analysis of co-existing waters by the Marina Lot Operator, in accordance with the contractual obligations discussed in Section 3.7 of this EIS..

- Current ambient water quality in the Bay, is, variable and is not always consistent with ANZECC, 2000 and QUEENSLAND 2006 Water Protection Guidelines. A series of investigation and intervention levels have been proposed in the Water and Sediment Quality Report. All waters discharging from the TOT Project Site will be better than 95% Species Protection Guidelines or current ambient levels or both. All sediments accumulating in the development will be consistent with QUEENSLAND HIL-A Soil Guidelines.

Potential impacts on water and sediment quality to the surrounding waters associated with construction and operations are discussed above and in the Water and Sediment Quality Report. These impacts and mitigation measures will include:

- During construction, dewatering activities will be such that turbidity levels of the discharge are kept to below + 10% ambient at the discharge points. These discharge points will be systematically shifted every 3-5 days to ensure points of impact are spread out rather than

being concentrated in particular zones. The preferred sites for the majority of the dewatering discharge lie along the northern breakwater. All discharge points will be sited to, as far as possible, avoid areas of obvious seagrass, to be determined pre construction to ensure best possible environmental outcomes.

- Dredging will occur annually to ensure adequate flushing is maintained. The dredge spoil obtained will be fully assessed chemically to ensure safe disposal. It is believed that all sediment will meet HIL-A standards. In any land disposal adequate bunding will be employed to ensure dewatering of the spoil will not cause any contamination or acidity problems.

- Release of contaminants from marine structure and vessels, including anti-foulant coatings will be managed as specified in an Operations Management Plan. Detailed chemical analyses of the sediments will be undertaken associated with the annual maintenance dredging.

- Stormwater run off from developed areas has been fully assessed using PHREEQC and MUSIC modelling incorporating dust compositional water. These studies indicate waters in and discharging from the development will meet water and sediment quality objectives with exiting waters being within 95% ANZECC Species Protection Guidelines or ambient ranges in the Bay or both.

- The accumulation of nuisance / harmful algal blooms will be avoided by adequate flushing.

- Maintenance of adequate flushing will be achieved by annual maintenance dredging. Flushing and chemical modelling indicate that turn-over times and nutrient levels are such that algal blooms should not be a problem providing adequate flushing is maintained.

- Strategies to limit impacts to acceptable levels include:

    - Detailed physical and chemical modelling

    - Annual maintenance dredging to ensure adequate flushing

    - Continuous real time monitoring of waters

    - Detailed regular monitoring of both sediments and co-existing water

    - Best practices documented in both Construction and Operations Management Plans

All data indicate that all aspects of current ambient water and sediment quality will be maintained if adequate annual maintenance dredging occurs. This will ensure that water and sediment quality meets the defined objectives and that:

- Water quality is better than 95% ANZECC, 2000 Species Protection Guidelines or within current ambient ranges or both

- Sediment quality remains at current ambient value and within HIL-A Soil Guidelines criteria.

Potential impacts on adjacent fisheries habitat will be ameliorated by:

- During construction, dewatering is undertaken in an environmentally sensitive manner involving both a regular shifting of the discharge points and suitable siting of such discharge points to minimise the exposure of seagrasses to continuous levels of elevated turbidity.

- During operations, all sediment and water quality objectives being achieved and maintained by annual maintenance dredging to achieve adequate flushing.

Thus, from the perspective of water quality it is considered that the water quality flushing from the development will have little or no effect on that already existing in the Bay. This conclusion is based on a range of worst case scenarios.

Generally, the sediment quality already existing within the development area and within the Bay is either of marginally lower quality or within sediment quality guidelines and ocean dumping guidelines. Also in the vast majority of cases the sediment quality is better than HIL-A Guidelines. These levels will not deteriorate as a result of the TOT Project and the material used to create the land for the construction will be better than HIL-A criteria (normal urban residential). Levels for critical analytes within the existing sediments are given in the Water and Sediment Quality report.

Given the quality of the water and sediment flushed from the TOT Project Site and the regime of annual maintenance dredging, there will be no harm to existing environmental values. All existing values relating to water and sediment quality will be maintained.

As discussed in detail in the Impact of TOT on water Quality of Cleveland bay report and the nature Conservation Study contained in Section 7, Appendix 12 and 19 respectively, as sediment and water quality will be within ambient ranges currently existing in the Bay, there will be no additional cumulative impacts on the environmental values caused by the TOT Project either in isolation or combination with other known existing or planned sources of contamination.

The environmental protection objectives of the TOT Project are to ensure that the relatively high water quality and sediment quality currently present in the impacted aqueous environments of the Bay are maintained. This can be achieved by regular monitoring. The data obtained from the monitoring program will then be assessed against the existing sediment quality and the recommended investigation levels given for water quality in the Water and Sediment Quality Report. These levels are based on both existing ambient levels and generally, the 95% ANZECC 2000, Species Protection Guidelines.

Details of environmental protection objectives relating to water and sediment quality including:

- Environmental elements and values affected and impacted
- Cumulative impacts on environmental elements and values
- Indicators to be assessed and criteria to be used
- Monitoring and auditing programs proposed
- Quality control assessment,

are given in the attached report.

Water quality and flushing of the adjoining existing Breakwater Marina has also been considered by the operating Proponent, City Pacific Limited as the owner of that facility through a subsidiary company entity. The open bridge design in the Strand Breakwater further expands the opening of the existing marina to Cleveland Bay from the current entrance width and the Proponent is satisfied that the management and monitoring criteria proposed as also suitable for that facility.

It should be noted that since the water and sediment quality will be within current ambient or guideline levels, it is considered that additional impacts of environmental values will not occur. However, to ensure that the likelihood of impact is minimised during both the construction and operations phases of the development, a program of water and sediment monitoring will be undertaken to ensure all current appropriate environmental protection criteria are maintained.

4.7.2.2 Coastal Processes

Impacts on Hydrodynamics

The Strand Beaches

In order to identify any impacts of the proposed development on the ambient wave climate along The Strand beaches, the wave transformation modelling was undertaken for three near shore sites representing the northern, central and southern sections of The Strand foreshore. Both the existing and post-development scenarios were modelled at each location at average high tide of RL+2.8m AHD, approximately Mean Sea Level of RL0.0m AHD, and at an average low tide of RL-0.8m AHD.

The results indicate that the substantial reclamations associated with the Breakwater Casino and the Townsville Port that currently exist to the immediate south of The Strand foreshore provide varying protection to The Strand beaches.

In particular, the existing breakwater that extends to the west from the Port entrance (and which will form part of the new Northern Breakwater for the TOT Project Site) creates a "wave shadow" on The Strand foreshore. The wave shadow is an area of reduced wave energy. This existing breakwater therefore strongly influences the wave climate on The Strand beaches. It consequently also affects the performance of these beaches since it is the prevailing waves which shape this foreshore.

Given that the proposed TOT Project Site will involve extension of the existing breakwater, the wave shadow will reach further north along The Strand foreshore than it does currently. The proposed dredging of an access channel and turning area into the new Breakwater Cove waterways will also affect the way in which incoming waves will sweep around this lengthened structure.

The results of the wave modelling also indicate that the incoming waves within the wave shadow south of around Burke Street headland tend to be refracted such that they arrive at The Strand foreshore on a more northerly approach. This will have implications to the orientation of the beaches along these southern reaches with a subtle change in the plan alignment of the foreshore in response to the changed wave directions.

There are negligible changes to the height and direction of waves arriving at the northern end of The Strand Beaches as a consequence of the proposed development.

Existing Port of Townsville

Given that the main entrance into the main Port of Townsville is in the vicinity of the proposed TOT Project Site, there is the possibility of altered wave conditions at the Port entrance. This was investigated by consideration of the wave coefficients and inshore wave directions at a location in the centre of the Port entrance. Both Distant and Local Sea waves were considered for the predevelopment and the post development scenarios.

The results show that there is negligible change to the height and direction of incoming Distant Seas and Local Seas at the existing Port entrance as a consequence of the proposed development. The frequency of occurrence of wave heights for both the pre-development and the post-development conditions has also been determined. The results indicate negligible change to the wave energy at the Port entrance as a consequence of the TOT Project Site.

Summary of Impacts on Local Wave Climate

The proposed TOT Project Site will have the following impacts to the local wave climate:

- The southern reaches of The Strand foreshore will experience lower waves and therefore have a more sheltered wave energy environment than at present. This effect will diminish further northward along these beaches with negligible impact at their northern end.

- Whilst the incoming waves on the central and southern reaches will be less, they will tend to arrive with a more easterly alignment, resulting in realignment of local beaches. This subtle readjustment of the beach will likely manifest itself as erosion of sand from one area and deposition in another.

- The sheltering of waves experienced along the central and southern sections of The Strand foreshore is caused primarily by the new Northern Seawall being longer than the existing breakwater, with its offshore end being some 225 metres further to the west-north-west.

- The wave energy currently arriving at the existing Port entrance will not be significantly altered by the proposed development.

Sediment Transport Processes

The various orientations of adjacent foreshores are in response to the prevailing wave climate, subtle shifts in the approach angle of the waves can result in changes to the alignment of adjacent beaches, which can result in local erosion, typically accompanied by accretion elsewhere.

In addition to the possible changing plan orientation of adjacent foreshores, the waves can reprofile the beach slope itself. The large waves and elevated water levels normally associated with storms and cyclones result in the beach being eroded. Sand is typically removed from the upper regions of the beach slope and deposited in sand bars further offshore.

Modelling Methodology

Longshore Sediment Transport

The QUEENSED mathematical model was used to assess the longshore sediment transport potential, the equilibrium beach-plan alignments and the seasonal rotations of beach-plan alignments along coastal reaches. This model uses the output from the Wave Transformation Module to determine sediment transport rates.

The model is also used to compute the extent of likely seasonal rotations within contained beach compartments/reaches on The Strand for both existing and post-development conditions. It is also used to determine the equilibrium beach angle that is the local plan alignment of the beach for which there would be no net longshore transport. This later information is vital when determining the influence of the proposed works on stable plan alignment of these adjacent foreshores.

Onshore / Offshore Sediment Transport

To determine any impacts of the proposed new works on adjacent foreshores during storm and cyclone conditions, the numerical model SBEACH has been applied. This model is a numerical simulation model of cross-shore beach, berm, and dune erosion produced by storm waves and elevated ocean water levels.

SBEACH incorporates a detailed description of breaking wave transformation and sediment transport across the beach profile, especially near the breakpoint. The model approximates the equation for conservation of sand in finite difference form - with vertical changes in water depth determined by horizontal gradients in sediment transport rate. It is therefore suited to simulating offshore sand bar formation and evolution. It also allows for the placement of a seawall in the active beach zone to investigate localised scour or accretion as a result of such a structure.

Verification of the Model

In order to verify the predictions of the model, the Wave Transformation and Sediment Transport modules were applied to three beaches within The Strand coastal reach. The model predictions of the preferred alignment for each location were then compared to the actual alignments. The locations selected included the beach alignments within the following compartments:

- Site 1 - between the headland at Stuart Street and Kissing Point;
- Site 2 - between the headlands at Bourke and Gregory Streets; and
- Site 3 - between the headland at Gregory Street and the marina.

The results indicate that the model predicted the actual beach alignments very well and can be used with confidence to predict the impacts on the alignment and stability of these beaches.

Impacts on The Strand Beaches

One of the expected impacts of the proposed development is the reduction and realignment of the wave energy propagating onto the southern reaches of The Strand foreshore. This will manifest itself as some localised realignment of the beach in this area. The extent of this induced change to the plan orientation has been investigated using mathematical modelling techniques.

The results of the Wave Transformation process indicated that the proposed lengthening of the existing breakwater to create the new Northern Breakwater, in conjunction with the proposed dredging of the new access channel entrance into Breakwater Cove, will result in some changes to the directional wave climate along the central and southern sections of The Strand foreshore.

This will induce changes to the orientation of the beaches in this location. The effects decrease with increasing distance from the southern end of The Strand. The following discussions relate to the various beach Precincts along The Strand inshore of these locations.

Mariners Peninsula - Gregory Street Headland

Being immediately adjacent to the significant reclamations that have been undertaken to create the Breakwater Casino and the Port of Townsville, this coastal reach is already somewhat protected from those Distant Sea waves entering Cleveland Bay and propagating to shore. The main exposure is to the Local Seas that propagate to this foreshore across the open water fetches to Magnetic Island.

The results of sediment transport modelling predict that the stable plan alignment along the section of this foreshore nearest the Gregory Street headland will realign itself so as to face some 0.5º more northwards (i.e. a very slight “anti-clockwise” rotation in its plan alignment). This very minor realignment of the naturally preferred plan form of the beach will occur through the transport of sand from this area by the changed wave conditions towards the southern end adjacent to Mariners Peninsula.

This readjustment and movement of sand will manifest itself as a slight narrowing of the beach width in the area south of the Gregory Street headland and the widening of the beach at its southern end.

This minor erosion will be accompanied by accretion of the same beach further south and as such there will be no net loss of sand from the beach Precinct. It is anticipated that the beach against the southern side of the Gregory Street headland will gradually migrate to a stable position that is only some 2m inland from its present location.

This will taper back to its approximate current position some 80 to 100m further southward towards Mariners Peninsula. This recession will not threaten the pathway that currently provides access to the beach from the southern side of the Gregory Street headland.

The impacts on this beach compartment are therefore minor. They will not threaten any foreshore infrastructure and will not adversely affect the beach amenity.

Gregory Street Headland - Burke Street Headland

This beach compartment will experience the greatest changes to the naturally preferred stable plan alignment. Nevertheless this is only entails a minor realignment of the stable plan position. Such realignment occurs because under the pre-development condition the wave shadow caused by the existing Northern Breakwater tends to diminish near the southern end of this compartment - but under the developed scenario, the shadow extends further northward to encompass most of this beach.

In addition to having reduced heights, the incoming waves also arrive at this foreshore from a slightly more northerly direction. This directional rotation will induce a corresponding realignment of the beach between these two headlands as it rotates in plan to align itself with the changed wave energy regime.

Calculations of the longshore sediment transport indicate that to achieve its stable alignment (of zero net annual longshore transport) the beach will realign itself by rotating some 0.75º more northwards (i.e. an “anti-clockwise” rotation in its plan alignment). Sand will gradually be moved by the prevailing waves from the northern end of the beach to its southern end against the northern side of the Gregory Street headland. The beach at the northern end of this compartment will recede by approximately 2.5m to attain its stable orientation with regard to incoming wave energy. A compensating accretion will occur against the Gregory Street headland and there will be no net loss of sand from the beach compartment.

The impacts on this beach compartment are therefore minor and will not threaten any foreshore infrastructure, nor adversely affect beach amenity.

Burke Street Headland - Stuart Street Headland

The wave shadow created by the existing breakwater near the Port entrance does not have a strong influence on this length of The Strand foreshore, as its effect is focussed on the foreshore to the south. The proposed extension of the Northern Breakwater will cause the influence of the shadow to migrate towards this compartment, nevertheless its effect will still be reasonably diminished this far north along The Strand foreshore.
The calculations of longshore sediment transport show that a new stable beach alignment will be some 0.5º further northward. This reorientation of the beach plan form will manifest itself as removal of sand from the northern end of the compartment and placement at its southern end. The recession of the northern end is predicted to be approximately 1m. However it is unlikely that the changed beach alignment will be visually detectable given the natural seasonal fluctuations to the beach alignment that presently occur.

Stuart Street Headland - Kissing Point

This is a long beach compartment stretching some 575m along The Strand foreshore. Calculations of the wave climate and the sediment transport regime along this beach Precinct indicates no detectable effect on the existing foreshore alignment.

Precinct

Timescales for Changes

The timescale of the adjustment to the various beach alignments will depend significantly upon the severity of future ambient wave conditions. However based on average conditions this is expected to take some 1 to 3 years to eventuate once the Northern Breakwater is extended and the access channel and entrance into the Breakwater Cove Precinct are dredged.

Performance of Breakwaters and Entrance Channel

Design Methodology

There are a number of permanent marine structures within the proposed Townsville Ocean Terminal TOT Project which rely on rock armouring to maintain their structural integrity. These being:

- The existing breakwater facing northeast directly out to Cleveland Bay, which will serve as a seawall when land is reclaimed immediately behind this structure (termed herein as the *Northern Seawall*);
- A new western breakwater along the northwest perimeter of the Breakwater Cove waterways (termed herein as the *Western Breakwater*);
- Revetments within the Breakwater Cove waterways.

It is important to appreciate that the following discussions and determination of structural concepts for rock armour works are preliminary and therefore will need to be confirmed by a more rigorous detailed engineering design and documentation phase prior to construction.

The intent of the subsequent detailed design phase is to utilise physical modelling techniques to determine the most appropriate structural arrangements.

Physical modelling is often used by the coastal engineering profession to design maritime structures. It involves the construction of scaled models of coastal structures to precise scaling laws of fluid dynamics, which are then subjected to scaled waves and/or currents to test and improve their structural performance.

Unlike analyses by mathematical means, physical model testing offers the opportunity to replicate the specific conditions associated with each individual component of the Townsville Ocean Terminal TOT Project. Important parameters such as the local wave spectrum (wave heights, periods, etc.), storm tide levels, wave setup, cyclone/storm durations, seabed approaches, rock sizes and densities, etc. can all be incorporated into the physical model.

Its performance can then be investigated and its design confidently optimised by tailoring it to the specific conditions of the site. This avoids the otherwise high costs that would be the consequence of an over-designed structure, or an under-designed structure.

However, the complexity and cost of physical modelling is only warranted during the detailed engineering design phase of TOT Project implementation. As a step towards this later stage, preliminary designs for the rock armouring works have been prepared using mathematical calculations. It is expected that the subsequent physical modelling of these preliminary designs will result in optimisation of their various components (eg. rock sizes, layer thicknesses, etc.) but the overall structural concepts will remain unchanged.

Various methods for calculating the size of rock armour under wave attack have been proposed by coastal engineers in the past few decades. The decision as to which mathematical technique is the most appropriate has been the subject of much deliberation, however most practitioners are

now generally agreed that the formulae developed by Van der Meer (1988) are the most appropriate. They are based upon an extensive series of model tests conducted at Delft Hydraulics, which included a wide range of core / underlayer permeabilities and incident wave conditions.

These *Coastal Engineering Studies* for the Townsville Ocean Terminal TOT Project have utilised design methodologies based on the formulae of Van der Meer when determining the structural requirements and the performance of rock armoured works.

The requirements of the Environmental Protection Agency's operational policy "*Building and engineering standards for tidal works - Version 1.2*" have been incorporated into the design of these various rock structures. Of particular relevance are the minimum acceptable standards for seawalls presented under Clause G of that policy. Some comment with respect to the application of the standards in Clause G to the proposed Townsville Ocean Terminal structures is therefore appropriate

Design Storm Event

The EPA's policy states that seawalls must be designed to withstand wave and water level conditions associated with the 50 year ARI event. Marine infrastructure associated with the TOT Project Site will be designed to accommodate the more severe 100 year ARI design storm event since the Designated Storm Tide Event required at this location under the State Coastal Plan policy 2.2.4 for storm tide hazard mitigation is the 100 year ARI event.

As discussed, the approach adopted when determining structural concepts for the marine works of the Townsville Ocean Terminal TOT Project has been to consider the following scenarios as potentially constituting the 100 year ARI event and to then select the one having the most adverse effect on structural performance:

- Scenario 1: 100 year ARI storm tide level occurring simultaneously with the 50 year ARI wave characteristics; or

- Scenario 2: 50 year ARI storm tide level occurring simultaneously with the 100 year ARI wave characteristics.

Calculations of rock armour requirements and structural performance of all exposed rock armour indicates that it is the former scenario which results in the greater impact on the structures. Consequently Scenario 1 for the 100 year ARI Designated Storm Tide Event has been used to prepare preliminary designs for the rock armour works

Overtopping

The EPA policy states that overtopping by waves is permitted but the design must be such that the structural stability of the wall is unaffected. The *Coastal Engineering Studies* have specifically investigated overtopping performance of all armoured works under both the 50 year ARI and 100 year ARI scenarios.

This has resulted in providing some additional armouring in the crest of the main Northern Breakwater. Elsewhere the crest levels on structures have been designed to either be high enough to prevent any adverse overtopping, or an armouring arrangement has been implemented to accommodate overtopping.

Toe of the Structure

The EPA policy requires that the toe of the structure be designed to accommodate potential long term erosion for at least 50 years. This has been incorporated into the designs by application of appropriate toe scour protection where necessary. All rock armoured structures are founded below the level of the Lowest Astronomical Tide as required by the EPA policy.

Water Levels

The EPA policy requires that all design water levels include an allowance of 0.3 metres for the influence of Greenhouse Effects on sea level rise. This has been included by the *Coastal Engineering Studies* in the design of the rock armoured coastal defences for the TOT Project Site.

Other Considerations

The EPA policy states that the armoured slopes are to be designed to minimise wave reflection and any "end effects" on the adjacent foreshores. A two layered armouring arrangement (with an additional two layers of underlying filter rock) of slopes that are typically 1 vertical to 1.5 horizontal is widely acknowledged to provide acceptable wave dissipation performance. This is the structural concept adopted for the TOT structures. End effects will not adversely impact on any adjacent foreshores or structures.

Northern Breakwater

The primary purpose of the Northern Breakwater is to protect the development along its exposed northern boundary. The Northern Breakwater faces directly towards the exposed fetches out across Cleveland Bay.

The crest level of the breakwater will be reasonably low and will accommodate any overtopping which might occur during extreme wave and storm tide events. The design philosophy applied to the rock armouring works for the TOT Project Site has been to limit any damage to less than 5% of armour being dislodged under a 100 year ARI Designated Storm Tide Event. The design wave parameters for such scenarios have been determined from the mathematical modelling of waves undertaken in these *Coastal Engineering Studies*.

The DSTE scenario that had the greatest structural requirement was that associated with the 100 year ARI storm tide in association with the 50 year ARI wave event. The design parameters associated with that occurrence are as outlined in Table 4.7.5.

Table 4.7.5: Design wave parameters for the Northern Breakwater

Design Parameter	100 year ARI
Significant Wave Height (H_s)	2.35 metres
Peak Period (T_p)	10 secs
Storm Tide Level	RL+2.84 AHD

When preparing the preliminary design of the armour on the front slope of the Northern Breakwater, the use of the existing breakwater as a structural solution has been adopted. The original design drawings for this structure indicate rock armour of 2 tonne to 5 tonne size, placed to a crest level of RL+4.4m AHD and with a seaward slope of 1 vertical to 1.35 horizontal.

Calculations of structural integrity indicate that if the armour rocks that currently constitute the existing breakwater were to be used as the new Northern Breakwater, then they could accommodate the loadings from the design conditions with acceptable levels of damage. However consideration of overtopping performance of this existing structure indicates that average overtopping rates during the 100 year ARI event will exceed the thresholds for crest damage offered for guidance by HR Wallingford Ltd (1999).

The front face of the new structure is unlikely to be significantly damaged, however it is predicted that green water overtopping would significantly scour unprotected fill material immediately behind the armour layers at the top of the seawall. Consequently, a scour blanket will be provided as crest armouring in this "at risk" region of the Northern Breakwater to ensure that the structural integrity is not compromised by the 100 year ARI event.

An alternative to providing a wide scour blanket at the crest of the seawall is to raise the level of the crest to such an extent that the amount of green water overtopping coming over the crest is reduced to levels that will not instigate significant scour. Calculation of overtopping rates indicates that the crest level would need to be raised to RL+6.0m AHD to achieve the necessary reduction.

Scour protection is also required at the toe of the Northern Breakwater. The selection of the most appropriate will be based upon constructability issues, however it is likely that a toe berm will be adopted as it does not require excavating and maintaining a trench in the submerged seabed when placing rocks.

Strand Breakwater

This breakwater provides wave protection along the western perimeter of the development. It faces directly out across the local fetches of Cleveland Bay towards Magnetic Island. Some overtopping of this structure can be tolerated provided such overtopping does not result in failure of the breakwater crest.

There were two potential scenarios that constituted the DSTE. However the scenario that had the greatest structural requirement was that associated with the 100 year ARI storm tide in association with the 50 year ARI wave event. The design parameters associated with that occurrence are outlined in Table 4.7.6.

Table 4.7.6: Design wave parameters for the Strand Breakwater

Design Parameter	100 year ARI
Significant Wave Height (H_s)	1.7 metres
Peak Period (T_p)	6 secs
Storm Tide Level	RL+2.84 AHD

A significant structural feature of this breakwater is the placement of larger rocks along the rear (shoreward) edge of the crest. This is to ensure that any green water overtopping of the breakwater that occurs during the DSTE does not initiate failure of the crest.

Internal Revetments

Rock revetments are proposed as the internal walls of the marina basin and waterways of Breakwater Cove. A two-layered rock armoured slope provides a very effective way of absorbing any waves which diffract into the marina, as well as dissipating any wash generated by vessel traffic in and around the TOT Project waterways.

The rock armour has been determined to be two layers of 300 kg nominal size (acceptable range in rock size being 100kg to 500kg). An appropriate geotextile is to be placed on the bank slope beneath the two layers of rock armour.

Impacts of Maintenance Dredging

The potential impacts of maintenance dredging on receiving environments have been assessed by C&R and are described in the Nature Conservation Report. Impacts will be mitigated by control measures outlined in Section 4.11, which have been incorporated into the TOT Project EMP.

Sustainability of Maintenance Dredging Disposal

Sustainable arrangements for disposal of dredge spoil material generated from maintenance dredging are discussed in Section 3.5.