Port of Townsville Channel Upgrade

Reclamation Integrity Plan

Prepared for: Port of Townsville Ltd
Reference No: 30032296/009
8/01/2020
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Glossary

The glossary of terms presented in Table 1 provides a summary of some of the key words and terms used in this document.

Table 1: Glossary of Terms

<table>
<thead>
<tr>
<th>TERM</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathymetry</td>
<td>Sea bed levels</td>
</tr>
<tr>
<td>Borehole</td>
<td>A hole that is bored into the ground to take a soil sample and enable analysis of the different soil types beneath the surface</td>
</tr>
<tr>
<td>Bund</td>
<td>An embankment of material that has been designed to contain another material</td>
</tr>
<tr>
<td>Cohesive soils</td>
<td>Very fine particle soils e.g. clay and silt</td>
</tr>
<tr>
<td>Design life</td>
<td>The period for which the structure has been designed to fulfil specified performance criteria</td>
</tr>
<tr>
<td>Dual Frequency Echosounder</td>
<td>A device that measures the distance between it and the sea bed. The device emits pulses of energy and measures the time taken for it to reflect back to the device sensor. This is done with two different frequencies of energy to measure the difference between the “True Bottom” and the “Apparent Bottom”, with the difference being the thickness of liquified or very soft or very loose sediments.</td>
</tr>
<tr>
<td>Factor of Safety</td>
<td>In the context of this document, the safety margin against bund instability is expressed as the ratio of resisting and destabilising forces and/or moments</td>
</tr>
<tr>
<td>Geophysical survey</td>
<td>In the context of this document, a geophysical survey is a technique that is used to determine sub-surface geological layers and features over a large spatial area</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Relating to the engineering performance of the ground and earth materials</td>
</tr>
<tr>
<td>Geotextile</td>
<td>Permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain the soil</td>
</tr>
<tr>
<td>Hydraulic stability</td>
<td>The stability of a structure when subjected to forces from waves, tides and currents</td>
</tr>
<tr>
<td>Integrity</td>
<td>To hold together under loading, including own weight, without breaking or deforming excessively</td>
</tr>
<tr>
<td>Joint probability</td>
<td>A statistical measure of two discrete events occurring at the same time e.g. a specific wave height and tide level. This is normally expressed as an annual probability of exceedance (e.g. 1%) or an average return period (e.g. 1 in 100 years).</td>
</tr>
<tr>
<td>Liquefaction (soil)</td>
<td>Loss of strength/stiffness in response to shaking during an earthquake</td>
</tr>
<tr>
<td>Metocean</td>
<td>Wind, wave, tide, current and climate conditions</td>
</tr>
<tr>
<td>Non-cohesive soils</td>
<td>Granular soils, e.g. sand</td>
</tr>
<tr>
<td>Numerical modelling</td>
<td>Computer generated simulation of a real-life environment to determine the response of an object or system to different scenarios.</td>
</tr>
<tr>
<td>Paleochannel</td>
<td>An ancient inactive water course that has been filled by younger sediments, creating a linear feature of deeper soft soils than the surrounding profile</td>
</tr>
<tr>
<td>TERM</td>
<td>DEFINITION</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Physical modelling</td>
<td>Physical modelling is a smaller or larger physical copy of an object and its environment. The geometry of the model is either a larger or smaller scaled version of the real-life object and its environment. The physical model is used to simulate an object’s response to different scenarios.</td>
</tr>
<tr>
<td>Reclamation</td>
<td>The use of material (usually soils) to create land for future use</td>
</tr>
<tr>
<td>Seismic</td>
<td>Relating to earthquakes. Can also refer to the transmission of motion or sound wave energy through earth.</td>
</tr>
<tr>
<td>Topography</td>
<td>Land levels</td>
</tr>
</tbody>
</table>
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Executive Summary

The Port of Townsville Limited (POTL) is seeking to increase the capacity of its existing shipping channel through dredging activities to increase the width along the channel. The construction of a new rock bund wall has been selected to provide a new reclamation area, which will be used to safely accommodate the dredge material. Given that Townsville is located in an active cyclone region and the rock bund wall construction is a significant undertaking, substantial design effort has been completed to achieve a robust design, in line with industry recognised good practice and adherence to Australian Standards and guidelines.

In order to comply with its requirements under Conditions 8 and 10 of the Environment Protection and Biodiversity Conservation (EPBC) Act Approval No. 2011/5979, POTL via its design consultants, has developed this Reclamation Integrity Plan. This document presents the methodology that POTL will be adopting to ensure the integrity of the rock bund walls and reclamation area remains fit for intended purpose over its design life. The overall methodology takes a risk-based approach, considering the identified risks and how these are to be mitigated by ensuring that adequate site investigations, design, construction practices, construction quality verification, monitoring and maintenance are all undertaken, in compliance with the relevant standards, guidelines and accepted engineering practice. This Plan has been produced in parallel with site investigation and design works and therefore it covers work already undertaken as well as future proposed elements of the Plan.

A risk assessment has been completed to identify the hazards that could affect the short and long-term integrity of the rock bund wall during its construction and longer-term operational life. The risk assessment process also identifies mitigation actions that will be applied during the design, construction and operational phases, which will reduce or eliminate the probability of the hazards occurring. This Reclamation Integrity Plan presents the key risks, mitigation actions and an overview of the methodology that has been adopted to implement the mitigation actions in the design, construction, ongoing monitoring and maintenance of the rock bund wall.

The rock bund design process is based on good quality data that provides a sufficient level of detail and covers the physical extent of the proposed works. The data includes bathymetry, geotechnical, geophysical, wave heights, environmental factors (e.g. adverse weather events), tide levels, rock quality and geotextile properties.

Industry recognised standards, guidelines and quality adherence processes have been followed in the design and will be followed in the construction process to achieve the bund structure performance criteria. These criteria include a 50-year design life and rock bund stability criteria for a 200-year average recurrence interval (ARI) storm event for minor damage and a 500-year ARI storm event for intermediate damage. Geotechnical stability design criteria include minimum factors of safety for temporary, permanent and seismic loading of 1.30, 1.50 and 1.10 respectively. Settlement criteria and the parameters for cohesive (e.g. clays) and non-cohesive (e.g. sands) materials have also been carefully selected in line with industry recognised practice.

A hydrographic survey has been undertaken to obtain sea bed level data to inform the detailed design of the bund structure and to provide data for the geophysical survey, numerical modelling and physical modelling.

A geophysical survey has been undertaken to determine whether significant paleochannels are present beneath the proposed rock bund wall; provide information about the location of different types of soil that are present beneath the proposed rock bund wall and determine the thickness and distribution of very soft sediments present beneath the proposed rock bund wall. No paleochannels have been identified in the vicinity of the proposed rock bund wall.
Numerical modelling has been completed to assess the interaction of storm tides and waves at the Port, typically under cyclonic weather conditions. The purpose of the numerical modelling is to accurately determine the range of different wave heights at the bund structure, as a key design input, taking into consideration the independent events of astronomical tide and storm surge. This methodology is consistent with accepted practice for the design of such a bund and reclamation and provides increased certainty and level of accuracy in relation to design wave conditions.

The design of the rock armour for the bund wall has been assessed based on industry recognised good practice, desktop calculations and supported by physical modelling. The physical modelling has been completed in a 2-D flume and a 3-D tank to accurately assess:
- The impact of breaking waves at the bund structure.
- Potential scour (erosion of the sea bed) at the toe (bottom) of the rock bund wall.
- A review of the wall to verify it is adequately designed for overtopping events.
- The stability of the bund during temporary and permanent construction stages and the associated risk.

A geotechnical assessment has been undertaken to assess the overall stability of the rock bund wall and the potential settlement of the underlying sea bed material. This assessment has been based on a ground model that integrates a desk study (geology, seabed depth, subsurface soil profiles etc.), geophysical studies and borehole data. Slope stability analysis has been completed to include construction and maintenance traffic loads, reclamation material loads and seismic (earthquake) loading. A settlement assessment has been undertaken to predict settlement of the subsurface soil below the rock bund wall. The settlement and overall stability assessments identified the requirement for the construction contractor to displace the top layer of soft sea bed Holocene clay material, until the rock is founded on the lower, stiffer layer of sea bed material, to mitigate the settlement and associated stability risk.

A detailed specification for rock materials has been developed to ensure that the rock that is supplied for the construction of the rock bund wall has the required properties to ensure the constructed bund performs in accordance with the design criteria. The grading of the bund layers, including primary armour, secondary armour and core rock material has been designed in accordance with industry defined ‘filter rules’, to ensure:
- Rock within the layers does not filter out between the voids within the structure;
- Small particles within the founding material do not wash or ‘pipe’ out through the structure.

As part of the rock bund wall design, a suitably designed filter fabric has been specified, which is called a geotextile. The geotextile is required to minimise the release of fines (dredge reclamation material) from the reclamation area that could cause adverse effects in the marine environment. The design and specification for the geotextile in the rock bund wall includes the following:
- filtering properties to minimise clay and silt fines flowing through the rock bund wall;
- installation requirements to ensure it is secured, including in weather events, and is not damaged during installation;
- The geotextile is installed to extend below the toe of the structure and is overlapped in accordance with industry guidelines to ensure the geotextile forms a continuous layer.

As part of the quality systems of the project, Inspection Test Plans (ITPs) have been developed and will be implemented to ensure that the rock is delivered to site in accordance with the requirements of the rock specification.

The proposed construction methodology has been developed in accordance with industry recognised good practice, to minimise or eliminate the following risks: poor geotechnical founding conditions;
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impacts of extreme water level and wave conditions; the ability to safely operate machinery in a tidal environment; and ensure that bund structure contains the dredged fill material. The proposed construction methodology comprises a staged construction, each of which have been assessed for geotechnical and hydraulic stability. A quality ITP for the construction of the rock bund wall will be developed and implemented to ensure that all aspects of construction of the rock bund wall comply with the design.

Monitoring of the rock bund wall will be required during the construction and operational phases. The monitoring plan has been developed prior to the construction phase and will ensure that robust measures are implemented over the life of the structure.

Maintenance of the rock bund wall will comprise the activities that are required on a periodic basis after the construction to ensure that the rock bund wall performs to an acceptable standard during its design life. The maintenance program will therefore include: inspection and monitoring of the environmental conditions and structural response; an appraisal of monitoring data to assess compliance of the performance with predetermined standards; actions in response to non-conformances, if any; and repair or replacement of elements of the rock bund wall due to minor damage or displacement of rock during the design life.
1. Introduction

1.1. Project Background
The Port of Townsville Limited (POTL) is seeking to increase the capacity of its existing shipping channel through dredging activities to increase the width along the channel. Due to the legislative requirements of both the Commonwealth and Queensland Governments, the option of offshore placement for dredge material generated by the channel upgrade works is prohibited. An onshore dredge material receival facility is required to contain this material, which also offers POTL long-term options to expand its existing usable area for port logistics activities.

The construction of a new rock bund wall has been selected to provide a new reclamation area, which will retain the dredge material. Given that Townsville is located in an active cyclone region and the bund construction is a significant undertaking, substantial design effort is required to achieve a robust design, in line with industry recognised good practice and adherence to Australian Standards and guidelines. Well planned construction works, rigorous construction quality verification and ongoing monitoring and maintenance will also be required in order to ensure the integrity of the bunds and reclamation area.

1.2. Legislative overview

The Port Expansion Project (PEP) was the subject of an Environmental Impact Statement (EIS) and a further Additional Information to the Environmental Impact Statement (AEIS), submitted in support of Commonwealth and State project approval applications.

The following approvals have been obtained for the PEP and the Channel Upgrade (CU) Project, as Stage 1 of the PEP.

1.2.1 Commonwealth Approvals
EPBC Approval No. 2011/5979 was issued on 5 February 2018.

Appendix A lists the conditions from this approval that are relevant to this plan.

1.2.2 State Approvals
The Coordinator-General’s Evaluation Report on the Environmental Impact Statement for the Townsville Port Expansion Project was issued in September 2017 (and all associated development approval / permits and environmental authorities).

1.3. Site Extent
The proposed rock bund wall is located within the approved tenure area on the north-eastern side of the existing POTL seawall as shown in Figure 1.

The reclamation for the CU Project represents Stage 1 (initial first stage) of PEP and covers an area of approximately 62ha.
1.4. Why is a Reclamation Integrity Plan Required?

In order to comply with its requirements under Conditions 8 and 10 of the EPBC Approval No. 2011/5979, POTL must develop and implement a Construction Environmental Management Plan (CEMP) that includes measures to mitigate impacts to Matters of National Environmental Significance (MNES) from the construction of the reclamation area. The CEMP consists of the following set of documents:

- Stormwater, Sediment & Erosion Control Plan;
- Site Monitoring Plan;
- Tailwater Monitoring Plan;
- Reclamation Integrity Plan; and
- Acid Sulfate Soil and Contamination Management Plan

The CEMP must be prepared in accordance with the Department's Environmental Management Plan Guidelines and include a program to monitor the integrity of the reclamation area, including monitoring locations, methods, and frequency (Condition 10e). POTL is complying with this clause by developing this Reclamation Integrity Plan.

This document presents the methodology that POTL is adopting to ensure that the integrity of the rock bund walls and reclamation area is maintained throughout the duration of its design life. The overall methodology adopts a risk-based approach, considering the identified risks and how these are mitigated by ensuring that adequate site investigations, design, construction practices, construction quality
Reclamation Integrity Plan

verification, monitoring and maintenance are all undertaken, in compliance with the relevant standards, guidelines and accepted engineering good practice. This Plan has been produced in parallel with site investigations and design analysis and therefore some of the proposed mitigation actions have already been undertaken.

This Plan presents potential risks to the integrity of the rock bund wall and the reclamation area over the design life, along with the proposed mitigation action methods. This report should be read in conjunction with the Tailwater Management plan, which provides an overview of the tailwater discharge and filtering layers. Some discussion is also provided in this Plan regarding the filtration and retention of reclamation material fines by the bund walls. This information is presented in the sequence in which the rock bund wall has been designed and will be constructed and operated, to enable the reader to follow the sequence of methods and mitigation actions, as they will be applied through the following key stages of the overall methodology:

- Performance criteria and standards
- Design data collection
- Assessment of the geotechnical and metocean (waves, tides and currents) conditions
- Design of the stability and integrity of the rock bund wall
- Materials and construction quality criteria
- Monitoring and maintenance
2. Risk and Mitigation Actions

The rock bund wall will be constructed to retain capital dredge material. A risk assessment has been completed to identify the hazards that could affect the short and long-term integrity of the rock bund wall during its construction and longer-term operational life. The risk assessment process also identifies mitigation actions that will be applied during the design, construction and operational phases, which will reduce or eliminate the probability of the hazards occurring.

The identified hazards that could have a detrimental impact on the integrity of the rock bund walls are presented in Table 2. A summary of the mitigation actions for each hazard are also presented along with a reference to the relevant section of this report, where a more detailed description of the mitigation action methodology is presented. The assessed mitigated risk rating for each hazard is also presented, having been assessed utilising the risk management guidelines within POTL’s Quality Management System (risk tables reproduced in Appendix B).
### Table 2: Identified Hazards and Mitigation Actions

<table>
<thead>
<tr>
<th>RISK ID</th>
<th>IDENTIFIED HAZARD</th>
<th>RESULTING CONSEQUENCE</th>
<th>MITIGATION ACTIONS</th>
<th>MITIGATED RISK RATING</th>
<th>REPORT SECTION</th>
</tr>
</thead>
</table>
| 1       | Inaccurate design wave and tide conditions at the bund, leading to an inadequate design and failure of the integrity of the bund | • Release of reclamation material into the marine environment  
• Rock bund wall remediation and environmental impact costs | • Carry out numerical modelling to define inshore design wave parameters, up to a 0.2% annual exceedance probability *  
• Carry out hydraulic stability design in accordance with accepted standards*  
• Carry out physical modelling to confirm and refine the hydraulic stability design*  
• Independent review of the design by Jentsje Van der Meer who is a Professor of Coastal Engineering, based at Deltares. | Low (rare) | Section 3.1  
Section 4.2  
Section 5  
Section 6.2 |
| 2       | Failure of rock bund wall due to embankment instability | • Release of reclamation material into the marine environment  
• Rock bund wall remediation and environmental impact costs | • Carry out adequate ground investigation work*  
• Design the rock bund wall with an adequate factor of safety against embankment failure*  
• Ensure construction is carried out in accordance with the design and accepted practice. | Medium (Unlikely) | Sections 3.2, 3.4.3, 3.4.4 and 3.5  
Section 4.3  
Section 7  
Section 8  
Section 10.3 |
| 3       | Unforeseen geotechnical conditions due to insufficient geotechnical investigation data along the bund alignment | • Unforeseen conditions not considered in the design and construction, leading to potential failure of the rock bund wall or construction delays | • Obtain further geotechnical information (e.g. vibrocoring prior to commencing construction)  
• Geotechnical ground truthing required during construction stage to verify design | Low (unlikely) | Section 10.3 |
<table>
<thead>
<tr>
<th></th>
<th>Fines sediments being released to the marine environment due to filter layers not being adequate</th>
<th>Release of reclamation material into the marine environment</th>
<th>Release of reclamation material into the marine environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ensure an adequate geotextile specification is selected to minimise specified reclaimed material from passing through the bund</td>
<td>Ensure an adequate geotextile specification is selected to minimise specified reclaimed material from passing through the bund</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The geotextile is to have adequate strength to avoid damage during placement and construction of the rock bund wall</td>
<td>The geotextile is to have adequate strength to avoid damage during placement and construction of the rock bund wall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure that the geotextile is placed in accordance with the manufacturer’s recommendations, with suitable overlap, it extends below the toe of the rock bund wall, and it is ‘anchored’ onto the rock bund wall by placing smaller rocks ~0.5m thick over the geofabric to ensure it is held in position during construction.</td>
<td>Ensure that the geotextile is placed in accordance with the manufacturer’s recommendations, with suitable overlap, it extends below the toe of the rock bund wall, and it is ‘anchored’ onto the rock bund wall by placing smaller rocks ~0.5m thick over the geofabric to ensure it is held in position during construction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriate quality controls (including diving inspections) are undertaken prior to the geotextile being placed and covered</td>
<td>Appropriate quality controls (including diving inspections) are undertaken prior to the geotextile being placed and covered</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Fine sediments being released to the marine environment due to the tailwater discharge system not being suitably designed</th>
<th>Release of reclamation material into the marine environment</th>
<th>Release of reclamation material into the marine environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ensure the tailwater discharge systems is adequately designed and ‘keyed’ into the rock bund wall.</td>
<td>Ensure the tailwater discharge systems is adequately designed and ‘keyed’ into the rock bund wall.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The discharge system is to contain a weir box configuration that contains gates that can be raised to</td>
<td>The discharge system is to contain a weir box configuration that contains gates that can be raised to</td>
</tr>
</tbody>
</table>
### Reclamation Integrity Plan

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Implication</th>
<th>Risk Level</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Project design criteria not being clearly communicated and understood by relevant stakeholders</td>
<td>Rock bund wall does not comply with project specific criteria leading to subsequent impact on the design and construction integrity.</td>
<td>Medium (possible)</td>
<td>Section 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prepare a Basis of Design report prior to completing the design, which clearly sets out the criteria and standards upon which the design will be based.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ensure that relevant stakeholders review the Basis of Design report prior to completion of the design.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Earthquake forces impact on the integrity of the rock bund design</td>
<td>Ground motion affects the stability of excavations and, groundwater movements</td>
<td>Low (Unlikely)</td>
<td>Section 3.2.1, Section 3.4.3, Section 8.1.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ground motion affects construction safety.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adopt appropriate design standards during the design.</td>
<td></td>
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</tr>
</tbody>
</table>

#### Construction Hazards and Risks
### POTL Channel Upgrade Project – EPBC Approval No. 2011/5979

**Reclamation Integrity Plan**

<table>
<thead>
<tr>
<th>Section</th>
<th>Issue Description</th>
<th>Actions</th>
</tr>
</thead>
</table>
| 8       | Poor construction of the rock bund wall leads to loss of integrity due to extreme wave conditions | - Release of reclamation material into the marine environment  
- Rock bund wall remediation and environmental impact costs  
- Ensure construction is carried out in accordance with the design and accepted practice.  
- Ensure adequate monitoring and surveillance during bund construction.  
- Good quality control over materials to be incorporated into the bund construction works. |
|         | Low (rare)        | Section 9  
Section 10  
Section 11 |
| 9       | Rock bund wall bridges over paleochannel filled with soft material, causing loss of sediment under the bund wall | - Release of reclamation material into the marine environment  
- Rock bund wall remediation and environmental impact costs  
- Carry out geophysical investigations focussed on identifying paleochannels within the bund footprint.  
- Paleochannel (if found to be present, based on current studies considered very unlikely) infill material will be reduced through displacement of softer material or other means. |
|         | Low (Unlikely)    | Section 4.3  
Section 10.3 |
| 10      | The end use of the reclamation area is unknown | - Future construction on reclamation area adversely affects the stability of the rock bund wall  
- Ensure that appropriate assumptions for future development are included in the Basis of Design*  
- Ensure that future development designers for the reclamation area are aware of the rock bund wall Basis of Design parameters  
- Prepare civil design (surface falls, drainage, access areas, etc) for implementation upon completion of filing |
|         | Low (Unlikely)    | Section 3  

## Reclamation Integrity Plan

### Section 10.1

| 11 | Lifting, separation or damage to the geotextile at the interface of the rock bund wall and reclamation fill | • Release of reclamation material into the marine environment  
• Rock bund wall remediation and environmental impact costs | • Design details and construction methodology to ensure that the geotextile is not damaged and if so, it is replaced prior to completing construction.  
• Ensure the selected geotextile is fit for purpose, has ample durability, and is constructed strictly in accordance with supplier recommendations  
• Ensure installation requirements include measures to ensure it is secure in poor weather events. | Low (Unlikely) | Section 10.1 |

### Section 10

| 12 | Damage to partially constructed rock wall during extreme weather events | • Rock bund wall remediation and environmental impact costs | • Schedule rock wall construction so that most of the rock wall construction without armouring occurs in the dry season.  
• Construction methodology to be implemented to minimise risk of damage to the core and secondary armour during construction. This will be managed by the Contractor through a combination of appropriate weather forecasting, rock stockpile management and contingency and flexibility in working methods to provide bund stability.  
• Implement pre-determined risk mitigation strategies for ensuring the integrity of the works in progress and the | Medium (Possible) | Section 10 |
**Reclamation Integrity Plan**

| | | protection of the rock bund wall and landward infrastructure. This would typically include forecasting weather, having sufficient stockpiles of larger rock and sequencing construction with flexibility. |

* indicates action completed at time of writing.
Reclamation Integrity Plan

Risk of Failure of this Plan:
A risk for the project is the risk of this Reclamation Integrity Plan not being successfully implemented. To address this risk, POTL has engaged a highly experienced contractor for the design. This contractor will also provide the RPEQ sign off of the rock wall construction in accordance with tidal works approval conditions.

Additionally, POTL will engage a rockwall construction contractor based on a detailed tender process, with selection of the contractor to include their capability and experience to perform the construction works and demonstration of successful completion of similar works.

Two key risks to the success of the Reclamation Integrity, and how these risks are mitigated, are:

Funding to implement:
A key risk to the implementation of the program will be sufficient funding to support the works to complete all actions. POTL has committed to ensuring the rock wall is constructed appropriately, with significant funding committed to ensure sufficient design testing and confirmation is carried out prior to commencing construction. Further to these works that have been completed, POTL has also committed within the project budget, sufficient resources to support the integrity monitoring during and post the construction of the works. Noting that the design and construction of the rock wall will require engineering certification, POTL is committed to devoting required resources to the implementation of this plan.

Weather:
Given the rockwall construction will occur in the marine environment, weather conditions and extreme weather events pose a significant risk to the integrity of the rock wall construction. Recognising this, the commencement of the rockwall construction has been scheduled to commence after the 2019-2020 wet/cyclone season. This will ensure that the majority of the rockwall construction will occur in the period of the year where there is low potential for severe weather, protecting the constructed wall when there is no armouring in place. While total construction period will include construction in the 2020-21 cyclone season, the construction sequencing will be scheduled by the contractor to provide as much protection to the core rock as is practical.

Additionally, post severe weather event monitoring has been incorporated into this integrity plan to ensure that an integrity review is undertaken soon after any events that occur during the construction period.
3. Design Basis

This section sets out the data, standards and methodology for determining the design basis and also presents the key performance criteria that will be achieved to mitigate risks, through the application of the proposed methodology.

3.1. Data

The rock bund design process is based on good quality data, that provides a sufficient level of detail and covers the physical extent of the proposed works, in order to mitigate the risks presented in Table 2.

The rock bund design is based on the data sets presented in Table 3.

Table 3: Design Data Sets

<table>
<thead>
<tr>
<th>DATA TYPE</th>
<th>DATA SOURCES</th>
<th>WHAT WILL THIS DATA TELL US?</th>
<th>HOW WILL THIS MITIGATE RISK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathymetry (sea bed levels)</td>
<td>Hydrographic survey data (see Section 4.2)</td>
<td>This enables us to model how waves and their energy change as they move inshore to the proposed bund location. This data has been used to determine an accurate existing sea bed level at the proposed bund site.</td>
<td>This data enables us to more accurately predict what size the waves will be at the bund and therefore produce a bund design that retains its integrity over the design life of the structure.</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Borehole data (see Section 7.3)</td>
<td>This data enables the type and strength of the ground conditions to be determined in individual locations in the vicinity of the rock bund wall.</td>
<td>This data confirms the accuracy of the geophysical data and enables the geotechnical risks associated with the strength and stability of the ground conditions beneath the bund to be mitigated.</td>
</tr>
<tr>
<td>Geophysical</td>
<td>Geophysical survey data (see Section 4.3)</td>
<td>The data enables the type and strength of the ground conditions to be determined along a continuous section of sea bed below the rock bund wall.</td>
<td>This data enables the geotechnical risks associated with the strength and stability of the ground conditions beneath the bund to be mitigated. This data also enables the potential presence of paleo channels to be identified.</td>
</tr>
<tr>
<td>Wave heights</td>
<td>Offshore wave modelling (See Section 5)</td>
<td>The size, direction, energy and frequency of waves at offshore locations have been used to model how waves and their energy change as they move inshore to the proposed bund location.</td>
<td>This data enables us to more accurately predict what size the waves will be at the bund and therefore produce a bund design that retains its integrity over the design life of the structure.</td>
</tr>
</tbody>
</table>
### 3.2. Standards and Guidelines

The rock bund wall design is based on the following relevant industry Standards, guidelines and industry recognised conference papers.

#### 3.2.1 Standards
- Standards Australia, AS4997-2005, Guidelines for the design of maritime structures.

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<table>
<thead>
<tr>
<th>DATA TYPE</th>
<th>DATA SOURCES</th>
<th>WHAT WILL THIS DATA TELL US?</th>
<th>HOW WILL THIS MITIGATE RISK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tide levels</td>
<td>Tide gauge data (See Section 5)</td>
<td>The frequency and magnitude of different tide levels.</td>
<td>This data enables us to more accurately predict what the tide levels will be at the bund and therefore produce a bund design that retains its integrity over the design life of the structure.</td>
</tr>
<tr>
<td>Rock quality</td>
<td>Quarry</td>
<td>It will confirm whether the rock will retain its integrity during construction and over the design life of the bund</td>
<td>Only appropriately sized rock that will retain its integrity over the design life will be used, thereby mitigating the risk of failure of the rock bund wall</td>
</tr>
<tr>
<td>Geotextile properties</td>
<td>Suppliers</td>
<td>The filtration properties (including the size of the fines that can pass through), how the geotextile is to be placed, how it is to be held in position prior to filling, how long the geotextile will last and its resistance to potential damage during construction.</td>
<td>Only durable geotextiles that are installed and appropriately secured as per the design and manufacturer specifications will be used. Only geotextiles that minimise specified reclaimed material from passing through the bund over its design life will be used.</td>
</tr>
</tbody>
</table>
3.2.2 Guidelines and Papers

- Department of Environment and Heritage Protection (2013), (now known as Department of Environment and Science), Operational Policy, Building and Engineering Standards for Tidal Works, Queensland Government
- Navigation Management Systems Pty Ltd, dated 13 November 2018, Port of Townsville CCU Reclamation Area and Port Channels, Hydrographic Pre-Survey.
- Van der Meer, JW; Allsop, NWH; Bruce, T; De Rouck, J; Kortenhaus, A; Pullen, T; Schüttrumpf, H; Troch, P and B Zanuttigh (2016), EurOtop, Manual on wave overtopping of sea defences and related structures, an overtopping manual largely based on European research, but for worldwide application, pre-release version, October.

3.3. Geometry

POTL has secured an agreement for a perpetual lease over land below the high-water mark for the construction of the rock bund wall. The rock bund wall is to be constructed within this 64.9ha tenure area shown in general layout Figure 2 (red line). The north rock bund wall will be approximately 1100m long and the east and west rock bund walls will be approximately 565m long. This footprint complies with Approval Condition 8a.

Figure 2: Rock bund wall Tenure Area
3.4.  Bund Structure Performance Criteria

3.4.1  Design Life
A 50-year design life up to 2070 has been adopted for the rock bund wall structure in accordance with:

- Australian Standard (AS) 4997-2005, Guidelines for the design of maritime structures, for ‘normal maritime structures’.
- Building and engineering standards for tidal works, by Department of Environment and Heritage Protection, now known as Department of Environment and Science.

3.4.2  Rock Stability Performance Criteria
Based on AS 4997-2005, ‘Guidelines for the Design of Maritime Structures’, the design is governed by the most conservative outcome of the following two design events:

- A design event with a 0.5% annual exceedance probability (AEP), equivalent to a 200-year average recurrence interval (ARI) storm event, combined with a damage factor (Sd) of 2 (initial damage). Initial damage is defined as 0 to 5% of rock armour units displaced during the design event, where displacement is defined as armour rock displacing by a distance of one rock diameter. Only the upper layer of armour rock (primary armour) is assumed to be displaced in this scenario. The intention of the adoption of this design event is to ensure that only minor damage is incurred in a 200-year ARI event.
- A design event with a 0.2% annual exceedance probability (AEP), equivalent to a 500-year average recurrence interval (ARI) storm event, combined with a damage factor (Sd) of 6 (intermediate damage). Intermediate damage is defined as armour units displaced without causing exposure of the lower levels of rock armour or core layer to direct wave attack. Only the upper layer of armour rock is assumed to be displaced in this scenario. This design event is adopted in order to ensure that the rock bund wall will not fail in a 500-year ARI event.

Following either of these design events, the rock bund wall maintenance manual will require POTL to replace the displaced rocks, to reinstate the full integrity of the rock bund wall.

3.4.3  Geotechnical Stability Design Criteria
The stability design criteria adopted for design of the rock bund wall includes the following:
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- Cohesive materials (e.g. clay) in the foundations are modelled for short-term (i.e. temporary condition) and long term (i.e. permanent condition) behaviour.
- For non-cohesive materials (e.g. sand), drained strength parameters are used for temporary and permanent conditions.
- A loading across the top of the embankment is adopted for construction and maintenance traffic.
- The primary method for slope stability analysis is undertaken using industry accepted software to derive a factor of safety.
- The minimum Factor of Safety considered acceptable during temporary conditions (i.e. prior to reclamation filling), permanent condition (i.e. post reclamation fill placement) and under seismic loading, are 1.20, 1.50 and 1.10 respectively.
- Based on the anticipated subsurface conditions it is expected that no foundation materials will liquefy during the design earthquake event.

### 3.4.4 Settlement Design Criteria

Settlement performance criteria for such rock bund walls are generally governed by the limiting criteria of other structures (e.g. pipes, pavements or piles) within the bund, or by minimum crest height requirements relating to the reclamation volume.

However, within the current rock bund wall design, there is only one additional structure to be considered. This structure is a tail water discharge pipe that will be used for short term temporary works. The tail water discharge pipe will be constructed entirely within the rock bund wall and therefore due to the relatively small size of this structure, differential settlement is not considered to be an issue.

Consequently, the settlement design criteria adopted for the overall rock bund wall is 250mm over the first 25 years after construction. This criterion has been used to determine the crest height of the rock bund wall in order to retain the required reclamation volume over the design life of the structure and to inform the maintenance specification.

### 3.5 Geotechnical Parameters

A desktop study of the regional geology of the Port of Townsville has been undertaken using the data available through the publicly accessible Department of Natural Resources, Mines and Energy website.

The representative geotechnical soil parameter values that have been used in the design of the rock bund wall are based on laboratory data collected for the PEP EIS and AEIS historical laboratory test data (collected over several years by POTL), published data and previous experience. For cohesive materials (e.g. clay), a critical stage of the construction of an embankment, in terms of stability, is during and immediately after construction. The water pressure in low permeability clays is instantaneously built up in response to the weight of the rock bund wall. At this stage, the soil is temporarily in an undrained condition and its stability is dominated by the undrained or short-term shear strength of the soil. The values adopted within the design were established by considering historical laboratory test results, past experience and published data.

When cohesive materials are subjected to permanent or long-term loading, drained strength parameters are used.

For non-cohesive materials (e.g. sand), drained strength parameters are used for temporary and permanent conditions, as the materials are deemed to act in a drained manner when loaded/unloaded. There are no direct laboratory tests available for the strength parameters of the non-cohesive materials on the site, hence the adopted design values have been derived based on past experience and published data.
3.6. **Fines Filtration and Containment**

As part of the bund wall design, a suitably designed filter fabric has been specified, which is called a geotextile. The geotextile is required to ensure the fines (dredge reclamation material down to approximately 50 microns) are retained in the reclamation area and are prevented from being released to cause adverse effects in the marine environment. The design and specification for the geotextile in the rock bund wall includes the following:

- filtering properties to minimise clay and silt fines to flow through the rock bund wall;
- permeability to allow water to flow through the geotextile;
- installation requirements to ensure it is secured, including in weather events, and is not damaged during installation;
- durability that is appropriate for the design life of the rock bund wall; and
- The geotextile is installed to extend below the toe of the structure and is overlapped in accordance with industry guidelines to ensure the geotextile forms a continuous layer.

Industry has advanced the manufacture of non-woven geotextiles for both strength and filtration performance considerably in past decades. The CU project specifies a heavy duty non-woven geotextile that is suitable for the rock bund wall.

The Geofabric is covered with a smaller rock to ensure the fabric is secured in place. The smaller rock chosen to further add to filtering and grading into the future reclamation material.
4. Hydrographic and Geophysical Surveys

4.1. Introduction

A detailed and accurate hydrographic survey of the sea bed has been carried out to:

- Inform the detailed design of the rock bund wall structure.
- Provide data for the geophysical survey.
- Provide input data to the metocean numerical modelling and to define the design wave conditions.
- Provide an input to the physical modelling of the rock bund wall structures, which is required to fully understand the response of the structures to the design wave and tide events.

A variety of geophysical survey methods have been applied to:

- Determine whether significant paleochannels are present beneath the proposed rock bund wall.
- Provide information about the location of different types of soil that are present beneath the proposed rock bund wall.
- Determine the thickness and distribution of soft sediments present beneath the proposed rock bund wall.

4.2. Hydrographic Survey

A bathymetric survey of the reclamation area and Port channels has been undertaken by POTL (see Figure 3). The survey was undertaken by Australian Hydrographic Surveys in November 2018, to a Maritime Safety Queensland Class C level of accuracy.

The relatively high-resolution bathymetric survey is a key input into the following design activities:

- Numerical modelling and bund rock stability analysis
- Design of the rock bund wall
- Calculating material quantities
- Geotechnical stability analysis

Figure 3: Bathymetric survey at the proposed reclamation site
4.3. Geophysical Survey

4.3.1 Methodology

*Marine Navigation and Positioning*
The geophysical investigation used a data acquisition, navigation and positioning system (Hypack), which was controlled from a series of laptop computers installed on the survey vessel. This system enabled the surveyor to accurately survey pre-defined geophysical survey lines. The navigation equipment provided the vessel operator with a real-time indicator of whether the vessel needed to move left or right to remain on the survey lines, which aided the accuracy and the quality of the survey.

The average height of the vessel above the previously surveyed seabed was determined using tide information provided by The Tide Unit, Marine Safety Queensland (MSQ), from the tide gauge located at Berth 1 Pump House.

*Marine Seismic Refraction Testing*
Marine Seismic Refraction Testing (MSRT) provides information on the seismic wave velocity distribution of the soils in place on the site. This information can be compared with borehole testing data in order to form a 3-dimensional model of the distribution of different soil types on the site.

The MSRT system was towed at a sufficient level above the sea bed, to improve the quality of the information recorded and to avoid marine hazards such as rapid changes in the sea bed level and seafloor obstructions.

Initial trials on-site ensured the MSRT system was towed at the required depth for the vessel speed, with on-board computers receiving navigation and seismic records. The vessel was operated at between 3 and 5 knots.

The MSRT data was acquired at a 62.5µs sample interval (i.e. 16,000 samples per second) using one digital seismograph and the data was stored on the on-board computers for processing.

*Sub Bottom Profiling by Single Channel Seismic Reflection.*
Sub-Bottom Profiling (SBP) provides an indication of any sudden changes in the soil strength across the surveyed site. This technique can be useful for locating the interface between two geological units such as:

- The interface between soft, compressible Holocene clays and older Pleistocene clays, which are much firmer and less compressible.
- Any rapid change from soil to rock.

The SBP system uses a surface towed seismic source (boomer), which sends out seismic pulses. The reflected seismic pulses were detected by a 4.5m long group of hydrophones, which was also towed near the water surface.

The SBP system was controlled in conjunction with the navigation system, which enabled the investigation line locations to be accurately tracked from the vessel. The SBP seismic information was recorded in accordance with accepted industry practice, including digital file formatting.

The seismic reflection information was observed by the geophysical contractor on the vessel for quality assurance purposes.
Dual Frequency Echosounder (DFE)

A Dual frequency echosounder (DFE) was used to measure the distance from the echosounder to the sea bed by measuring the time for a pulse of energy to travel to the sea bed and back. A DFE survey can provide valuable information in relation to the thickness of soft sediment on the sea bed. The higher frequency energy pulse detects the level of the top of the sediment, while the lower frequency energy pulse penetrates the ‘softer’ sediment and is reflected from firmer material below. The difference between the depth readings from the two frequencies gives an indication of the thickness of soft sediment.

The DFE equipment was set up on the vessel with transmission frequencies including 200KHz and 30KHz with a beam angle of 8 and 19 degrees respectively.

4.3.2 Results

The results of the geophysical survey are reported in Geophysical Study - Channel Upgrade Project – Channel Widening and Reclamation Area Revision 3 (SMEC, 11/03/19).

4.3.3 Paleochannel Assessment

The conclusion of the paleochannel assessment is that no paleochannels have been identified within the vicinity of the rock bund wall, or reclamation, to the extent of the investigations completed.
5. Numerical Metocean Modelling

5.1. Scope
Numerical metocean modelling has been completed to assess the interaction of storm tides and waves at Port of Townsville, typically under cyclonic weather conditions. The purpose of the numerical modelling is to accurately determine the probability of different wave heights arriving at the bund structure, as a key design input, taking into consideration the independent events of astronomical tide and storm surge. This methodology is consistent with accepted industry good practice for the design of rock bund wall structures and provides increased certainty and levels of accuracy in relation to design wave conditions.

The overall methodology that was adopted for numerical metocean modelling comprises:

1. An artificial cyclone track dataset has been developed for Townsville using a probability model, which has been used as the basis of a joint probability assessment of waves and storm water levels, with annual exceedance probability (AEP) up to 0.1% or a 1 in 1000-year Average Recurrence Interval (ARI). The joint probability assessment has been used as the basis for the structural and hydraulic design of the rock bund wall, with the significant wave height (Hs) nominated as the primary design parameter.

2. A joint probability assessment has been undertaken of combined waves and water levels. Within the assessment, the largest Hs value of a specific probability has been used to characterise the event. The outcome of the joint probability assessment was a graph of Hs and total water level values with the same joint probability, which forms a curve. A family of joint probability curves has been presented, each with its own AEP of 2%, 1%, 0.2% and 0.1%(cyclonic). The AEP events are based on a joint probability of total water level (astronomical tide plus storm surge) and wave height (Hs).

3. The deliverables include a time series of data for Hs, peak wave period (Tpeak) and total water level for the 6 hours preceding the highest Hs value occurring and up to 3 hours after the highest Hs value occurs.

4. A sea level rise allowance has been adopted for up to 2070, in accordance with current Queensland government guidelines.

5. For each AEP event, wave height distribution parameters have been determined at specific output locations along the rock bund wall.

6. Using the related parameters from the model relationships, the corresponding wave period parameters and wave direction have been developed.

7. The validation process comprised a comparison of extreme events through statistical analysis of measured wave height and water level (Cape Cleveland) versus the numerically modelled results.

8. Sensitivity analysis of future climate change has been modelled, with respect to tropical cyclone (TC) intensity and frequency.

9. Non-TC storm tide hazards are known to influence Townsville AEPs up to approximately 0.5%. A non-cyclonic storm tide hazard analysis has been undertaken. This has been achieved by analysing long-term tide gauge data during time periods that are not impacted by TC events, up to a 0.1% AEP.

10. An assessment has been undertaken on the ‘known/anecdotal’ interaction effects of the shipping channel and local bathymetry on the wave parameters.
5.2. Numerical Model Summary
The modelled bathymetry, with depth relative to LAT datum, is presented in Figure 4.

A summary of the nearshore bathymetry and the modelling output location points are provided in Figure 5 and Figure 6. The modelling output location points are points of design interest that have been set to capture data for design consideration and comparison. Modelling output point reference numbers are shown adjacent to each point of interest, which are located around the perimeter of the rock bund wall and at other key locations.
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Figure 5: Nearshore bathymetric modelled surface and numerical modelling output points

Figure 6: Numerical modelling output points
6. Hydraulic Stability Design

6.1. Design Methodology
An analytical model has been developed for the design of rubble mound structures (based on Van Der Meer equations), which has been applied to determine the primary rock armour size. Calculations have been undertaken in accordance with the performance criteria set out in Section 3.4.

Bund crest design calculations have been undertaken to determine the anticipated volume (per second and per linear length of rock bund wall) of water that flows over the rock bund wall (known as overtopping) during the design storm events. The bund toe design has been undertaken in accordance with guidance from the CIRIA Rock Manual. These design outputs have been verified through physical modelling, which is an industry best practice approach.

6.2. Physical Modelling
Physical modelling has been undertaken by a professional research laboratory, using 2-dimensional flume and 3-dimensional large basin physical model testing. Physical modelling of the bund structure is proposed to:

- Accurately assess the impact of breaking waves at the rock bund wall and confirm the calculated rock size for stability.
- Investigate the potential reflection and focusing effects due to the geometric arrangement of the channel in relation to the surrounding infrastructure, including the proposed reclamation.
- Identify the potential risk for scour at the bund toe.
- Assess the overtopping rate, overtopping distribution and overtopping jet velocity.
- Assess permanent and temporary bund construction stages. This approach enables optimisation of the crest design for the permanent case and informs risk management practices during construction.

The physical modelling work comprises:

- 3-dimensional large basin (see 3d large basin model in Figure 7);
- 2-dimensional flume (see 2d model in Figure 8);
- Quasi 3-dimensional testing (see quasi 3d model in Figure 9).

The purpose of the 3-dimensional large basin physical model testing is to:

- Accurately determine extreme wave heights at the structure, prior to the waves breaking onto the bund structure.
- Model wave reflection and focusing effects due to the channel, natural bathymetry, and surrounding infrastructure, including the proposed reclamation.

The 2-dimensional and quasi 3-dimensional flume testing assesses rock stability (at a greater scale leading to greater level of accuracy and verification), current velocities along the bund toe, average overtopping volumes, overtopping jet velocities and the extent of overtopping at the bund crest.
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Figure 7: CU 3d large basin model by WRL (bund on right hand side of photograph)

Figure 8: CU Rock Bund Wall of 2d model by WRL
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Figure 9: Quasi-3d large model by WRL
7. Geotechnical Assessment

7.1. Introduction
To assess the overall stability of the rock bund wall and the settlement of the underlying sea bed material, it was necessary to create a ground model that integrates a desk study (geology, seabed depth, subsurface soil profiles etc.), geophysical and borehole data.

Factual investigation data from relevant geotechnical reports, which specifically related to the Port of Townsville CU project, were compiled into a single database. This digitised dataset and its corresponding reports, were used in conjunction with knowledge of the surrounding area to develop a geotechnical model for the proposed site.

A geophysics survey/assessment was carried out across the marine area of the CU project including the area of the proposed rock bund wall.

7.2. Geophysical Assessment
A geophysical assessment was undertaken to collect data on the different soil types below the sea bed and their corresponding properties. This information is required for the geotechnical assessment of the rock bund wall. A more detailed description of the geophysical assessment is presented in Section 4.3 of this report and therefore the following information is only a summary:

- Seismic compression wave information was recorded along longitudinal lines of the rock bund wall site using the Marine Seismic Refraction Testing (MSRT) method. This data has been used to form a 3-dimensional model of the distribution of different soil types on the site.
- Single channel seismic reflection information was recorded using a sub-bottom profiling system. This survey method is used to identify any sudden changes (i.e. sharp interfaces) in the soil strength across the site.
- A dual frequency echosounder survey has been undertaken to determine the thickness of soft sediment layers on the sea bed.
- Seismic and dual frequency echosounder data has been collected in accordance with recognised industry good practice.
- The geophysical information has been analysed in conjunction with geotechnical data.

As shown in Appendix C of this report, the lines completed were parallel to the shoreline. REC-1 was recorded generally along the north-eastern external bund of the reclamation area and REC-2 was recorded approximately 150m landwards from REC-1.

7.3. Borehole Data Analysis
A dataset was compiled from historical factual geotechnical investigations. A total of eight boreholes are in the vicinity of the rock bund wall and reclamation area. These boreholes include:

- POTL Log BH141
- POTL Log BH145
- POTL Log BH151
- POTL Log BH153
- POTL Log BH168
- POTL Log BH267
- POTL Log BH268
- POTL Log BH269

The proximity of these boreholes to the proposed bund locations are shown in Appendix C.
8. Geotechnical Design

8.1. Slope Stability

8.1.1 Introduction
Slope stability assessments have been undertaken to mitigate the risk of geotechnical failure of the rock bund wall. General stability assessments were undertaken, based on geophysical data (SMEC, 2019), and supplemented by borehole data. Geophysical data from this report indicated that the location of REC-1, corresponded to the alignment of the external bund running in a north-west to south-east direction. This data was used to identify the different geotechnical conditions likely to be encountered on site.

8.1.2 Slope Stability Assessment
Stability assessments have been carried out using Slope/W software, adopting limit equilibrium methods to achieve a minimum factor of safety (FOS) of 1.1, 1.2 and 1.5 for seismic, temporary conditions (i.e. before reclamation fill placement) and permanent conditions (i.e. following reclamation fill placement) respectively.

The expected soil conditions for the stability assessments were based on the geotechnical model (as described in Section 7).

A uniformly distributed live loading was adopted at the top of the bund for both short term and long-term loading conditions. This uniformly distributed live loading has been adopted to represent loads applied by construction and maintenance traffic on the top of the bund. The analysis incorporated a minimum setback distance of 1 m from the face of the bund as an assumed construction safety offset (i.e. a distance from the edge of the rock bund wall in which construction traffic will not operate for safety reasons).

As a conservative approach and in the absence of any information regarding the expected reclamation fill material composition, it has been assumed that this material is soft clay. It is likely the dredge material will have a range of consistencies from very soft to hard but its behaviour will be governed by the weakest materials.

Seismic loading analysis has been undertaken within the stability checks of the proposed rock bund wall. The behaviour of soil structures that are subjected to earthquake loading is often modelled using pseudo-static analysis, whereby the earthquake loading is represented by an equivalent static horizontal force. This force is often quoted in proportion to the weight (i.e. force) of the soil structure in terms of gravity, g (m²/s) i.e. acceleration (or seismic) coefficient. An earthquake design acceleration has been applied to the rock bund wall stability modelling in accordance with AS1170.4 (Standards Australia, 2007). An earthquake design acceleration has been determined based on equation 8.2 (2) of AS1170.4. The design pseudo-static acceleration used in the stability modelling was assumed to be half of the peak ground acceleration (Kramer, 1996).

Based on the assessed subsurface conditions, there is considered to be a low probability that foundation materials will liquefy during the design earthquake event. Also, Townsville is located in a region with low probability of significant seismic events. As such it is considered that a detailed assessment is not required due to the low probability of an earthquake event, and the properties of the underlying geotechnical conditions.

The stability analysis of the construction stages is presented in Section 10.
8.2. **Settlement Assessment**

8.2.1 **Introduction**
Settlement predictions depend on several factors including design criteria and timelines, fill placement, geological conditions and geotechnical parameters. These factors influence the settlement during loading, the residual settlement, and therefore the final crest height.

Fill placement and timelines for construction will be determined by the construction contractor. Total settlements (rather than only consolidation estimates for clay soils) are considered appropriate based on the level of geotechnical information available for use in the assessment (including consolidation data), and the limited thickness of soft material that will be present below the rock bund wall after construction.

8.2.2 **Settlement**
The finite element modelling package PLAXIS 2D was used to predict settlement of the subsurface profile below the rock berm.

Stability analyses of the bund design have indicated that the bund stability is highly sensitive to the top layer of the subsurface profile, which has a shear strength of less than 50kPa. However, due to the minimal thickness of the soft layer and method of rockfill placement, the impact of any remaining soft material should be limited. This was a similar observation made in the existing eastern reclamation rock bund wall constructed in the 1980s, that has never experienced instability.

The input geometry for the model assumes a three-layered subsoil profile with the rock berm on top. The core material, secondary and primary armour rock layers have been delineated within the rock berm modelled in accordance with the current proposed design.

Model geometry was sufficiently extended in the horizontal directions so that there is no interference with the results. The influence of model depth on the predicted settlement was mitigated by running the model with a depth of 33m (maximum depth of the closest borehole to the bund).
9. Rock Size and Quality

9.1. Introduction
A detailed specification for rock materials has been developed to ensure that the supplied rock has the required properties to ensure the constructed rock bund wall performs in accordance with the design. The major properties are:

- Density – important for hydraulic stability against wave attack
- Shape – important for good interlocking for hydraulic stability against wave attack
- Durability properties – to ensure that the rock is durable in the environment over the rock bund wall structure design life
- Grading within each rock material type – important in ensuring adequate filtering such that lower and smaller rocks are not pulled out of the rock bund wall through the upper layers of larger rocks (e.g. it is important the secondary armour is graded such that it cannot be pulled through the primary armour layer)

9.2. Rock Grading Design
The grading of the bund layers, including primary armour, secondary armour and core rock material has been undertaken in accordance with well-established industry ‘filter rules’, to ensure:

- Rock is not able to pass between the voids of the upper layer of rock within the bund wall.
- Small particles within the founding material do not wash or ‘pipe’ out through the rock bund wall.

The risk of small particles within the founding material ‘piping’ out through the bund structure is considered extremely low. Notwithstanding this, the risk has been mitigated as follows:

- An assessment of shear stress at the seabed versus the shear strength of the founding calculations has been undertaken.
- A geotechnical performance specification has been developed for the preparation of the seabed and founding bund formation level. In situ verification of the founding material is incorporated into the geotechnical performance specification.

9.3. Rock Specification
The primary armour, secondary armour and core rock material will be required to satisfy the following criteria in relation to rock bund wall stability and durability:

- Rock will comprise individual stones, which are either igneous or metamorphic in origin, which are dense, sound, resistant to abrasion and free of cracks, cleavage planes, seams and other defects, which would result in breakdown of the rock in the environment of the site of the works.
- Rock will be rough and angular.
- The ratio of the maximum dimension of any rock to the minimum dimension, measured at right angles to the maximum dimension will not exceed 2.5.
- All rock will be unweathered and free from damaging minerals such as expansive clay minerals.
- The water absorption will not exceed 3% when determined by relevant methods described in AS1141 Section 6 or AS4133.2.
- Rock will show no signs of stress-relief.
Inspection test plans and processes for the rock quality have been developed and will be implemented to ensure that the rock is delivered to site in accordance with the requirements of the rock specification. The rock quality requirements include the following:

- Quality management procedures
- Detailed Inspection and Testing Plans (ITPs)
- Documentation and record keeping requirements to ensure auditability and traceability

The quality testing requirements have been developed in accordance with the recommendations of the CIRIA Rock Manual.
10. Construction

10.1. Overall Construction Methodology and Sequencing
The proposed construction methodology has been developed based on the following key constraints:

- Geotechnical founding conditions
- Exposure to both ambient and extreme water level and wave conditions
- Ability to safely operate machinery in a tidal environment
- Bund structure containment of the dredge material

The rock bund wall comprises three different types of rock, as follows:

- Core rock – this is generally smaller pieces of rock (see green shaded area in Figure 10)
- Secondary armour – this rock is larger than the core rock but smaller than the primary armour. This material is placed above the core rock (see yellow shaded area in Figure 10) and is designed so that core rock cannot pass through.
- Primary armour - this is the largest rock on the structure and is placed above the secondary armour (see pink shaded area in Figure 10). Primary armour is designed so that only initial damage to the structure occurs during the design event and so that secondary armour cannot pass through it.

Large continuous (overlapping) sheets of geotextile (non-woven needle punched staple fibre) will also be placed within the landward backing face of the rock bund wall with smaller rock covering to anchor and secure the geotextile in place, to minimise fine reclamation material from being washed from the reclamation area and through the rock bund wall.

The following proposed construction stages (and sub-stages) are presented in
Figure 10 (Stage 1) and Figure 11 (Stage 2), noting that the bund illustrations are conceptual illustrations to convey a typical construction method. Reference should be made to the final issue of the construction drawings for specific bund detail. Each of the sub-stages has been assessed in the design for both hydraulic and geotechnical stability:

- Stage 1.1 – construct the core material (green area) using ground verification and quality test checks to ensure limited to no soft material is present as per the detailed design;
- Stage 1.2 - place the secondary armour rock (yellow area) and the primary armour rock (pink area) up to the top of the rock bund wall slope;
- Stage 1.3 – place geotextile and secure in position as per the design and extend the geotextile from the top of the crest to below the rear toe of the rock bund wall to provide a continuous filter system over the full height of the rock bund wall;
- Stage 2.1 – Construct the primary armour at the crest of the rock bund wall (including overlapping and placed geotextile and filtering layer);
- Stage 2.2 – Place the dredge material up to the crest of the rock bund wall.
10.2. Rock Placement Methodology
Correct rock placement is a critical factor to ensure;

- The integrity and containment of the dredged fill.
- Performance of the bund structure during extreme conditions.

The proposed methodology follows industry best practice and aims to minimise the risks as outlined in Table 2, during the rock bund wall construction and operational phases.

To reduce the risk of loss of integrity of the core, secondary armour or primary armour, the maximum distance between the construction of core rock and the two layers of secondary armour will be managed by the Contractor through a combination of appropriate weather forecasting, rock stockpile management and contingency and flexibility in working methods to provide bund stability. This approach reduces the risk of the more mobile core material being washed out during construction, leading to potential loss of integrity.

In the event of extreme weather, the construction contractor will be required to implement predetermined risk mitigation strategies for ensuring the integrity of the works in progress and the protection of the rock bund wall and landward infrastructure. The construction contractor will be required to ensure that all contingencies are in place for mitigation at all times, including sufficient quantity of onsite stockpiled secondary and primary armour rock. No reclamation filling will be undertaken until the Stage 2 Primary armour is complete.

The construction of the secondary and primary armour rock will be required to comply with the following criteria:
Geotechnical Construction Methodology

To ensure integrity of the bund structure in both the construction and operational phases, ground truthing of subsurface conditions will be required to ascertain bed and founding levels.

The construction contractor will be required to submit a Works Method Statement (WMS) for these ground truthing and verification activities for approval prior to construction.

It is expected that ground truthing and verification of founding levels will be conducted systematically as the rock bund wall is constructed.

10.4. Construction Quality Management and Verification

A set of Inspection Test Plans (ITPs) to manage quality will be developed and implemented to ensure that all aspects of construction of the rock bund wall comply with the design. These quality ITPs will be reviewed by RPEQ engineers before implementation.

The quality checks will be developed and implemented in collaboration with POTL acting in the role of the Principal Contractor in accordance with the requirements of the technical specification for the works and ensure compliance and suitability. It is envisaged that the quality documentation will include the following matters:

- Quality management procedures
- Detailed Inspection and Testing Plans (ITPs), including witness and hold points
- Documentation and record keeping requirements to ensure auditability and traceability

The quality documentation will be developed in accordance with the recommendations of the CIRIA Rock Manual.

The Technical Manager and Designers will review the quality of the works by general surveillance, attendance at all witness points and hold points and by carrying out audits on the implementation of the quality documentation.

Inspection & Test Plans (ITPs) identifying the tests, frequencies, rejection criteria and responsibilities will be prepared as part of the quality documentation. At the commencement of the rock bund wall construction, the construction contractor will construct a test panel, 25 metres in length. Construction will be in accordance with the technical specification and in accordance with the construction
contractor’s approved work method statement (WMS). The test panels will demonstrate the quality of placing of all materials within each stage.

The construction contractor will be required to survey cross sections of each layer or element on a two-metre grid to provide evidence that the completed works comply with the placing tolerance nominated in the specification. The construction contractor will be required to make any adjustments to the completed rock layer necessary to comply with the technical specification before practical completion of the rock bund wall is granted and the rock bund wall is approved by RPEQ as fit for intended purpose of use.
11. Monitoring

11.1. Monitoring Plan
Monitoring of the rock bund wall is required during the construction and operational phases. The monitoring plan has been developed prior to the construction phase and will ensure that robust measures are implemented over the life of the structure. The monitoring plan herein is additional to monitoring by the construction contractor, who will undertake surface observations and underwater surveys to confirm construction compliance.

11.2. Purpose and Objectives
Rock structures respond to the action of waves and tides in the form of changes in the shape of the structure. These changes may occur due to the movement of rock or changes in the geotechnical conditions beneath the structure.

A regular monitoring program of the structure and the environment enables the owner to plan repairs and respond in a timely manner. Deterioration of rock structures often occurs gradually and therefore may not be noticed without a monitoring plan in place. By setting out a plan that enables comparison of measurements at consistent locations over time, a structural monitoring program allows these changes to be identified at an early stage and therefore enables appropriate maintenance activities to be carried out.

This monitoring plan is designed to:

- Conduct the monitoring in a consistent manner, which meets the requirements of the appropriate environmental approvals and any standards;
- Identify trends across a range of parameters;
- Identify areas of potential concern, which may require maintenance or design adaptations; and
- Establish a temporal and spatial dataset to inform discussions with regulators and provide supporting information for ongoing performance.

11.3. Monitoring Locations
Reclamation integrity monitoring will be conducted at several monitoring locations (Figure 12) regularly spaced around the rock structure. Indicative global positioning system (GPS) co-ordinates for all monitoring locations are included in Table 4 and will be updated as the rock bund wall is constructed. Monitoring may be conducted at other locations, as required for complaint investigation, incident monitoring, if environmental conditions change, or based on field observations of the nominated locations and additional locations requested.

<table>
<thead>
<tr>
<th>LOCATION NAME</th>
<th>INDICATIVE LOCATION: EASTING</th>
<th>INDICATIVE LOCATION: NORTHING</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI01</td>
<td>483900</td>
<td>7870899</td>
</tr>
<tr>
<td>RI02</td>
<td>484036</td>
<td>7871038</td>
</tr>
<tr>
<td>RI03</td>
<td>484186</td>
<td>7871209</td>
</tr>
<tr>
<td>RI04</td>
<td>484030</td>
<td>7871420</td>
</tr>
<tr>
<td>RI05</td>
<td>483866</td>
<td>7871651</td>
</tr>
<tr>
<td>RI06</td>
<td>483710</td>
<td>7871876</td>
</tr>
<tr>
<td>RI07</td>
<td>483514</td>
<td>7872153</td>
</tr>
<tr>
<td>RI08</td>
<td>483371</td>
<td>7871945</td>
</tr>
<tr>
<td>RI09</td>
<td>483254</td>
<td>7871776</td>
</tr>
</tbody>
</table>
Figure 12: Site Location
11.4. Methodology & Frequency

When conducting monitoring, assessments are focused on reviewing the performance and condition of the rock bund wall and reclamation during and following construction. In effect, monitoring entails reviewing the performance of the rock bund wall and reclamation against the potential risks as identified in Table 2 – these linkages are shown in Table 5. Typical observations and assessments for the rock bund wall and reclamation include:

- Settlement of the rock bund wall both during construction and ongoing for several years. While small consolidation settlement is expected due to the limited ‘soft’ material directly below the rock bund wall, the total settlement is estimated to be in the order of 250mm or less. By conducting surveys at several locations around the rock bund wall, the survey results will enable POTL to ensure that this design estimation is not exceeded. If periodic surveys indicate that more than 250mm has occurred, POTL can place rock at the rock bund wall crest during maintenance activities, to ensure that the height of the rock bund wall is kept to the design specifications.

- Monitoring for potential piping holes or turbidity in the water, should filtering layers be damaged or not installed correctly. While this is considered to be low risk due to the quality testing and compliance requirements within the technical specification, daily observations will be undertaken during the construction of the reclamation, and in response to varying weather events, in accordance with good practice. Following completion of the reclamation, periodic inspections will be undertaken for the next two years. This monitoring will enable POTL to implement repairs early, should they be required.

- Stability of the rock bund wall. Reviews of rock bund wall movement or visual observations of cracking in the rock armour provides indication that the wall may potentially be under early signs of stress. This is undertaken during POTL’s maintenance activities and allows POTL to implement corrective actions early.

There are two principal types of monitoring that can be undertaken; measurement of the structure and measurement of the environmental conditions (i.e. wind, waves and tides) to assist with observations to address the above.

The types of structural monitoring and measurement that will be taken include:
- Surveying nine points on the structure on a well-established grid.
- Outer surface description.
- A survey and record of the position of individual rocks, including unstable rocks, new voids (holes) in the structure and exposure of secondary armour / core material. This includes land based and underwater using hydrographic surveying with an angled beam to provide a 3-d image of the relief of the rock wall.
- A survey and record of the condition of individual rocks, including fractures and breakages.

The types of environmental monitoring and measurement that will be taken include:
- Water level - e.g. data from a nearby tide gauge.
- Wind climate – e.g. wind meter.
- Bathymetry and topography – e.g. bathymetric and topographic surveys of the seabed and beach.

During the construction phase, visual observations will be conducted by POTL every 6 months and any necessary repairs will be undertaken by the construction contractor. Once the rock bund wall is completed, a survey will be conducted 6 months after the end of construction and on an annual basis for the next three years. Additional surveys will be undertaken following every severe weather event.
Reclamation Integrity Plan

Following the initial three years after construction, the wall will be included with the other rock bund wall assets within the Port of Townsville and monitored for condition every 1-2 years.
## Reclamation Integrity Plan

**Table 5: Monitoring Program aspects and risk linkages**

<table>
<thead>
<tr>
<th>MONITORING ASPECT</th>
<th>RISK/HAZARD TO MEASURE</th>
<th>METHOD</th>
<th>FREQUENCY</th>
<th>TRIGGER</th>
<th>MITIGATION ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlement of bund</td>
<td>1, 2, 6, 7, 8, 12</td>
<td>Surveying at 9 locations</td>
<td>6 Monthly</td>
<td>250mm of settlement</td>
<td>Maintenance of wall by installing more rock at crest</td>
</tr>
<tr>
<td>Piping/release through walls</td>
<td>2, 4, 9, 11</td>
<td>Visual observation</td>
<td>Daily</td>
<td>Visual observation of turbidity in the water (beyond natural background levels)</td>
<td>Diver survey</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Subsidence of reclamation material</td>
<td>Site survey</td>
</tr>
<tr>
<td>Stability of rock bund wall</td>
<td>1, 3, 6, 7, 8, 12</td>
<td>Outer surface description</td>
<td>6-monthly via UAV survey for above waterline and hydrographic survey below waterline</td>
<td>Every 6 months</td>
<td>Undertake survey comparison to identify rock movements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Survey of position of individual rocks – land based</td>
<td>6-monthly via UAV survey for above waterline and hydrographic survey below waterline</td>
<td>Every 6 months</td>
<td>Undertake survey comparison to identify rock movements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Survey of position of individual rocks – hydrographic survey</td>
<td>6-monthly via UAV survey for above waterline and hydrographic survey below waterline</td>
<td>Every 6 months</td>
<td>Undertake survey comparison to identify rock movements</td>
</tr>
</tbody>
</table>
### Reclamation Integrity Plan

<table>
<thead>
<tr>
<th>MONITORING ASPECT</th>
<th>RISK/HAZARD TO MEASURE</th>
<th>METHOD</th>
<th>FREQUENCY</th>
<th>TRIGGER</th>
<th>MITIGATION ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual survey of</td>
<td>6-monthly via UAV</td>
<td>6-monthly via UAV survey for above waterline and hydrographic survey</td>
<td>Every 6 months</td>
<td>Undertake survey comparison to identify</td>
<td>rock movements</td>
</tr>
<tr>
<td>condition of individual</td>
<td>survey for above</td>
<td>below waterline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rocks</td>
<td>waterline</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tailwater release</td>
<td>5</td>
<td>Tailwater Monitoring of 6 parameters</td>
<td>Prior to, and daily during tailwater release</td>
<td>As per Tailwater Monitoring Plan</td>
<td>As per tailwater Monitoring Plan</td>
</tr>
<tr>
<td>Post event observations</td>
<td>12</td>
<td>Visual observation</td>
<td>Following an event</td>
<td>Automatic release for another round of UAV</td>
<td>Undertake survey comparison to identify rock movements</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>survey</td>
<td></td>
</tr>
</tbody>
</table>
11.5. Reporting

POTL will produce an annual summary of the monitoring results from this monitoring plan. Copies of all report(s) will be kept on-site and will be available for regulatory inspection. If requested by the regulators, all monitoring data and information related to this monitoring plan will be submitted within 30 business days of the request, or within a timeframe agreed by the relevant regulator in writing.

11.6. Continuous Improvement

This Reclamation Integrity Plan is a “living document” which requires review at least annually during the construction phase and amendment, as necessary to ensure it remains fit for purpose and to allow new or changing environmental risks and mitigation actions to be addressed. Feedback systems will be in place for the duration of the CU Project to enable this plan to be updated and responsive to learning from any incidents, complaints and ongoing monitoring results and to reflect knowledge gained. Other triggers for review may include:

- Changes in operations or management;
- Changes in environmental legislation and/or policies; and
- New technologies / innovation relevant to applied monitoring methods and mitigation actions that provide innovative means of executing activities.

Changes to this plan may be developed and implemented in consultation with relevant regulators and other stakeholders over time. All changes are to maintain the approval conditions and be approved by the CU Project Management before implementation.

Information from this plan will be used to assist with improving the control measures in the Construction Environmental Management Plan where relevant and required.

As noted in section 11.5, an annual summary of the monitoring results will be produced that will identify the results found and an interpretation of the results in relation to the integrity of the rockwall construction. Where the monitoring identifies the need for revised management actions, the CEMP will be revised to incorporate the adaptive management arrangements. This may include the assessment of any monitoring program modifications needed also.

As per Condition 38 of the EPBC Act Approval (EPBC 2011/5979), any changes to this Monitoring Plan, or any of the Management Plans as a result of the outcomes of the reclamation integrity monitoring will be notified to the Department.
12. Maintenance


Maintenance of rock structures comprises the activities that are required on a periodic basis after construction, to ensure that the rock bund wall continues to perform to an acceptable standard during its design life. A maintenance program will therefore include:

- Inspection and monitoring of the environmental conditions and structural response (Section 11).
- An appraisal of monitoring data to assess compliance of the performance with predetermined standards, which may vary over the design life of the structure (e.g. due to rising sea levels).
- Repair or replacement of elements of the rock bund wall due to minor damage or displacement of rock during the design life.

Following construction of the rock bund wall, a Maintenance Manual will be developed based on the design principles presented in Section 3 to ensure that periodic repair and replacement are undertaken at prescribed periods and in a timely manner, to ensure the long term integrity of the Port of Townsville newest rock bund wall.
13. Conclusions

In order to comply with the requirements of its Approval Conditions, POTL has developed, inter alia, a Reclamation Integrity Plan to demonstrate that the key risks associated with the proposed reclamation rock bund wall have been assessed and that industry recognised good practice will be applied to mitigate or eliminate these risks throughout the 50-year design life of the structure.

The overall methodology takes a risk-based approach and considers the identified risks (Section 2) and how each of these will be mitigated by ensuring that adequate site investigations, design, construction practices, construction quality verification, monitoring and maintenance are all undertaken, in compliance with the relevant standards, guidelines and accepted engineering good practice.

It is recommended that the proposed risk mitigation methodologies presented in this Reclamation Integrity Plan are adopted to manage the construction and operational risk associated with the Port of Townsville’s newest reclamation rock bund wall.
# Appendix A  EPBC Approval Conditions Reference Table
### Reclamation Integrity Plan

<table>
<thead>
<tr>
<th>Ref</th>
<th>Cond. No.</th>
<th>Condition Requirement</th>
<th>Plan Reference</th>
<th>Demonstration of how the plan addresses the condition requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8a</td>
<td>the reclamation area does not exceed 110 hectares at stage 1 of the action in accordance with Appendix B;</td>
<td>1.3 3.3 11</td>
<td>Section 1.3 and 3.3 establish the size of the reclamation area for the CU Project (stage 1 reclamation). Section 11 details the monitoring plan that will include geospatial identification of the boundary of the reclamation area.</td>
</tr>
<tr>
<td>2</td>
<td>8b</td>
<td>the reclamation area does not exceed 152 hectares in total, in accordance with Appendix C; and</td>
<td>1.3 3.3 11</td>
<td>Section 1.3 and 3.3 establish the size of the reclamation area for the CU Project (stage 1 reclamation). Section 11 details the monitoring plan that will include geospatial identification of the boundary of the reclamation area.</td>
</tr>
<tr>
<td>3</td>
<td>8c</td>
<td>the design, materials and methods of construction for the reclamation area must prevent water quality impacts from leaching material through the bund wall, release of tailwater and storm-water run-off.</td>
<td>9 10 11.4</td>
<td>Section 9 and 10 provides an overview of the rock size and quality requirements, along with the construction methodology that demonstrates the wall is fit for purpose. Section 11.4 details the monitoring approach for determining if there is any leaching, piping etc of material from through the bund wall.</td>
</tr>
<tr>
<td>4</td>
<td>10a</td>
<td>The person taking the action must submit a Construction Environmental Management Plan (CEMP) for the Minister’s approval, which includes measures to mitigate impacts to MNES from the construction of the reclamation area before the commencement of the action. The person taking the action must not commence the action unless the Minister has approved the CEMP. The CEMP must be prepared in accordance with the Department’s Environmental Management Plan Guidelines and include at least the following: clearly defined objectives and performance criteria to mitigate impacts to MNES from the construction of the reclamation area and the placement of dredge material in the reclamation area;</td>
<td>3</td>
<td>Section 3 details the design basis, standards and performance criteria associated with the rock wall construction and design to ensure it meets a fit for purpose design.</td>
</tr>
<tr>
<td>5</td>
<td>10b</td>
<td>details on the design, materials, and methods to be used for constructing the reclamation area, that meet best practice and/or recognised industry standards;</td>
<td>3 10</td>
<td>Section 3 details the design basis, standards and performance criteria associated with the rock wall construction and design to ensure it meets a fit for purpose design. This includes identification of best practice/minimum standards.</td>
</tr>
</tbody>
</table>
### Reclamation Integrity Plan

<table>
<thead>
<tr>
<th>Ref</th>
<th>Cond. No.</th>
<th>Condition Requirement</th>
<th>Plan Reference</th>
<th>Demonstration of how the plan addresses the condition requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Section 10 provides an overview of the construction methodology for the rock wall that demonstrates the wall will be fit for purpose.</td>
</tr>
<tr>
<td>6</td>
<td>10e</td>
<td>a program to monitor the integrity of the reclamation area, including monitoring locations, methods, and frequency;</td>
<td>11</td>
<td>Section 11 details the monitoring plan for the rockwall/reclamation area integrity, include monitoring approaches, locations and frequencies.</td>
</tr>
<tr>
<td>7</td>
<td>10g</td>
<td>management measures to maintain the integrity of the reclamation area in the case of extreme weather events;</td>
<td>5, 6, 8, 9, 10, 11, 12</td>
<td>The rock bund wall has been designed in accordance with industry standards and best practice approaches, including numerical and physical modelling of the impact of extreme weather events and design peer reviews by international experts. The impact of extreme weather events on the reclamation area will be monitored and any observed or surveyed damage will be repaired, to maintain the integrity of the rock bund wall and reclamation area.</td>
</tr>
</tbody>
</table>
Appendix B  
Extract from POT442 – Risk Management Guidelines

ANNEXURE A – QUALITATIVE MEASURES OF CONSEQUENCE OR IMPACT
<table>
<thead>
<tr>
<th>Rank</th>
<th>Operations (Trade)</th>
<th>Financial Loss</th>
<th>Asset Loss</th>
<th>Interruption to Services</th>
<th>Reputation, Image &amp; Political Implications</th>
<th>Performance</th>
<th>Criminal Penalty</th>
<th>Information Security</th>
<th>Safety</th>
<th>Health</th>
<th>ENVIRONMENT</th>
<th>Frequency, Intensity, Duration, Offensiveness of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Insufficient</td>
<td>$0 - $50K</td>
<td>Little or no impact on assets</td>
<td>&lt; ½ day</td>
<td>Unsubstantiated, low impact, low profile or no news items. No political implications.</td>
<td>Up to 5% variation to KPI</td>
<td>Pecuniary</td>
<td>Can be dealt with by routine operations.</td>
<td>Reversible health effects of concern.</td>
<td>Environmental nuisance resulting in insignificant impacts on the natural receiving environment, plants and/or wildlife. No impact on community or business.</td>
<td>Low frequency / intensity / duration activity (days). No substantiated offensive amenity impacts on surrounding area.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minor</td>
<td>$50K - $500K</td>
<td>Minor loss or damage to assets</td>
<td>½ - 1 day</td>
<td>Substantiated, low impact, low news profile. Minor political implications resulting in minor local media attention.</td>
<td>5 -10% variation to KPI</td>
<td>Pecuniary</td>
<td>May threaten the efficiency or effectiveness of some aspect of the infrastructure but would be dealt with internally.</td>
<td>Minor temporary – medical treatment required.</td>
<td>Environmental nuisance resulting in minor adverse impacts on or unreasonable interference with the natural receiving environment, plants and/or wildlife, but noticeable effect on amenity. Minimal impact on community or businesses.</td>
<td>Minor frequency / intensity / duration activity carried out during normal operating hours over a short term (weeks). Minor amenity impacts experienced within surrounding area with potential to trigger complaints.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Serious</td>
<td>$500K - $5m</td>
<td>Major damage to assets</td>
<td>1 day – 1 week</td>
<td>Substantiated, public embarrassment, moderate impact, moderate (local) media attention. Political implications resulting in directions given by the shareholding Ministers.</td>
<td>10-25% variation to KPI</td>
<td>Imprisonment</td>
<td>Would not threaten the infrastructure but would mean that the program could be subject to significant review or changed ways of operating.</td>
<td>Major permanent – loss of body part or function.</td>
<td>Short term health problems or irreversible health effects of concern.</td>
<td>Actual or potential material environmental harm resulting in no adverse or unreasonable impact on the natural environment, plants and/or wildlife within surrounding area. Noticeable impact on community or businesses.</td>
<td>Medium frequency / intensity / duration activity carried out for a significant period of time on most days or over a period of months. Adverse amenity impacts on community giving rise to multiple/sustained substantiated complaints.</td>
</tr>
<tr>
<td>4</td>
<td>Major</td>
<td>$5m - $10m</td>
<td>Significant loss of assets</td>
<td>1 week – 1 month</td>
<td>Substantiated, public embarrassment, high impact, high (local and national) news profile, third party actions. Political implications resulting in state/ national inquiry.</td>
<td>25-50% variation to KPI</td>
<td>Imprisonment</td>
<td>May threaten the survival or continued effective functioning of the infrastructure or project and require top-level management intervention.</td>
<td>Major permanent – single fatality, total blindness, quadriplegia.</td>
<td>Health impacts, long term/chronic health problems or life threatening or disabling illness.</td>
<td>Material environmental harm resulting in significant adverse or unreasonable impact on the natural receiving environment, plants and/or wildlife over an extensive area as a result of the duration or magnitude or nature of impact. Extended disruption/impact to community or businesses. Potential exists to remedy the impact if the activity is ceased or impact is reversible.</td>
<td>High frequency / intensity / duration activity resulting in significant adverse or unreasonable impact on the natural receiving environment, plants and/or wildlife.</td>
</tr>
<tr>
<td>5</td>
<td>Catastrophic</td>
<td>&gt;$10m</td>
<td>Complete loss of assets</td>
<td>&gt; 1 month</td>
<td>Substantiated, public embarrassment, very high multiple impacts, high widespread (national and international) news profile, third party actions. Political implications resulting in state/national inquiry. Significant national and worldwide attention from governments and media condemning activity.</td>
<td>&gt;50% variation to KPI</td>
<td>Imprisonment</td>
<td>May threaten the survival of not only the infrastructure but also the business, possibly causing major problems for clients.</td>
<td>Multiple fatalities</td>
<td>Long term, permanent or irreversible health problems. Chronic health affects too many people.</td>
<td>Serious environmental harm resulting in irreversible, high or widespread adverse impact on the natural receiving environment and special significance area. Severe and protracted disruption/impact to community or businesses. Irreversible loss of amenity experienced.</td>
<td>Permanent high frequency / intensity / duration activity carried out 24/7. Serious adverse impacts on community.</td>
</tr>
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ANNEXURE B – QUALITATIVE MEASURE OF LIKELIHOOD

<table>
<thead>
<tr>
<th>Level</th>
<th>Descriptor</th>
<th>Description</th>
<th>Ongoing Activities</th>
<th>Projects</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Rare</td>
<td>May only occur in exceptional circumstances</td>
<td>Unlikely in the life of the facility</td>
<td>0.1% chance</td>
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<tr>
<td>2</td>
<td>Unlikely</td>
<td>Could occur at some time</td>
<td>Once in 20 years</td>
<td>1% chance</td>
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<tr>
<td>3</td>
<td>Possible</td>
<td>Might occur at some time</td>
<td>Once in 5 years</td>
<td>10% chance</td>
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<tr>
<td>4</td>
<td>Likely</td>
<td>Will probably occur in most circumstances</td>
<td>Once per year</td>
<td>50% chance</td>
</tr>
<tr>
<td>5</td>
<td>Almost Certain</td>
<td>Expected to occur in most circumstances</td>
<td>Many times per year, continuous</td>
<td>99% chance</td>
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ANNEXURE C – RISK EVALUATION FACTORS

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Consequence</th>
<th>Insignificant</th>
<th>Minor</th>
<th>Serious</th>
<th>Major</th>
<th>Catastrophic</th>
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<tr>
<td>Rare</td>
<td>1</td>
<td>L</td>
<td>1</td>
<td>2</td>
<td>L</td>
<td>3</td>
</tr>
<tr>
<td>Unlikely</td>
<td>2</td>
<td>L</td>
<td>2</td>
<td>4</td>
<td>M</td>
<td>6</td>
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<tr>
<td>Possible</td>
<td>3</td>
<td>L</td>
<td>3</td>
<td>M</td>
<td>6</td>
<td>9</td>
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<tr>
<td>Likely</td>
<td>4</td>
<td>L</td>
<td>4</td>
<td>M</td>
<td>8</td>
<td>S</td>
</tr>
<tr>
<td>Almost Certain</td>
<td>5</td>
<td>M</td>
<td>5</td>
<td>S</td>
<td>10</td>
<td>H</td>
</tr>
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<td></td>
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Appendix C  Investigation Locations Plan