Project: South West Creek Dredging and Reclamation Project  
Document: Environmental Referral Document  
Position Responsible for Document: Project Development Manager

<table>
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<tr>
<th>Rev</th>
<th>Description</th>
<th>Date</th>
<th>Prepared</th>
<th>Reviewed</th>
<th>Approved</th>
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<td>A</td>
<td>Draft for Developers review</td>
<td>29/10/2010</td>
<td>Various</td>
<td>G Connell</td>
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EXECUTIVE SUMMARY

Background

Port Hedland Port Authority (PHPA) proposes to expand port infrastructure in Port Hedland. Specifically, PHPA proposes the development of a mixture of eight Cape size berths in South West Creek, a tributary of the Port Hedland Inner Harbour estuary. The development includes dredging with associated onshore and offshore disposal of dredge material. Figure ES.1 shows the proposed dredge footprint and onshore and offshore disposal areas.

Due to the size and nature of the proposed works, environmental approvals are required under both State and Commonwealth environmental legislation.

An application for a sea dumping permit for the ocean disposal aspect of the project was submitted to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC, formerly Department of Environment, Water, Heritage and the Arts (DEWHA)) in August 2010 and the project was referred to DSEWPaC under the Environmental Protection and Biodiversity Conservation Act 1999 in October 2010.

The concept of the port development in South West Creek, including the dredging campaign and associated land based infrastructure is referred to in this document as the South West Creek Development. The dredging campaign and onshore disposal of dredged material for the South West Creek Development is referred to as the Project.

The completion of the South West Creek Development, including any port and land based infrastructure, will be subsequent to this Project and subject to separate environmental impact assessment and where applicable, statutory approvals.

The ocean disposal components are mentioned in this document when necessary for context.

Proposal description

The expansion project includes dredging of approximately 14.2 million cubic metres (Mm³) of marine sediment from South West Creek, to enable the construction of eight berths and a turning circle. The berths will accommodate vessels with a ship size of up to 300 m in length by 50 m width.

The Project requires widening of South West Creek and therefore includes the disturbance of mangroves.

It is proposed that dredge material will be disposed of both onshore and offshore with approximately 5.5 Mm³ to be disposed offshore, and the remaining 8.7 Mm³ placed onshore. Surficial material
down to (nominally) -6.0 m Chart Datum (CD), including the surficial seabed layer where potential acid sulfate soil (PASS) may be present, will be dredged most likely using a mechanical dredge and disposed of offshore. The remaining material from (nominally) -6.0 m CD to design depth will be dredged using a Cutter Suction Dredge (CSD) and pumped onshore to five designated Dredge Material Management Areas (DMMAs), of which two are existing, and one has statutory approval but is yet to be constructed. Two new DMMAs are proposed for the Project. To maximise the beneficial use of dredged material for construction purposes, the surficial material determined not to contain PASS may be dredged with a CSD with dredge material disposed onshore.

An application for a sea dumping permit has been lodged with the DSEWPaC for offshore disposal of all dredged material (down to nominally -6.0 m CD). The spoil ground is situated in federal waters with no impacts expected in state waters.

The key characteristics of the South West Creek Project are outlined in Table ES.1.

- **Table ES.1 Overall key project characteristics**

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
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<tbody>
<tr>
<td>Dredge footprint</td>
<td>116 ha</td>
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<tr>
<td>Total dredge volume</td>
<td>14.2 Mm³</td>
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<tr>
<td>Offshore disposal dredge component</td>
<td>5.5 Mm³</td>
</tr>
<tr>
<td>Onshore disposal dredge component</td>
<td>8.7 Mm³</td>
</tr>
<tr>
<td>Duration of dredging</td>
<td>Approximately 2.7 years (based on continuous operation to completion)</td>
</tr>
<tr>
<td>Duration onshore disposal</td>
<td>Approximately two years (based on continuous operation to completion)</td>
</tr>
</tbody>
</table>
| Area of land disturbance for onshore disposal (Figure 2-2) | DMMA G: 139 ha  
DMMA B-North: 81 ha  
Corridors (for access and pipelines): 7.40 ha  
Total: 227 ha |
| Area of mangrove clearance                      | Closed canopy mangroves: 31.5 ha  
Scattered mangroves: 8.66 ha |

**Environmental management**

Port Hedland Port Authority considers that the Project has been designed, and will be undertaken, in a manner that will minimise impacts on the surrounding biophysical and social environments.
Figure ES.1 Location of the proposed South West Creek Project
The Project has been developed to avoid, minimise, manage and mitigate environmental impacts. Some decisions which significantly reduce both environmental and social impacts are as follows:

- Design of the dredging footprint configuration to minimise the impact on sensitive habitats specifically mangroves, whilst allowing safe navigation of shipping vessels;
- Utilisation of results from planning studies to determine the location of the onshore DMMAs with an emphasis on avoiding disturbance to areas of high environmental value (such as mangroves) where possible;
- Disposal of PASS material offshore to ensure that acid sulphate soils (ASS) do not become an environmental legacy in the future; and
- Selection of Spoil Ground I as the preferred location for offshore disposal of dredged material due to factors including its existing use and the lack of benthic primary producer habitat within close proximity.

This document describes the impacts of the Project, and for each factor discusses the:

- objective for that factor;
- relevant guidance material;
- potential impacts;
- management of impacts; and
- outcome.

Environmental and social factors were determined to be key issues for the Project if they:

- Had a high inherent risk to the environment if left unmanaged;
- Required detailed assessment; and
- Required specific management measures and controls to ensure minimal impacts.

The key environmental factors were identified as:

- Marine water quality; and
- Mangroves.

PHPA is committed to minimising environmental impacts where possible and will ensure all impacts are managed through the implementation of management plans. PHPA has developed the following Project specific management plan to specifically address the environmental impacts associated with the key factors:

- Dredging Management Plan (Appendix A)
Environmental and social factors were determined to be relevant (but not key) issues if they:

- Had a minor or low impact and thereby would require less detailed assessment; and
- Required a lower level of management measures and controls to ensure minimal impacts.

The relevant environmental factors have been identified as:

- Coral Reef Communities;
- Other BPPH;
- Marine Fauna;
- Introduced Marine Pests;
- Coastal Processes;
- Potential Acid Sulfate Soils;
- Hydrology and Hydrogeology;
- Terrestrial Flora and Fauna;
- Dust;
- Noise;
- Visual Amenity;
- Hydrocarbons and Chemicals;
- Waste Management;
- DMMA Land Use Management; and
- Cultural Heritage.

PHPA believes that for all factors assessed and with the management and mitigation measures outlined, the EPA’s objectives can be met and the Project’s impacts will be minimised.

For all factors assessed, it is considered that with the implementation of the proposed management and mitigation the EPA objectives can be met and environmental impacts will be minimised to ‘As Low as Reasonably Practicable’ (ALARP). PHPA’s environmental commitments to achieve this are detailed for each factor in Sections 6 and 7 and summarised in Section 8.

Table ES.2 summarises PHPA’s evaluation of each the environmental factors, potential environmental impacts and discusses proposed management actions to reduce the environmental impact.
### Table E5.2 Potential Environmental Impacts and Management

<table>
<thead>
<tr>
<th>Environmental Factor</th>
<th>Management Objectives</th>
<th>Potential Impacts</th>
<th>Management Strategies / Proponent Commitments</th>
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</thead>
</table>
| Marine Water Quality | • Ensure the water quality is sufficiently high to maintain the structure and functions of the marine ecosystems.  
• Ensure water quality is safe for recreational activities and that aesthetic values of the marine environment is protected.  
• Ensure water quality is sufficient to enable seafood caught or grown in the area is of a quality safe for human consumption.  
• Ensure cultural and spiritual values of the marine environment are protected.  
• Ensure water quality is suitable for industrial supply purposes. | Deterioration in water quality during dredging and onshore disposal activities has the potential to impact on the Environmental Values and Environmental Quality Objectives set for the Pilbara Coastal Waters, which Port Hedland and the creek systems are a part of. The following activities may lead to impacts on the marine water quality:  
• Increased turbidity/TSS from dredging and discharge from the DMMAs;  
• Increased sedimentation from dredging and discharge from the DMMAs;  
• Mobilisation of potential contaminants through the disturbance of sediments by the dredge, and through discharge water from the DMMAs;  
• Acidification of the discharge water from the DMMAs caused by PASS in the dredged material exposed to oxygen during onshore disposal;  
• Altered physio-chemical parameters in the discharge water; and  
• Deterioration of water quality from dust, waste and hydrocarbon spills. | Implementation of the DMP which outlines water quality monitoring and corrective action requirements, including:  
• Ensuring no dredging occurs outside required area;  
• Use of suitable dredge equipment to minimise turbidity;  
• Maintain calibration of hydrographic survey systems  
• Monitor weather and sea conditions;  
• Implement water quality monitoring program following a water quality trigger breach;  
• Maximise residence time in reclamation area to reduce turbidity plume of discharge water;  
• Cease dewatering when turbidity exceedence occurs;  
• Regular inspection of erosion and sediment control structures;  
• Stabilise uncovered areas of soil;  
• Install scour protection measures;  
• Implement Routine Water Quality Monitoring Program;  
• Implement Routine Surface Sediment Profiling Monitoring Program and Routine Mangrove Health Monitoring Program;  
• Implement Reactive Mangrove Health Monitoring Program and Reactive Coral Health Investigation in the event of a breach of the water quality or sedimentation triggers.  
• Dredge contractor to continually monitor the operation and report incidents likely to cause changes to water quality. |
| Mangrove Habitats | • Maintain ecological function and sustainability of habitats and dependent habitats.  
• Reduce impacts of development on mangrove habitat and ecological function | Potential impacts on mangroves associated with the South West Creek Project include:  
• Direct loss due to clearing within the dredge footprint and associated access corridors;  
• Indirect impacts due to excessive sedimentation associated with dredging and | Areas of direct mangrove loss to the proposed dredging and DMMA footprint will be restricted. Management measures to limit the direct impact on the mangrove habitats include:  
• Workforce briefings regarding clearing procedures and environmental awareness training; |
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<tr>
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<td>of the mangroves to the minimum practicable level.</td>
<td>DMMA discharge;</td>
<td>- Reporting incidents with the potential to impact mangroves;</td>
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<td>• Indirect impacts due to reduced water quality resulting from DMMA discharge water (toxicants, low pH); and</td>
<td>- Prohibiting access outside the immediate disturbance area;</td>
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<td>• Indirect impacts due to changes in inundation regime.</td>
<td>- Delineation of clearance boundaries; and</td>
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<td>- Where possible, scrub rolling mangroves rather than removing mangroves.</td>
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<td>Other management measures to limit the indirect impact to mangrove habitats include:</td>
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<td>- Installation of satellite based monitoring system onboard vessel to ensure no dredging outside required area occurs;</td>
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<td></td>
<td></td>
<td>- Use of suitable dredging equipment to minimise turbidity and sedimentation;</td>
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<td></td>
<td></td>
<td>- Maintain calibration of hydrographic survey systems onboard dredge;</td>
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<td>- Monitor weather and sea conditions;</td>
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<td>- Implement Tiered Monitoring Framework following a water quality trigger breach in accordance with the DMP;</td>
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<td>- Use of suitable controls for sedimentation, including weir boxes at discharge point and regular inspection and maintenance of erosion; and</td>
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<td></td>
<td>- Monitoring potential impacts by implementing Routine Surface Sediment Profiling Monitoring Program and Routine Mangrove Monitoring Program</td>
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<td></td>
<td>- Implementation of the Reactive Mangrove Health Monitoring Program in the event of a breach of water quality or sedimentation triggers.</td>
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<tr>
<td>Coral Reef Communities</td>
<td></td>
<td>The Project will not result in any direct removal of coral habitat.</td>
<td>The same management measures that will be implemented to limit the indirect impact to mangrove habitats will be used to manage potential impacts to coral reef communities.</td>
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<tr>
<td></td>
<td>• Maintain ecological function, abundance, species diversity and geographic distribution.</td>
<td>The dredge and DMMA discharge plumes are predicted to cause elevated levels of suspended solids and increased sedimentation rates in the</td>
<td>In addition to the above measures, monitoring to assist in the management of potential impacts to coral reef communities</td>
</tr>
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<td></td>
<td>• Limit the direct loss of BPPH associated with dredging and onshore disposal activities.</td>
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<tr>
<td>Environmental Factor</td>
<td>Management Objectives</td>
<td>Potential Impacts</td>
<td>Management Strategies / Proponent Commitments</td>
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<td></td>
<td>• Ensure the protection of ecosystems associated with Port Hedland Port from indirect impacts associated with the project.</td>
<td>Creek systems which may impact coral reef communities.</td>
<td>Comprise implementation of the DMP including: * Routine Water Quality Monitoring Program; * Routine Surface Sediment Profiling Monitoring Program; and * Reactive Coral Health Monitoring Investigation. This includes a baseline coral health survey to be undertaken, and coral health monitored following an exceedence of water quality trigger levels. Post dredging monitoring will define any impacts between pre and post dredging/disposal.</td>
</tr>
<tr>
<td>Other Benthic Primary Producer Habitats</td>
<td>• Maintain the integrity, ecological functions and environmental values of the seabed and coast. • Maintain the abundance, diversity, geographic distribution and productivity of flora and fauna at both species and ecosystem levels.</td>
<td>Other BPP which has the potential to be impacted by dredging activities include: * Salt marsh – direct loss may occur as a result of smothering/removing of saltmarsh for the construction of the DMMAs, however the conservation status will not be affected; * Cyanobacterial mats - a small proportion of the tidal flats being impacted support cyanobacterial mats however giving the total area of this habitat, the loss is considered negligible; and * Macroalgae - small areas of macroalgal habitat will be directly lost due to dredging, however these habitats are considered well-represented within the creek systems surrounding the inner port area and therefore the loss is considered negligible.</td>
<td>The same management measures that will be implemented to limit the indirect impact to mangrove habitats and coral reef communities will be used to manage potential impacts to other BPPH. In line with the above measures, monitoring to assist in the management of potential impacts to BPPH include: * Implementation of the DMP including the Routine Water Quality Monitoring Program; * Routine Surface Sediment Profiling Monitoring Program; and * Reactive Coral Health Monitoring Investigation.</td>
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<tr>
<td>Marine Fauna</td>
<td>• To maintain the ecological function, abundance, species diversity, geographic distribution and ecological functions of marine faunal communities. • To protect EPBC Act listed</td>
<td>Potential impacts on marine fauna may be due to: * Artificial light spill and disorientation; * Loss of benthic habitat through increased levels of turbidity and sedimentation; * Spills and hydrocarbon leaks; * Collision with dredge vessel; and</td>
<td>Management measures and procedures will be developed to reduce the potential impacts to marine fauna. To reduce the risk of vessel collision or entrapment procedures include: * Inductions for work-site personnel regarding proper response to marine fauna;</td>
</tr>
<tr>
<td>Environmental Factor</td>
<td>Management Objectives</td>
<td>Potential Impacts</td>
<td>Management Strategies / Proponent Commitments</td>
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<tr>
<td>Threatened and Migratory species and Specially Protected (Threatened) Fauna.</td>
<td>Underwater noise generated from dredging.</td>
<td>• Dedicated marine fauna observations;</td>
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<td></td>
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<td>• A 150 m radius from the dredge and 500 m from the hopper barge at Spoil Ground I for marine fauna sightings, where fauna may likely be captured or injured due to dredging and disposal. Activities will be either relocated or materials not disposed of until it is determined marine fauna is unlikely to interact;</td>
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<td>• Vessels and workforce limited to designated areas; and</td>
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<td>• Recreational boating, fishing fossicking prohibited.</td>
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<td>Procedures developed to minimise the effects of underwater noise include:</td>
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<td>• Equipment and vessels operating in accordance with industry standards and specifications for noise levels and fitted with covers, muffles and other noise suppression equipment;</td>
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<td>• An ‘avoidance boundary’ will be defined and dredging activities will cease if marine fauna are sighted within the boundary and be delayed until the fauna has left the ‘avoidance zone’; and</td>
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<td>• The use of excessively noisy equipment will be avoided wherever practicable.</td>
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<tr>
<td>Introduced</td>
<td>• Minimise the risk of introduction</td>
<td>The potential impacts of introduced marine</td>
<td>The following management measures shall be applied prior to</td>
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<tr>
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</table>
| Marine Species       | of unwanted marine organisms consistent with the Australian Quarantine Inspection Services (AQIS) guidelines for ballast water management; and The Australian and New Zealand Environment and Conservation Council (ANZECC) code of practice for anti-fouling and in-water hull cleaning and maintenance. | organisms are:  
  - Establishment of non-indigenous marine pest species;  
  - Competition for food and space with native species;  
  - Removal of native species;  
  - Predation of native species;  
  - Introduction of associated pests and disease;  
  - Reduction or loss of biodiversity; and  
  - Reduction or loss of ecosystem function. | mobilisation and during dredging to minimise the risk of introduced marine species:  
  - Vessels to comply with AQIS Ballast Water Management requirements;  
  - Any vessels carrying ballast water and entering Port Hedland from other Australian locations are required to have a risk assessment in accordance with the requirements of the National System for the Prevention and Management of Marine Pest Incursions to determine potential for IMO introduction will be undertaken prior to any equipment mobilising to site;  
  - A risk evaluation of marine equipment (vessels and other);  
  - Any vessels coming to Port Hedland from overseas will be subject to a biofouling risk assessment, and inspected to ensure they are free of biofouling;  
  - Areas where mud and sediment can collect (i.e. anchor) should be inspected and cleaned prior to entering Port Hedland and should be repeated prior to departure from Port Hedland; and  
  - Monitoring and surveillance of dredge vessels and barges in accordance with AQIS and PHPA quarantine requirements. |
| Potential Acid Sulfate Soils |  
  - To maintain the integrity, ecological functions and environmental values of landforms and soils; and  
  - To minimise the risk to receiving waters resulting from low pH discharge, runoff and groundwater caused by acid sulfate soils (ASS). | Potential onsite and offsite impacts anticipated from the disturbance of ASS material during excavation and dredging works include:  
  - Contamination of surface/ground water through disturbance of ASS material;  
  - Formation and accumulation of ASS material as a result of the separation of sulphuric fines found in marine sediments;  
  - Loss of visual amenity from staining, scum and slime within local standing waters;  
  - Loss of biodiversity such as deterioration of mangrove ecosystems;  
  - To ensure that pH does not fall below 4.2;  
  - To maintain the integrity of all soils and landforms surrounding DMMAs;  
  - To ensure that no ASS material is included in local standing waters; and  
  - To implement a Vegetation Management Plan for the establishment of native vegetation to revegetate the area. | Offshore dredge disposal management includes:  
  - Only ASS material will be disposed of in Spoil Ground I, ensuring PASS material is selectively cut using mechanical dredging methods and kept saturated during transport and disposal.  
  - Onshore management of dredge material includes:  
    - All material proposed for use in the construction of earth bunds surrounding DMMAs will only be used once a detailed soil assessment determines no PASS material is present;  
    - Only non-ASS material will be pumped into the DMMAs;  
    - DMMA discharge will be monitored to ensure it meets criteria for Acid Sulfate Soil Areas outlined by DEC. |
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<tr>
<td></td>
<td></td>
<td>• Mobilisation of heavy metals such as nickel and chromium;</td>
<td>Management measures implemented to ensure potential impacts are minimised include:</td>
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<td></td>
<td>• Corrosion of concrete, iron, steel and aluminium structures; and</td>
<td>• Ensuring the DMMAs do not intersect any major waterways;</td>
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<td></td>
<td></td>
<td>• Acid and heavy metals leaching from stockpile ASS material.</td>
<td>• DMMA return waters will be channelled via culverts or floodways, with discharge points especially chosen</td>
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<td>to minimise erosion, and control rates of discharge;</td>
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<tr>
<td>Hydrology and Hydrogeology</td>
<td>• Maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected.</td>
<td>Potential impacts to the hydrology and hydrogeology of the Port Hedland Harbour include:</td>
<td>• Ponding of water in and around the DMMAs will be avoided where possible and any ponding will be inspected</td>
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<td>• Local drainage changes and surface flows of the coastal flats as a result of DMMA construction walls creating a barrier to natural water flow;</td>
<td>for mosquitoes and larvae;</td>
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<td>• Unnatural or accelerated erosion to intertidal flats due to disruptions in natural surface water flow and stormwater runoff;</td>
<td>• Discharge waters will be monitored and required to meet water quality objectives outlined in the DMP; and</td>
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<td>• Pollution of ground and surface water;</td>
<td>• Bund walls will be constructed with scour protection.</td>
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<td>Terrestrial Flora and Fauna</td>
<td>• Maintain the abundance, species diversity, geographic distribution and productivity of terrestrial flora and fauna;</td>
<td>Potential impacts on flora and fauna include:</td>
<td></td>
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<td></td>
<td>• Protect Specially Protected (Threatened) fauna; and</td>
<td>• Direct loss of vegetation and habitat;</td>
<td>The following management plans will be implemented to reduce the impacts on terrestrial flora and fauna:</td>
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<tr>
<td></td>
<td>• Protect Declared Rare Flora and Priority flora.</td>
<td>• Injury or mortality, disturbance or stress to individual fauna;</td>
<td>• The disturbed footprint shall be minimised and the clear demarcation of vegetated areas marked for clearing;</td>
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<td>• Reduced health of the vegetation and habitat surrounding the DMMAs due to dust deposition and/or changes in surface water flows, and through</td>
<td>• During construction, dust suppression shall be implemented;</td>
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<td>hydrocarbon leaks and</td>
<td>• Surface water flows shall be managed to prevent flooding and erosion;</td>
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<td>• A spill contingency plan shall be implemented in the event of an</td>
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<td>accident.</td>
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### Environmental Factor

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<tbody>
<tr>
<td><strong>Dust</strong></td>
<td>Spills or incorrect disposal of liquid wastes;</td>
<td>Accidental hydrocarbon spill;</td>
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<td>Spillage or mortality of fauna through</td>
<td>Waste management measures shall be implemented;</td>
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<td>accidental ingestion of spill hydrocarbons or</td>
<td>Speed restrictions, driver awareness and removal of road kill</td>
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<td>solid and liquid wastes that are incorrectly</td>
<td>shall be enforced to minimise potential impacts arising from</td>
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<td>disposed of.</td>
<td>vehicular movement;</td>
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<td>Introduction or spread of weed species.</td>
<td>Equipment and vehicles shall be washed down prior to arrival at</td>
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<td></td>
<td>Blocking access of locally migrating fauna and</td>
<td>the project site;</td>
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<tr>
<td></td>
<td>reducing freedom of movement for local fauna,</td>
<td>Weed-free fill material shall be used; and</td>
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<td></td>
<td>causing cut-offs from foraging, feeding,</td>
<td>Noise emissions and use of lighting shall be minimised where</td>
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<td></td>
<td>breeding or resting areas.</td>
<td>practicable.</td>
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**Dust**

- Ensure that atmospheric emissions (dust) do not impact on environmental values or the health, welfare and amenity of the population and land uses; and
- Use all reasonable and practicable measures to minimise airborne dust.

**Potential impacts resulting in dust generation include:**

- Construction activities, land clearing and vehicular movement resulting in the excessive generation of dust;
- Wind-borne dust from DMMA surfaces; and
- Limited and temporal impact on ambient air quality.

**Management measures to minimise the excessive generation of dust include:**

- Regular watering of unsealed roads, exposed surfaces and active construction areas;
- Restriction of vehicle movements and speed;
- Use of environmentally safe dust suppressants;
- General housekeeping practices to ensure no accumulation of waste materials which may generate dust;
- Staff induction programs to ensure employees minimise dust generation; and
- Report all community complaints regarding dust levels.

**Noise**

- To protect the amenity of nearby residents from noise impacts resulting from activities associated with the Project
- Ensuring the noise levels meet statutory requirements and applicable standards.

**Potential impacts resulting from the noise emissions of dredging operations and DMMA construction include:**

- Disturbance to local residents; and
- Disturbance to terrestrial and marine fauna.

**Development and implementation of Noise Management Plan(s) as required by Environmental Protection (Noise) Regulations 1997.**

**Measures that may be undertaken to reduce noise emissions include:**

- Educating and training employees and contractors on noise management;
- Consider noise emissions when sourcing plant equipment;
- Ensure all equipment is maintained and meets equipment noise.
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| **Visual Amenity**   | • To reduce potential visual impacts associated with the project and its activities on the local communities and key users of the Project Area. | The potential visual impacts as a result of the Project include:  
• Loss of visual amenity due to the presence of DMMA sites from Wedgefield, Port Hedland and surrounding transport routes; and  
• Temporary and localised reduction within Port limits due to the sediment plume generated by dredge activities. | The following management measures are designed to minimise impacts to the visual amenity of the area:  
• Height of DMMA not to exceed 12mAHD;  
• Vegetation screening and landscaping; and  
• Dredge material management to keep the footprint and height of dredged material to a minimum. |
| **Hydrocarbons and Chemicals** | • To minimise spills and impacts of hydrocarbons and chemicals in the marine and terrestrial environment.  
• To ensure hydrocarbons are handled and stored correctly. | Degradation of mangroves and sandy shores of South West Creek  
Potential impacts from the risk of spillage of hydrocarbons or chemicals from shipping include:  
• Marine fauna toxicity;  
• Mangrove in the nearshore environment;  
• Soil or groundwater contamination; and  
• Degradation of water quality | Hydrocarbon spills will be managed in accordance with the requirements of PHPA’s Marine Oil Pollution Management Plan and the DMP. In addition, the following strategies will be implemented:  
• Dredge vessels shall be equipped with measurement and overflow protection;  
• Land based plant and equipment shall be appropriately maintained and designed to prevent spills and leaks;  
• All project personnel will be trained in spill prevention, management and clean up;  
• Spill kits will be provided at appropriate locations and all employees to be familiar with the use;  
• Switch off equipment when not in use;  
• Schedule maintenance to minimise noise emissions; and  
• Restrict high levels of noise to appropriate daylight hours.  
For construction activities at night, the additional measures apply:  
• Consideration of acoustic enclosure of noise sources;  
• Need for work to be done out of hours and consider / predict the types of activities which could be noisy;  
• Control measures for noise and vibration, and procedures adopted to monitor noise emissions; and  
• Complaint response procedures to be adopted. |
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| Waste Management     | To ensure that wastes do not adversely affect the health, welfare and amenity of people and land uses.  
To ensure best practice management for the handling and storage of all waste. | The potential impacts of wastes include:  
- Risk of harm or death to terrestrial and marine wildlife caused by ingestion or entanglement of waste;  
- Increase in nutrients and pathogens in the water column (potentially leading to algal blooms or toxicity);  
- Increased landfill requirements caused by unnecessary wastes; and  
- Reduction in aesthetic value. | Waste management measures will be undertaken according to the DMP which include:  
- Compliance with Regulations and Standards when disposing of hazardous waste to ensure the relevant requirements are met and waste is labelled and stored appropriately;  
- Antifouling Systems on ships shall comply with regulations;  
- Sewage and grey water systems will be frequently monitored and maintained;  
- No noxious substances will be discharged within 12 nm of the nearest land;  
- Waste management requirements shall be communicated to all personnel and handled by trained personnel only;  
- Vessel communication systems will be capable of handling generated volumes;  
- Hazardous material storage areas shall be engineered and designed to handle the volumes and operating conditions specifically required for each substance  
- Incompatible products will not be stored together; and  
- Empty liquid waste containers shall be segregated from other wastes and stored in designated areas. |
### Environmental Factor

#### DMMA Land Use Management
- **Management Objectives**
  - To reduce potential visual impacts associated with the project and its activities on the local communities and key users of the Project Area.
  - To ensure, as far as is practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.

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</table>
| DMMA Land Use Management | • To reduce potential visual impacts associated with the project and its activities on the local communities and key users of the Project Area.  
• To ensure, as far as is practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values. | Potential impacts associated with DMMAs and corridors include:  
• Increases in dust generation from the DMMAs;  
• Introduction and establishment of weed species;  
• Modification of landform resulting in altered local drainage leading to erosion;  
• Long term visual impacts associated with failure to re-establish vegetative cover; and  
• Changes in surface water flows and soil stability which could lead to erosion and adjacent vegetation damage. | Management measures designed to reduce potential impacts of DMMAs include:  
• Stabilising the DMMA surface to minimise dust generation;  
• Surface water run-off from the DMMAs will be contained where appropriate and any discharge controlled;  
• Public access will be restricted;  
• Declared Weeds and significant environmental weeds will be controlled; and  
• If the DMMAs and corridors are not re-used or developed within five years of completion of the dredging program the PHPA will rehabilitate these areas. |

#### Cultural Heritage
- **Management Objectives**
  - To comply with the Aboriginal Heritage Act 1972.
  - To avoid or prevent adverse effects on the Project Area’s cultural associations due to Project where practicable.

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| Cultural Heritage | • To comply with the Aboriginal Heritage Act 1972.  
• To avoid or prevent adverse effects on the Project Area’s cultural associations due to Project where practicable. | Potential impacts on cultural heritage that may arise from the Project’s operations include:  
• Impacts on cultural associations to the site and surrounding areas;  
• Loss/disturbance of culturally significant sites during construction;  
• Restricted access to South West Creek for the Kariyarra people; and  
• Unintentional disturbance of cultural heritage sites due to insufficient cultural heritage knowledge of the area to be disturbed during dredging and construction (e.g. DMMAs). | To minimise potential impacts on cultural heritage it is proposed that:  
• Further archaeological and ethnographic surveys will be conducted prior to ground disturbing activities;  
• If cultural heritage sites are identified approval will be obtained, and a Cultural Heritage Management Plan, as required under the Aboriginal Heritage Act 1972 shall be developed to reduce impacts on these sites;  
• PHPA shall allow members of MPL to be present during dredging and construction works in order to monitor impacts on cultural values and will provide the Kariyarra people with a continued right of access where practical. |
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1. INTRODUCTION

1.1 Background

The Port Hedland Port Authority (PHPA) proposes to expand port infrastructure in the Port Hedland inner harbour. Specifically, PHPA proposes the development of a mixture of eight Cape size berths in South West Creek, a tributary of the Port Hedland Inner Harbour estuary. The development includes dredging with associated onshore and offshore disposal of dredge material (see Figure 1-1).

Five of the eight proposed berths have been allocated to three separate port facility infrastructure developers (the Developers), with the remaining three berths currently unallocated. The three Developers are:

- North West Iron Ore Alliance (NWIOA);
- Roy Hill Infrastructure Pty Ltd (RHI); and
- Fortescue Metals Group (FMG).

Due to the size and nature of the proposed works, environmental approvals are required under both State and Commonwealth environmental legislation.

To eliminate the submission of discrete State and Commonwealth environmental approvals by the Developers, the Office of the Environmental Protection Authority (OEPA) requested that PHPA be the lead proponent for the dredging and dredge material disposal works under Part IV of the Environmental Protection Act 1986 (EP Act).

During discussions with the OEPA it was indicated that, based on similar projects within the Port Hedland Inner Harbour, it anticipated that the level of assessment may be set at Assessment on Proponent Information (API). An API level of assessment is usually applied to proposed developments that raise a small number of significant environmental factors that can be readily managed (EPA, 2002a).

The construction of wharves and other land based infrastructure (rail, conveyors etc) is the responsibility of the individual Developers, and will be subject to separate regulatory approvals processes outside the scope of this Proposal.

Prior to PHPA becoming the proponent, some relevant studies and field investigations had been undertaken by the Developers. These studies varied in nature and extent, and many have since been consolidated into summary reports addressing the Proposal.

To ensure consistency, PHPA will also obtain the necessary approvals under the Commonwealth Environmental Protection (Sea Dumping) Act 1981 and the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act).
An application for a sea dumping permit under the Commonwealth Environmental Protection (Sea Dumping) Act 1981 was submitted to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC, Formerly Department of Environment, Water, Heritage and the Arts, DEWHA) in August 2010.

At the request of DSEWPaC the Proposal was referred under the EPBC Act on 6th October 2010. It is anticipated that the project will not be a controlled action.

The concept of the port development in South West Creek, including the dredging campaign and associated land based infrastructure is referred to in this document as the South West Creek Development. The dredging campaign and onshore disposal of dredged material for the South West Creek Development is referred to as the Project.

The ocean disposal components are mentioned in this document when necessary for context.

**Figure 1-1  Location of the proposed South West Creek Project**

### 1.2 Purpose and Scope

The purpose of this document is to formally refer the proposed Project to the Environmental Protection Authority (EPA) for setting a level of assessment under Section 38 of the EP Act. This
document has been prepared in accordance with referral guidelines and provides key environmental information about the Project.

The document:

- Demonstrates that potential environmental impacts from dredging and onshore placement of the dredged material associated with the South West Creek Project can be managed to meet the EPA’s environmental objectives;
- Defines PHPA’s commitment as the proponent to manage the Project in an environmentally acceptable manner; and
- Demonstrates that the environmental impact of the proposed Project will result in environmental impacts similar to or less than those already assessed by the EPA for other marine projects in the Port Hedland area, and as such can be managed to meet the EPA’s objectives.

Specifically, this document provides details on the following:

- Describes the proposed dredging campaign for the entire footprint, and onshore disposal of part of the dredged material;
- Provides details of consultation undertaken with external stakeholders, including relevant government agencies and interested parties;
- Provides a summary description of the existing environment within the footprint of the dredging and onshore disposal of dredged material;
- Provides an assessment of the environmental impact of the Project, based on technical information, policies and guidelines relevant to those effects;
- Details PHPA proposed environmental management of the Project; and
- Details Project’s environmental commitments.

1.3 Proponent Details

The proponent for the Project is:

Port Hedland Port Authority
PO Box 2
PORT HEDLAND, WA 6721
Tel: (08) 9173 0000
Fax: (08) 9173 0060
Email: php@phpa.com.au
The key contact for this proposal is:

Warren Farrow
Development Manager
Tel: (08) 9212 8107
Mobile: 0437 619 675
Email: warren.farrow@phpa.com.au

The Port Hedland Port Authority is a Western Australian Government statutory authority. The Port Authority has a charter to operate along commercial lines and its primary purpose is to facilitate trade through the port.

One of PHPA’s major functions is to control all shipping and maximise the loaded capacity of ships using the Port Hedland Harbour, through the use of world leading technology that allows the port to maintain minimum safe under keel clearances. PHPA also has a responsibility to plan for and manage new developments whilst protecting the environment of the port area.

Further information on PHPA can be found at their website: www.phpa.com.au.

1.4  Assessment Approach

The environmental factors for the planning and assessment of the Project have been identified through existing information, findings of investigative studies, monitoring of existing operations, consultation with relevant stakeholders and experience gained from similar projects being undertaken within the Port Hedland Harbour.

1.4.1  Key environmental factors

Environmental and social factors were determined to be key issues for the Project if they:

- Had a high inherent risk to the environment if left unmanaged;
- Required detailed assessment; and
- Required specific management measures and controls to ensure minimal impacts.

The key environmental factors identified as requiring management for the Project were:

- Marine habitats (mangroves); and
- Marine water quality.
1.4.2 Other relevant environmental and social factors

Environmental and social factors were determined to be relevant (but not key) issues if they:

- Had a minor or low impact and thereby would require less detailed assessment; and
- Required a lower level of management measures and controls to ensure minimal impacts.

The other relevant environmental factors have been identified as:

- Coral Reef Communities;
- Other Benthic Primary Producer habitats;
- Marine fauna;
- Introduced marine species;
- Coastal processes;
- Potential Acid Sulfate Soils;
- Hydrology and hydrogeology;
- Terrestrial flora and fauna;
- Dust;
- Noise;
- Visual amenity;
- Hydrocarbons and Chemicals;
- Waste management;
- DMMA land use management; and
- Cultural heritage.

The potential impacts associated with these relevant factors are discussed in Section 7 and include management actions to minimise the associated potential impacts.

A Dredging Management Plan (DMP) has been developed to manage impacts on the water quality and associated sensitive receptors, and is included in Appendix A. Management measures for the key factors are described in Section 6 and for the other factors described in Section 7.

1.5 Applicable legislation and standards

The implementation of the Project will require compliance with Western Australian legislation and regulations, Commonwealth legislation and regulations, international environmental agreements, EPA position statements and guidelines, and Department of Environment and Conservation (DEC) guidelines.
Key Western Australian legislation and regulations that may apply to the Project include, but are not limited to:

- *Aboriginal Heritage Act* 1972;
- *Australian Maritime Safety Act* 1990;
- *Clean Air (Determination of Air Impurities in Gases Discharged to the Atmosphere)* Regulations 1983;
- *Contaminated Sites Act* 2003;
- *Dangerous Goods Safety Act* 2004;
- *Environmental Protection Act* 1986;
- Environmental Protection Regulations 1987;
- Environmental Protection (Liquid Waste) Regulations 1996;
- Environmental Protection (Noise) Regulations 1997;
- Environmental Protection (Clearing of Native Vegetation) Regulations 2004;
- Environmental Protection (Controlled Waste) Regulations 2004;
- *Fisheries Management Act* 1991;
- *Heritage of Western Australia Act* 1990;
- *Pollution of Waters by Oil and Noxious Substances Act* 1987;
- Pollution of Waters by Oil and Noxious Substances Regulations 1993;
- *Port Authorities Act* 1999;
- *Wildlife Conservation Act* 1950; and

**1.5.2 EPA and DEC Guidelines**

The EPA and DEC provide direction for environmental protection and impact assessment through published guidelines and position statements. PHPA has referred to these publications in investigating and reporting on aspects of this Project. The key EPA position statements and guidelines that are of relevance to the Project include:

- EPA Environmental Assessment Guideline No. 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (EPA 2009a);
- EPA Guidance Statement No. 1: Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2001);
- EPA Guidance Statement No. 3: Separation Distances between Industrial and Sensitive Land Uses (EPA 2002b);
- EPA Guidance Statement No. 8: Environmental Noise (EPA 2007a);
- EPA Guidance Statement No. 12: Minimising Greenhouse Gases (EPA 2002c);
- EPA Guidance Statement No. 18: Prevention of Air Quality Impacts from Land Development (EPA 2000c);
- EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2008a);
- EPA Guidance Statement No. 34: Linkage between EPA Assessment and management strategies, policies, scientific criteria, guidelines, standards and measures adopted by National Councils (EPA 1998);
- EPA Guidance Statement No. 41: Assessment of Aboriginal Heritage (EPA 2004f);
- EPA Guidance Statement No. 51: Terrestrial Fauna Surveys for Environmental Impact Assessment (EPA 2004d);
- EPA Guidance Statement No. 55: Implementing Best Practice in Proposals Submitted to the Environmental Impact Assessment Process (EPA 2003);
- EPA Guidance Statement No. 56: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2004e);
- EPA Interim Industry Consultation Guide to Community Consultation (EPA 2003b);
- EPA Position Statement 2: Environmental Protection of Native Vegetation in Western Australia – Clearing of Native Vegetation with Particular Reference to the Agricultural Area (EPA 2000b);
- EPA Position Statement 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002d);
- EPA Position Statement 6: Towards Sustainability (EPA 2004b); and

DEC guidelines of relevance to the Project include:

- Draft Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes – Acid Sulfate Soils Guideline Series (DEC 2009b); and
- Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes (DEC 2009a).

Other State policies that are also applicable to the Project include:

- Coastal Protection Policy for Western Australia (Department for Planning and Infrastructure (DPI) (2006);
- Contaminated Sites Management Series: Assessment Levels for Soil, Sediment and Water, Draft for Public Comment, Version 3, November 2003 (DoE 2003);
- DoE 2005, Landfill Waste Classification and Waste Definitions 1996 (as amended);
- Draft Coastal Zone Management Policy for Western Australia (Western Australian Planning Commission (DPI) (2001);
- Environmental Weed Strategy for Western Australia. Department of Conservation and Land Management, Perth, Australia (Department of Conservation and Land Management 1999);
1.5.3 Commonwealth Legislation and Approvals

Key Commonwealth legislation and regulations that may apply to the Project include, but are not limited to:

- *Aboriginal and Torres Strait Islander Protection Act 1984*;
- ANZECC/ARMCANZ Guidelines for Fresh and Marine Water Quality 2000;
- Australian Ballast Water Management Requirements and Australian Quarantine Regulations 2001;
- *Australia Heritage Council Act 2003*;
- *Environment Protection (Sea Dumping) Act 1981*;
- *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*;
- *Hazardous Waste (Regulation of Exports and Imports) Act 1989*;
- *Historic Shipwrecks Act 1976*;
- *National Environment Protection Measures (Implementation) Act 1998*; and

1.5.4 International Agreements

Australia is a signatory to a number of international environmental agreements that are relevant to the Project including:

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979;
- The China-Australia Migratory Bird Agreement (CAMBA) 1986; and
2. PROPOSAL DESCRIPTION

2.1 Key Characteristics

PHPA proposes to expand port operations into South West Creek, a tributary of the Port Hedland Inner Harbour estuary. The expansion project includes dredging of approximately 14.2 million cubic metres (Mm³) of marine sediment from South West Creek, to enable the construction of eight berths and a turning circle (Figure 2-1). The berths will accommodate vessels with a ship size of up to 300 m in length by 50 m width.

Five of the eight planned berths have been allocated to the Developers, with three berths currently unallocated:

- Berths SP1 and SP2: Roy Hill Infrastructure Pty Ltd;
- Berths SP3 and SP4: North West Iron Ore Alliance;
- Berth AP4: Fortescue Metals Group Pty Ltd; and
- Berths AP5, AP6 and AP7: Proponent (unallocated) (proposed for future support for the Boodarie Industrial Estate).

The Project has been referred to the EPA in two parts based on the Project being undertaken in two stages as follows:

- Stage 1: Initial dredging of 2.5 Mm³ of material from within the proposed dredge footprint from 0 to -6.0 m CD and disposal of this material offshore.
- Stage 2: Dredging of the remaining 14.2 Mm³ of material from within the proposed dredge footprint from 0 to design depth:
  - A further 5.5 Mm³ is proposed to be dredged from 0 to -6.0 m and disposed offshore to Spoil Ground I; and
  - 8.7 Mm³ is proposed to be dredged from -6.0 m to design depth and pumped onshore to five designated Dredge Material Management Areas (DMMAs), of which two are existing, one is approved but not yet constructed and two new DMMAs, DMMA G and DMMA B -North are proposed (as shown in Figure 2-2).

To maximise the beneficial use of grit dredged material for construction purposes, the Developers may also consider dredging surficial material determined not to contain PASS using a Cutter Suction Dredge (CSD) with disposal of this material onshore to the DMMAs.

The referral document for Stage 1 (known as the South West Creek Tug and Small Vessel Cyclone Protection Facility, Port Hedland) was approved by the EPA on 15 November 2010 as ‘not assessed –
public advice given’. This Environmental Referral Document (ERD) is the subject for Stage 2 of the Project.

An application for a sea dumping permit has been lodged with the Department of Sustainability, Environment, Water, Pollution and Communities (DSEWPaC) for offshore disposal of all dredged material (down to -6 m CD). The spoil ground is situated in federal waters with no impacts expected in state waters.

The key characteristics of the South West Creek Project are outlined in Table 2-1 with the dredge footprint shown in and the DMMA footprints in Figure 2-2.

- **Table 2-1  Overall key project characteristics**

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredge footprint</td>
<td>116 ha</td>
</tr>
<tr>
<td>Total dredge volume</td>
<td>14.2 Mm³</td>
</tr>
<tr>
<td>Offshore disposal dredge component</td>
<td>5.5 Mm³</td>
</tr>
<tr>
<td>Onshore disposal dredge component</td>
<td>8.7 Mm³</td>
</tr>
<tr>
<td>Duration of dredging</td>
<td>Approximately 2.7 years (based on continuous operation to completion)</td>
</tr>
<tr>
<td>Duration onshore disposal</td>
<td>Approximately two years (based on continuous operation to completion)</td>
</tr>
<tr>
<td>Area of land disturbance for onshore disposal</td>
<td>DMMA G: 139 ha</td>
</tr>
<tr>
<td></td>
<td>DMMA B-North: 81 ha</td>
</tr>
<tr>
<td></td>
<td>Corridors (for access and pipelines): 7.40 ha</td>
</tr>
<tr>
<td></td>
<td>Total: 227 ha</td>
</tr>
<tr>
<td>Area of mangrove clearance</td>
<td>Closed canopy mangroves: 31.5 ha</td>
</tr>
<tr>
<td></td>
<td>Scattered mangroves: 8.66 ha</td>
</tr>
</tbody>
</table>
- Figure 2-1  Dredge footprint, berth layouts and turning circle layout
Port Hedland Port Authority

South West Creek Dredging and Reclamation Project:
Environmental Referral Document

**Figure 2-2** Location of new Dredge Material Management Areas (DMMAs)
2.2 Other Dredging Programs

The Port Hedland Harbour has been progressively developed with initial dredging undertaken in 1965 in association with the development of iron ore industry in the Pilbara. Since this time significant volumes of seabed material has been dredged from the harbour (Figure 2-3) (GHD 2009).

Overall, maintenance and capital dredging works have resulted in the removal of an estimated 43 Mm³ of dredged material from the inner harbour. Major modifications include:

- Dredging of a 13 km long approach channel to the harbour;
- Dredging of a turning basin and berthing pockets within the harbour;
- Reclamation of East Creek to enable development of Nelson Point;
- Construction of general cargo, iron ore and salt loading wharves;
- Construction of the Finucane Island causeway which has closed West Creek;
- Dredging of three berth pockets for the FMG at Anderson Point;
- Dredging at Nelson Point for expansion of BHP Billiton Iron ore export facilities; and
- Dredging at Harriet Point for expansion of BHP Billiton Iron ore export facilities.

![Annual Dredging Volumes](image)

- Figure 2-3  Timeline of Dredging of Port Hedland Harbour since 1974.
It is proposed that dredging in South West Creek will commence mid-2011. It is understood that the BHP Billiton Iron Ore (BHPBIO) RGP5 dredging project at Harriet Point is complete. By the proposed commencement date it is expected that the dredging of BHPBIO RGP6 Nelson Point dredging and FMG’s third berth at Anderson Point will be complete. The South West Creek Tug Boat and Small Vessel Cyclone Mooring Facility dredging program is planned for the first half of 2011 and is expected to be complete prior to this Project commencing. The only other potential dredging activities that may be active in 2011 (other than maintenance dredging by PHPA) is dredging at Lumsden Point.

The methodology proposed for the South West Creek dredging is consistent with the approach used on the dredging campaigns noted above.

2.3 Project Justification

PHPA is the statutory body responsible for the management of the Port of Port Hedland. Current economic forecasts indicate an increased demand for cargo volumes to be exported through the port, and that the current port infrastructure will be unable to meet this demand. The proposed South West Creek Development will allow materials to be exported to meet the strong and increasing world demand for iron ore.

PHPA recognised the need for a planning strategy to promote, facilitate and expand trade through Port Hedland and undertook a planning study to produce a development plan for, which was described in the draft 2003, and revised 2007 Port Planning Study and Ultimate Development Plan for Port Hedland (2007 UDP) (Worley Parsons 2007). The plan was further updated in 2009 (PHPA 2009).

The proposed South West Creek Development is in accordance with the Port’s 2009 UDP (Worley Parsons 2007, PHPA 2009).

2.4 Evaluation of Alternatives

Overall considerations in the development of the layout of the facility included:

- Locating the berths to meet PHPA’s long-term requirements while also taking into account tidal currents for manoeuvring ships;
- Locating dredge spoil disposal areas to maximise use by current and future developments, whilst minimising impacts on mangroves and heritage sites;
- Minimising impacts of the development on water flows in the harbour including tidal flows and storm surge;
- Locating the stockpiles as close as possible to the ship-loading berths to allow safe practical ship trimming to occur; and
• Minimising environmental impacts including benthic primary producer habitat loss and dust and noise impacts on the Port Hedland community.

2.4.1 Dredge footprint and alignment of berths

The conceptual layout of the development in South West Creek was initially discussed in the 2007 UDP (Worley Parsons 2007) with subsequent amendments as discussions and workshops were held between the three Developers and PHPA.

SKM (2010a) undertook an options assessment to minimise the dredge footprint, the dredge volume and the disturbance of mangroves associated with the South West Creek Development. Five options were reviewed and discussed in detail (SKM 2010a):

• Option 1: Original Layout proposed by PHPA – which is the layout assessed in this document (Figure 2-1);
• Option 2: Straightening the alignment of berths AP4 to AP7;
• Option 3: Adjusting the location of the turning basin so that it would be central to the centreline of the South West Creek Dredge Area;
• Option 4: Option 1 rotated to prevent disturbance to the mangroves behind berth AP7; and
• Option 5: Option 1 extended into South West Creek by 70 m.

The option assessed in this document is the configuration proposed by PHPA (Option 1) as this was the most suitable solution in terms of minimising both dredging volumes and impacts on mangroves.

2.4.2 Disposal options for dredged material

A crucial element of the South West Creek dredging campaign was the development of an appropriate dredge material disposal strategy. Both potential onshore and offshore disposal areas were identified and evaluated for suitability through a detailed options assessment (SKM 2010a) before a disposal strategy was developed.

The existing approved Offshore Spoil Ground I, located in federal waters, was identified as suitable for offshore disposal.

A series of potential onshore DMMAs were identified within the PHPA UDP Development Areas (Worley Parson 2007). The selection criteria for identifying suitable DMMAs included consideration of the location and potential capacity, distance from the dredge (i.e. pumping distance), and the requirements by each Developer for construction material. Consideration was also given to avoid disturbance of mangrove habitat and heritage areas.

Five potentially viable scenarios for the management of dredge material were defined. In essence these scenarios consisted of combinations of onshore and offshore disposal to consider the management of the Potential Acid Sulfate Soils (PASS) in the top seabed layer, minimising the
amount of fines disposed on land, maximising the onshore disposal of potential useful material (coarse sediments), minimising the duration of the project and overall minimising the environmental impact associated with either type of disposal.

The placement of all material onshore could generate a large terrestrial disturbance footprint with significant quantities of residual fines in settlement ponds. Without rehabilitation works the settlement pond areas could not be used for any other purpose. In addition a full onshore disposal scenario has the potential to bring PASS material onshore, which if not managed correctly increases the risk of environmental impacts to both the creek system, surface hydrology and the ground water.

A full offshore disposal scenario would not provide any fill material to the Developers, which would be a major obstacle to the development of onshore infrastructure, and would also go against the National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia 2009) where beneficial uses for dredged material should be prioritised over ocean disposal.

A compromising disposal scenario was reached with the proposed combination of onshore/offshore disposal scenario. In this option the surficial sediments, where PASS may exist and the majority of fines are found, are disposed offshore, while the deeper coarser and inert layers are brought ashore for beneficial uses. The division of onshore and offshore volumes is discussed in detail in Section 2.5.

### 2.4.3 No Development Option

The Project is located within an operating port, however at present the waters of South West Creek are not navigable to any shipping. The Project will enable PHPA to meet the demand to increase export capacity within the Port.

Failure to expand the port facility could ultimately cause current PHPA leaseholders to identify alternative locations for iron ore exports.

The no development option would also result in the loss of opportunity to add value to Australia’s raw materials, loss of employment opportunities and community development, particularly within regional communicates. The increasing global demand for iron ore would then be met through the development of projects predominantly overseas, with the loss of associated benefits to Western Australia.

### 2.5 South West Creek Dredging Proposal

#### 2.5.1 Dredge Area Design

The proposed South West Creek Development includes a large dredging component for the construction of eight berth pockets, a turning circle, and a link to the existing departure channel. The
total dredge volume is approximately 14.2 Mm$^3$ of material, including tolerances and over-dredging to achieve the required design depths for safe navigation.

Specifically, the proposed dredging campaign at South West Creek comprises (Figure 2-1):

- Dredging of berth pockets SP1 to SP4 to 19.0 m CD, and AP4 to -19.3 m CD;
- Dredging of berth pockets AP5 to AP7, the departure channel, and the 400 m turning circle to -14.8 mCD;
- Dredging of a silt trap adjacent to the turning basin to -21.0 m CD 200 m x 200 m in dimension;
- Extending the existing Inner Harbour departure channel into South West Creek adjacent to the berths to a design depth of -14.8 mCD to enable safe departure of loaded vessels;
- Batters at 1:10 for marine muds (i.e. from 0 up to +6 m CD) and 1:2.5 for the deeper consolidated material below 0 mCD; and
- Associated over-dredging of approximately 0.7 m due to dredging tolerances and siltation protection.

The components of the South West Creek dredging program are shown in Figure 2-1 including the total area to be disturbed by dredging activities. This area is indicated as the disturbance envelope and includes the top of the dredge batters. This area is approximately 112 ha. A 20 m corridor on the outside of the dredge footprint has also been set to capture future land based construction disturbance. The total area of disturbance for the dredge footprint and future construction footprint is approximately 116 ha.

### 2.5.2 Dredging and disposal

Details of the geology in South West Creek are provided in Section 4.3.4. Based on this information, it is anticipated that the dredge material would comprise variable thicknesses of soft marine mud overlying calcareous sandstone (also referred to as ‘red beds’) and conglomerate. The top of the granite in the area typically lies below an elevation of -45 mCD, and drilling and blasting is therefore not expected to be necessary (SKM 2010). Recent geotechnical and refraction survey results from the south end of the dredge footprint confirmed this (SKM 2010; Marine & Earth Science 2010).

As discussed in Section 4.3.6 PASS is typically found in the surficial sediments of Port Hedland to a depth of -2.0 mCD. For management of PASS and for optimisation of use of the dredged material on land, dredging and disposal is proposed undertaken using two types of dredges and with a combination of offshore and onshore disposal of dredge material:

- Backacter dredges: Initial dredging of both PASS and Non-PASS (N-PASS) material to a nominal depth of -6.0 m CD with the dredge material transported via split hopper barges to an offshore disposal ground in Commonwealth waters (note offshore disposal is subject to a separate approval);
- Cutter Suction Dredge: Dredging of deeper non-PASS material from -6.0 mCD down to design depth, pumping the dredged material onshore to several designated Dredge Material Management Areas (DMMAs); and
- To maximise the use of grit material for construction purposes, the Developers may also consider dredging surficial material determined not to contain PASS, using a CSD with dredge material disposed onshore.

A backacter is a large backhoe type dredge with an excavator specifically designed for dredging. They are a new class of backhoe dredge, and the largest, and as such are in limited supply worldwide, however two backacters are currently working in Port Hedland.

It is proposed using two backacter dredges for the South West Creek dredging campaign, at times working concurrently depending on available access depth to South West Creek, which will change as dredging progresses. It is proposed that one CSD will undertake dredging for the deeper occurring material, i.e. below -6.0 m CD. The CSD would cut and pump the dredged material onshore as a slurry mixture via pipelines and no overflow from the dredge itself would occur.

The use of one or two backacters to dredge the surficial sediment layers, and use of one large CSD to execute part of the works is consistent with the methodology currently being employed in Port Hedland and has previously been approved by relevant government agencies.

A summary of the proposed dredge and disposal management of the dredged material is given in Table 2-2.

### Table 2-2 Estimated volumes of dredged material for disposal offshore and onshore

<table>
<thead>
<tr>
<th>Depth of material</th>
<th>PASS risk</th>
<th>Disposal option</th>
<th>Proposed type of dredge</th>
<th>Total volume (approx) (Mm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlying sediments</td>
<td>Yes: upper 0-2 m</td>
<td>Offshore</td>
<td>Backacter Dredge</td>
<td>5.5</td>
</tr>
<tr>
<td>Deeper occurring sediments</td>
<td>No</td>
<td>Onshore</td>
<td>Cutter Suction Dredge</td>
<td>8.7</td>
</tr>
</tbody>
</table>

#### 2.5.3 Dredge Material Management Areas

In order to effectively manage the dredged material for onshore disposal, and to meet the requirements of the Developers, five onshore Dredge Material Management Areas (DMMAs) have been identified for the South West Creek Development, all located within the PHPA UDP.
Development Areas A, B and G* (PHPA 2009). Two of the DMMAs have already been constructed, one has been granted approval under Part IV of the EP Act, but is yet to be constructed and approval is sought for the remaining two via this ERD. The DMMAs are shown in Figure 2-4 and described below:

- Existing DMMA A and B are located to the south of Anderson Point. Both these DMMAs are existing dredge material management areas and were used as a disposal ground for dredged material arising from FMG’s third berth at Anderson Point;
- DMMAB South is located to the south of DMMA B, with approval under Part IV EP Act already obtained by FMG (Ministerial Statement 771);
- Proposed DMMA G is located to the south of South West Creek and east of the BHPBIO rail line; and
- Proposed DMMA B-North situated north of the existing DMMA B.

The material to be disposed of onshore will be dredged by a CSD and pumped to land via pipelines. The material will consist of both coarse and fine material. While the coarse material will settle out of suspension rapidly and constitute valuable material for the Developers to use for onshore construction projects, the fines have the potential to stay in suspension for prolonged periods (‘slimes’).

Generation of significant quantities of slimes is a well known characteristic of dredging in Port Hedland, and settlement ponds are needed for the fines to sufficiently settle prior to discharge of the return water into the creek systems.

Due to the bulking (with water) of slimes, the final volume of slimes to be disposed of onshore will be significantly greater than the volume of solids actually dredged. An approximate bulking factor or 5.5 applies to the slimes in Port Hedland, while a bulking factor of 1.0 applies to the coarse material (SKM 2010). The bulking factors and assumptions on proportions of coarse and fine content given in Table 2-3 were used to calculate the bulked volume of dredged material for ocean and land disposal (Table 2-4).

*Within this document the nomenclature of DMMAs is as per the PHPA UDP (PHPA, 2009).*
Port Hedland Port Authority
South West Creek Dredging and Reclamation Project:
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- **Table 2-3** Onshore disposal slurry volume estimation factors

<table>
<thead>
<tr>
<th>Material</th>
<th>Dredge material before bulking</th>
<th>Bulking factor</th>
<th>Dredge slurry after bulking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>85 %</td>
<td>1.0</td>
<td>51 %</td>
</tr>
<tr>
<td>Fine</td>
<td>15 %</td>
<td>5.5</td>
<td>49 %</td>
</tr>
</tbody>
</table>

*Based on publicly available information from previous dredging environmental approvals applications (SKM 2010).*

- **Table 2-4** Estimated dredge material disposal volumes

<table>
<thead>
<tr>
<th>Dredge vol (offshore) (m³)</th>
<th>Dredge vol (onshore) (m³)</th>
<th>Onshore vol bulked – total (m³)</th>
<th>Onshore vol bulked – grits (m³)</th>
<th>Onshore vol bulked – slimes (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,500,000</td>
<td>8,700,000</td>
<td>14,572,500</td>
<td>7,395,000</td>
<td>7,177,500</td>
</tr>
</tbody>
</table>

The proposed DMMA G and B North will comprise an earth bunded perimeter, to a maximum level of +12.0 m Australian Height Datum (AHD). Internal bunds in all DMMAs will allow for the separation of fine and coarse material. The actual bund heights are subject to further refinement of the engineering design, however a review of current capacities of the DMMAs was undertaken in July 2010 (SKM 2010c), showing that the combined holding capacity of the existing, approved and proposed DMMAs is sufficient for onshore disposal of all dredge material below -6.0 m CD to design depth. The actual bund heights will determine the final DMMA capacities, with the actual capacity requirements ultimately depending on the fraction of fines and coarse material in the deeper occurring material again determining the volume of slimes needing management.

Onshore use of the dredge material by the Developers will primarily be localised raising of ground so that it lies above the flood threshold level stated in the 2007 UDP (WorleyParsons 2007). The specific use of the dredged material, including any port and land based infrastructure, will be subsequent to this Project and subject to separate environmental impact assessment and where applicable, statutory approvals.
Project DMMA and associated corridors layout

During dredging the CSD will cut and pump the dredged material onshore as a slurry mixture at varying densities depending on the nature of material dredged and the pumping distance required. It is proposed that the slurry will be pumped ashore via a combination of floating, submerged, and onshore pipelines. The pipeline will likely have an internal diameter of 900 mm, depending on the CSD available. Due to the abrasive qualities of the dredge material, two parallel steel pipelines will be utilised onshore, allowing the contractor to alternate between pipelines to minimise downtime during pipeline maintenance. Two pipeline corridors running from the dredge to DMMA G and DMMA A will be needed. The pipeline to DMMA B will run along the existing road to As the pipeline to DMMA A will run along the existing road to Anderson Point, Anderson Point, the construction of a pipeline corridor is needed for DMMA A and DMMA G, as shown in Figure 2-4.

The pipeline corridor will be constructed approximately 30 m wide to accommodate the installation of the pipelines.

The slurry is proposed to be circulated between the DMMAs for management of the coarse and fine material, and to meet water quality guidelines for the discharge. Construction of internal bunds and additional pipeline systems between DMMAs will allow for management of the dredged material. DMMA B-North will only be constructed and used if necessary to either obtain sufficient DMMA capacity, or for sufficient settlement pond periods to meet the water quality guidelines.
DMMA B currently has a discharge point into South Creek. A discharge point from DMMA G into South West Creek is proposed, as shown in Figure 2-4. Return water will be discharged into South Creek from DMMA B, and from DMMA A and DMMA G into South West Creek. Discharge of return water will occur primarily into South Creek from DMMA B, with secondary discharge from DMMA G into South West Creek, with discharge points shown in Figure 2-4. The return water will be subject to monitoring to ensure compliance with Total Suspended Solids (TSS) and turbidity requirements prior to discharge. Based on the assumption that material in South West Creek has similar properties to material dredged within the Inner Harbour, retention time of slurry in the DMMAs to meet water quality objectives would be approximately 48 hours, though longer retention times may be required.

After disposal of the dredged material on land, an indicative land disposal height of 8 m above existing ground level has been estimated (SKM 2010b).

A 20 m wide construction boundary is proposed around all disturbance areas. The area within this boundary will only be disturbed for construction activities and will be minimised where practicable. All lay-down areas will be accommodated within the DMMAs and therefore not require further land disturbance.

The proposed DMMA G and DMMA B-North are located in areas mostly free of vegetation. However, some clearing of vegetation, including mangrove habitat, would be required for the construction of the proposed DMMAs including access and pipeline corridors. These areas are shown in Figure 2-4 and listed below:

- For the construction of the DMMA perimeter earth bunds;
- Within the DMMA footprints themselves;
- To provide land backed access for the removal of mangroves from the dredging footprint in two locations (approximately 30 m wide);
- For the construction of a temporary pipeline corridor from South West Creek to DMMA G (approximately 30 m wide); and
- For the construction of temporary pipeline corridors from South West Creek to the existing DMMA A (approximately 30 m wide).

The mangroves will be cleared using land based equipment.

**2.5.4 Modelling of the dredge and disposal program**

Hydrodynamic modelling has been undertaken to predict impacts associated with the dredge program and disposal of dredged material. Specifically, modelling considered the impacts associated with using the following combinations of dredges at any one time:

- Using one or two backacters to remove sediment above nominally -6.0 m CD;
- Using one large CSD to remove the material from -6.0 m CD to design depth; and
- Disposing the material from -6.0 m CD to design depth onshore including associated return water discharge into South and South West Creek.

Modelling to assess the potential impact of the offshore disposal of all surficial material to a maximum depth of -6.0 m CD was undertaken by Asia-Pacific Applied Science Associates (APASA). This was prepared to support an application for a Sea Dumping permit and is described in a separate document.

The model assumed that during some periods one or two backacters will work concurrently with each other and/or with the CSD as required.

2.5.4.1 Backacters

The use of one or two backacters to dredge the surficial sediment layers is consistent with current works being undertaken in Port Hedland harbour. The backacters will be supported by a number of self propelled split hull hopper barges. These barges will moor alongside the backacter to be loaded with dredged material. Once full the barges will sail to Spoil Ground I and dump the material. Multiple barges may be deployed to ensure that the backacter/backacters are not left idle whilst dumping is being undertaken. It has been estimated that a single backacter with supporting barges could achieve an offshore disposal rate of approximately 50,000 m$^3$ per week. This includes an allowance for maintenance downtime and operational issues and is therefore lower than the theoretical maximum output for this equipment. The estimate is based on the parameters outlined in Table 2-5 used in the modelling.

<table>
<thead>
<tr>
<th>Table 2-5</th>
<th>Backacter dredging specifications used in the dredge modelling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
<td><strong>Parameter value</strong></td>
</tr>
<tr>
<td>Dredge (specifications used in the dredge modelling)</td>
<td>Backacter 1100</td>
</tr>
<tr>
<td>Disposal of dredged material</td>
<td>Offshore (subject to separate approvals process)</td>
</tr>
<tr>
<td>Split hull hopper barge capacity</td>
<td>3700 m$^3$</td>
</tr>
<tr>
<td>Bucket size</td>
<td>25m$^3$</td>
</tr>
<tr>
<td>Overflow from split hopper barges</td>
<td>No overflow of barges permitted</td>
</tr>
<tr>
<td>Number of barges</td>
<td>Two per backacter</td>
</tr>
<tr>
<td>Dredging operational hours</td>
<td>24 hours per day, 7 days per week</td>
</tr>
<tr>
<td>Backacter effective hours</td>
<td>65% (i.e. the backacter is physically dredging 65% of the time, the remainder consumed by maintenance downtime, barge change over etc)</td>
</tr>
</tbody>
</table>
2.5.4.2 Cutter Suction Dredge

Table 2-6 summarises the CSD dredging, land disposal and return water specifications used in the dredge modelling.

The use of one large CSD to execute part of the works is consistent with the methodology currently being employed in Port Hedland and has previously been approved by relevant government agencies. Production rates of 130,000 m³/week were accomplished during the BHPBIO’s RGP5 project in Port Hedland (BHP Billiton 2008); however a lower rate of 100,000 m³/week was adopted in this assessment for modelling purposes due to:

- Longer pumping distances. BHPBIO’s RGP5 dredging works involved much shorter pumping distances. Further, the production of the CSD used in the RGP5 dredging works becomes pump limited beyond 3 km; and
- Nature of material. A significant quantity of softer materials will be disposed of offshore in the South West Creek project, with harder consolidated materials disposed of onshore. This would decrease the average production rate for onshore disposal due to the harder consolidated materials.

Table 2-6 Dredge modelling specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredge type</td>
<td>Large CSD</td>
</tr>
<tr>
<td>Production rate (of dredge)</td>
<td>100,000 m³/week</td>
</tr>
<tr>
<td>Dredging and disposal operational hours</td>
<td>24 hr/day, 7 days/week</td>
</tr>
<tr>
<td>Effective hours (dredging)</td>
<td>60% (remaining time consumed by maintenance downtime, change of side anchors, spuds, pick points, etc.)</td>
</tr>
<tr>
<td>Effective production rate (during dredge operations)</td>
<td>992 m³/hr</td>
</tr>
<tr>
<td>Discharge water production (from dredge)</td>
<td>5,000 m³/hr or 1.39 m³/sec</td>
</tr>
<tr>
<td>Mobilisation of fines (from dredge)</td>
<td>5% of fines in dredge material</td>
</tr>
<tr>
<td>Disposal</td>
<td>All material below -6.0 m CD pumped onshore</td>
</tr>
<tr>
<td>TSS limit on return water discharge</td>
<td>150 mg/L</td>
</tr>
<tr>
<td>Discharge water locations</td>
<td>Stages C to F, 14% from DMMA G, 86% from DMMA B-North through discharge point at DMMA B, Stage G, 14% from DMMA G, 86% from DMMA B-North through discharge point at DMMA B</td>
</tr>
</tbody>
</table>
2.6 Ancillary Requirements

2.6.1 Access Roads

Access to DMMA A and DMMA B will be via the existing road network. Access to DMMA G and DMMA B-North will require access tracks to be constructed. All access tracks will be within the designated DMMA construction footprints, nominated corridors and/or existing disturbed areas.

2.6.2 Contractor Laydown Areas

All laydown areas will be within the designated DMMA disturbance footprint, nominated corridor areas, or within existing laydown areas.

2.6.3 Plant and Equipment

It is anticipated that the following dredges, plant and vehicles will be required for the earthworks associated with the construction of the DMMAs, as well as for the dredging operation itself:

- One large Cutter Suction Dredge;
- Two Backacter Dredges;
- Supporting marine plant;
- Bulldozers;
- Excavators;
- Trucks and water trucks;
- Rollers/compactors;
- Wheel loaders/pipe layers;
- Cranes; and
- Graders.

2.6.4 Maintenance and Monitoring

Following the initial dredging program for the South West Creek Development, maintenance dredging to maintain the required depths for safe navigation will be undertaken by PHPA. Spoil from maintenance dredging will be disposed of either onshore or offshore, depending on the characteristics of the spoil. Maintenance dredging is expected to be undertaken annually.

PHPA will manage their allocated components of the South West Creek Development in accordance with their Environmental Management System and associated management plans to ensure there are no unacceptable impacts on the environment as a result of ongoing operations. Ongoing monitoring and stakeholder consultation will enable PHPA to evaluate and modify management measures.
2.7 Project Schedule

Dredging of overlying material (nominally down to -6 m CD) using backacters with associated offshore disposal is scheduled to start in the first quarter of 2011. Dredging with a CSD is likely to commence in second quarter of 2011. As described in Section 2.5.2 the backacters would in part work in parallel with the CSD.

Construction of the proposed DMMA G and the approved DMMA B-South is proposed to start in the second quarter of 2011. DMMA B-North will only be constructed if necessary for capacity and/or management of the slimes.

If undertaken in its entirety as a continuous single continuous campaign, the duration of the dredging campaign, including both the backacter and CSD components, is currently estimated at 994 days, or 2.7 years. This time line is based on the assumption that the dredging works and activities at the DMMAs would continue for 24 hours per day, 7 days a week, and that the DMMAs would be ready to receive material at commencement of the CSD works.

It is however likely that the full execution of the Project will be staged depending on the development timeframes of each Developer. As such the 2.7 years represents the minimum duration of the Project.
3. **STAKEHOLDER CONSULTATION**

PHPA recognises the importance of community and government consultation for the proposed Development of South West Creek. PHPA understands that the proposed Development has potential to impact the local community and the environment and that stakeholder communication is essential to ensure that all of the impacts are carefully considered and appropriately managed throughout construction and operation of the facility.

From a community perspective the project, as defined in this document, is simply one component of the overall South West Creek Development, including the construction of wharves and associated infrastructure and operation of the facilities. As such all stakeholder consultation has been undertaken from a holistic perspective including all aspects of the Development.

The stakeholder consultation has formed an integral role in the planning and design stages of the Project. PHPA has undertaken consultation with representatives from local community groups, relevant local and state government bodies, local indigenous groups and neighbouring industry. Consultation was undertaken based on the Community Consultation Guideline (DEC 2006). In addition to the work undertaken by PHPA, consultation has also been undertaken by the individual Developers.

### 3.1 Consultation Program

#### 3.1.1 Consultation methods

Consultation for the South West Creek Development has been conducted widely by PHPA, while the three Developers have also conducted consultation individually with varying levels of detail concerning their individual development of infrastructure.

Major stakeholders were contacted for a face-to-face meeting and shown a presentation describing the proposed Development. Other stakeholders, including PHPA leaseholders and service providers, were contacted by email, provided a description of the Project and given an opportunity to respond. The information provided to stakeholders included:

- A brief history of the project;
- A summary of a demands study on users of the Port Hedland Port, providing a justification of the reasons for the upgrade;
- The objectives of the new facility;
- A summary of the alternatives considered;
- A summary of the proposed dredging program;
- A summary of the preliminary investigations and planning already undertaken, and future investigations planned prior to construction;
• The planned project schedule; and
• An opportunity for questions and comments.

3.2 Key Stakeholders

The three Developers were identified as major stakeholders with a significant interest in the proposed Project:

• RHI;
• FMG; and
• NWIOA.

The following were also identified as stakeholders requiring consultation:

• Environmental Protection Authority (EPA)
• Office of Environmental Protection Authority (OEPA);
• Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC);
• Department for Environment & Conservation (DEC), including the Perth branch, the Pilbara branch, Marine Ecosystems, Air Quality, Environmental Management and Corporate;
• Town of Port Hedland (ToPH);
• Department of State Development;
• Department of Transport;
• Department of Infrastructure, Transport, Regional Development and Local Government;
• Pilbara Native Title Service;
• Local Aboriginal groups;
• Care for Hedland Environmental Association; and
• Pilbara Development Commission.

3.3 Stakeholder Comments

A summary of consultation undertaken for the South West Creek Development Project is provided in Table 3-1.

Table 3-1 Summary of stakeholder consultation

<table>
<thead>
<tr>
<th>Stakeholder meeting date</th>
<th>Stakeholder meeting attendees</th>
<th>Comment Resolution of issues raised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing</td>
<td>FMG</td>
<td>Project in general – project design, environmental impacts and management measures</td>
</tr>
<tr>
<td>Ongoing</td>
<td>Roy Hill Infrastructure</td>
<td>Project in general – project design, environmental impacts and management measures</td>
</tr>
<tr>
<td>Stakeholder meeting date</td>
<td>Stakeholder meeting attendees</td>
<td>Comment Resolution of issues raised</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Ongoing</td>
<td>NWIO</td>
<td>Project in general – project design, environmental impacts and management measures</td>
</tr>
<tr>
<td>Ongoing</td>
<td>OEPA</td>
<td>23/04/10 Discussion with developers, OEPA Marine Branch, OEPA assessing officer and PHPA on the scope of works for environmental referral 26/08/10 – Discussion of modelling scope of works being undertaken for dredging of the development footprint</td>
</tr>
<tr>
<td>Ongoing</td>
<td>DSEWPaC</td>
<td>Sea Dumping Permit application requested Submission of Sea Dumping Permit 21/08/10, permit decision expected by December 2010 Referral under the EBPC Act required 10/09/10 Sea dumping permit application and EPBC referral for South West Creek offshore dumping will be assessed by DSEWPaC EPBC Referral for offshore dumping lodged 23/09/10. DSEWPaC requested additional information on whole of scope of South West Creek dredging. Revised EPBC referral lodged 6 October 2010. Expect ‘not a controlled action’ determination advice on 9 November 2010 29/09/10: Vicki Middleton (delegate to the Federal Minister for the Environment) will brief the Federal Minister for the Environment (Tony Burke), monitor the assessments and advise RHI of issues if required Discussion of project and DSEWPaC approvals required</td>
</tr>
</tbody>
</table>

The dredging of South West Creek is critical element in the development of the Roy Hill 1 Iron Ore Project. RHI has completed a comprehensive consultation program with relevant State and Commonwealth departments and continues to develop productive working relationships with relevant community stakeholders. RHI has obtained the support of key decision making authorities and has made firm commitments to contribute to the development of the Town of Port Hedland.

Although not included in the table above, extensive consultation was undertaken relating to the South West Creek Project between March 2008 and September 2010. This consultation included regular briefings to the Care for Hedland Environmental Association and the Town of Port Hedland, a community forum and regular briefings of key government agencies including the EPA, DEC and the Pilbara Development Commission.

### 3.3.1 EPA Consultation

Consultation with the EPA has been undertaken over a series of meetings since January 2010. Initial queries from PHPA covered the level of assessment that the EPA expected the proposal to be set at. Based on previous approved dredging projects within the inner harbour area, and understanding of the key likely impacts arising from the proposal, it was considered that Assessment on Referral Information (ARI) may be an appropriate level.
3.3.2 DSEWPaC consultation

WorleyParsons, on behalf of PHPA, submitted a Sampling and Analysis Plan (SAP) Implementation Report and Sea Dumping Permit application for sediment contamination assessment of the spoil ground and all material within the South West Creek Development dredge footprint down to -6.0 m CD intended for offshore disposal. This was done on behalf of PHPA to DSEWPaC on 20 August 2010. The DSEWPaC are currently reviewing the report and permit application and a decision on the application is expected on 26 November 2010. During consultation with DSEWPaC it was identified that a referral under the Environmental Protection and Biodiversity Conservation Act1999 (EPBC Act) was required to be submitted for the project. PHPA submitted the referral on 23 September 2010 and a decision on this information is expected on 9 November 2010.

3.4 Key Issues Raised by Stakeholders

Key issues raised throughout the consultation process are discussed briefly below, and more fully in the relevant sections of this document.

3.4.1 Dredging Impacts

There was concern that there may be cumulative impacts should the South West Creek dredging program coincide with other dredging programs within the harbour. PHPA does not believe that concurrent dredging will be necessary to achieve operational schedules. In the event that concurrent operations of CSDs may occur within the inner harbour, PHPA will liaise closely with the EPA regarding any additional requirements.

3.4.2 Cumulative Mangrove Impacts

The impacts of the Utah Point Project, RGP 5 and RGP 6 are included in the assessment of cumulative impacts to mangroves provided in Section 6.2.

3.4.3 Assessment of Coral Communities

Scattered sparse coral communities occur within Port Hedland Harbour, particularly on the channel walls near the mouth of the harbour. Sections7.1 and 7.2 of this document have incorporated assessment of coral communities and other benthic primary producer habitat and communities in the inner harbour.

3.4.4 Marine Turtles and other marine biota

Following queries raised by Care for Hedland on the potential impacts to marine turtles, FMG commissioned Pendoley (2009) to assess the risk of proposed development in South West Creek to turtles. The potential impacts and proposed management measures are addressed in Section 7.3.
review of the subsequent assessment reporting, Care for Hedland indicated that it was satisfied that FMG had adequately addressed the potential environmental issues and provided the management mechanisms described were implemented, was comfortable with the scope of the Project. PHPA is proposing the same management measures as proposed by FMG.

3.4.5 Public Access

Community and indigenous concerns were raised regarding continued access to the harbour creek systems for recreational pursuits.

PHPA advised that access to the immediate operational areas would be restricted because of maritime security requirements however access to other parts of the harbour system would remain. Landside construction may result in removal of current landside access points.

3.4.6 Air Quality and Noise Impacts

Concerns were raised around increased air quality and noise impacts, particularly as a result of operations. Stakeholders were advised that this Project was dealing with the dredging component only and that the individual developers would be addressing the dust and noise impacts of their operations.

It was discussed that there may be some dust impacts, particularly from the bund construction, however measures would be in place to ensure that this was adequately managed. Noise levels would not exceed current levels in noise sensitive areas due to the nature and location of the activity. The potential impacts and proposed management measures for dust and noise related to the dredging operations are addressed in Sections 7.9 and 7.10.

3.4.7 Social Impacts

The Town of Port Hedland enquired about the assessment of social impacts from the Project. There is currently a high demand for town facilities and further port expansion would increase the pressure on the existing social infrastructure in this area.

PHPA advised that it is responsible for the dredging component of the development only and that the current dredging workforce residing in the town would be utilised resulting in no additional impact on social infrastructure. The dredging project would be associated with new port facilities which would require additional social infrastructure. PHPA explained that the individual developers would need to address the social impacts associated their projects separately.
4. EXISTING ENVIRONMENT

4.1 Regional Setting

4.1.1 Location

The Pilbara region is sparsely populated, with a total resident population of approximately 46,000 people in 2008 (ABS 2010). The majority of the Pilbara’s resident population is centred in the towns of Port Hedland, Karratha, Newman, Tom Price, Paraburdoo, Roebourne, Wickham, Dampier, Onslow and Marble Bar.

The town of Port Hedland supports a population of approximately 19,000 people with a combination of residential, commercial, administrative and industrial facilities including the port operations (ToPH 2010). The population fluctuates in relation to the construction and operation phases of major resource and related infrastructure projects (PDC 2003). Port Hedland includes both the original Port Hedland town site and South Hedland (located 15 km inland). Port Hedland is the largest Australian port for the export of iron ore. Other commodities exported through the port include manganese ore, copper concentrate, salt and chromite ore (from the east Pilbara area). Port Hedland’s other industries include tourism and pastoral use.

4.1.2 Climate

The Pilbara is a sub-tropical region and experiences warm winters and hot summers. It is the most cyclone prone area in Australia with a cyclone season which generally lasts from November to April (BOM 2010). The region is characterised by consistently high temperatures with low and variable rainfall associated with cyclones and thunderstorms.

4.1.2.1 Temperature

Figure 4-1 shows the monthly mean minimum and maximum temperatures in Port Hedland. Summer temperatures range from a mean maximum of 36°C to a mean minimum of 24°C. The maximum temperatures in summer are usually moderated by warm, humid sea breezes. During the winter months, temperatures range from a mean maximum of 27°C to a mean minimum of 12°C (BOM 2010).
4.1.2.2 Rainfall

Average annual rainfall for the Pilbara region varies between 250 and 400 mm, with many years reporting no significant rainfall events (BOM 2010). Most rainfall occurs during the summer months and is associated with tropical storms and cyclone weather patterns. A second rainfall peak occurs during the winter months of May and June in response to the formation of tropical rain bands. Figure 4-2 displays the mean annual rainfall and maximum rainfall in Port Hedland recorded from 1942 to the present.
4.1.2.3 Wind

Wind direction and speed are highly variable throughout the year in response to seasonal weather patterns. Dominant annual wind directions in Port Hedland are north westerly during summer months, becoming south easterly during winter months, as shown in the wind roses in Figure 4-3. The wind roses are derived from meteorology from the 2004/2005 financial year. The mean monthly wind speed is displayed in Figure 4-4. Actual wind conditions at any location within the Project Area may differ slightly to that shown in the wind roses due to local terrain and micro meteorological effects.
Port Hedland Port Authority
South West Creek Dredging and Reclamation Project:
Environmental Referral Document

**Figure 4-3** Seasonal Average Wind Speed and Directions for Port Hedland

**Figure 4-4** Average Monthly Wind Speed for Port Hedland
4.1.2.4 Humidity

Port Hedland experiences high humidity levels during January, February and March. The long term humidity in Port Hedland at 9am and 3pm is presented in Figure 4-5.

![Graph showing mean relative humidity for Port Hedland](image)

- **Figure 4-5** Mean Relative Humidity for Port Hedland

4.1.2.5 Cyclones

The coast from Port Hedland to Exmouth Gulf experiences the highest frequency of tropical cyclones per annum in Australia. Figure 4-6 displays the category and associated wind gusts of cyclones that have impacted upon the ToPH within the last century. The region has been subjected to several severe tropical cyclones in the last 30 years which have caused considerable damage to residential areas and infrastructure.
4.2 Environmental values and environmental quality objectives

The State Water Quality Management Strategy No 6 (GoWA 2004) outlines the framework for Western Australia for fresh and marine water quality, and water quality monitoring and reporting. The framework requires that all significant resources in Western Australia are spatially defined on a priority basis and that Environmental Values (EVs) are developed for each of these resources. For each environmental value there are Environmental Quality Objectives (EQOs) and subsequent Environmental Quality Criteria.

The Pilbara Coastal Water Quality Consultation Outcomes: EVs and EQOs (DoE 2006) defines key environmental values and maps with levels of ecological protection for the Pilbara region, including the Port Hedland area. The EPA endorses the environmental values and levels of ecological protection as a guide for assessing environmental impacts. The EVs and EQOs are shown in Table 4-1.

- **Table 4-1  Environmental values and environmental quality objectives (from DoE 2006)**

<table>
<thead>
<tr>
<th>Environmental Value</th>
<th>Environmental Quality Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Health (ecological value)</td>
<td>Maintain ecological integrity. This means maintaining the structure (i.e., the variety and quantity of life forms) and functions (e.g., the food chains and nutrient cycles)</td>
</tr>
</tbody>
</table>
Four different levels of ecological protection for Pilbara waters for the EQO were developed through extensive stakeholder and community consultation (Table 4-2). Most of the working areas of the inner harbour at Port Hedland have been assigned a ‘moderate’ level of environmental protection (90% ecological protection) in recognition of existing and approved projects as at 2006 (EPA 2009a). A high level of environmental protection has been applied to all other areas in the Port Hedland region (DoE 2006).

Areas of high and moderate levels of ecological protection are recognised within the Port Hedland area with a high level of protection within the proposed Project footprint (Figure 4-7). Areas of high protection have been described as areas having very low levels of contaminants and where biological indicators show no detectable change from natural variation (DoE 2006).

PHPA proposes a realignment of the moderate level of environmental protection to include the proposed berths in South West Creek. The proposed modifications to the moderate level of ecological protection were developed in accordance with the Pilbara Coastal Water Quality Consultation Outcomes: Environmental Outcomes and Environmental Quality Objectives (DoE 2006) and the State Water Quality Management Strategy No 6 (GoWA 2004). TheEVs and EQOs (developed for Pilbara coastal waters), have been taken into consideration in the assessment of potential environmental impacts resulting from the Project.

Table 4-2  Levels of ecological protection linked to the EQO for maintenance of ecosystem integrity

<table>
<thead>
<tr>
<th>Level of Ecological Protection</th>
<th>Environmental Quality Condition</th>
<th>Limit of Acceptable Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>No contaminants - pristine</td>
<td>No detectable change from natural variation</td>
</tr>
<tr>
<td>High</td>
<td>Very low level of contaminants</td>
<td>No detectable change from natural variation</td>
</tr>
<tr>
<td>Moderate</td>
<td>Elevated levels of contaminants</td>
<td>Moderate changes from natural variation</td>
</tr>
<tr>
<td>Low</td>
<td>High levels of contaminants</td>
<td>Large changes from natural variation</td>
</tr>
</tbody>
</table>
Figure 4-7  Recommended Water Quality Management Areas: Port Hedland (DoE 2006)
4.3 Marine Physical Environment

4.3.1 Oceanography

The North West Shelf marine area, where Port Hedland is situated, is subject to broad influence from the Indonesian Throughflow and the Leeuwin Current, while large tidal ranges and cyclones also play an important role in local oceanographic processes.

4.3.1.1 Tides

Water movement within the Port Hedland harbour is dominated by tidal flows through the harbour entrance. The tides in the Port Hedland region are predominantly semi-diurnal with a range from 1.5 to 5.8m during neap and spring tidal phases respectively. As a result, the peak tidal currents generally reach one knot but currents of three knots can occur at some locations (Halpern, Glick & Maunsell 1997). These tidal currents can impact significantly on ship handling during berthing and departure manoeuvres (Halpern, Glick & Maunsell 1997).

Spring tides circulate in a counter-clockwise pattern in the existing turning basin in the inner harbour, which results in the deepest part of the basin not being as effectively flushed as the rest of the harbour. During neap tides, the harbour is generally well flushed although stratification is evident as lower water velocities decrease mixing efficiency and increase the residence time of water, particularly in the northeast region of the main basin (Halpern, Glick & Maunsell 1997).

4.3.1.2 Storm Surge

During cyclonic activity, storm surge occurs as a result of a drop in atmospheric pressure, extreme winds and wave pumping, raising sea levels above normal tide fluctuations. At Port Hedland, winds of over 200 km/h and waves of up to 20 m, combined with floodwaters from rivers flowing into the harbour can result in extensive inundation and scouring of low lying coastal areas (Environ 2004).

The design peak flood levels developed by modelling for the Greater Port Hedland Storm Surge Study (GEMS 2000) vary throughout the harbour area and were highest over mudflats and sandy lowland areas where the higher ground elevation tends to lift the storm surge water level. In the general area of the South West Creek Project, the design 100-year average recurrence interval storm surge levels vary from RL 10 m AHD at Anderson Point to slightly higher at the BHPBIO Port Hedland–Shay Gap Railway. The storm surge study reports that the Port Hedland–Shay Gap Railway acts as a barrier to the inland penetration of ocean flooding during storm surge events (GEMS 2000).

4.3.2 Water Quality

The Port Hedland harbour is situated in an estuary fringed by mangroves and is a naturally turbid environment. The waters are saline with occasional small freshwater inflows via the creeks and from...
drains from Nelson Point. Constant movement of ships, large tidal range and the presence of large volumes of unvegetated silt and mud contribute to the high turbidity in the inner harbour.

The main source of contaminants in the Port Hedland Harbour is from shipping and dust from iron ore loading and handling activities. In addition, the harbour catchment is partly urbanised and may contribute some contaminants following rainfall events (DAL 2004).

The main anthropogenic effects on water quality in the harbour are:

- Creation of turbidity from ship movements;
- Turbidity from dredging activities;
- Deposition of dust from ore loading operations;
- Run off from port and surrounding infrastructure;
- Spillage;
- Leaching of anti-foulants from hulls; and
- Leaching of corrosion protection products from infrastructure (e.g. zinc anodes).

The anthropogenic effects described above may be responsible for the elevated iron, copper, lead and zinc levels in the water column near existing berths, recorded in several surveys (Environ 2004).

4.3.2.1 Turbidity and Suspended Solids

Turbidity (measured in Nephelometric Turbidity Units [NTU]) and TSS have been measured within and outside Port Hedland Harbour in a number of studies, which were summarised by BHP Billiton (2008a) as shown in Table 4-3.

WorleyParsons (2010a) recently undertook a water quality baseline survey in support of a small dredging project within South West Creek for the creation of South West Creek Tug Boat and Small Vessel Cyclone Mooring Facility (Figure 4-8). Due to an overlap of dredge footprints, this study is highly relevant to the Project. The study is attached in Appendix B with a summary provided in Table 4-4.
Figure 4-8  Water quality monitoring locations in South West Creek
Table 4-3  Summary of turbidity (NTU) and TSS data within Port Hedland inner harbour

<table>
<thead>
<tr>
<th>Proponent</th>
<th>Date</th>
<th>Study Description</th>
<th>Duration</th>
<th>Observations</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHPBIO Ore Product and Capacity Expansion</td>
<td>2002</td>
<td>Long-term monitoring pre, during and post dredging. Two data loggers measured data alongside Finucane Island wharf at surface and 1 m above seabed.</td>
<td>12 months</td>
<td>Turbidity varied from 0 to 80 NTU. Surface and seabed turbidity peaked during maximum tidal movement. Dredging increased seabed turbidity while only marginally affecting surface turbidity. Shipping and loading activities not distinguishable from tidal activity.</td>
<td>SKM (2002)</td>
</tr>
<tr>
<td>FMG</td>
<td>2005</td>
<td>NTU monitoring pre dredging. Data logger deployed in Port Hedland Harbour for turbidity. TSS measured at 7 sites (town jetty, boat ramp, mangroves, mangrove mud, mangroves deep, creek and creek mud).</td>
<td>2 weeks</td>
<td>Turbidity varied from 33.8 to 130.5 NTU with an average of 80 NTU. One high TSS reading at very muddy location near mangroves 380 mg/L, other sites 18 to 69 mg/L.</td>
<td>Worley Parsons (2005)</td>
</tr>
<tr>
<td>BHPBIO RGP3 works</td>
<td>2007</td>
<td>Weekly measurements of turbidity taken over dredging period at a range of sites in inner harbour.</td>
<td></td>
<td>Turbidity varied from 2.1 to 121.6 NTU. Dependent on shipping movement, tidal and weather rather than dredging activities.</td>
<td>SKM (2007)</td>
</tr>
<tr>
<td>FMG</td>
<td>2006-2007</td>
<td>Tailwater monitoring in South West Creek and Salmon Creek (reference site) pre and during dredging.</td>
<td>10 months</td>
<td>Turbidity varied from 11 to 18 NTU (80th percentile). 80th percentile trigger values were calculated using baseline data pre tailwater discharge. Turbidity levels in the tailwater were always below the trigger value during periodic discharge. Turbidity levels exceeded trigger levels temporarily on several occasions during continuous discharge.</td>
<td>URS (2008a)</td>
</tr>
</tbody>
</table>

Table 4-4  Southwest Creek Water Quality Baseline Report summary

<table>
<thead>
<tr>
<th>Proponent</th>
<th>Date</th>
<th>Study Description</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHPA</td>
<td>Period Dec. 2009 to June 2010</td>
<td>Fortnightly measurements of nutrients, metals and TSS were measured at two sites in South West Creek. Temperature, pH, DO, salinity and turbidity data were logged.</td>
<td>TSS ranged between 8 mg/L and 137 mg/L (Figure 4-9). Median turbidity at H1 and H2 was 15.2 NTU and 7.1 respectively. 80th percentile values at H1 and H2 were 34.1 NTU and 29.3 NTU respectively. Water temperatures ranged between 19 and 32°C. Salinity ranged from 38.3 to 41.7 ppt. Dissolved oxygen ranged between 86 and 97% saturation.</td>
</tr>
</tbody>
</table>
4.3.2.2 Metals

Previous investigations of chemical water quality within Port Hedland have identified elevated concentrations of some metal species (zinc and copper) compared with other areas of the North West such as the Dampier Archipelago (Wenziker et al. 2006).

Some subsequent investigations have not had access to laboratory with ultra-trace analysis capabilities and as such, many of the results were reported as below insufficiently low laboratory detection limits. However, other investigations of metal concentrations in Port Hedland inner harbour and shipping channel have confirmed that copper, lead and zinc concentrations are elevated (e.g. HDMS Services 2002; PHPA 2003; and BHP Billiton 2008b).

The values reported by Wenziker et al. (2006) for Port Hedland Harbour are probably the most accurate given the techniques employed and they are reproduced in Table 4-5 below. The waters of the Port Hedland Inner Harbour are managed as a moderate level of ecological protection and the Outer Harbour as a high level of ecological protection (Figure 4-7; and DoE 2006). Based on these levels of protection the background concentrations do not exceed any of the relevant guideline values.

Samples have also been taken from part of the Project Area and results are summarised in Table 4-6, as with other studies, standard laboratory methods pose problems in generating background water results for dissolved metals (WorleyParsons 2010a).
Table 4-5  Background metal concentrations Port Hedland Inner and Outer Harbour waters

<table>
<thead>
<tr>
<th>Site</th>
<th>Cd (µg/L)</th>
<th>Cr III(µg/L)</th>
<th>Cu (µg/L)</th>
<th>Hg (µg/L)</th>
<th>Pb (µg/L)</th>
<th>Zn (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit of detection</td>
<td>0.001</td>
<td>0.15</td>
<td>0.005</td>
<td>0.0001</td>
<td>0.006</td>
<td>0.003</td>
</tr>
<tr>
<td>99% Level of protection (ANZECC/ARMCANZ, 2000)</td>
<td>0.7</td>
<td>7.7</td>
<td>0.3</td>
<td>0.1</td>
<td>2.2</td>
<td>7</td>
</tr>
<tr>
<td>Outer Harbour (surface)</td>
<td>0.003</td>
<td>&lt;0.15</td>
<td>0.161</td>
<td>0.0003</td>
<td>&lt;0.006</td>
<td>0.063</td>
</tr>
<tr>
<td>Outer Harbour (bottom)</td>
<td>0.005</td>
<td>&lt;0.15</td>
<td>0.193</td>
<td>0.0003</td>
<td>0.010</td>
<td>0.637</td>
</tr>
<tr>
<td>Moderate Protection Guideline</td>
<td>14</td>
<td>49</td>
<td>3</td>
<td>0.7</td>
<td>6.6</td>
<td>23</td>
</tr>
<tr>
<td>Inner Harbour (surface)</td>
<td>0.007</td>
<td>&lt;0.15</td>
<td>0.435</td>
<td>0.0005</td>
<td>0.006</td>
<td>5.13</td>
</tr>
<tr>
<td>Inner Harbour (bottom)</td>
<td>0.007</td>
<td>&lt;0.15</td>
<td>0.414</td>
<td>0.0006</td>
<td>0.011</td>
<td>5.47</td>
</tr>
</tbody>
</table>

Table 4-6  Summary sediment metals results from within South West Creek

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Limit of Reporting (µg/L)</th>
<th>Moderate EQG (µg/L)</th>
<th>H1 (median) (µg/L)</th>
<th>H2 (median) (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>0.5</td>
<td>1.6</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.2</td>
<td>14</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Chromium(III)*</td>
<td>0.5</td>
<td>49</td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.2</td>
<td>14</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Copper</td>
<td>1</td>
<td>3</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Lead</td>
<td>0.2</td>
<td>6.6</td>
<td>0.2</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.1</td>
<td>0.7</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.5</td>
<td>200</td>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>5</td>
<td>23</td>
<td>&lt;5</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>

*Chromium is mostly as Cr III in natural systems (Wenziker et al. 2006)

4.3.3  Coastal and Seabed Morphology

4.3.3.1  Overview

The coastal flats of Port Hedland include beach and dune calcareous sands, tidal mangrove communities, cyanobacterial mats, samphire/salt marshes, and extensive flats of mud and silt. These overlay consolidated deposits of red brown sands of the Holocene period, which are underlain by variably cemented carbonate rich deposits of the Pleistocene period (Coffey 2005).

The seabed within Port Hedland Harbour has been significantly modified since dredging commenced in 1965. Modifications to the natural bathymetry both inside and outside the harbour have occurred as a result of both dredging and disposal of dredge material onshore and nearshore (as well as offshore). As a result of these modifications, the bathymetry of the harbour has been significantly altered, affecting patterns of sedimentation, water velocities and mixing, and harbour flushing times.

Overall, maintenance and capital dredging works have resulted in the removal of an estimated 43 Mm³ of dredged material from the inner harbour. Major modifications include (Figure 4-10):
• Dredging of a 13 km long approach channel to the harbour;
• Dredging of a turning basin and berthing pockets within the harbour;
• Reclamation of East Creek to enable development of Nelson Point;
• Construction of general cargo, iron ore and salt loading wharves;
• Construction of the Finucane Island causeway which has closed West Creek;
• Dredging of three berth pockets for the FMG at Anderson Point;
• Dredging at Nelson Point for expansion of BHPBIO export facilities; and
• Dredging at Harriet Point for expansion of BHPBIO export facilities.

Furthermore the PHPA expect to undertake development of the South West Creek Tug Boat and Small Vessel Cyclone Mooring Facility prior to the implementation of this project. The Mooring Facility will result in the removal and ocean disposal of approximately 2.5 Mm³ of material.

4.3.3.2 Bathymetry

The approach channel to Port Hedland harbour cuts through a gently sloping seabed from the 16 m contour approximately 13 km from shore to the mouth of the harbour. The approach channel has an average depth of -14.6 m CD to allow unrestricted vessel access to the harbour. Within the harbour the existing turning circle has a depth of -9.1 m CD, while the berth pockets range in depth from -1.2 to -19.0 m CD.

South West Creek is currently undeveloped and is overall shallow and narrow. It is a tidal creek with current seabed levels ranging from 0.0 m to -4.0 m CD. The site is sheltered but is subject to high velocity tidal flow. The seabed at the mouth of the creek has been dredged to allow vessel access to the FMG Anderson Point Berths. The bathymetry in South West Creek and in the main harbour is shown in Figure 4-11.
- Figure 4-10 Proposed Development and Existing Infrastructure within Port Hedland Harbour
4.3.4 Marine Geology

The marine sediments underlying Port Hedland Harbour are described by the Port Hedland-Bedout Island 1:250,000 Geological Series Map as primarily Pleistocene aged sediments consisting of clays, silts sands and gravels, with varying degrees of cementation (WorleyParsons 2009a). These deposits are underlain by a sequence of variably cemented Tertiary sediments, comprising silts, sands, gravels, siltstone, sandstone and conglomerates, with a provenance associated with the underlying Archaean basement rock which underpins the sequence. A veneer of recent marine mud and fine grained sediment is present at the sea bed (WorleyParsons 2009a).

Overlying surface sediments within the Port Hedland harbour are relatively homogenous across the entire area. These surface sediments are generally unconsolidated fine material classed as clayey silts and silty fine sands which extend to depths of approximately 2.5 m below seabed surface. Beneath these sediments are layers of consolidated material that consist of sand/clay and gravel sediments, overlying more cemented materials. Historical geotechnical investigations for various projects across Port Hedland have generally encountered a similar profile, making for relatively consistent geology across the area.
A generalised description of the main layers were summarised by WorleyParsons (2009a) as:

- Upper Marine Muds: recent surface deposits varying from 0.0 m to 2-3 m thick, some of which have been classified as PASS;
- Upper Red Beds: red to red-brown clayey to sandy clayey lightly cemented material containing a high proportion of fines (15-20%) (Figure 4-13) and extend down to between -10.0 m CD and -12.0 m CD; and
- Lower Red Beds and Conglomerates: harder materials including heavily cemented clayey sands and conglomerates that include large crystals of silica and extend from the upper redbeds down to between -15.0 and -18.0 m CD.

Two geotechnical surveys were undertaken within the Project dredge footprint as part of the baseline surveys (Table 4-7), with the borehole locations show in Figure 4-12. The northern boreholes were drilled by URS (2008b) with the southern boreholes drilled by SKM (2010a). The two surveys found similar stratigraphy, however SKM (2010a) reported large variability in conditions both laterally and vertically within the geological layers. They noted discontinuous ‘lenticular’ soil/rock layers with zones of stronger material within weaker material and vice versa, caused by cementation of some sediments by precipitation of mineral matter from the groundwater over geological time. It should be noted that the URS (2008b) survey extended deeper than SKM (2010a), and the latter did not encounter granite rock – with both surveys strongly indicating that granite is not present within the three dimensional dredge footprint.

Table 4-7 Summary of geological units in the northern part of the South West Creek footprint

<table>
<thead>
<tr>
<th>WorleyParsons (2009b) unit description</th>
<th>SKM (2010a) interpreted equivalent unit</th>
<th>Main elevation at top of unit (mCD)</th>
<th>Max elevation at base of unit (mCD)</th>
<th>Thickness of unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent marine and tidal sediments</td>
<td>Unconsolidated Holocene Sediments (unit 2b)</td>
<td>+2.0m</td>
<td>-2.0m</td>
<td>3.0m</td>
</tr>
<tr>
<td>Clayey sand/sandy clay (Upper Red Beds)</td>
<td>Upper Red Beds (unit 6a)</td>
<td>+2.0m</td>
<td>-11.0m</td>
<td>12.5</td>
</tr>
<tr>
<td>Clayey sandstone (Lower Red Beds)</td>
<td>Lower red beds (unit 6b)</td>
<td>-2.5m</td>
<td>-15.5m</td>
<td>13.0</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>Conglomerate sandstone (unit 6b*)/ Breccia (unit 7)</td>
<td>-13m</td>
<td>-21m</td>
<td>7.0</td>
</tr>
<tr>
<td>Older alluvium</td>
<td>Upper sandstone</td>
<td>-16m</td>
<td>-50m</td>
<td>-</td>
</tr>
<tr>
<td>Clayey Sandstone/RSXW Granitic Rock</td>
<td>(not encountered)</td>
<td>-43m</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Weathered granitic rock</td>
<td>(not encountered)</td>
<td>-45m</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Figure 4-12 Geotechnical boreholes sampled

Figure 4-13 Particle size distribution from the encountered geological strata
4.3.5 Sediment Quality

Sediment investigations have been undertaken in the Port Hedland inner harbour on numerous occasions since 1990, to identify potential contamination risks associated with dredging and disposal of dredged material. However, by far the majority of these surveys have targeted the easily accessible upper 1-2 m of unconsolidated material. Such surveys have been summarised in previous Environmental Impact Assessment documents such as RGP6 referral document (BHP Billiton 2009a), and have generally shown occasional elevations of anthropogenic contaminants such as hydrocarbons, organotins and potentially some metals near existing industry, while arsenic, nickel and chromium have been reported to be naturally elevated throughout the region (Oceanica 2005; Koskela Group 2007).

Three specific surveys were undertaken within the South West Creek Project dredge footprint in July 2008, April 2010 and June 2010. The two 2010 surveys were reported in PHPA (2010a) with a summary of the 2008 survey included and submitted to DSEWPaC in support of an application for a sea dumping permit for the proposed Project. Combined, the surveys tested for a suite of metals (arsenic, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver and zinc), organotins, Polyaromatic Cyclic Hydrocarbons (PAHs), and Total Organic Carbon (TOC). The summary report showed that the surficial sediments were clean and suitable for unconfined ocean disposal with the 95% Upper Confidence Limit (UCL) for all parameters below the NAGD Screening levels.

4.3.5.1 Material below -6.0 m CD

Deeper occurring material is logistically much more difficult to sample, and is generally only achievable through geotechnical drilling. While several geotechnical studies have been undertaken within the Port Hedland Harbour, only four surveys included analysis of the deeper occurring material for potential contaminants.

Across all surveys within the inner harbour, including surveys of both surficial and deeper sediments, low level contaminant concentrations have generally been reported within the sediments. Nickel and chromium concentrations have, however, generally been found elevated across all depths, when compared with the NAGD screening levels for assessment of suitability for ocean disposal (CoA 2009a). While nickel concentrations have generally been found below Ecological Investigation Levels (EILS) (DEC 2010), used for assessing the suitability of dredged spoil for onshore disposal, chromium has been found at elevated levels in several studies.

These elevated concentrations of nickel and chromium across all depths are considered to be natural and not anthropogenic inputs. This has been confirmed in a number of studies, where chromium and nickel concentrations were compared to referenced aluminium concentrations (URS 2004; Oceanica 2005; Koskela Group 2007).
Environmental screening of material for onshore disposal during two recent geotechnical surveys at Nelson Point and Harriet Point on behalf of BHPBIO, are summarised in Table 4-8.

During the survey at Nelson Point (BHP Billiton 2009a) 26 samples were collected from the geotechnical cores between -4.2 and -30.0 m CD, mainly from the red bed material. Based on the results it was concluded that contaminants liberated during dredging and spoil disposal activities were not likely to have an impact on the marine environment surrounding Nelson Point due to contaminant mobilisation.

During the geotechnical survey at Harriet Point (SKM 2008a) between 93 and 96 samples were collected and submitted for analysis (Table 4-8). The results showed that chromium levels exceeded EILs across several of the sites and both depth strata, triggering further elutriate testing. Elutriate testing of the two depth strata showed that chromium did not exceed screening levels for neither 90 nor 99% ecological protection levels. However, copper exceeded the 99% ecological protection screening levels and a further two-fold dilution of excess water (in addition to dilution during dredging) would be required for copper levels in elutriates to meet 99% ecological protection guidelines (ANZECC/ARMCANZ 2000a). Such a two-fold dilution was considered easily achievable within the mixing zone of the return water from both the CSD and the DMMAs discharge points. The study concluded that based on the available information, the proposed dredge material was deemed suitable for land disposal into the designated DMMAs for the project.

- **Table 4-8** Summary of previous deeper sediment environmental screening studies

<table>
<thead>
<tr>
<th>Project</th>
<th>Survey details</th>
<th>Analytes</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>BHPBIOS Nelson Point (BHP Billiton, 2009a)</td>
<td>22 Samples from -4.2 m and -15.6 m CD; Three samples from -22 Samples from -4.2 m CD and -15.6 m CD; Three samples from -17.5 m CD to -19.5 m CD; and One sample from -25.0 m CD to -30.0 m CD.</td>
<td>Total metals; Deionised water leachate; and Acetic acid leachate testing. (Metals analytes: Sb, As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Zn).</td>
<td>Total metals all below EILs and Health Investigation Levels apart from chromium and manganese: max results exceeded EILs at several sites (chromium) and at one site (manganese). 95% UCL of both chromium and manganese was below EIL. Deionised water and Acetic Acid leachate testing of metals were 'acceptably low' compared with the Landfill waste classification definition limits (DoE 2005). In summary, the dredge material was found suitable for land disposal.</td>
</tr>
<tr>
<td>BHPBIO’s Harriet point (SKM, 2008a)</td>
<td>93 samples obtained below -2 m CD from 23 sites.</td>
<td>PAHs, Tributyltin (TBT); Total metals; Elutriate metals; and Leachate metals. (Metals analytes: As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn).</td>
<td>TBT, PAH below Practical Quantitation Limit and EILs. Total metals below EILs apart from Chromium. All elutriate metals (dilution 1:7) below 99% species protection, apart from copper, which was above the 95% species protection. All leachate metals below ASLP1. In summary, the dredge material was found suitable for land disposal.</td>
</tr>
</tbody>
</table>
Two recent geotechnical studies have been undertaken within the South West Creek dredge footprint for screening of the deeper occurring material intended for onshore disposal:

- URS (2008b): 18 borehole locations, of which 14 fell within and between proposed Berths SP1, SP2, AP4 and AP5 (and 4 outside the current dredge footprint); and
- WorleyParsons (2010b): seven borehole locations within Berths SP3 and SP4, including the proposed turning circle.

In total 26 borehole locations were drilled and sampling undertaken for discrete geological horizons from the creek bed surface down to below design depth (-21.7 m CD and -25.7 m CD for the 2010 and 2008 sampling investigations, respectively). The locations of the boreholes from both surveys are shown in Figure 4-12.

A total of 42 and 21 samples were obtained from below -6 m CD within the dredge footprint and analysed for total metals from the 2008 and 2010 survey, respectively. The 2008 survey analysed for total and ‘bioavailable’ metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc) as well as for the organotin Tributyltin (TBT). The 2010 survey analysed for total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc), elutriate metals (nickel), PASS (Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) and Chromium Reducible Sulphur (Scr) methods) as well as Acid Volatile Sulphur (AVS). The PASS results are discussed in Section 4.3.6.

The results from the 2010 survey are described in Appendix C, which also includes a summary of the results from both surveys assessed for suitability for onshore disposal. All metals in all samples were below EILs and NAGD screening / Interim Sediment Quality Guideline (ISQG)-Low levels, with the exception of 16 samples (seven in 2008 and nine in 2010) which were above the NAGD screening level for nickel. One sample from the 2010 survey was above the NAGD for chromium. The implications for potential impacts to water quality from dredging this material and placing it onshore is discussed in Section 0.

4.3.6 Potential Acid Sulfate Soils

The DEC’s acid Sulfatesoil (ASS) risk map for the Pilbara coastline incorporated in Planning Bulletin 64 (WAPC 2009) indicates there is a ‘moderate to low risk’ that PASS may be present within the sediment of the proposed dredge footprint. However, Planning Bulletin 64 is not intended to provide site-specific information on ASS and the depth at which ASS are found can vary greatly from site to site (WAPC 2009).

Over recent years, information has been gathered regarding the presence, extent and distribution of PASS in dredged material from Port Hedland. PASS material appears to be isolated to the most recent deposits (the last 10,000 years) which generally represent the upper 1 to 2 m of the seabed in the inner harbour. This layer is referred to in Section 4.3.4 as ‘recent marine and tidal sediments’.
Previous investigations of surficial sediments undertaken by Oceanica (2005) and URS (2005a; 2009a) in the vicinity of Anderson Point near South West Creek reported that the sediments were generally non-acid generating, with the exception of a small volume of sulphide-bearing material (marine muds). Likewise, investigations associated with the onshore disposal of dredge sediments at Harriet Point displayed PASS to a maximum depth of 2 m (BHP Billiton 2008b).

The deeper occurring material is generally not considered likely to be acid generating. This material consists of clay, sand and other calcareous material such as sandstone, and is referred to as the ‘red beds’ (Section 4.3.4). ASS analysis of samples obtained from these deeper layers during a geotechnical survey at Andersen Point (Coffey 2005) near South West Creek identified an available buffer capacity against PASS within the sediments themselves (URS 2005b; 2008b). The geotechnical logs in conjunction with calcium carbonate analyses (Coffey 2005) suggested that shell fragments (which do not constitute readily available acid neutralisation (DEC 2009)) were only a portion of the available Acid Neutralising Capacity (ANC) within the red bed and/or carbonate material. Results of pH buffering conducted on the calcareous clayey sand profile (Graeme Campbell & Associates 2005) detected reactive carbonate minerals that would be readily available for buffering. URS (2005b; 2008b) concluded that sufficient available in-situ ANC was present in the deeper strata to neutralise any acid sulfate material.

To confirm that the deeper occurring material within the Project footprint is non-PASS, ASS testing was undertaken of 21 samples below -6.0 m CD obtained during the geotechnical survey in the southern end of the dredge footprint (WorleyParsons 2010b; Appendix C). These samples were subjected to ASS analysis using both the SPOACAS and Chromium Reducible Sulphur (SCr) methods.

The SPOCAS results showed one sample within the red beds exceeded the DEC (2009) Action Criteria of 0.03%S (w/w). However the SCr results showed all samples were below the Action Criteria (Appendix C).

The risk of PASS impacting on the water quality when the lower geological material is dredged and placed onshore is discussed in Section 0.

### 4.4 Marine Biological Environment

#### 4.4.1 Benthic Primary Producers and their Habitats

Benthic Primary Producers (BPPs) are classified as organisms that use light to produce energy through photosynthesis. Marine species that photosynthesize include marine algae (macroalgae, turfing algae, benthic microalgae), seagrass, mangroves and coral. Benthic primary producer habitat (BPPH) is the communities of marine flora (e.g. seagrasses, turf algae, seaweeds and mangroves) and marine invertebrates (e.g. scleractinian corals) and the substrata that can or do support these communities (EPA 2009b).
4.4.2 Marine Habitats

4.4.2.1 Regional Context

The marine habitats found in Port Hedland are characteristic of those found along the arid coastlines of the Pilbara. Within the intertidal zone, the principal BPPH are mangroves, samphire flora and to a lesser extent cyanobacterial mats (algal mats). Dense mangrove assemblages typically occupy the intertidal zone in areas of sufficient tidal inundation. As the distance from the waterline increases, mangrove height and cover decreases; and eventually, as sediments become dryer and more saline, mangrove assemblages give way to saltmarsh vegetation and bare tidal flats (Saenger 2002; BHP Billiton 2009a). The distribution of mangroves, saltmarsh vegetation and bare tidal flats in the upper intertidal areas of Port Hedland harbour form a mosaic (PHPA 2003).

Cyanobacterial mats are often found in association with or in close proximity to mangroves and saltmarsh habitats in tropical and subtropical regions (Sheppard et al. 1992). In the Port Hedland region, some areas between the mangrove and saltmarsh habitats of the upper intertidal zone support cyanobacterial mats under suitable conditions (Paling et al. 1989; 2003).

The majority of the subtidal benthic habitats are characterised by unvegetated fine mud or shell grit substrate (78.77%), with sparse patches of turf algae, small foliaceous macroalgae and sessile filter feeding invertebrates (SKM 2009). Habitats supporting coral communities are sparsely distributed and do not represent a high percent cover across the Inner Harbour (0.09% cover). A community of the canopy-forming macroalga, Sargassum sp., exists in dense patches in the eastern creeks of Stingray Creek. These subtidal BPPH communities support occasional benthic fauna, epifauna and invertebrates (Environ 2004). No seagrass communities have been found in the Harbour.

4.4.2.2 Project Area

A benthic habitat survey was undertaken by WorleyParsons in August 2010 within the proposed South West Creek Tug Boat and Small Vessel Cyclone Mooring Facility dredge footprint and including a wider area covering its predicted dredge plume (Appendix D). Survey results were combined with data from other sources including the above-mentioned reports, high-resolution aerial imagery and previous maps to produce a benthic habitat map of the inner port area (Figure 4-14).

The benthic habitats located within the proposed South West Creek Mooring Facility dredge footprint generally comprised bare sediments (91%), while macroalgae represented 7% cover and turfing algae 2% cover. The habitats were considered typical of those found within the creek systems surrounding the Inner Harbour area, with bare sediments and macroalgae being the most dominant habitat types (Figure 4-14).
- Figure 4-14: Benthic habitats located within Port Hedland Inner Harbour (Appendix D)
4.4.2.3 Mangroves

Mangroves are highly specialised plants from a variety of genera that are adapted to living in intertidal habitats (Duke 2006). The intertidal habitat in the Project Area is typical of arid zone coastlines of the north-west of Australia, and is characterised by dense mangrove stands along the seaward margins of tidal channels and creeks. The density and height of mangroves typically decreases with increasing distance from mean sea level due to increased soil salinity and decreased tidal inundation. Upper intertidal areas beyond the mangrove habitats are typically a mosaic of samphires and other salt marsh plants, cyanobacterial mats and large areas of bare substrate.

Port Hedland’s Inner Harbour is surrounded by large areas of arid-zone mangroves that are predominantly associated with tidal creek systems. These mangroves cover an area of approximately 16.37 km² and are the most dominant BPPH in the Port Hedland area (BHP Billiton 2009a).

Seven mangrove species are known to occur in the Port Hedland region:

- *Avicennia marina*;
- *Aegialitis annulata*;
- *Bruguiera exaristata*;
- *Ceriops tagal*;
- *Aegiceras corniculatum*;
- *Osbornia octodonta*; and
- *Rhizophora stylosa*.

Recent mangrove assessments adjacent to the proposed South West Creek Project dredge footprint identified the following mangrove assemblages (Appendix E):

- *A. marina* low forest to scrub;
- Mixed *A. marina* and *R. stylosa* low forest to scrub;
- *R. stylosa* low forest to scrub;
- *A. marina* scrub to open heath;
- *C. tagal* scrub to closed heath to open heath;
- Mixed *C. tagal* and *A. marina* scrub and heath;
- Scrub, to heath to open heath of mixed *A. marina*, *R. stylosa*, *B. exaristata*, *C. tagal*, *A. annulata* and locally *O. octodonta*; and
- Mixed *A. annulata*, *A. corniculatum* and *A. marina*.

Investigations undertaken as part of the BHPBIO Harriet Point dredging project identified intertidal habitats located at Stanley Point and Harriet Point. Stanley Point flora communities were dominated by two mangrove species, *A. marina* and *R. stylosa*. Shoreline communities were identified as
A. marina forest, with individual trees reaching up to 7 m in height. The mangrove community then changed to R. stylosa, with trees ranging from 1–6 m. The community became less dense with increasing distance from the shoreline as R. stylosawas replaced by A. marina. Other species identified included A. corniculatum and Ceriops australis (BHP Billiton 2008b).

Studies undertaken as part of the Hope Downs environmental approvals process identified similar mangrove community types to the Harriet Point survey adjacent to the proposed South West Creek Project. Again, A. marina and R. stylosa were co-dominant with dense mature stands of either species near to the creek line. The community became less dense with increasing distance from the shoreline as R. stylosa was replaced by A. marina, with occasional monospecific stands of C. tagal, A. corniculatum and A. annulata (HDMS 2002).

In May 2009, WorleyParsons undertook a survey of mangrove communities adjacent to the proposed South West Creek dredge footprint to complement data previously collected as part of the Hope Downs and Harriet Point environmental impact assessments (Appendix E). Three of the potential seven mangrove species previously identified in the Pilbara region were identified during this survey, namely:

- Ceriops australis;
- Rhizophora stylosa; and
- Avicennia marina.

The mangrove community distribution within the area of the South West Creek Project is shown in Figure 4-14.

Communities described as part of this survey were similar to those assemblages previously described by Paling et al. (2003), Semeniuk (2007) and BHP Billiton (2008b). However, this recent survey identified the locally-occurring Ceriops species as being Ceriops australis rather than C. tagal, as was previously suggested by Semeniuk (2007). This amendment is based on the distribution of C. tagal not extending to Western Australia (Duke 2006). Interestingly, previous mangrove investigations undertaken as part of the nearby Hope Downs Iron Ore Project included identification of two mangrove species, Aegialitis annulata and Aegiceras corniculatum, that formed occasional monospecific stands. Neither species were encountered during the recent survey.
The species composition and condition of mangrove communities within the study area appeared to be driven primarily by tidal inundation and topographical gradients. *A. marina* was more abundant and widespread than all other mangrove species identified during the survey. *A. marina* was the dominant species in areas likely to experience least tidal inundation but was also prevalent in lower intertidal areas that would experience frequent inundation. In these lower areas, *A. marina* formed mature, well-developed forest communities. *A. marina* is considered to be a pioneer species; a species that is able to survive in areas that experience high levels of disturbance that other species cannot tolerate. *A. marina* has been found to be able to tolerate a wide range of tidal inundation levels (1–10 m) and has a high tolerance to variation in salinity levels (Duke 2006). The two remaining species identified, *R. stylosa* and *C. australis*, tend to be restricted to more frequently inundated areas, particularly *R. stylosa* which forms generally single species, dense, closed scrub and forest communities within a distinct intertidal band. *C. australis* tended to form mixed scrub communities with *A. marina* landward of the *R. stylosa* fringe. The distribution of these two species is likely to be a consequence of tolerance limits to salinity and tidal inundation. Subsequently this survey was able to characterise mangrove communities further by application of site data to ground truth aerial photography of the study area.

The condition of mangroves generally declined with increasing elevation from Lowest Astronomical Tide (LAT). Leaf cover and condition was relatively higher and healthier in mangroves species nearer to LAT. This would be expected given the limits of tolerance to salinity and exposure associated with mangrove communities. The number of crab holes also tended to vary, with increased density of crab holes in denser mangrove stands with higher leaf coverage.

WorleyParsons described the distribution, species composition, density and health of mangrove communities (habitats) in the Project Area using a combination of high-resolution aerial imagery and field surveys (see Appendix D). The resulting mangrove habitat distribution is shown in Figure 4-14. Results of the field surveys indicated that mangrove communities were mostly dominated by stands of *A. marina* and less frequently by *R. stylosa*, each with varying densities and canopy heights. A third species, *C. australis*, also occurred locally and tended to form mixed communities with *A. marina*.

Field survey results were also used to develop a series of mangrove classification maps based on the aerial photography. Distinct zonation patterns were observed of mangrove communities with fringing *A. marina* forest communities in areas nearest to LAT levels, often bordered by mature *R. stylosa* forest communities and then by *R. stylosa* scrub communities, *A. marina* scrub and *A. marina* open heath communities respectively with increasing distance/height from the LAT mark. The dominance of *A. marina* species in the study area is thought to be a result its high tolerance to
varying salinity and inundation levels (Duke 2006). A total of five mangrove habitat types were identified:

- *Avicennia marina* & *Ceriops australis* open heath – an open formation (<60% vegetated), dominated by *A. marina*;
- *Avicennia marina* & *Ceriops australis* scrub – closed vegetation with trees 2–4 m high;
- *Avicennia marina* low forest – closed vegetation with trees 4–6 m high;
- *Rhizophora stylosa* scrub – closed vegetation with trees 2–4 m high; and
- *Rhizophora stylosa* low forest – closed vegetation with trees 4–6 m high.

### 4.4.3 Cyanobacterial Mats

Cyanobacteria are blue-green algae that obtain their energy through photosynthesis. Cyanobacteria have been found to occur in extensive mats between the mangrove and samphire-dominated zones of the upper intertidal areas in the Pilbara region (Paling *et al.* 1986; cited in BHP Billiton 2009). Within the Pilbara region, they have been observed to occur on the landward side of mangroves where, with the exception of two halophytic samphire genera, no other vegetation occurs (BHP Billiton 2009).

Cyanobacterial mats are a naturally ephemeral community that are not present for a substantial period of the year. They develop into mats in areas of open canopy beneath mangroves and salt marsh plants and the open tidal pan, where sufficient light reaches the substrate. Mats are formed by the trapping of sediment between successive layers of cyanobacteria. In most areas where cyanobacteria form mats, there are periods when the mats dry out and become active again in response to tidal inundation and/or rainfall (BHP Billiton 2009).

In contrast to cyanobacterial mats in Dampier and Onslow, which commonly contain seven or more species, the cyanobacterial mat communities in the Pilbara region are typically found to have between one and three genera present (BHP Billiton 2009). The lower diversity in the Pilbara is considered an indication of stress such as soil/sediment moisture content, salinity and temperature (Paling *et al.* 1986; cited in BHP Billiton 2009).

Diverse cyanobacterial communities are known to colonise the leaves and roots of mangroves and form extensive mats on the surrounding sediment. The genera *Oscillatoria*, *Phormidium* and *Microcoleus*, which have been observed in the Pilbara region, are widespread in these habitats (Paling *et al.* 1986; cited in BHP Billiton 2009).
The EPA advised in Bulletin 1304 that cyanobacterial mats should be considered as BPPH in accordance with EAG No.3, which specifically refers to intertidal organisms, the communities they form and the habitats that support them.

There are limited historical data for any cumulative assessment of cyanobacterial mats in the Port Hedland (EPA 2008). While the presence of scattered clumps of samphire is relatively easy to ascertain, the presence and extent of cyanobacterial mats are much more difficult to determine. This is because the mats are very thin layers that are not always evident in aerial photography, and because the mats are ephemeral, increasing in size and thickness when sufficient moisture is present in surface layers, making the exact extent of these habitats (both present and past) difficult to determine (Paling et al. 1989). Previous vegetation mapping by Biota (Biota 2004a) indicated that the Project Area does not include areas of cyanobacterial mats however, as cyanobacterial mats are an ephemeral community that are not present for a substantial period of the year, it is possible that they may be present within the Project Area. During a survey of intertidal areas in 2009 by WorleyParsons for the South West Creek Mooring Facility (Appendix D), the presence of cyanobacterial mat formations was observed sporadically throughout the study area. At the time of the field survey these mats appeared to be dead and did not seem to be capable of photosynthesis.

4.4.3.1 Salt Marsh and Supratidal Mudflats

In Port Hedland, mangrove habitats tend to be replaced by salt marsh with increasing distance from the shoreline and eventually by bare tidal flats as sediments become dryer and more saline. In these intertidal areas the frequency of inundation tends to define areas of salt marsh habitat and mangroves. Salt marsh communities primarily comprise halophytic (salt tolerant) perennial shrubs such as the samphire species, Tecticornia halocnemoides and Tecticornia indica.

The extensive supratidal mudflats located in the Port Hedland area are sporadically interspersed by low lying sandy islands that are dominated by Triodia sp. grasslands over open tussock grasslands (Biota 2008a). This vegetation type is considered to be of moderate to low conservation significance due to the limited distribution of Triodia secunda found in these areas. A survey of supratidal areas during 2009 confirmed these areas surrounded mangrove communities adjacent to the proposed dredge footprint (ENV 2010).

4.4.3.2 Corals

Coral communities are sparsely distributed in the Port Hedland region and are almost completely absent within the harbour itself with an estimated cover of less than 0.1% (SKM 2009). The few coral communities within the harbour and wider estuary are made up of small colonies of low diversity and coverage (BHP Billiton 2009a). These coral communities are likely to be ephemeral due
to the extreme environmental conditions, such as elevated water temperatures and turbidity, which typically occur in the harbour on a daily tidal cycle.

Within the Inner Harbour area and creek systems, coral communities have been identified within Stingray Creek, South East Creek and South West Creek (Figure 4-14).

Coral communities in South East Creek and Stingray Creek consist of small, sparsely distributed individuals. A survey undertaken in 2009 by SKM (2009) described the corals in South East Creek and Stingray Creek as similar in species composition, and was mixed with filter feeders, algae and soft corals. The hard corals present in these mixed communities were described as being dominated by the species from the morphological classes of massive, foliose and tabular including the families Poritidae, Mussidae, Faviidae and Dendrophylliidae.

The small area of coral habitat identified in South West Creek is located at the mangrove limit of a western tributary (Figure 4-14). The coral community here was described by SKM (2009) being composed of dense, hard corals with a unique morphology. The report described the habitat as dominated by Faviidae species forming an almost perfect ball shape with colonies up to one meter in diameter. This hard coral family is well known to be able to survive in highly turbid environments that are encountered continually in the upper stretches of the creek systems feeding into the Inner Harbour. The species diversity appeared to be low.

Coral reef communities occur outside the harbour (GHD 2009), where they grow in nearshore locations close to the entrance where there are areas of hard substrate. These communities are dominated by the genera Turbinaria and Porites (BHP Billiton 2009a). The three main areas with coral habitat on the ocean side of the mouth of Port Hedland harbour are (URS 2005c in GHD 2009):

- East Finucane Island located on eastern tip of Finucane Island on the western side of the shipping channel. This is a rocky reef, with the corals aggregated around large bommies. The coral bommies are predominantly comprised of large, dome-shaped Porites;
- Port Hedland, a rocky reef containing sinkholes located to the east of the Harbour entrance. The Port Hedland Reef coral assemblages were similar to those observed at the East Finucane Island Reef; and
- West Finucane Island, a rocky reef containing sinkholes located towards the western end of Finucane Island. It is an intertidal reef platform characterised by sinkholes of various sizes and depths. Within many of the holes are coral colonies, typically Turbinaria encrusted with faviids and large Porites.

Studies carried out in January 2009 (URS 2009b) suggested that these nearshore coral communities are primarily small bommie fields, which at the time of the surveys were in poor health due to a
recent bleaching event. In comparison, bommies at the Port Hedland reference site had shown only a small decline in health, with less than 10% of coral showing signs of bleaching (URS 2009b). URS identified that it is likely that elevated water temperatures, possibly in conjunction with calm periods increasing insulation, caused the bleaching.

Benthic habitats further offshore of Port Hedland are characterised primarily by soft sediments and occasional ridge lines of hard pavement with a thin veneer of sand/silt. The harder pavement areas support low abundances of hard and soft corals. Hard coral species that are found in these areas include *Turbinaria* spp. with occasional patches of *Porites* spp. and *Acropora* spp, while soft coral species comprise of gorgonians and sea whip species (BHP Billiton 2008a). Coral communities have also been recorded 3.5 km northeast of Spoil Ground I. This reef supports a diverse and abundant community consisting mainly of *Turbinaria* spp. along with encrusting and massive *Porites* colonies, *Acropora* spp., faviids, sponges and Christmas tree worms (*Spirobranchus giganteus*) (URS 2005c).

### 4.4.3.3 Macroalgae

Macroalgal communities are relatively sparse in Port Hedland. A common canopy-forming macroalgal species in NW Australia, *Sargassum* spp., has been identified in Stingray Creek east of the port while other areas are generally devoid of macroalgae due to lack of hard substrates for colonisation. Macroalgae were identified on the intertidal rocky substrates of Finucane Island and on shoals located offshore of Port Hedland (Le Provost *et al.* 1984, cited in BHP Billiton 2008a). As found during the recent survey in South West Creek (Appendix D), macroalgae covers approximately 7% of the South West Creek Mooring Facility dredge footprint (Figure 4-14), dominated by an unidentified brown algal species.

### 4.4.3.4 Seagrasses

Four species of seagrass have previously been identified offshore of Port Hedland (Walker & Prince 1987); *Thalassia hemprichii, Halodule uninervis, Halophila ovalis* and *Halophila decipiens*. Seagrass communities are found at low densities in this area and are generally dominated by *Halophila* spp. and *Halodule uninervis*. These species tend to display high temporal variability in abundance as they are considered ‘pioneer’ species that colonise areas rapidly in response to disturbance events. Investigatons undertaken in nearshore areas that are likely to be impacted directly by dredging activities have not identified any seagrass communities (SKM 2007). Likewise, no seagrass was found within the South West Creek Mooring Facility dredge footprint (Appendix D).
4.4.4 Marine Fauna

4.4.4.1 Regional Context

Port Hedland harbour lies at the southern edge of the extensive tropical Indo-West Pacific biogeographical region. The composition and diversity of marine fauna found in Port Hedland are characteristic of this region and the comparatively low diversity of marine fauna within the Port Hedland Harbour is reflective of the harbour’s highly disturbed nature (BHPBilliton 2009a).

A database search of ‘Matters of National Environmental Significance’ as defined under the EPBC Act was undertaken for the marine area, including PHPA marine disposal grounds (Appendix F). This tool has a relatively low resolution and there was no difference in the outcome if the offshore area was excluded and the search area solely included the South West Creek system and inner harbour of Port Hedland.

The EPBC Act Protected Matters Report (excluding terrestrial species) (DEWHA 2010) identified ten species as Threatened marine fauna species and 47 species as listed Migratory species, which may inhabit the Project Area. Eighty-six listed marine species and 12 whales and other cetaceans were also identified in the search (Appendix F).

4.4.4.2 Project Area

Within the Port Hedland Harbour, mangrove assemblages support much of the marine fauna and provide suitable breeding, feeding and nursery habitats for a number of fish, invertebrate and bird species (SKM 2008b). Marine invertebrates that are strongly affiliated with the mangrove assemblages are mud whelks (Terebralia spp.), fiddler crabs (Uca coactarta flammula) and a range of infauna, including polychaete worms, annelid worms, flatworms and various molluscs (Hutchings & Recher 1982 in SKM 2008b).

Studies conducted by BHPBIO (BHP Billiton 2008a; 2009a), PHPA (VSCRG 2007; SKM 2008b) and FMG (Environ 2004; FMG 2008) show that, of the marina fauna identified in the EPBC Act Protected Matters Report(Appendix F), the following are most likely to be found within the proposed dredge footprint and Spoil Ground I:

- Humpback whale (*Megaptera novaeangliae*);
- Indo-Pacific humpback dolphin (*Sousa chinesis*);
- Spotted bottlenose dolphin (*Tursiops aduncus*);
- Flatback turtle (*Natator depressus*); and
- Green turtle (*Chelonia mydas*).
Humpback whales migrate north along the east and west coasts of Australia to breeding areas off Western Australia, Queensland and possibly waters further north from about May to August, returning to feeding grounds in the Antarctic from September to December. The migration route is close to the coast so whales can be seen from prominent coastal headlands. Humpback whales are most likely to be seen at Port Hedland between June and November. However, humpback whales tend to occur in water deeper than 20 m (Prince 2001) and are therefore highly unlikely to enter the Port Hedland Harbour and be present near South West Creek.

Regional aerial surveys conducted by the DEC have recorded the presence of dolphins within Port Hedland Harbour, and it is possible that the two listed species of the Indo-Pacific humpback dolphins and spotted bottlenose dolphins utilise the harbour waters for foraging and for refuge during migration (Prince 2001, cited in Environ 2004).

Juvenile green turtles and juvenile flatback turtles are known to occur within the harbour, while adults of these species are not likely to be present due to a lack of suitable breeding, feeding or nesting sites (SKM 2008b; Pendoley 2009). Juvenile green turtles routinely forage within the waters of the harbour and surrounding mangrove creek systems for food, mainly foraging near the seaward fringes of the mangrove assemblages (Pendoley Environmental 2008, cited in SKM 2008b). Anecdotal evidence suggests that juvenile flatback turtles may also forage within the harbour (Pendoley Environmental 2008, cited in SKM 2008b). Turtle hatchlings are not known to actively swim into the harbour or to use the mangrove habitats as nurseries (SKM 2008b).

Recent environmental assessments and approvals for similar projects within the Port Hedland Port Management Area for both dredging and onshore disposal activities have not triggered any specific EPBC Act requirements other than a Marine Fauna Management Strategy within the Dredging Management Plan.

While dugongs (Dugong dugong) are not as likely to occur in Port Hedland Harbour as the species described above, they are of high conservation significance and have been reportedly sighted in Port Hedland Harbour, although no formal records exist. Dugongs are not listed in the EPBC Act Protected Matters Report for the South West Creek system (Appendix F), but are listed for the area including Spoil Ground I. Dugongs are known to occur from the Exmouth to Bedout Island, north-east of Port Hedland (Prince 2001). However, Port Hedland is not known to be an important aggregation area for dugongs due to the lack of extensive seagrass meadows, protected embayments and offshore islands (Prince 2001).
4.4.4.3 Mangrove Dependent Vertebrate Fauna

The mangroves of the Port Hedland area may be considered of high fauna conservation significance as they provide foraging, feeding and roosting habitat for several species of birds and bats (Churchill 1998; Johnstone 1990).

Mangrove systems provide habitat for a group of bird species that appear to be largely restricted to mangal and associated littoral habitats (Johnstone 1990). Biota (2004) recorded 12 species of avifauna in mangroves in Port Hedland which were regarded as effectively restricted to mangrove and associated littoral habitats (Biota 2004). These included, but were not limited to: the mangrove golden whistler, mangrove gerygone, mangrove robin, bar-shoulder dove and the mangrove fantail (Biota 2004).

The mangroves of Port Hedland also support the little north-western mastiff bat, Mormopterus loriae cobourgensis. This bat was recorded within the Utah Point area and is assumed to rely, at least partly, on the mangrove habitat for prey foraging and roosting habitat (Biota 2002). It is listed as a Priority 1 species by the DEC, with few or poorly known populations on threatened lands along the north-west coast (Churchill 1998). As a result, the occurrence of this bat in Port Hedland is considered regionally significant.

4.4.5 Introduced Marine Pest Species

Introduced marine species (IMS) are animals and algae that are not indigenous to Australia (or particular habitats within Australia) but have been transferred to local waters and have either established or have the potential to establish within the marine environment (DAFF 2010). In contrast to introduced marine species, introduced marine pests (IMP) are species introduced to, or translocated within Australian waters that pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports or tourism (DAFF 2010). Such is the risk posed by IMP that the National System was developed to provide a comprehensive national approach to marine pest management and prevention. This national approach seeks to minimise the risk of introduction, establishment and spread of invasive marine species by the management of potential vectors including ships’ ballast water and bio-fouling.

The Port Hedland Harbour is recognised as an ‘at risk’ Australian port for the introduction and establishment of marine pest species. This assessment is based on the high volume of large ships using the port and the subsequently high volume of ballast water and biofouling the harbour environment is exposed to (SKM 2008; BHPIO 2009a).
A total of 12 introduced marine species are known to exist within the Port Hedland Harbour. Of the introduced species, seven species are bryozoans, four are barnacles and one is a hydroid. None of the 12 introduced marine species are included on the National Target List of Potential Introduced Marine Pest Species (Appendix G).

The ongoing management of this issue will be conducted through the PHPA in conjunction with WA Department of Fisheries. A literature review detailing investigations undertaken on IMP species in Port Hedland Harbour has been provided in Appendix G.

4.5 Terrestrial Physical Environment

4.5.1 Topography and Landforms

Port Hedland lies on the northern coastline of the Abydos Plain, which is generally flat and bounded by the Chichester Plateau (part of the Chichester Ranges) to the south and west and the George Ranges and Great Sandy Desert to the east (HDMS 2002). The Chichester Ranges are approximately 200 km south west of Port Hedland and rise to around 300 m to 400 m above the mean sea level. The existing Port Hedland port area topography varies from the open harbour to tidal creeks, intertidal mudflats, bare coastal mudflats and sandy lowlands. The Project Area is located within a coastal area that is generally flat with gently sloping beaches and numerous headlands as shown in Figure 4-15.

The Project Area includes South West Creek, and has an elevation declining to the north as the creek drains into the Port Hedland harbour.
4.5.2 Land Systems

Land systems are grouped into land types according to a combination of landforms, soils, vegetation and drainage patterns. The Pilbara region has 102 land systems (van Vreeswyk et al. 2004). The South West Creek Project Area consists of only one land system, the littoral land system (van Vreeswyk et al. 2004). This land system occurs along much of Pilbara coast line (approximately 50%), and covers a total of 0.9% or 1,577 km² of the Pilbara bioregion.

Much of the littoral land system (70%) is made up of tidal flats, which support no vegetation. The mangrove vegetation on this land system (5%) is considered a significant habitat (van Vreeswyk et al. 2004).

The littoral land system is susceptible to erosion by coastal winds if plants cover is lost by fire or other disturbance.
4.5.3 Geology and Soils

The western part of the Pilbara is dominated by the Pilbara Craton, comprising metamorphosed granitoid rocks and gneiss. These Archaean aged geological strata are overlain by volcanic sediments which form the Hamersley Basin, which in turn is overlain by clastic sedimentary sequences and banded iron formations (Coffey 2010).

The Port Hedland area is at the northern tip of the Hamersley Basin and underlain by superficial Quaternary deposits comprising estuarine deposits adjacent to the creeks and alluvial sediments further inland. There are also localised Aeolian and beach deposits in the Port Hedland area, as shown in Figure 4-16. Within these deposits lie consolidated elements which are described as sandy calcarenite, oolite and calcilutite, all of which outcrop discontinuously near the coast.

The majority of sand and dune deposits are marine in origin, but some aeolian barrier dune deposits are present. These windblown barrier dune deposits are generally stabilised by vegetation, and are common along this stretch of coast line (SKM 2008b). Inland soils frequently include patches of hard, red alkaline earths and Pindan soils (SKM 2008b).

The Project Area is dominated by sedimentary deposits, which are mostly estuarine origin, with the exception of DMMA B-South which lies over sediments of largely alluvial origin (Figure 4-16).
4.5.4 Potential Acid Sulfate Soils

The DEC has produced an acid Sulfate risk map for the Pilbara coastline which has been incorporated into the Western Australian Planning Commission’s (WAPC) Bulletin 64 (WAPC 2009), as shown in Figure 4-17. While Bulletin 64 does not provide site specific information on ASS or PASS (location and depth) it does highlight the need for investigations prior to ground disturbing activities including the dredging of sediments in the marine environment.

PASS have previously been identified in sediments in various DMMAs within the Port area for other onshore disposal projects (BHP Billiton 2009a; 2008b), and PASS are therefore likely to be present within the terrestrial component of the South West Creek area. No quantification or assessment of the extent of PASS within the terrestrial components of the Project Area has been completed to date.

Section 4.3.6 discusses the ASS risk in the marine sediments within the dredge footprint.
Figure 4-17 Acid Sulfate Soils Risk Map for the Project Area

4.5.5 Hydrology

Port Hedland lies within a discrete coastal water catchment area, between the De Grey River Catchment to the east and the Fortescue River Catchment to the west and south. A summary of the catchment statistics is provided in Figure 4-18.

Table 4-9 Summary of Surface Water Catchment Statistics (National Water Commission 2010)

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area (km²)</th>
<th>Estimated Catchment Waters Consumption (Mlpa)</th>
<th>Estimated Sustainable Catchment Yield? (Mlpb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Hedland Coast</td>
<td>35,378C</td>
<td>13,695</td>
<td>29,200</td>
</tr>
<tr>
<td>De Grey River</td>
<td>56,717</td>
<td>3,387</td>
<td>124,000</td>
</tr>
<tr>
<td>Fortescue River</td>
<td>49,759</td>
<td>10,724</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Notes:

- a Millilitres per annum
- b Estimated for 2004/05
- c N.B. Catchment area previous quoted as 35,190 km² (SKM 2008b)
The rivers within the Port Hedland Coastal Catchment are considered to be fresh and generally flow from the George Ranges and Chichester Plateau in the south, across the Abydos Plain to the Indian Ocean in the north. The major rivers within the Port Hedland Coastal Catchment are the Maitland, Harding, George, Sherlock, Yule and Turner Rivers. Rivers in the northern Pilbara, such as the Yule, have flows which are dominated by summer rainfall. These rivers generally have low salinities with a moderate turbidity when not in flood (HDMS 2002).

To the west of Port Hedland lie the Yule and Turner Rivers, which experience 300 mm mean annual rainfall, together with mean annual flows of 223 GL and 20 GL, respectively (HDMS 2002). To the east of Port Hedland, within the coastal catchment, lies the Beebingarra Creek (HDMS 2002). There are a number of creeks which converge at Port Hedland Harbour, namely; Stingray Creek, South Creek, South East Creek, South West Creek and West Creek (Coffey 2010). These creeks are ephemeral and predominantly dry, but do respond to periods of heavy rainfall and can cause flooding across the coastal plain, especially after storm events (WAPC 2003). The two main surface water drainage pathways in the Project Area are South West Creek and South Creek (Figure 4-18).

4.5.5.1 South West Creek

South West Creek is approximately 5.3 km in length and has an estimated catchment area of 395 km$^2$. This catchment is relatively flat with poorly defined stream systems, resulting in indistinguishable catchment boundaries and flow paths in the lower reaches (BHP Billiton 2009a). The primary flow channels have discontinuities and are connected by overland flow paths that experience relatively shallow, slow moving sheet flow (GEMS 2000).

The South West Creek main flow channel and floodplains are crossed by the existing BHPBIO Port Hedland–Shay Gap Railway embankment between the Anderson Point train unloaders and stockpile area. Drainage culverts have been installed through the embankment (Environ 2004).

At low flows, floodwaters from South West Creek pass under the BHPBIO railway embankment into the Port Hedland Harbour via 12 culverts, each with an approximate diameter of 600 mm. During large flood events, these culverts have insufficient hydraulic capacity for peak catchment discharges and surface water ponds on the upstream side of the railway embankment (WorleyParsons 2008). This ponded water discharges westwards along the upstream side of the BHPBIO railway to alternative natural drainage pathways (GEMS 2000). A large capacity drainage channel has been excavated along the upstream side of the BHPBIO railway embankment to discharge excess flows from South West Creek to the west. It is possible that this bypass route has a limited capacity and that during peak flood events floodwater would also discharge over the railway formation (Environ 2004; WorleyParsons 2008).
Catchment response times for South West Creek were assessed for major rainfall events as part of the modelling undertaken for the Greater Port Hedland Storm Surge Study (GEMS 2000). For the peak 50 and 100-year average recurrence interval design floods, the times to flood peak generally varied between 8 to 12 hours, depending on the rainfall pattern being modelled, demonstrating that river flood peak discharge generally occurs well after any ocean storm surge and that the direct combination of the two events is unrealistic (Environ 2004; Worley Parsons 2008).

**Figure 4-18 Port Hedland Coastal Catchment**

4.5.5.2 South Creek

South Creek is approximately 8.5 km in length and has an estimated catchment area of 23 km². This catchment, much like the South West Creek Catchment, lacks a defined stream system (GEMS 2000). As with South West Creek, the existing BHPBIO Port Hedland–Shay Gap Railway embankment crosses the South Creek main flow channel and floodplains approximately 2 km southeast of DMMA B-North. Drainage culverts have been installed through the railway embankment. The Wedgefield townsite is located adjacent to South Creek downstream from the railway formation. South Hedland town site is located adjacent to South Creek, approximately 2 to 4 km upstream from...
the railway formation. During peak flood events in South Creek, both town sites are potentially subjected to inundation.

At low flows, floodwaters from South Creek pass under the railway formation via culverts into Port Hedland Harbour. As at South West Creek, during large floods the culverts would have insufficient hydraulic capacity for the peak catchment discharges and surface water would pond on the upstream side of the railway embankment. In peak floods, floodwater would discharge over the railway formation (GEMS 2000; WorleyParsons 2008).

4.5.6 Hydrogeology

The four main aquifers within the Pilbara Region (SKM 2008b) are:

- Coastal Plain Alluvial Deposits;
- Granite Terrain;
- Fortescue Group and Marra Mamba Iron Formation; and
- Wittenoom Formation.

The Port Hedland area is underlain by the Coastal Plain Alluvial Deposits (alluvial aquifer) which comprise permeable sand and gravel units, together with relatively impermeable weathered and fractured rocks such as sandstone found in South West Creek (Environ 2004). The alluvial aquifer can be sub-divided into three main water bearing units, namely:

- Upper Aquifer – unconfined within alluvium and calcarenite;
- Middle Aquifer – confined within red clay and sand beds of low permeability; and
- Lower Aquifer – confined within low permeability conglomerate and highly permeable gravel lenses (SKM 2008b).

The depth to groundwater has been measured to be approximately 2 m below ground level in the vicinity of Lumsden Point, which is immediately south east of Anderson Point and South West Creek (BHP Billiton 2009a). The quality of groundwater within the alluvial aquifer varies between highly saline and brackish, but is still used for industrial and domestic use (SKM 2008b). Groundwater sampled at Harriet Point, immediately north of South West Creek was found to have a pH range between 6.7 and 8.4, together with salinity levels between 940 mg/L and 61,000 mg/L (BHP Billiton 2008a). Due to the alluvial aquifer being shallow and within close proximity of the coastline, groundwater is likely to be influenced by tidal movements (BHP Billiton 2009a).
4.6 Terrestrial Biological Environment

4.6.1 Vegetation Associations

Field surveys (conducted in July 2010) of DMMA B-North and DMMA G recorded a low level of taxa richness (Appendix H). Six vegetation associations were recorded in DMMA B-North (Table 4-10, Figure 4-19). Five vegetation associations were described in DMMA G, in addition to Completely Degraded areas (Table 4-10, Figure 4-20). None are considered to represent Threatened Ecological Communities (TECs), Priority Ecological Communities (PECs) or Environmentally Sensitive Areas (ESAs).

Table 4-10 Vegetation associations identified in DMMA B-North and DMMA G

<table>
<thead>
<tr>
<th>Vegetation Association Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AmCt1</td>
<td>Open Shrubland to Shrubland of <em>Avicennia marina</em> and <em>Ceriops tagal</em>over Scattered Low Shrubland to Low Scattered Shrubs of <em>Tecticornia</em> spp. and <em>Muellerolimon salicorniaceum</em>.</td>
</tr>
<tr>
<td>AbCiTs</td>
<td>High Open Shrubland of <em>Acacia bivenosa</em> over Low Open Shrubland of <em>Corchorus incanus subsp. incanus</em> and <em>Gomphrena canescens subsp. canescens</em> over Grassland of <em>Triodia secunda</em>, <em>Triodia epactia</em> and <em>Cenchrus ciliaris</em> over Scattered Herbs of <em>Portulaca oleracea</em>.</td>
</tr>
<tr>
<td>Am</td>
<td>Scattered Shrubs of <em>Avicennia marina</em> over Closed Low Shrubland of <em>Muellerolimon salicorniaceum</em> and <em>Tecticornia</em> spp.</td>
</tr>
<tr>
<td>AmCt2</td>
<td>Closed Shrubland of <em>Avicennia marina</em> and <em>Ceriops tagal</em> over Low Open Shrubland to Scattered Shrubland of <em>Muellerolimon salicorniaceum</em>, <em>Suaeda arbusculoides</em> and <em>Tecticornia</em> spp..</td>
</tr>
<tr>
<td>Ts</td>
<td>Low Shrubland to Scattered Shrubs of <em>Tecticornia</em> spp. and <em>Muellerolimon salicorniaceum</em>.</td>
</tr>
<tr>
<td>TsSv</td>
<td>Closed Hummock Grassland of <em>Triodia secunda</em> with Scattered Tussock Grasses of <em>Sporobolus virginicus</em> and <em>Eragrostis falcata</em>.</td>
</tr>
<tr>
<td>TeTs</td>
<td>Closed Hummock Grassland to Grassland of <em>Triodia epactia</em> and <em>Triodia secunda</em>.</td>
</tr>
</tbody>
</table>

Note: An asterisk (*) indicates the taxon is introduced.
Figure 4-19 Vegetation association map of DMMA B-North (from Appendix H)
- Figure 4-20 Vegetation association map of DMMA G (from Appendix H)
4.6.2 Flora

A total of 24 taxa (including species, subspecies, affinities and variants) were recorded within the DMMA B-north project area (Appendix H). These 24 taxa consisted of 13 families, nine of which were represented by only one taxon, and 20 genera, 18 of which were represented by only one taxon. The plant families that were most taxa rich in the DMMA B-north were:

- Poaceae (5 taxa);
- Chenopodiaceae (4 taxa); and
- Asteraceae (2 taxa).

The plant genera that were most taxa rich in the DMMA B-north were Tecticornia and Triodia, each with two taxa. All other genera were only represented by a single taxon. The most common taxon recorded in the project area was Tecticornia halocnemoides.

A total of 45 taxa (including species, subspecies, affinities and variants) were recorded within the DMMA G project area during the field survey. These 22 taxa consisted of 23 families, 15 of which were represented by only one taxon, and 35 genera, 30 of which were represented by only one taxon. The plant families that were most taxa rich in the project area were:

- Chenopodiaceae (5 taxa);
- Fabaceae (5 taxa); and
- Poaceae (5 taxa).

The plant genera that were most taxa rich in the DMMA G were Acacia, Euphorbia and Tecticornia, each with two taxa. The most common taxon recorded in the project area was Tecticornia halocnemoides.

The low level of taxa richness in the project areas is attributed to the fact both project areas are situated in coastal vegetation associations, which typically have low taxa richness. In addition, the survey was undertaken after insufficient rainfall and consequently a number of annual taxa were likely to have been absent.

The composition of flora and vegetation in the project areas were generally typical of the families and genera frequently recorded in the Pilbara coastal region (ENV 2010).

4.6.3 Flora of Conservation Significance

No Conservation Significant Flora, have been recorded in DMMA B-North or DMMA G (Appendix H). The following Priority Flora have the potential to occur on the sandplain habitats in the DMMAs, but
may not have been identified due to the lack of significant rainfall prior to the survey. A targeted, seasonally appropriate survey will therefore be undertaken prior to any ground disturbance.

- *Abutilon pritzelianum* (Priority 1) - this species is considered to ‘Possibly’ occur because habitat suitable for this species occurs in the DMMAs. This species is an annual/perennial, so may have been absent at the time of survey due to low rainfall prior to surveying;

- *Pterocaulon sp.* (Priority 2) - this species is considered as ‘Possibly’ occurring because habitat suitable for this species occurs in the DMMAs. Two individuals of dead unidentifiable *Pterocaulon* spp. Herbs were recorded in the DMMAs, one at PA05 and one at PG02. There is a high likelihood these stems are of the commonly occurring *Pterocaulon sphacelatum*, but because the individuals were dead they could not be identified;

- *Goodenia nuda* (Priority 4) - this species is considered to ‘Possibly’ occur as it had been recorded nearby in similar habitat. Furthermore, this species is an annual, therefore may have been absent at the time of survey due to low rainfall prior to surveying.; and

- *Bulbostylis burdigaeae* (Priority 4) - this species is considered as ‘Possibly’ occurring, because it has previously been recorded less than 1 km south of the DMMAs in similar habitat (Biota 2008b). Furthermore, this species is an annual, therefore may have been absent at the time of survey due to low rainfall prior to surveying.

No TECs, PECs, DRF or ESAs were recorded within the DMMAs.

### 4.6.4 Introduced Flora (Weeds)

Three introduced flora were recorded in the surveys, *Aerva javanica* (Kapok), *Cenchrus ciliaris* (Buffel Grass) and *Portulaca oleracea* (Purslane) (Appendix H). These species comprised 5% of total taxa richness of DMMA B-North, and 7% of total taxa richness of DMMA G.

*Cenchrus ciliaris* was recorded on the sand plain habitat in both DMMAs (vegetation associations TeTs in DMMA B-North and TeTs in DMMA G) and the low limestone hill in DMMA G (vegetation association AbCiTs). The cover was generally low (less than 1%), except for on the limestone hill where the species dominated the understorey with 35% cover. *Cenchrus ciliaris* is a perennial grass that occurs across much of northern Australia, and semi-arid areas (Hussey et al. 1997).

*Aerva javanica* was only recorded in DMMA G, in the sandplain habitat (vegetation association TeTs) and low limestone hill habitat (vegetation association AbCiTs). The cover was two percent in the sandplain habitat, but less than one percent on the low limestone hill. *Aerva javanica* is a perennial herb that is widespread in many types of vegetation from the Kimberley to Carnarvon (Hussey et al. 1997).
*Portulaca oleracea* was recorded on the limestone hill habitat (vegetation association AbCiTs) in DMMA G. The cover of the species was relatively high (one percent), which is generally only represented by a few occasional individuals in the Pilbara region. *Portulaca oleracea* is probably native in the Pilbara region, although it is considered introduced flora by the Western Australian Herbarium (2010) because it has been introduced to south-west Western Australia (Hussey et al. 1997).

None of the introduced flora in the DMMAs are Declared Plant under the *ARRP Act 1976*. However, control of *Cenchrus ciliaris* and *Aerva javanica* may be desirable because both taxa have high rating under the Environmental Weed Strategy for Western Australia (CALM 1999).

### 4.6.5 Fauna Habitat Types

Five terrestrial habitat types (including cleared/developed land) have been identified in DMMA B-North and DMMA G (Figure 4-21 and Figure 4-22) (Appendix H).

#### 4.6.5.1 Mangroves

Mangroves occur throughout intertidal areas of Port Hedland. The Mangrove habitat is considered of high habitat value, as this type of habitat is uncommon in the Pilbara and supports ‘specialist’ species that will only be recorded in this habitat; for example the White-bellied Mangrove Snake (*Fordonia leucobalia*), Mangrove Robin (*Eopsaltria pulverulenta*), Mangrove Golden Whistler (*Pachycephala melanura*) and the Little Northern Free-tail-bat (*Mormopterus loriae cobourg ensis*). The Mangroves only formed a small portion (12.6%) of habitat within the DMMAs.

#### 4.6.5.2 Tidal Flats

This habitat is characterised by large open bare areas and scattered *Avicennia marina* shrubs and scattered low samphire species. The Tidal Flats is considered of low habitat value, as it contains limited microhabitat diversity for fauna to exploit. The vegetation complexity is low thereby reducing the amount of leaf litter and other microhabitats for fauna species to occupy. The Tidal Flats are different from the intertidal flats near the Port Hedland estuary in that they are not subject to as extensive tidal flows. The intertidal flats provide foraging opportunities for migratory shorebirds and waders, whereas the Tidal Flats in the DMMAs are less regularly inundated with seawater, and therefore provide fewer foraging opportunities. The Tidal Flats formed a major portion (65.3%) of the DMMAs and occur along the coastline within the region.
4.6.5.3 Sandplain

This habitat, with its thick vegetation dominated by Triodia species, is considered of low habitat value, as it lacks diversity of microhabitats for fauna to exploit. The low complexity of the vegetation structure provides limited niches available from leaf litter and logs. The soft soils offer niches for ground-dwelling reptiles and mammals and are suitable for burrowing species. Sandplains are known to support conservation significant species such as the Woma (Aspidites ramsayi), Australian Bustard (Ardeotis australis), and Brush-tailed Mulgara (Dasycercus blythi). Sandplains formed only a small portion (12.2%) of habitat within the DMMAs.

4.6.5.4 Limestone Hill

This habitat with its rocky substrate provides a small array of microhabitats for ground dwelling reptile and mammal species to exploit such as rock crevices, leaf litter and hollows. The vegetation structure was more complex than the surrounding Sandplain providing different areas for fauna refuges and foraging. However, this habitat was noted as having a low level of biodiversity and was disturbed and heavily invaded by introduced flora species. This isolated feature may provide a ‘stepping stone’ for aerial bird species to move from one habitat to the next, including the White-winged Fairy-wren (Malurus leucopterus), the Variegated fairy-wren (Malurus lamberti), and Yellow White-eyes (Zosterops luteus). This habitat only occurred in DMMA G, and comprises <1.5% of total habitat.

4.6.5.5 Cleared/Developed

In addition to the habitat types described above there are areas that have been cleared or developed. These provide little to no habitat value and are principally made up of infrastructure (i.e. roads, rail and tracks). These areas are not given a habitat value as they do not provide true fauna habitat.
Figure 4-21 Fauna habitat map of DMMA B-North (from Appendix H)
Figure 4-22  Fauna habitat map of DMMA G (from Appendix H)
4.6.6 Fauna

A desktop review of the Western Australian Museum, DEC, DSEWPaC and Birds Australia fauna records and of previous fauna studies indicated that a total of 190 species of terrestrial vertebrate have been recorded in the region (Appendix H). These include:

- Six species of amphibians;
- Fifty-four species of reptiles;
- One hundred and seven species of birds; and
- Twenty-three species of mammals.

It is important to note that many of these species are unlikely to occur in the DMMAs because the records are from a large area encompassing a wide range of habitats.

4.6.7 Fauna of Conservation Significance

Forty-five conservation significant species were identified as ‘potentially occurring’ in DMMA B-North and DMMA G from previous studies in the near vicinity of the DMMAs. Thirteen of these conservation significant fauna are considered to ‘possibly occur’ or ‘likely to occur’ within the DMMAs, including one reptile, ten birds and two mammals (Table 4-11). Nine of the conservation significant bird species are listed as Migratory under the Environment Protection and Biodiversity Conservation Act 1999. One species, the Woma (Aspidites ramsayi), is listed under the Wildlife Conservation Act 1950. Four species, the Woma, the Australian Bustard (Ardeotis australis), the Brush-tailed Mulgara (Dasycercus blythi) and the Little Northern Free-tail Bat (Mormopterus loriae cobourg ensis) are listed as Priority species by the DEC.

- **Table 4-11 Conservation Significant Fauna Previously Recorded in the Vicinity of the DMMAs.**

<table>
<thead>
<tr>
<th>Conservation Significant Species</th>
<th>Conservation Status</th>
<th>Habitat Relevance</th>
<th>Likelihood of occurring in DMMAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reptiles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woma (Aspidites ramsayi)</td>
<td>S4, P1</td>
<td>Suitable habitat is present within the DMMAs (Sandplain) and has been previously recorded in the local region.</td>
<td>Possible</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Birds</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White - bellied Sea Eagle (Haliaeetus leucogaster)</td>
<td>Mi</td>
<td>The White - bellied Sea Eagle possibly uses the DMMAs on a transitory basis, for searching for prey. However, no suitable nesting habitat is present in the DMMAs.</td>
<td>Likely</td>
</tr>
<tr>
<td>Eastern Osprey (Pandion haliaetus)</td>
<td>Mi</td>
<td>The Eastern Osprey is likely to forage within the DMMAs, because it has been previously recorded nesting nearby.</td>
<td>Likely</td>
</tr>
</tbody>
</table>
### Conservation Significant Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Conservation Status</th>
<th>Habitat Relevance</th>
<th>Likelihood of occurring in DMMAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Bustard (<em>Ardeotis australis</em>)</td>
<td>P4</td>
<td>The Australian Bustard may possibly utilise the Sandplain habitat in the DMMAs. Any activity is likely to be greatest in the southern sections of the project areas that have greater connectivity to similar habitat.</td>
<td>Possible</td>
</tr>
<tr>
<td>Oriental Plover (<em>Charadrius veredus</em>)</td>
<td>Mi</td>
<td>Suitable habitats present in the DMMAs.</td>
<td>Possible</td>
</tr>
<tr>
<td>Oriental Pratincole (<em>Glareola maldive</em>)</td>
<td>Mi</td>
<td>Suitable habitat in the DMMAs.</td>
<td>Possible</td>
</tr>
<tr>
<td>White-winged Black Tern (<em>Chlidonias leucopterus</em>)</td>
<td>Mi</td>
<td>Suitable habitat in the DMMAs.</td>
<td>Possible</td>
</tr>
<tr>
<td>Caspian Tern (<em>Sterna caspia</em>)</td>
<td>Mi</td>
<td>Suitable habitat in the DMMAs.</td>
<td>Possible</td>
</tr>
<tr>
<td>Fork-tailed Swift (<em>Apus pacificus</em>)</td>
<td>Mi</td>
<td>It is possible that the Fork-tailed Swift passes through the project area on a transitory basis. However, it is unlikely to use the habitats in the DMMAs.</td>
<td>Possible</td>
</tr>
<tr>
<td>Rainbow Bee-eater (<em>Merops ornatus</em>)</td>
<td>Mi</td>
<td>It is possible that the Rainbow Bee-eater may forage on insects aerially within the DMMAs; however it is unlikely habitats within the DMMAs will be used for any breeding or sheltering purposes.</td>
<td>Possible</td>
</tr>
<tr>
<td>Barn Swallow (<em>Hirundo rustica</em>)</td>
<td>Mi</td>
<td>It is possible that the Barn Swallow may forage on insects aerially within the DMMAs, however it is unlikely habitats within the DMMAs will be used for any breeding or sheltering purposes.</td>
<td>Possible</td>
</tr>
</tbody>
</table>

#### Mammals

<table>
<thead>
<tr>
<th>Species</th>
<th>Conservation Status</th>
<th>Habitat Relevance</th>
<th>Likelihood of occurring in DMMAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brush-tailed Mulgara (<em>Dasycercus blythi</em>)</td>
<td>P4</td>
<td>This species possibly occurs in Sandplain habitats, for foraging, dispersal and shelter.</td>
<td>Possible</td>
</tr>
<tr>
<td>Little Northern Free-tailed bat (<em>Mormopterus loriae coburg ensis</em>)</td>
<td>P1</td>
<td>This bat is likely to forage and or reside in the Mangrove habitat of the DMMAs.</td>
<td>Possible</td>
</tr>
</tbody>
</table>

### Notes

- **S** Scheduled under the WC Act 1950. Schedule 1 and 2 fauna are also protected by the EBPC Act 1999.
- **P** Listed as Priority by the DEC.
- **Mi** Listed as Migratory under the EBPC Act 1999.
- **Vu** Listed as Vulnerable under the EBPC Act 1999.
- **Likely** The DMMAs fall within the species known distribution, and suitable habitat is present within the DMMAs. Possible Limited or no suitable habitat is present in DMMAs but is nearby, the species has good dispersal abilities and is known from the general area.
- **Unlikely** No suitable habitat is present in DMMAs but is nearby, the species has poor dispersal abilities, but is known from the general area; or suitable habitat is present, however the DMMAs are outside of the species’ known distribution.
- **Highly Unlikely** The species has poor dispersal abilities, no suitable habitat is present, and the species is uncommon; or the species is thought to be locally extinct.

### 4.6.8 Short Range Endemic Fauna

The DMMA areas were considered unsuitable for supporting Short Range Endemic (SRE) Fauna, with only the Limestone Hill habitat in the northern section of DMMA G considered to be a possible SRE.
fauna habitat. Rocky outcrops often constitute a disjunct habitat that supports SRE fauna amongst the invertebrate and vertebrate fauna. However, a targeted search in the Limestone Hill area did not identify any SRE fauna (Appendix H). Coastal low-lying limestone outcrops are widespread in the region and the absence of any SRE fauna from within these isolated outcrops during the targeted searches indicates that SRE fauna are unlikely to be present.
5. SOCIAL AND REGIONAL ENVIRONMENT

5.1 Planning Context

The ToPH is responsible for the regulation of the use and development of land within its area. The main mechanism for controlling this land use is through the Council’s Town Planning Scheme No.5. The Scheme zones and reserves land for a variety of uses and controls elements of development, such as building size, car parking and open space provision (ToPH 2008).

The future development of Port Hedland is also addressed in the ToPH ‘Land Use Master Plan’ 2007. The Land Use Master Plan has been developed by the ToPH as a guide to the growth and development of Port Hedland during the next 20-25 years (ToPH 2007). It defines the community’s long range vision of how the town should develop and the plan will be incorporated into future statutory regulations controlling the location and forms of future development.

Under the Town Planning Scheme, the Project Area is zoned for ‘other public purposes – port facilities’.

The Project Area is within administrative boundary of the Port of Port Hedland. PHPA undertook a development planning study in 2003 which was updated in 2007, which identified suitable areas for future port development (WorleyParsons 2007). This project is consistent with the outcomes of this Port Planning Study and Ultimate Development Strategy.

5.2 Recreation and Tourism

Coastal recreational activities, such as fishing, are popular in Port Hedland. The Department of Fisheries estimates that there are approximately 2,000 recreational craft in the Port Hedland area (WAPC 2003).

There are two major boat-launching areas in Port Hedland, one at Finucane Island which is located at the north western end of Finucane Island and the other is to the north of PHPA berths (WAPC 2003). PHPA also has a jetty near the existing port area which allows commercial fishing boats access to the coast when commercial wharves are unavailable (WAPC 2003).

Tourism is an expanding industry in the Pilbara and north-west Western Australia, with ecotourism becoming increasingly popular. Port Hedland acts as a “gateway” to the Pilbara region, especially for people travelling to Karijini National Park, Karratha and the Kimberley region (WAPC 2003).
5.3 **Visual Amenity**

The Port Hedland Port currently hosts berths and ship loading operations operated by PHPA, BHPBIO and FMG, with expanded operations proposed from each of these developers and others, to meet the growing export demands for Pilbara iron ore.

The Port Hedland town site is located to the east of the port and is comprised of several land use types. The Port Hedland town centre is located at the western most point of Port Hedland and is a predominantly commercial area providing for retail, service and office businesses. The Wedgefield locality to the south of Port Hedland was developed as a light industrial area and is zoned for industrial use (ToPH 2009). However, as permitted by the Town Planning Scheme residential development has been permitted and is present within the Wedgefield locality, primarily in the form of caretakers dwellings (ToPH 2008).

The landforms around the port are low lying and the visual landscape of the Port Hedland area is dominated by the built environment, especially port infrastructure, iron ore stockyard and material handling infrastructure and vessels in port.

5.4 **Heritage**

5.4.1 **Indigenous Heritage**

The proposed dredge footprint, and DMMAs fall within the Kariyarra Native Title claim and contain a number of registered Aboriginal sites (Figure 5-1). Marakurrinya Pty Ltd (MPL) were nominated by the Kariyarra Native Title Claim group to conduct heritage surveys and deal with all other heritage matters in the Port Hedland area on their behalf. PHPA entered into an agreement with MPL on 30 May 2008 that allowed for a period of consultation by PHPA with MPL regarding any proposal to lodge a Section 18 Notice under the Aboriginal Heritage Act 1972. A heritage survey of the proposed dredge footprint area, excluding areas of land and mangroves (the Section 18 area in Figure 5-2) was undertaken in July 2010 in accordance with this agreement (Anthropos Australis 2010). Consultation with the Marapikurrinya people regarding PHPA’s proposed works also took place during the heritage survey.

Subsequent surveys over other Project Areas have been undertaken and reports are currently in preparation.

The survey area is located within the Marapikurrinya clan estate, within the broader Kariyarra native title claim area (WC 99/003), which has been continuously used and occupied by the Marapikurrinya people until and including the present day. One Aboriginal site was identified within the survey
area; site 22874 - *Marapikurrinya Yintha*, translated as living water (Figure 5-2). During consultation, the *Marapikurrinya* consultants explained their belief that the *kata karrarra*, also referred to as the serpent, is present in the Port Hedland Harbour, travelling within the waters and the creeks ( Anthropos Australis 2010). Therefore, they consider the waters and creeks of the Port Hedland Harbour to be of high cultural significance ( Anthropos Australis 2010).

On 20 August 2010 PHPA lodged a notice under Section 18 with the Department of Indigenous Affairs (DIA) seeking to dredge areas of the inner harbour to enable construction and operation of additional berths and ship loading facilities in South West Creek. They are currently awaiting a decision. PHPA and FMG received Ministerial Consent for a Section 18 on 29 October 2009 to dredge areas of South West Creek covering approximately 95% of the water (by area) of the most recent application.

Surveys for sites of indigenous heritage are planned for DMMA B-North and DMMA G. The land and mangroves in the proposed dredge footprint have not been surveyed and no surveys are currently planned. Anthropos Australis (2010) noted that: “... in the original *Heritage Scope of Works* provided by PHPA, specifically, the map marking out the proposed Survey Area in and around South West Creek, included areas of land and mangroves that would be impacted by the proposed construction and dredging works in South West Creek. The Author informed PHPA that they would require an archaeological survey if the Project was to impact the surrounding land. Prior to the conduct of the Survey, PHPA revised the proposed Survey Area to exclude the land and mangroves from the Survey Area.”
Figure 5-1  Registered aboriginal heritage sites in the Project Area
Figure 5-2  Cultural heritage survey area
5.4.2 European Heritage

Places of European heritage significance within the Port Hedland area are predominantly located within the Port Hedland townsite.

A search of the Database of Heritage Places listed 75 places of heritage significance existing within the Port Hedland local government area (HCWA 2010). Of these, four places are registered on the State Register of Heritage Places: Dalgety House, the former District Medical Officer’s Quarters, Mundabullangana Station and St Matthew’s Anglican Church.

Three of these sites are located within the Port Hedland townsite, and Mundabullangi is located to the south of the Project Area.

No places of European heritage significance are located within or in close proximity to the Project Area.

5.5 Air Quality

In January 2009 the EPA released an Environmental Protection Bulletin (EPA 2009c) expressing concern about the levels and management of dust and noise levels within the Port Hedland townsite. This Bulletin acknowledges that historic dust levels had been, and continued to be at that time above accepted recommended levels and called upon a coordinated government and industry approach to managing dust (and noise) issues at Port Hedland.

In May 2009, at the direction of the Premier, the State Government established the Port Hedland Dust Management Taskforce which in March 2010 published the ‘Port Hedland Air Quality and Noise Management Plan’ (DSD 2010).

This Management Plan assesses the issues and drivers associated with dust and noise at Port Hedland and documents an implementation strategy and governance framework to guide future actions and supports the responsible development of Port Hedland for its residents, the port and its users.

One of the strategies within this Management Plan PHPA has committed to ‘develop and implement best practice port development dust management guidelines’. These guidelines are currently under development.
5.6 Noise

The Port Hedland port precinct (containing multiple industries) has historically given rise to community concerns regarding noise impacts, particularly for those community members living in close proximity to the port facilities. The EPA acknowledged the history of these concerns within its Environmental Protection Bulletin No 2 (EPA 2009c) and the State Government established the Port Hedland Dust Management Taskforce to address dust and noise issues, and the inability to reach accepted recommended levels, within Port Hedland. This taskforce prepared the Port Hedland Air Quality and Noise Management Plan (DSD 2010) which provides an implementation strategy and governance framework for managing noise while supporting the responsible development of Port Hedland for its residents, the port and its users.

Recommendations of the taskforce include the establishment of a State Environmental Policy for Port Hedland by the EPA, to monitor and management noise using exemptions to the Environmental Protection (Noise) Regulations where appropriate.
6. KEY ENVIRONMENTAL IMPACTS AND MANAGEMENT

Environmental and social factors were determined to be key issues for the Project if they:

- Had a high inherent risk to the environment if left unmanaged;
- Required detailed assessment; and
- Required specific management measures and controls to ensure minimal impacts.

6.1 Marine Water Quality

6.1.1 Overview

Deterioration in water quality during dredging and onshore disposal activities has the potential to impact on the Environmental Values and Environmental Quality Objectives set for the Pilbara Coastal Waters, which Port Hedland and the creek systems are a part of (DoE 2006) (Section 4.2). The following activities may lead to impacts on the marine water quality:

- Increased turbidity/TSS from dredging and discharge from the DMMAs;
- Increased sedimentation from dredging and discharge from the DMMAs;
- Mobilisation of potential contaminants through the disturbance of sediments by the dredge, and through discharge water from the DMMAs;
- Acidification of the discharge water from the DMMAs caused by PASS in the dredged material exposed to oxygen during onshore disposal;
- Altered physio-chemical parameters in the discharge water;
- Construction, operation and completion of activities at DMMAs leading to the deterioration of water quality from dust, waste and hydrocarbon spills; and
- Introduction of waste and hydrocarbons into the water from dredges and associated machinery.

6.1.2 Objectives, Applicable Standards and Guidelines

The environmental objective of managing the water quality during the proposed Project is to protect the Environmental values of the Port and associated creek systems, as set for the Pilbara Coastal Waters (Section 4.2). As described in DoE (2006) the environmental values are protected by:

- Ensuring the water quality is sufficiently high to maintain the structure and functions of the marine ecosystems;
• Ensuring water quality is safe for recreational activities and that aesthetic values of the marine environment is protected;
• Ensuring water quality is sufficient to enable seafood caught or grown in the area is of a quality safe for human consumption;
• Ensuring cultural and spiritual values of the marine environment are protected; and
• Ensuring water quality is suitable for industrial supply purposes.

The relevant policies and standards that have been considered in the environmental assessment process for marine water quality include:

• Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006);
• Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000a);
• National Assessment Guidelines for Dredging (NAGD) (CoA 2009);
• The State Water Quality Management Strategy No 6, Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (GoWA 2004);
• Assessments levels for soil, sediment and water (DEC 2010); and
• Identification and investigation of acid sulfate soils and acidic landscapes (DEC 2009).

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000a) provide guidance for activities operating in state waters that may affect water quality. These guidelines provide criteria for establishing various levels of ecological protection for marine areas based on existing levels of disturbance and also recommend deferring to locally developed consultative guidelines where they exist.

All potential water quality impacts to the marine environment from the proposed Project have been considered in the context of the Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006). These guidelines suggest a 90% level of ecological protection for the Port Hedland Harbour within 250 m of existing facilities and infrastructure (DoE 2006). Following the objectives of these guidelines, the 90% ecological protection level has been updated to also include areas within 250 m of new and approved infrastructure (BHP Billiton 2009a; EPA 2009a). Accordingly, the 90% protection level is proposed to be extended to include the South West Creek Development as shown in Figure 6-1. All other marine environments within the state waters of the Port Hedland region fall within a 99% ecological protection level (DoE 2006).
6.1.3 Sediment Plume Modelling – Dredging and Onshore Disposal

For the purpose of assessing the potential impacts on water quality from an increase in TSS and sedimentation levels, a computer simulation of the dredging and onshore disposal campaign was undertaken. A Delft3D hydrodynamic and dredge plume model system was used to assess the impact of increases in TSS and sedimentation associated with the Project (Appendix I) (Cardno 2010). This model system is a world leading hydrodynamic sediment transport and water quality modelling system developed by Deltares in the Netherlands. It has been applied to coastal and ocean investigations and engineering studies worldwide, including Port Hedland and other sites in Australia. The details of the model set-up, associated input, model calibration and validation are described in Appendix I.
Modeling of the dispersion of TSS resulting from offshore disposal activities was undertaken by APASA using an advanced sediment fate model – Suspended Sediment FATE (SSFATE), operating within the Applied Science Associates (ASA) DREDGEMAP system.

6.1.3.1 Modelled scenarios

The dredge and onshore disposal campaign was simulated as a non-stop dredging and disposal campaign with commencement in the second quarter of 2011 and a duration of 2.7 years. The dredge campaign was simulated based on the following components:

- One or two backacter dredges removing the upper sediment layers down to a depth of -6.0 m CD with associated offshore disposal using hopper barges;
- One large CSD dredging from -6.0 m CD down to the design depth with associated disposal into the four onshore DMMAs;
- Changes to TSS concentrations and sediment deposition associated with the disposal of dredge material within Spoil Ground I;
- Average and exceedences 5% of the time were modelled for TSS concentrations and sediment deposition within the inner port area;
- TSS concentrations from two water depths within the inner harbour, surface and bottom were modelled to define differences in TSS concentrations between different layers of water; and
- Disposing the material from -6 m CD to design depth onshore including associated return water discharge into South Creek and South West Creek.

For internal project management and numerical modelling purposes the dredge footprint was divided into four smaller areas, as shown in Figure 6-2. The overall dredge and onshore disposal campaign was divided into seven phases, detailing the number and type of dredges engaged concurrently and the associated disposal method (offshore or onshore) (Table 6-1). The phased dredge program was based on the preliminary dredge design program and has been used for predictive modelling purposes only.

The model uses the assumption that during some periods, one or two backacters will work concurrently with each other and/or with the CSD to reflect the proposed program. The backacters will target the surficial layers, thereby creating sufficient depth for the CSD to access the creek to target the deeper occurring material. The discharge regime was captured as an average scenario with the majority of the discharge occurring into South Creek from DMMA B (on average 6 days a week) with an additional smaller discharge volume into South West Creek from DMMA G (on average 1 day a week) for the duration of the onshore disposal campaign.
Discharges from the DMMAs for modelling purposes were assumed to occur continuously throughout the project once onshore disposal was initiated during Phase C (Figure 6-2). To simulate a worst case scenario, 150 mg/l of TSS was assumed in all discharge water. In reality though, the TSS level will be lower depending on available retention times within the DMMAs and the quantity of slimes produced. The TSS level of 150 mg/L was chosen as this has been set as the maximum allowable TSS concentration in discharges from previous projects in Port Hedland (BHP Billiton 2009a).

The discharge from DMMAG is proposed to occur when relatively course material from South West Creek is being dredged. In such situations, the retention time required to achieve a TSS concentration in the overflow water of 150 mg/L will be significantly less than other times when the CSD is dredging relatively fine material.

![Figure 6-2 Dredge sequence modelled](image)

6.1.3.2 Model Assumptions

The dredge plume modelling assumes three separate sediment fractions in the dredged material (Table 6-2), excluding fine sand and coarser material (>75 µm diameter) which may initially become suspended in the water column but which will tend to settle to the seabed relatively quickly. The
The proportion of each size fraction used in the simulation was based on the geotechnical data from the northern end of the South West Creek dredged footprint (WorleyParsons 2009b). When additional geotechnical data from the southern end of the dredge footprint became available (SKM 2010a) it was compared against the findings of WorleyParsons (2009b) with good correspondence between the two surveys.

The plume model essentially tracks the fate of the finer particles (<75 µm diameter) suspended by the dredges during disturbance of the creek bed and the finer particles that may be released via the DMMA discharge water. The volume and particle size composition used in development of the modelling sediment plume extent associated with dredging and dewatering activities has been provided in Table 6-2.

Table 6-1  Summary of modelled dredging periods and dredge types for the Project.
The model assumes a certain production rate of the dredges with details given in Appendix I. The production rates include downtimes caused by spud changes, repair, dredge relocation etc. The model moves the dredge to a new grid cell every 2 weeks to mimic progress according to these production rates.

At the start of each phase (Table 6-1) the model updated the bathymetry to mimic the progress of the dredging program.

6.1.3.3 Sensitivity testing of model assumptions

To test the sensitivity of the model assumption on bathymetry (changing between each phase), the fines content in the dredge material, and the particle size distribution of the discharge water, four case studies were undertaken:

- An inclusion of an alternative bathymetry layout with an intermediate bathymetry between Phase B and C was undertaken;
- Bathymetry layout (Phase C) and simulation for the first 90 days of this phase was used to provide a comparison dataset to the alternative bathymetry layout scenario;
- An increase in fines content (<64 mm) was increased to 30% within the dredge material to test differences in TSS outputs if the dredge encounters pockets with high fines content. Phase C was used for this simulation; and
- Discharge from DMMA B consisting entirely of clay particles. The same TSS concentration of 150 mg/L used for the main model outputs was assumed. Again, Phase C was used for the simulation.

The results showed that the TSS concentration levels increased the intermediate bathymetry included in the model by up to 5 mg/L in South West Creek. This outcome is the result of the shallower depths in the dredged area and associated increased tidal current velocity which increases the horizontal dispersion. This result indicates that the model may slightly underestimate TSS levels by including bathymetry updates only between phases. However, the difference was not considered significant (Appendix I).

The results also showed that an increase in the dredge material fine contents from 18% to 30% lead to an increase in TSS concentration of between 10 mg/L to 20 mg/L in some location. This indicates that should the CSD dredging reach material with a high concentration of fines (~30%), the dredge plume and TSS concentrations may increase significantly in South West Creek. In South Creek (near the DMMA B discharge point) the increase of the fines content in the dredge material resulted in an
increase of about 5 mg/L in terms of the TSS concentration due to the larger sediment plume generated near the head of the CSD and backacters operating in South West Creek.

When discharge from the DMMAs was considered to be composed entirely of clay particles, the TSS levels in the bottom layer reached levels of up to 35 mg/L (over a 250 m x 500 m surface area) in terms of the average contours and up to 50 mg/L (over a 100 m x 500 m surface area) in terms of the 5% probability of exceedence contours.

Based on these results the current model outputs are considered a reasonable representation of the proposed Project, based on input assumptions adopted. An increase in the fines content within the dredge material is predicted to drive the TSS level up significantly, and this should be taken into account when interpreting the model results.

- Table 6.2 Summary of the sediment properties included in the dredge model

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Median particle diameter (µm)</th>
<th>% of fine fraction (&lt;64µm)</th>
<th>Fall velocity (mm/sec) based on Stokes’ Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt</td>
<td>43</td>
<td>25%</td>
<td>1.7</td>
</tr>
<tr>
<td>Fine silt</td>
<td>8</td>
<td>25%</td>
<td>0.06</td>
</tr>
<tr>
<td>Clay</td>
<td>2</td>
<td>50%</td>
<td>0.004</td>
</tr>
</tbody>
</table>

6.1.4 Potential Impacts

6.1.4.1 Total Suspended Solids

The average TSS levels in surface and bottom waters during each phase of the dredging and onshore disposal campaign are shown in Figure 6-3 and Figure 6-4. Note that Phase A, where a single backacter will be operating with associated offshore disposal, is not included in the figures as little influence on water quality is predicted by the model, however outputs are included in the model report in Appendix I.

Higher TSS values are consistently predicted in bottom waters compared to the surface layer during all phases. The highest average TSS values are predicted during Phase C, D and E when one or two backacters will dredge concurrently with the CSD. However, all plots indicate that the dredge plume is likely to be confined to the area around the dredge footprint in South West Creek and to the area around the DMMA discharge point in South Creek. The dredge and discharge plume is predicted to influence South West Creek and South Creek with average surface TSS values no greater than 20 mg/L, and bottom values up to 35 mg/L. The area of West Creek to the east of the existing Finucane Island causeway is predicted to experience average TSS levels around 15 mg/L in both surface and bottom layers during the most intense period of the campaign (Phase C). During the less
intense phases, the TSS levels are predicted to be much lower, with average values of 5-10 mg/L. The remaining part of the creek system and the harbour are predicted to receive relatively little suspended material from the dredging and discharge.

The TSS contours shown in Figure 6-5 and Figure 6-6 show TSS concentration 5% of the time in surface and bottom waters, respectively, during each phase of the dredging and onshore disposal campaign. These plots indicate the areas predicted to experience the peaks in TSS values, and generally show the same pattern as the average outputs. Specifically, the peaks in TSS are likely to be confined to South West Creek and South Creek with higher TSS levels near the bottom layer in comparison to the surface layer.

A 14-day time series of TSS levels during the last part of the Phase C simulation is shown in Figure 6-7 as an example of the oscillations of the predicted TSS levels in relation to the tidal cycle. The time series are shown for at various locations within South West Creek (as per figure 5-1 in Appendix I). The time series show how the TSS oscillations are mainly driven by the tidal cycle, with an overall tendency of lower TSS levels during the spring-neap tides.

Overall the main water quality impacts from the dredge and discharge plumes are expected within South West Creek, South Creek and to a lesser extent within the lower part of West Creek. However, water quality is expected to be influenced by slight increases in TSS concentrations throughout the creek systems and in the harbour for the duration of dredging and dewatering activities. While the plume is not predicted to exit the harbour to any great extent (see Section 7.1.3) the water quality is predicted to be influenced by a light plume in the near-shore marine environment along Finucane Island and the northern near-shore area off the town of Port Hedland.
Figure 6-3  Average TSS concentration in surface waters (mg/L) from phase B to G

(Note: Phase A is not shown due to low and uniform TSS concentration across the creek system of less than 5 mg/L.)
Figure 6.4  Average TSS concentration in bottom waters (mg/L) during phase B to G

(Note: Phase A is not shown due to low and uniform TSS concentration across the creek system of less than 5 mg/L.)
Figure 6-5  TSS Concentration Contours Exceeded 5% of the time in surface waters (mg/L) during phase B to G

(Note: Phase A is not shown due to low and uniform TSS concentration across the creek system of less than 5 mg/L).
Figure 6-6  TSS Concentration Contours Exceeded 5% of the time in bottom waters (mg/L) during phase B to G

(Note: phase A is not shown due to low and uniform TSS concentration across the creek system of less than 5 mg/L).
6.1.4.2 Sedimentation

Figure 6-8 shows the predicted sediment deposition patterns during each phase. For assessment purposes, these model outputs are not additive, but outline the deposition pattern of each phase separately. Note that Phase A, where a single backacter will be operating with associated offshore
disposal, is not included in the figure as little sedimentation is predicted by the model, however the outputs are included in the model report in Appendix I.

The sedimentation pattern indicates highest depositions during Phase C, when the two backacters will be dredging concurrently with the CSD. All phases, however, indicate a localised sedimentation pattern with little impact outside South West and South Creek. The sedimentation may exceed 25000 g/m2 within the dredge area, however some of this material may be dredged during the next phase of dredging. In South Creek deposition may reach up to 20000 g/m2 during Phase C near the location of the DMMA discharge point.

For assessment of the cumulative impact of sedimentation, the mass of the settled material was converted to deposition in height by simulating consolidation of the settled material as a function of time. The sedimentation height on the seabed was calculated considering that consolidation had occurred and by using dry bed density of 400 kg/m3 for clays, 900 kg/3 for fine silts, and 1100 kg/m3 for silts (Van Rijn 2004).

The accumulation of sediments at the end of each phase is shown in Figure 6-14, with each phase adding to the outcome of the previous. Note that Phase A is not included due to the low predicted sedimentation, however the model output is included in Appendix I.

Sedimentation will likely exceed 60 mm within the proposed dredge footprint, however some of this material would be dredged during successive dredging phases. Sedimentation will likely reach up to 60 mm and 25 mm [averaged over a 50 m² area] near the location of the water discharge in South Creek and South West Creek, respectively. However as these values are averages over a 50m² area in the model it is possible that localised sedimentation rates near outlets may exceed these grid averaged levels.

The model predicts cumulative sedimentation to reach 15 mm within the upper reach of South West Creek and within the south part of Port Hedland Harbour. Despite that, low chronic sedimentation is predicted to occur in the wider creek system (Figure 6-8). The settled particles are not predicted to remain and accumulate, but are predicted to resuspend, as indicated in Figure 6-9.

The creek systems in Port Hedland harbour are naturally turbid with relatively high natural sedimentation rates. The Project is likely to significantly add to the overall sedimentation in particular within South West and South Creek. Sediment deposition in the remaining creek systems is not predicted to significantly add to the high natural background levels.
- **Figure 6-8** Predicted sediment deposition (in mass) at the end of each phase B to G simulations

(Note: Phase A is not shown due to low predicted sedimentation. These plots are not additive).
- Figure 6-9  Predicted cumulative sediment deposition (in mm) at the end of each phase B to G simulations

(Note: Phase A is not shown due to low predicted sedimentation).
6.1.4.3 Release of potential contaminants

As described in Section 4.3.5 the surface sediments within the dredge footprint intended for ocean disposal were screened and assessed against the National Assessment Guidelines for Dredging. The sediment was found clean and suitable for unconfined ocean disposal, and is subsequently not likely to release potential contaminants into the water during dredging.

The deeper occurring material intended for onshore disposal was screened during two separate geotechnical surveys, as described in Section 4.3.4. The total metal concentrations of samples were compared against EILs and ISQG-low levels adopted from the Assessment Levels for Soil, Sediment and Water (DEC 2010) and ANZECC/ARMCANZ (2000a) ISQG guidelines, respectively. Both sets of guidelines are often used to determine the suitability of sediments for onshore disposal activities and/or reclamation.

The EIL levels refer to acceptable levels of potential contaminants in soil and have been used to guide assessments of suitability for onshore disposal of dredged material in previous projects in Port Hedland (BHP Billiton 2008a; 2008b; 2009a). The ISQG-low levels are identical to the NAGD screening levels for metals, used as guides for assessment of the likelihood of impacts to the marine environment (seabed and water column) from dredging and disposing sediment at sea. Samples from both surveys displayed metal concentrations below EILs and ISQG-Low, with the exception of nickel and chromium. In all samples, nickel concentrations were below the EIL guideline of 60 mg/kg, however 16 samples displayed concentrations above the ISQG-low of 21 mg/kg. One sample of chromium was above the ISQG guideline of 80 mg/kg, displaying a chromium concentration of 89 mg/kg, however it was below the EIL Guideline of 400 mg/kg. As a result, further assessment was undertaken to define the potential bioavailability risk associated with elevations in both nickel and chromium in the receiving waters during dewatering activities.

Nickel elutriate testing was carried out on samples that displayed elevated levels collected during the 2010 study. Elutriate results showed that one sample (8.6 µg/L) was just above the ANZECC/ARMCANZ (2000a) 99% species protection level of 7 µg/L for nickel, but well below the 95% species protection level of 70 µg/L and the 90% species protection level of 200 µg/L. In situations when elutriate results exceed guideline levels, the NAGD recommends that a dilution factor is applied, in addition to the standard 1:4 dilution sediment: water that is used during laboratory testing, to take into account the effects of mixing following discharge to the receiving environment. The dredged material from below 6 m CD is proposed for onshore disposal at the DMMAs and application of a dilution factor of 1:5 would reduce the sample concentration below the 99% ANZECC/ARMCANZ (2000a) species protection level, which would be easily achievable at the DMMA discharge points.
In conclusion the risk to the water quality from mobilisation of metals from the dredged material, and from the discharge water is considered negligible.

6.1.4.4 Acidification of the discharge water

As described in Section 4.5.4 the lower geological material intended for onshore disposal was screened for PASS during the 2010 geotechnical survey (Appendix C). The results strongly indicated that little or no PASS material is likely to be present in the deeper layers of the seabed within the south-eastern area of the dredge footprint where the sampling was undertaken. Conclusions by URS (2005b; 2008b) in regards to the north-western part of the footprint strongly support these results despite the 2008 survey not testing for PASS.

The risk of PASS causing acidification of the DMMA discharge water, following exposure of dredge material to oxygen in the DMMAs, is considered negligible given the low likelihood of PASS occurrence. Should isolated pockets of PASS occur, mixing of sediments during dredging and onshore disposal would alleviate the potential for ASS generation due to neutralising capacity associated with material that displayed no PASS, as reported from the 2010 survey (Appendix C).

Given the results from the 2010 survey and the conclusions made by URS (2005b; 2008b), the risk of PASS occurring in the lower geological layers below -6.0 m CD within the dredge footprint is considered low.

6.1.4.5 Altered physio-chemical parameters

Parameters such as Dissolved Oxygen (DO), temperature and salinity may be altered and impact on the receiving creek system. However, this is considered a low risk and only applicable to the immediate creek system receiving discharge water (i.e. South Creek and to a lesser extent South West Creek).

6.1.4.6 Deterioration of water quality from dust, waste and hydrocarbon spills

Deterioration of water quality may occur from dust generated during construction of DMMAs and from dust lift-off from the DMMA slime management areas once these dry out. However, the risk is considered low.

The inappropriate handling and disposal of waste also has the potential to impact on water quality within the creek systems and on barges in transit to the spoil grounds. Inappropriate handling, storage and disposal of hydrocarbons, including during bunkering, also poses a potential threat to the water quality of the creek systems and near-shore areas. The length of the dredging program
dictates the presence of dredges for a prolonged period in South West Creek, with associated use of hydrocarbon products presenting the potential for impacts to the creek ecosystem.

6.1.5 Management of Impacts

Water quality is predicted to be influenced in the inner harbour through disturbance of sediments within the dredge footprint and discharge of decant water during dewatering of proposed DMMAs. While the extent of plume migration is likely to remain within South West Creek, the predicted influence of plume migration is predicted to extend throughout the inner port area albeit at low levels. Water quality management and monitoring has been provided in detail within the DMP (Appendix A).

6.1.5.1 Tiered Monitoring Framework

The Tiered Monitoring Framework (TMF) has been developed in conjunction with management performance indicators, management triggers, and monitoring programs described in the DMP (Appendix A). The main objective of the TMF is to ensure that a set of compulsory and optional management actions are in place during dredging and offshore spoil disposal that can be implemented should environmental monitoring detect a change in water quality, mangrove health and/or coral health which are greater than the changes seen ‘naturally’ across reference sites; that is, quantifiable changes which can be attributed to dredging activities, (i.e. compared to reference sites), or where development activities are considered to be of a higher environmental risk, warranting more conservative management.

A flow diagram of the proposed TMF for water quality/coral health and sedimentation/mangrove health management and monitoring has been provided in Figure 6-10 and Figure 6-11, respectively, for the predicted area of impact. As part of the TMF, a set of water quality and sedimentation monitoring triggers have been developed (refer to the DMP in Appendix A) to provide a proactive management strategy for the protection of coral and mangrove communities during the monitoring program. These water quality/sedimentation triggers will be regularly reviewed on a monthly basis during dredging to ensure that they remain relevant and applicable to the health of corals and mangroves within the predicted impact areas.
Figure 6-10: Routine Water Quality and Reactive Coral Monitoring Tiered Management Framework

Figure 6-11: Routine Surface Sedimentation Profiling and Reactive Mangrove Health Tiered Management Framework
6.1.5.2 Summary of Proposed Management and Monitoring

A summary of proposed management and monitoring is provided below:

- Installation of a satellite-based vessel monitoring system on the dredge, allowing a track plot analysis to ensure maximum efficiency of the dredging effort and that no dredging occurs outside the required area;
- Use of suitable dredging plant and equipment to minimise turbidity, including well maintained floating pipelines to be utilised to minimise leakage of turbid water during pumping of material to the DMMAs;
- Maintaining calibration of the hydrographic survey systems onboard the dredge;
- Monitoring of weather and sea conditions;
- Implementation of the Tiered Monitoring Framework (see Section 6.1.5.1) following a water quality trigger breach in accordance with the monitoring program. Water quality trigger levels will be established prior to commencement of dredging based on baseline water quality data and reference site data.; and
- Install the following management measures to control tailwater discharge associated with reclamation:
  - Maximise the residence time in the reclamation area to reduce the turbidity plume of the tailwater discharge. Suitable controls (e.g. weir boxes) will be used at the discharge point to control the water level and the rate of discharge;
  - Cease dewatering or move tailwater within reclamation cells when turbidity is excessive;
  - Regular inspection and maintenance of erosion and sediment control structures particularly following heavy or prolonged rainfall;
  - Stabilise uncovered areas of soil promptly; and
  - Install scour protection measures such as gabions where scouring is likely to occur.

Monitoring will include:

- Implementation of Routine Water Quality Monitoring Program (refer to the DMP in Appendix A). Water quality monitoring locations will be established at key receptor locations and will be monitored in situ for a range of physicochemical parameters continuously for the duration of dredging.
- In the event of a breach of water quality or sedimentation triggers, implementation of the Reactive Coral Health Investigation and Reactive Mangrove Health Monitoring Program, where relevant.
• Dredge Contractor to monitor the operation on a continual basis and report any incidents that are likely to cause substantial changes to water quality.

• Discharge water associated with DMMA areas will be monitored to ensure the discharge quality meets the action criteria outlined in Dewatering Effluent and Groundwater Monitoring Guidance For Acid Sulfate Soil Areas (DEC 2006b). Total Titratable Acidity (TTA), Electrical Conductivity (EC) and pH will be monitored weekly to ensure that water quality parameters are maintained at a pH > 6 and a TTA < 40 mg/L (see Section 6.6.1.2).

Potential impacts to sensitive receptors are discussed in Section 6.2 (mangroves), Section 7.1 (corals) and Section 7.2 (other BPPH) but have also been considered in the development of the proposed water quality management and monitoring.

6.1.6 Predicted Outcome

The Project has the potential to impact on marine water quality however, given the results of the plume dispersion modelling, the management of discharge water quality during previous dredging programs and the proposed management outlined in the DMP (Appendix A), it is considered that the requirements of the Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006) will be met.

6.2 Mangrove Habitats

6.2.1 Overview

Mangrove communities provide a range of key ecological functions along the north-west coast of Australia, including stabilisation of coastal shorelines and sediments (Semeniuk 1985), provision of important fauna habitats, feeding grounds and nurseries (Duke 2006; Semeniuk et al. 1978), and input of nutrients to coastal ecosystems (Semeniuk et al. 1978; Paling et al. 1989). This is in addition to their intrinsic cultural and scientific values (EPA 2001).

6.2.2 Objectives, Applicable Standards and Guidelines

The EPA's (2001) overall environmental objective for tropical arid zone mangroves of the Pilbara coastline (Pilbara mangroves), habitats and dependent habitats is ‘to maintain ecological function and sustainability’. Specifically, their operational objective is that the impacts of development on mangrove habitat and ecological function of the mangroves in these areas should be reduced to the minimum practicable level.
The relevant policies and standards that have been considered in the environmental assessment process for mangrove habitats include:

- EPA Guidance Statement No.1: Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2001); and
- EPA Environmental Assessment Guideline No.3 – Protection of Benthic Primary Producer Habitats in Western Australia’s Marine Environment (EPA 2009b).

Other applicable legislation and guidelines for the management of mangroves include:

- Environmental Protection Act 1986 (WA);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC&ARMCANZ 2000a);
- Pilbara Coastal Water Quality Consultation: Environmental Values and Environmental Quality Objectives (DoE 2006); and
- Draft Environmental Protection (State Marine Waters) Policy (EPA 1998).

### 6.2.3 Potential Impacts

Potential impacts on mangroves associated with the South West Creek Project include:

- Direct loss due to clearing within the dredge footprint;
- Removal of mangroves to provide a temporary pipeline corridor running from the dredge to DMMA G;
- Removal of mangroves from the dredging footprint in two locations to provide land backed access;
- Indirect impacts due to excessive sedimentation associated with dredging and DMMA discharge;
- Indirect impacts due to reduced water quality resulting from DMMA discharge water (toxicants, low pH); and
- Indirect impacts due to changes in inundation regime.

The EPA acknowledges the ecological value that BPPs and BPHBs have from an environmental perspective. Consequently, the EPA have produced two Guidance Statements (EPA 2001; EPA 2009b) that provide advice on the considerations that must be addressed by any proposed development that may negatively impact upon the suite of environmental services and ecological functions supported by BPHB.

In accordance with the Environmental Assessment Guideline No. 3 (EPA 2009), PHPA is required to submit an estimate of cumulative loss within a designated management unit, which is comprised of
historical loss plus any loss predicted from the current proposal under consideration. The Port Hedland Industrial Management Unit is presented in Figure 6-12. This management unit defines the basis to which habitat losses are calculated and has previously been used in the assessment of impacts to BPPH (i.e. BHP Billiton 2008; 2009).

The second EPA Guidance Statement, Guidance Statement No. 1 (Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline) (EPA 2001), categorizes Port Hedland as being covered by ‘Management Area 4: Other mangrove areas—inside designated industrial areas and associated port areas’. These include all mangrove areas that occur inside areas that have been designated as industrial areas, associated ports or other development and not covered by Guideline No. 3.

- **Figure 6-12** Port Hedland Industrial Area Management Unit for mangrove management

6.2.3.1 Direct impacts

The Project will result in the direct loss of up to 40.10 ha of mangroves. These losses are comprised of 26.19 ha due to the South West Creek dredging footprint and disturbance envelope, and 13.91 ha due to the construction of the unapproved DMMAs and temporary pipeline and access corridors.

Specifically, the Project will have the following direct impacts to mangrove habitat:
- Removal of mangroves within the dredge footprint;
- Removal of mangroves to provide a temporary pipeline corridor running from the dredge to DMMA G; and
- Removal of mangroves to provide land backed access for the removal of mangroves from the dredging footprint in two locations.

Using mangrove assemblage classifications described by Semeniuk (2007), and adopted by WorleyParsons (2010c) during the baseline mangrove community investigation, the breakdown of direct loss of mangroves is predicted to be as follows:

- 25.52 ha of *Avicennia marina* scrub;
- 8.44 ha of *Avicennia marina* open heath;
- 3.14 ha of *Rhizophora stylosa* scrub; and
- 2.99 ha of *Rhizophora stylosa* low forest.

The EPA (2001) designated a Port Hedland Industrial Area Management Unit as the appropriate management unit for mangrove and other BPP communities in the Port Hedland Harbour region. An EPA bulletin presented in 2008 which included most recent port development project RGP6 identified a total loss of 302.1 ha (11.3%) based on an estimated historical mangrove area of 2676 ha. A recent reassessment by BHP Billiton (2009) has shown that losses are below this threshold (<10%) based on historical aerial photography between 1963 and 2008. For the purposes of this assessment, calculation of mangrove loss for this Project has been calculated using gross cumulative loss estimates, in accordance with EPA guidance.

The EPA has proposed that the total cumulative mangrove loss associated with the Port Hedland Industrial Area Management Unit have exceeded 10% total loss. Based on the presented EPA cumulative loss of mangrove area of 297.1 (11.15 %) the predicted cumulative total loss including losses associated with this Project would increase from 297.1 to 337.04 ha (12.8%) an increase of 1.5% (Table 6-3).

Table 6-3 Cumulative loss of mangrove BPPH in Port Hedland Industrial Area Management Unit (Option 1)

<table>
<thead>
<tr>
<th>BPPH Loss Calculations</th>
<th>Area (ha)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Size of Management Unit</td>
<td>15430</td>
<td></td>
</tr>
<tr>
<td>Historical Area of Mangroves 1963</td>
<td>2676</td>
<td></td>
</tr>
<tr>
<td>Current Area of Mangroves 2009</td>
<td>2373.9</td>
<td></td>
</tr>
<tr>
<td>EPA Category and Cumulative Loss Guideline E (&gt;10%)</td>
<td></td>
<td>1.50%</td>
</tr>
<tr>
<td>Potential Permanent mangrove Loss due to Project</td>
<td>40.10</td>
<td></td>
</tr>
<tr>
<td>Estimated Historic Mangrove Loss</td>
<td>302.1</td>
<td>11.29%</td>
</tr>
<tr>
<td>Predicted Total Cumulative Mangrove Loss including Project</td>
<td>342.20</td>
<td>12.8%</td>
</tr>
</tbody>
</table>
The Port Hedland Industrial Management Unit (Figure 6-12) has been termed Category E under Guideline No. 3 (EPA 2009) following calculation of previous loss estimates associated with projects and addition of BPPH through changes in accretion and erosion factors affecting the management unit. A Category E rating is defined as an area identified either by the EPA or through the literature as having moderate conservation or ecological significance, and where the land use has been designated for heavy industry, large coastal proposals or related purposes by a State Cabinet decision (e.g. inner harbour areas). The primary requirements associated with a Category E rating based on EAG 3 include:

- A substantial justification for the proposal, supported by technically defendable information that demonstrates understanding of the ecological role and value of the benthic primary producer habitat within the local context. Using this understanding, the proponent would be expected to evaluate any impacts, and to determine the significance of those impacts on ecological integrity.

- Proponents will need to demonstrate and commit to a ‘best practice’ approach to minimising impacts and must ensure the maintenance of ecological integrity, overall biological value and environmental quality of the area.

- The EPA expects the proponent to develop and commit to the implementation of a comprehensive environmental management plan that has as its primary objective the long-term maintenance of ecological integrity.

It is expected from this ERD that all of the above requirements will be met in accordance with EAG 3.

EAG3 is based on a premise that as general rule, the EPA is comfortable with ecological function of areas being retained by inherent system robustness when loss is retained below 10%. Above this value, the onus is on the proponent to demonstrate as far as practical that this additional loss will not result in a serious impairment of the ecological function of the management unit as a whole.

Based on the calculations presented in this section, the current loss of mangroves within this area is 11.3%, and this Project anticipates increasing this loss by 1.5% to 12.8%. PHPA believes the cumulative loss guideline of 10% has not been significantly exceeded for the reasons below and which are discussed in detail in Appendix E.

Given that the distribution and percent coverage of mangroves in the Inner Harbour appears to be largely determined by physical factors i.e. tidal inundation (Figure 6-13), it could be assumed that not only are the mangroves fringing the Mean High Water Spring (MHWS) likely to be more diverse, and cover a larger surface area, with a potentially more complex three-dimensional structure, but are
also likely to be more productive (i.e. to produce more carbon per unit of area of coral) than the mangroves occupying the more “higher ground” i.e. Highest Astronomical Tide (HAT).

BHPBIO demonstrated that mangrove areas had increased over time within the Port Hedland Industrial Area Management Unit (BHP Billiton 2009). First, using 1963 aerial imagery they established that 2699 ha of mangrove were present within the management unit at that time. Comparison with 1993 aerial imagery showed that a net loss of 59 ha was evident, despite mangrove losses due to existing or approved developments amounting to 342 ha. The discrepancy between these two loss values indicated that an increase in the area of mangroves had occurred, amounting to 283 ha (BHP Billiton 2009). Changes in mangrove coverage were attributed to various environmental drivers including sediment accretion, landward colonisation, consolidation of mangrove areas, and species substitution within areas of existing mangrove habitat (Appendix E).

Direct comparisons of benthic microalgae and macroalgae primary production suggest that mangroves are not as productive, per unit of area, (Hatcher 1990) and given that Inner Harbour mangroves comprise approximately half the area of the total mangrove habitats within the management unit, it is likely that the overall contribution to primary productivity (as fixed carbon/m²/d) within the management unit or even broadly the Pilbara is also correspondingly small. Consequently, the loss of an additional 1.5% of mangroves in the management unit is highly unlikely to represent a significant loss in terms of the management unit, or the region as a whole.
6.2.3.2 Indirect impacts

The Project has the potential to have the following indirect impacts on mangroves in the Port Hedland Harbour:

- Reduced health or mortality of mangroves due to increased sedimentation resulting from dredging and construction activities;
- Changes in mangrove coverage and/or species composition resulting from altered hydrodynamic processes (including tidal flows, currents, surface water flows and erosion patterns);
- Reduced health or loss of mangroves resulting from excess turbid water discharge from DMMAs and ancillary infrastructure due to dust deposition during construction of DMMAs; and
• Reduced health of mangroves surrounding slime management areas once these areas dry out.

Sedimentation

Mangroves are considered specialised plant species due to their ability to survive in brackish, anoxic environments that experience tidal inundation. One of the specialist adaptations that mangroves have developed to survive in such conditions are pneumatophores. Pneumatophores are aerial roots that extend above the soil surface to assist in the absorption of oxygen for respiration.

The primary effect of dredging activities on mangrove communities within the Project Area is the indirect impact of increased sedimentation causing burial of mangrove pneumatophores. Increased sedimentation can result when material disturbed and suspended by dredging activities descend through the water column wherever local conditions are calm enough to allow particles in suspension to settle. Larger (heavier) particles typically settle out of the water column faster than smaller particles. As such, coarse sediment particles generally deposit close to the source of disturbance and suspension, while finer sediments may travel some distance before settling out of the water column. Finer sediment particles are also likely to be resuspended more easily after deposition (Fabricius 2005).

Consequently, mangroves are susceptible to adverse impacts from dredging activities by sedimentation effects that cause smothering or burial of the pneumatophores, reducing the mangroves’ ability to respire. Limitation of gaseous exchange through pneumatophores has the potential to reduce respiration efficiency, resulting in decreased available energy for growth and reproduction. This in turn may lead to an overall decline in mangrove health or, in severe cases, mortality of mangrove trees.

Mangroves typically inhabit depositional environments (Woodroffe 1992; Saenger 2002) where sediments are accreting and, in fact, promote sedimentation by reducing water movement. Burial by increased sedimentation can, however, have deleterious impacts. In a review of the existing scientific literature, Ellison (1998) has reported that most mangroves can tolerate sedimentation rates ranging from less than 5 to 10 mm per year. Burial of the pneumatophores in 10 cm or more of sediment was generally lethal, although substantial differences existed among species.

Differences in sensitivity to sedimentation rates have been shown in seedling survival and growth of South East Asian mangrove species (Terrados et al. 1997; Thampanya et al. 2002; Terrados et al. 1997) reported that sediment accretion rates of 32 cm were lethal to Rhizophora apiculata seedlings. Thampanya et al. (2002) found that burial by sediment had a significant negative impact on seedling survival and growth rates of Avicennia officinalis and Sonneratia caseolaris, but not Rhizophora
mucronata. Avicennia seedlings were increasingly sensitive to burial above 16 cm; there was 100% mortality in A. officinalis after 225 days at 32 cm deep burial, and almost 90% mortality at 24 cm.

These results are consistent with the pneumatophores of Avicennia spp. typically extending 10 cm but sometimes reaching 30 cm or more above ground level, such that it requires prolonged sedimentation to have an effect on respiration. Pneumatophores differ in architecture among different mangrove species; the pencil root pneumatophores of Avicennia originate from the below-ground cable root and stick out vertically from the soil (Dahdouh-Guebas et al. 2007). Avicennia marina growing in Kenya has been shown to be able to adjust the height and density of its pneumatophores in responses to changes in the micro-topography (Dahdouh-Guebas et al. 2007).

Harbour sedimentation and thus mangrove sedimentation has been examined in detail by Halpern, Glick & Maunsell (1999) and MJ Paul & Associates (2001). The key findings were:

- The harbour is continually undergoing sedimentation and maintenance dredging is required at 3–4 year intervals in some areas;
- The five tidal creeks are a significant source of sediment loading to the harbour;
- Sedimentation tends to occur in the deeper and calmer areas of the harbour, i.e. on the inside of each bend within the shipping channel, in the southeast corner of the turning basin inside the inner harbour, near the South West Creek Mooring Facility and small boat ramp;
- Sediment also enters the harbour from the outer channel;
- Cyclonic activity causes some sedimentation in the channel bottom; and
- South West Creek was found to be silting at a rate of about 40 mm/yr.

Based on the literature, the tolerance limit of mangroves to sedimentation is considered to be 100 mm in an acute event. That is, mangroves are unlikely to tolerate acute deposition events exceeding 100 mm, which would effectively bury their pneumatophores. Though mangroves may tolerate deposition of 100 mm accumulating slowly over time, a worst-case scenario approach was taken in the assessment of potential indirect mangrove impacts from excessive sedimentation.

The predicted cumulative sediment deposition at the end of the dredging and onshore disposal campaign, as described in Section 0, is shown in Figure 6-14. The high deposition areas are within the dredge footprint and at the DMMA B discharge location, however the cumulative output post dredging does not indicate the amount of sediment which settled out with subsequent resuspension during the campaign. Figure 6-15 and Figure 6-16 show sedimentation time series at selected location, as shown in Figure 6-14. These figures indicate that the pattern of sedimentation caused by dredging and onshore disposal discharge is a steady increase in deposition with no dramatic inundation events followed by resuspension. Rather, the sediment accumulates steadily depending on the intensity of the dredging and with proximity to the dredge and DMMA discharge locations.
Using a background sedimentation rate of 40 mm/year within the Inner Harbour, which may or may not occur as a steady deposition over the year, it has been assumed that mangrove loss will occur in areas experiencing more than 60 mm/year sedimentation associated with the dredge and onshore disposal campaign. The model was interrogated to identify any areas of deposition in excess of 60 mm at the end of the dredging program, i.e. any area which experienced in excess of 60 mm over a duration of 2.7 years. As the deposition is predicted by the model to occur in a steadily increasing manner (and not in acute sedimentation events with subsequent resuspension as discussed above), the 60 mm contour at the end of the dredging program delineates any area predicted to receive in excess of 60 mm of deposition, in acute or chronic events.

- Figure 6-14 Cumulative sediment deposition at the end of the dredging and disposal campaign. Locations where sedimentation time series were extracted are marked with crosses

The 60 mm sediment deposition contour is presented in Figure 6-17. The contour around the dredge footprint indicates how the model predicts the high sedimentation events to occur within and in
proximity to the dredge footprint. The mangrove habitat within the 60 mm contour lies within the dredge footprint and will be removed directly; hence no additional indirect losses are predicted due to sedimentation in the vicinity of the dredge footprint. Near the DMMA B discharge point a small area is predicted to exceed the 60 Mm over the course of the project (2.7 years). As the sediment is predicted to steadily increase in depth as the DMMA B starts to discharge, no acute deposition events are expected. This is in line with the steady but chronic influx of discharge waters into South Creek with a maximum TSS concentration of 150 mg/L (Figure 6-16). It is therefore expected that mangrove communities are unlikely to experience impacts associated with sediment deposition based on the model outputs simulating the sediment deposition patterns and depth over the duration of the dredging and onshore disposal campaign. However, the model outputs outline the areas at potential risk of sedimentation related impacts, in particular at the discharge point at DMMA B, and these model results have been used to guide the monitoring program outlined in the DMP (Appendix A).

- Figure 6-15 Cumulative sediment deposition time series from mangrove habitat locations near the dredge footprint as indicated in Figure 6-14. The different colours represent the different dredging phases (A,B,C,E, F and G)
- Figure 6-16 Cumulative sediment deposition time series from locations near the DMMA B discharge point as indicated in Figure 6-14. The different colours represent the different dredging phases (A, B, C, E, F and G)
Hydrodynamics

An investigation of mangrove communities and other BPPH in the vicinity of the Dredge Area and adjacent to DMMA G was undertaken by WorleyParsons (2009c). The species composition and condition of mangrove communities within the study area appeared to be driven primarily by tidal inundation and topographical gradients. *Avicennia marina* was more abundant and widespread than all other mangrove species identified during the survey. *A. marina* was the dominant species in areas likely to experience least tidal inundation but was also prevalent in lower intertidal areas that would experience frequent inundation. In these lower intertidal areas, *A. marina* formed mature, well-developed forest communities. *A. marina* is considered to be a pioneer species; able to rapidly
colonise and survive in areas that experience high levels of disturbance. *A. marina* has been found to tolerate a wide range of tidal inundation levels (1–10 m).

The two other species identified within the study area by WorleyParsons (2009c), *Rhizophora stylosa* and *Ceriops australis*, tended to be restricted to more frequently inundated areas. In particular, *R. stylosa* generally forms monospecific, dense, closed scrub and forest communities within a distinct intertidal band. *C. australis* tended to form mixed scrub communities with *A. marina* landward of the *R. stylosa* fringe. The distribution of these two species is likely to be a consequence of tolerance limits to salinity and tidal inundation.

- **Figure 6-18 Water level time series at selected locations in South West Creek and the wider creek system**

The Project has the potential to affect the hydrodynamics within mangrove communities in the Project Area. The altered bathymetry on completion of the dredging activities may result in changes to the inundation regime of nearby intertidal areas. Construction of the DMMAs will result in changed drainage patterns and surface water flows of the surrounding environment. Potential indirect impacts on mangrove communities include disruption of natural drainage channels and
surface flows, erosion, and minor scouring of the creek bank in the vicinity of the excess water discharge point.

Hydrodynamic modelling was undertaken to assess changes to intertidal inundation regimes and bed shear stress. This is discussed in further detail in Section 7.4.1. Model results from a selection of locations in South West Creek and the wider creek system show that non-significant changes in wetting and drying within intertidal mangrove habitat is expected due to the change in bathymetry associated with dredging (Figure 6-18 and Figure 6-19). A 1% reduction in the amount of time that the substrate is wet was predicted at one location (Oc3; Figure 6-20) in South West Creek, upstream of the dredge footprint and adjacent to DMMA G (Figure 6-18). *Avicennia marina* and *R. stylosa* scrub is found at this site. The model predicted no changes on completion of dredging to the inundation regime at any of the other seven locations selected.

- **Figure 6-19** Water level time series at selected locations in South West Creek and the wider creek system

The construction of bund walls for DMMA B-North and DMMA G is, however, predicted to restrict the tidal excursion at HAT (Figure 6-20); this is not expected to result in any indirect loss of mangrove habitat.
- Figure 6-20 Water level differences at Highest Astronomical Tide between the developed and existing case

**Water quality**

Potential water quality impacts resulting from dredging and disposal activities, including excess water discharge, are discussed in detail in Section 6.1. Appropriate management of water quality impacts is expected to minimise potential impacts to nearby mangrove communities within the South West Creek area and the Inner Harbour. Water quality management measures are detailed in Section 6.1.5 and described in detail in the DMP (Appendix A).

**Dust deposition**

Dust generated from the DMMA construction earthworks and from drying out, transport and/or movement of dredged material within these areas could result in dust being deposited on surrounding mangrove habitats. Dust may also be generated when the slime management areas dry out. Dust deposited on mangrove vegetation has the potential to cause negative physiological impacts. However, Paling et al. (2001) showed that iron ore dust particles present in the Port
Hedland region did not block mangrove leaf stomata or restrict transpiration, and did not significantly impact the health of the mangrove vegetation.

Potential impacts on air quality from the generation of dust from the Project are discussed in Section 7.9 including proposed management measures to reduce dust impacts to the lowest practicable level. On this basis it is considered unlikely that the proposed Project will pose a risk to the mangroves through an increase in dust generation.

6.2.4 Management and Mitigation Measures

6.2.4.1 Direct impacts

The Project has been designed to minimise the impact on mangroves. As summarised in Section 2.4, the alignment of the dredge footprint was developed to minimise the impact the surrounding mangrove communities in South West Creek.

The primary mechanism for the management of direct mangrove losses will be to restrict areas of direct loss to the proposed dredging and DMMAs footprint. Other management measures to limit the impact on the mangroves in association with the Project include:

- Workforce management including briefings and instructions regarding clearing procedures and information on the ecological significance of mangroves in environmental awareness training;
- Prohibiting access into mangrove areas outside the immediate disturbance area;
- Reporting and investigating incidents with the potential to impact on mangroves;
- Delineation of clearance boundaries through the use of flagging or other suitable techniques prior to site clearing activities to avoid unnecessary disturbance of mangroves; and
- Where possible, scrub rolling mangroves rather than removing mangroves to provide maximum opportunity for vegetative recovery along the boundary of the cleared areas.

6.2.4.2 Indirect impacts

Sedimentation

Management of sedimentation impacts is through the implementation of the DMP. In summary, the following management actions will be employed:

- Installation of a satellite-based vessel monitoring system on the dredge, allowing a track plot analysis to ensure maximum efficiency of the dredging effort and that no dredging outside the required area occurs;
Use of suitable dredging plant and equipment to minimise turbidity and subsequent sedimentation;
Maintaining calibration of the hydrographic survey systems onboard the dredge;
Monitoring of weather and sea conditions;
Implementation of Monitoring to assist in the management of potential impacts on mangroves, as described in the DMP (Appendix A);
Implementation of the Tiered Monitoring Framework following a water quality trigger breach in accordance with the monitoring program (Section 7.1); and
Install the following management measures to control sedimentation from the tailwater discharge associated with reclamation:
  - Suitable controls (e.g. weir boxes) will be used at the discharge point to control the water level and the rate of discharge; and
  - Regular inspection and maintenance of erosion and sediment control structures particularly following heavy or prolonged rainfall.

Monitoring of sedimentation impacts is through the proposed Routine Surface Sediment Profiling Monitoring Program, as detailed in the DMP. Sedimentation during dredging will be used as a proxy to monitor mangrove health condition during dredging activities. A mangrove health investigation will be triggered should sedimentation levels at impact sites display statistically significant differences to reference locations.

*Hydrodynamics*

The primary mechanism for management of changed hydrodynamics due to altered bathymetry is through the location and alignment of the dredge footprint to minimise potential impacts.

Management of hydrodynamic impacts associated with the construction of the DMMAs is through the design and location of the DMMA footprints to avoid major drainage channels and areas of high value mangrove habitat (low forest and scrub close in lower intertidal areas). Potential scouring of creek banks will be minimised by discharging excess water only on an as-needed basis and controlling flow rates. Scour protection will be placed at the discharge point.

Mangrove mapping and mangrove health assessments, as detailed in the DMP, will identify any areas that are indirectly impacted due to changed hydrodynamics.

*Water quality*

Potential water quality impacts will be managed through the implementation of the DMP, which includes a routine water quality monitoring program.
Dust

Current port operations include numerous management measures designed to reduce dust generation. These management measures may be used to control dust generation during the implementation of the Project, and are discussed in Section 7.9.

6.2.5 Predicted Outcome

The Project will result in the direct loss of 39.94 ha of mangrove habitat. Of this, 31.50 ha will be high value, closed canopy (low forest and/or scrub) habitat while the remaining 8.44 ha will be scattered, open heath habitat. Direct losses of mangrove habitat, while unavoidable, will be minimised by restricting areas of loss to the dredge and construction footprints. Cumulative direct loss of mangrove habitat within the Port Hedland Industrial Area Management Unit, with the inclusion of losses due to the South West Creek Project, is estimated, depending upon the method as 12.6% (EPA verified) or 6.00% (EPA non-verified) of the pre-European extent of mangrove coverage.

Indirect losses of mangrove habitat as a result of water quality (TSS, sedimentation), hydrodynamic or dust impacts are not expected to occur as a result of the Project. It is anticipated that the proposed management measures outlined in this document and the DMP (Appendix I) will prevent any indirect losses of mangrove habitat.

Based on the relatively small amount of direct losses of mangrove habitat, the prevention of indirect losses through effective management measures, the application of a ‘best practice’ approach to environmental management and the development and implementation of the DMP (Appendix A) it is considered that the requirements of the EPA’s Guidance Statement No.1 (EPA 2001) and Environmental Assessment Guideline No.3 (EPA 2009b) will be met.
7. OTHER ENVIRONMENTAL IMPACTS AND MANAGEMENT

Environmental and social factors were determined to be relevant (but not key) issues if they:

- Had a minor or low impact and thereby would require less detailed assessment; and
- Required a lower level of management measures and controls to ensure minimal impacts.

7.1 Coral Reef Communities

7.1.1 Overview

Hard corals are dependent on symbiotic photosynthesising zooxanthellae for their survival and are therefore sensitive to increases in suspended sediment and the corresponding reduction in light penetration. Elevated levels of suspended sediments can also clog the respiratory and feeding apparatus of the corals. Increased sedimentation levels may bury corals, or overwhelm them with settled sediments in excess of the coral removal capacity. This may apply to large settled volumes during a short period, or chronically elevated levels over prolonged periods. Any direct removal of substrate for settlement of coral larvae will cause a permanent loss of BPPH.

Small sporadic areas of coral communities have been recorded in the Inner Harbour to date, specifically in South East and Stingray Creek. These coral colonies are typically small (<30 cm) and both diversity and coverage of the substrate is low. However, *Porites* spp. bommies of up to 1 m in diameter have been found in a side arm to South West Creek. The corals are likely to have settled opportunistically where hard substrate occurs and are also limited in their distribution to areas where sedimentation and turbidity levels are sufficiently low to enable their survival. They have been recorded in areas adjacent to previous dredging works in the Inner Harbour, where they are exposed to regular sedimentation events during spring tides and the berthing of bulk carriers. The distribution of corals within the Inner Harbour is discussed in Section 4.4.3.2 and shown in Figure 4-14.

7.1.2 Objectives, Applicable Standards and Guidelines

The EPA’s objective for BPPH communities is to maintain the ecological function, abundance, species diversity and geographic distribution of marine biota and habitat in order to protect ecosystem health, in accordance with the principles identified in Perth Coastal Waters Environmental Values and Objectives (EPA 2000a) and the Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006).
Specifically for the South West Creek Project, the environmental objective is to limit the direct loss of BPPH associated with dredging and onshore disposal activities, and to ensure the protection of ecosystems associated with Port Hedland Port from indirect impacts associated with the project.

The relevant policies and standards that have been considered in the environmental assessment process for coral reef communities include:

- EPA Environmental Assessment Guideline 3: Protection of Benthic Primary Producer Habitats in Western Australia’s Marine Environment (EPA 2009b);
- Perth Coastal Waters Environmental Values and Objectives (EPA 2000a); and
- Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006).

7.1.3 Potential Impact

The Project will not result in any direct removal of coral habitat. However, the dredge and DMMA discharge plumes are predicted to cause elevated levels of suspended solids and increased sedimentation rates in the creek systems with the highest levels predicted in South Creek and South West Creek, as discussed in Section 0.

Coral species sensitivity to sedimentation is determined largely by the particle trapping properties of the coral community and the ability of individual polyps to reject settled materials. As discussed in Section 4.4.3.2 hard corals identified within the Inner Harbour are dominated by species tolerant to high levels of turbidity and sedimentation (such as faviids and *Turbinaria* spp). However, as these communities possibly exist at or near their environmental limits in regards to turbidity, sedimentation and light levels, the South West Creek dredging campaign is likely to contribute with additional stress and cause some impact.

In an attempt to understand light reaching the bottom at coral communities from previous projects and the proposed Project, a mathematical model of light attenuation was undertaken using the results from predictive modelling from previous projects and the proposed dredging (Figure 7-1 and Figure 7-2). Whilst the impacts are derived from predictive modelling, it does give an estimate of previously approved TSS concentrations within the vicinity of the communities and likely concentrations received by the communities during dredging.

The underwater light environment during the growing season is the most important period that determines the survival and productivity of BPP (Moore, Wetzel et al. 1997; Batiuk, Bergstrom et al. 2000; Dixon 2000). The amount of light needed for growth and reproduction is the cumulative light received during the growth period of the BPP (coral) life history. Light levels below the minimum physiological requirement, leads to loss of BPP dependent on physiological requirement.

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The attenuation of light through the water column is the major water property that influences the underwater light climate experienced by coral communities. As light penetrates through the water column it is attenuated from the surface levels to the bottom. Factors that contribute to light attenuation or the light extinction coefficient include:

- TSS: particles absorb light quanta;
- Chlorophyll-a: algae absorb light quanta and use the energy to fix inorganic carbon to organic forms; and
- Coloured dissolved organic matter (CDOM) often measured as dissolved organic carbon (DOC) also effectively absorb light quanta in the water column.

Baseline water quality data collected for this Project has been used to set baseline values against which parameters measured at previous dredging project’s monitoring sites will be compared. These sites are illustrated in Figure 7-1. Estimates of the light extinction coefficient from the median values of TSS and Chlorophyll-a at each of these previous project monitoring sites are illustrated in Figure 7-2. Seasonal variations in TSS and Chlorophyll-a were not assessed due statistics showing there were no significant differences (p<0.05) between seasons (Appendix B).

Comparison of the bottom light environment to baseline and previous dredging projects has been undertaken to understand previously approved and tolerated TSS and sedimentation impacts in relation to this project (Appendix E). Figure 7-2 shows that altered light regimes due to dredging of South West Creek at these sites are low in relation to previously encountered light regimes both natural and from previous dredging and would be considered, short and episodic. It could therefore be reasonably assumed that communities could survive/recover from this disturbance given the history of resilience of in the Port Hedland harbour and the little variance between sites in Figure 7-2.
Figure 7-1: Locations for light penetration assessments

Figure 7-2: Percentage of surface irradiance at key BPPH from predictive modelling from the major dredging campaigns within Port Hedland harbour
The model predictions on the increase in TSS levels within the creek systems are presented in Section 0. For the duration of the dredging and onshore disposal campaign the model predicts a slight but chronic increase in TSS across the creek systems, with the density of the plume increasing in the vicinity of dredging and DMMAs discharges. The coral community in South West Creek is located on the edge of the predicted plume influence, with average increases in TSS of 15-20 mg/L likely to occur during most phases (Figure 6-3 and Figure 6-4). It is expected that these chronic increases in TSS will have some impact on the coral community, though the tolerance of the corals located in this tidal mangrove creek is not known. Cumulative sedimentation in the range of 10-15 mm over the duration of the dredging and onshore disposal campaign (2.7 years) was also predicted in the vicinity of the South West Creek coral community (Figure 6-14). Seeing that background sedimentation rates in South West Creek have been recorded of up to 40 mm/year, the corals in South West Creek may not be significantly impacted by the dredging, however background sedimentation rates in the small side arm to South West Creek where the coral occur is not known. Little resuspension of settled sediment from the dredging is expected and some impacts may consequently occur.

In contrast, the coral communities in South East Creek and Stingray Creek are more likely to experience low but chronic elevations in TSS in the order of 5 mg/L for the duration of the campaign (Figure 6-5 and Figure 6-6). Little sedimentation is predicted (Figure 6-14). Impacts to these coral communities are consequently not considered likely.

The dredge plume leaving the harbour is predicted to be low in TSS. Figure 7-3 and Figure 7-4 show the 1 and 5 mg/L contour lines, indicating where these levels are predicted to be exceeded 5% of the time during dredging Phase C. In the model, Phase C shows the heaviest plume exiting the harbour, and therefore indicates the worst case scenario for the density of the plume exiting the harbour mouth.
Figure 7-3  TSS concentration contours exceeded 5% of the time during Phase C (surface layer)
Figure 7-4  TSS concentration contours exceeded 5% of the time during Phase C (bottom layer)
7.1.4 Management and Mitigation Measures

As the coral community in the sidearm of South West Creek is thought to exist at or near its environmental limits in regards to turbidity, sedimentation and perhaps also light levels, it is likely that the South West Creek Project dredging campaign will contribute with additional stress from suspended and settling particles. Relocating these corals to a nearby area where a similar community occur is perceived as the best option for preservation (i.e. South East Creek or Stingray Creek), though relocation may not necessarily be successful due to the complexity of such operations.

Monitoring and management of the turbidity in the South West Creek coral area is not perceived practicable due to the proximity of the dredging to the coral community. Corals in South West Creek are extremely limited in the extent of their occurrence and, combined with the sparse coral cover, make designing a monitoring program which has sufficient statistical power to detect changes challenging and not cost effective compared to the ecological value of the coral community. It is expected that the community would recover or new coral larvae would settle here once the water quality improves after the completion of dredging.

Given the negligible risk of significant impacts to the corals in Stingray Creek and South Creek, and the limitations for conducting meaningful monitoring within the harbour, no monitoring is proposed. Within South West Creek, the corals communities are expected to recover (if impacted) after completion of dredging and restoration of the water quality.

Given the length of the dredge program, monitoring of coral site at east Finucane Island (EF0 in Error! Reference source not found.) is proposed, as described in the DMP (Appendix A).

7.1.5 Predicted Outcome

No direct impacts to coral habitat will occur. Some impact may occur to the coral community located in the side arm of South West Creek, however the extent is not known as the tolerance of these corals to additional TSS and/or sedimentation is not known.

Little or no impact is expected to the coral communities in South East Creek and Stingray Creek. No impacts are expected to occur to the coral communities outside the harbour along Finucane Island and at Port Hedland Reef. Indirect losses of corals are predicted to be restricted to the side arm of South West Creek, where a small community is located.

Based on this limited potential indirect loss, it is considered that the requirements of the EPA’s Environmental Assessment Guideline No.3 (EPA 2009b) will be met.

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7.2 Other Benthic Primary Producer Habitats

7.2.1 Overview

Benthic primary producers (BPP) are predominantly photosynthetic marine plants (e.g. seagrasses, mangroves, seaweeds and turf algae) but include invertebrates such as scleractinian corals, which acquire a significant proportion of their energy from symbiotic microalgae that live in coral polyps (EPA 2009b). These organisms grow attached to the seabed (i.e. subtidal and intertidal), sequester carbon from surrounding seawater or air and convert it to organic compounds through photosynthesis. BPP communities are biological communities including the plants and animals within which the BPP predominate. BPP habitats (BPPH) are both the BPP communities as well as the substrata that can/do support these communities, although the EPA (2009a) recognise that not all seabed (benthos) in the photic zone are BPPH.

The dominant BPP in the Port Hedland region are mangroves, which have been discussed separately in Section 6.2, and coral reef communities which have been discussed in Section 7.1. Other BPP discussed in this section are salt marsh, cyanobacterial mats, macroalgae and seagrasses. Salt marshes and cyanobacterial mats occur in the intertidal zone, while macroalgae and seagrasses in the Project Area are restricted to subtidal areas.

7.2.2 Objectives, Applicable Standards and Guidelines

The EPA’s objectives relating to the protection of BPP and BPPH (EPA 2009b) are to maintain the integrity, ecological functions and environmental values of the seabed and coast, to maintain the abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

- The relevant policies and standards that have been considered in the environmental assessment process for other benthic primary producer habitats include: EPA Environmental Assessment Guideline No.3 – Protection of Benthic Primary Producer Habitats in Western Australia’s Marine Environment (EPA 2009b).

Other applicable legislation and guidelines for the management of BPPH include:

- Environmental Protection Act 1986 (WA);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC&ARMCANZ 2000a);
• Pilbara Coastal Water Quality Consultation: Environmental Values and Environmental Quality Objectives (DoE 2006); and
• Draft Environmental Protection (State Marine Waters) Policy (EPA 1998).

7.2.3 Potential Impact

Direct Impacts

Salt marsh

The South West Creek Project will result in the direct loss of 94.2 ha of salt marsh habitat from DMMA G and 45.2 ha from DMMA B-North (Appendix H), giving a combined total of 139.4 ha. These calculations are based on the areas designated as ‘tidal flats’ (Table 7; Appendix H), although it is likely that not all of these areas support salt marsh vegetation. Specifically, direct loss of salt marsh due to the South West Creek project will be the result of smothering/removal of salt marsh for the construction of the DMMAs (including perimeter earth bunds, access tracks for earthmoving equipment, and within DMMA footprints themselves). Direct loss of salt marsh BPPH will not affect the conservation status of any species within the Port Hedland Industrial Area Management Unit.

Cyanobacterial mats

Extensive mapping of cyanobacterial mats has not been carried out in the Port Hedland region, primarily because their ephemeral nature makes them difficult to accurately delineate. Within the Project Area, cyanobacterial mats are likely to occur within the DMMA footprints and associated access/pipeline corridors, on the landward side of the mangroves and intermingled among salt marsh habitat. This corresponds to the area designated as ‘tidal flats’ (Table 7; Appendix H), and covers 94.2 ha and 45.2 ha in DMMA G and DMMA B-North, respectively. However, it is likely that only a small proportion of the tidal flats would support cyanobacterial mats account and that compared to the total area of this habitat within the Port Hedland Industrial Area Management Unit the area of loss is considered negligible. Furthermore, the relative ecological and intrinsic value of cyanobacterial mats is considered small compared to other BPP such as mangroves.

Macroalgae

For the purposes of this impact assessment, macroalgae includes both the small-sized turf algae and the larger, foliaceous macroalgae. The dredge footprint covers an area of 116 ha, some of which could potentially support macroalgae. A survey of the South West Creek Mooring Facility dredge footprint and its predicted dredge plume area found that 9% of the benthic habitat was colonised by macroalgae and/or turf algae (Appendix D). These areas of macroalgal habitat will be directly lost due to dredging, but these habitats are considered well-represented within the creek systems.

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surrounding the inner port area. Consequently, the small area of direct loss is considered to be negligible in terms of the total area of macroalgal BPPH within the Port Hedland Industrial Area Management Unit.

**Seagrasses**

No seagrass was found within the South West Creek Mooring Facility Project dredge footprint and a benthic habitat map of Port Hedland Harbour compiled from various sources (Figure 4-14) did not identify any seagrass within the Port Hedland Inner Harbour area (Appendix D).

**Potential indirect impacts**

Potential indirect effects on macroalgae from plumes of turbid water include smothering by particles which settle out of suspension onto the BPP (sedimentation) and reduction in light due to suspended particles (turbidity). Benthic macroalgae within the Inner Harbour are adapted to the natural sedimentation and low light regimes, although tolerance varies between species. Over chronic periods increased sedimentation or reduction in light could have a negative effect on the energy budgets of the macroalgae, resulting in reduced productivity and possible loss. If the physical processes within the Inner Harbour are maintained, however, the BPPH which supported the macroalgal communities are likely to recover once the disturbance from the dredging and disposal activities are completed, as macroalgae are able to recolonise impacted areas relatively quickly after a disturbance.

Higher TSS values are consistently predicted in bottom waters compared to the surface layer during all phases of the dredging program (Section 0). Modelling indicates that the dredge plume is likely to be confined to the area of dredging and DMMA discharge, in particular the discharge outlet from DMMA B where the majority of discharge will occur. The dredge and discharge plume is predicted to influence South West Creek and South Creek with average surface TSS values no greater than 20 mg/L, and bottom values up to 35 mg/L.

Sedimentation may reach up to 60 mm and 25 mm averaged over a 50 m² area near the water discharge locations in South Creek and South West Creek, respectively. Modelling also predicts cumulative sedimentation to reach 15 mm within upper reach of South West Creek and within the south part of Port Hedland Harbour. Although low, chronic sedimentation is predicted to occur in the wider creek system (Figure 6-8), the settled particles are predicted to resuspend rather than remain and accumulate.

Based on the model predictions, macroalgal and turf algal communities adjacent to the dredge footprint and the excess water discharge locations in South West Creek and South Creek could be impacted as a result of increased TSS levels. These communities comprise sparse patches of turf
algae and foliaceous macroalgae with low diversity and are dominated by fast growing species that are tolerant to the dynamic physical processes of the Inner Harbour.

### 7.2.4 Management and Mitigation Measures

**Salt marsh**

No management or mitigation measures specific to salt marsh are proposed, as direct losses within DMMA G and DMMA B-North are unavoidable but are considered to be negligible. Direct losses will be confined to within the DMMA and pipeline corridor footprints.

**Cyanobacterial mats**

No management or mitigation measures specific to cyanobacterial mats are proposed, as direct losses within DMMA G and DMMA B-North are unavoidable but are considered to be negligible. Direct losses will be confined to within the DMMA and pipeline corridor footprints.

**Macroalgae**

No management or mitigation measures specific to macroalgae are proposed, as impacts are expected to be negligible. The management measures to be implemented during the dredging and operation of the DMMAs (Section 6.1.5) are considered sufficient to minimise indirect impacts. A suite of parameters as proxies for water quality will be monitored and results compared against trigger levels used to identify when a potential environmental impact may occur. The exceedence of the initial trigger level would then initiate a series of predetermined management responses. The proposed water quality monitoring program is detailed in the DMP (Appendix A).

### 7.2.5 Predicted Outcome

Direct losses of subtidal BPPH within the dredge footprint, and intertidal BPPH within the DMMA footprints, are unavoidable as part of the development of the South West Creek Project. However, direct losses will be minimised by restricting dredging and construction activities to within the proposed footprints. Overall, direct losses of BPPH due to the South West Creek Project are considered negligible in terms of the total area of the relevant BPPH types within the Port Hedland Industrial Area Management Unit, and when considering that the BPPHs in question are capable of recolonising disturbed areas if post-disturbance conditions are favourable.

Indirect losses of macroalgal BPPH, if any, is predicted to be restricted to localised areas around the dredge footprint and excess water discharge locations, where macroalgae are sparsely distributed.

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Relatively small amount of direct losses of other BPPH (i.e. salt marsh and cyanobacterial mats BPPH) are expected.

Based on these potential direct and indirect losses, it is considered that the requirements of the EPA’s Environmental Assessment Guideline No.3 (EPA 2009b) will be met.

### 7.3 Marine Fauna

#### 7.3.1 Overview

The Project has the potential to pose a risk to marine fauna due to dredge operations and barge movements to the disposal site. Port Hedland is not known as an area for aggregation of whales, with migration routes further offshore in waters greater than 20 m depth. Small numbers of dolphins have been identified within inner port areas although their distribution is considered sparse given the lack of resident populations. Juvenile green turtles and juvenile flatback turtles are known to occur within the harbour, while adults of these species are not likely to be present due to a lack of suitable breeding, feeding or nesting sites within the harbour. Dugongs have been identified within the inner harbour, but it is not known to be an important aggregation area for this species due to the lack of extensive seagrass meadows.

#### 7.3.2 Objectives, Applicable Standards and Guidelines

The EPA’s objective is to maintain the ecological function, abundance, species diversity and geographic distribution of marine biota and habitat in order to protect ecosystem health, in accordance with the principles identified in Perth Coastal Waters Environmental Values and Objectives (EPA 2000a).

The relevant policies and standards for marine fauna include:

- Wildlife Conservation Act 1950;
- Environment Protection and Biodiversity Conservation Act 1999; and
- Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006).

#### 7.3.3 Potential Impact

The proposed development could have the following direct impacts upon marine fauna:

- Vessel collisions;

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• Artificial light spill and disorientation (i.e. marine turtles);
• Hydrocarbon spills (refer to Section 7.12);
• Underwater noise; and
• Loss of benthic habitat through increased levels of turbidity and sedimentation (refer to Sections 7.1 and 7.2).

7.3.3.1 Marine Mammals

Offshore waters of Port Hedland are not known to be humpback whale resting areas and the majority of individuals following the northern/southern migration routes are generally not found in waters less than 20 m in depth (Prince 2001). There is very little risk of whales coming into the South West Creek system, but they may come within the vicinity of the barge during transit to the disposal site. However, the barge will be operating at very slow speeds (≤12 knots), which will allow whales enough time to avoid collision with the barge(s).

It is reported that dugongs (Dugong dugon) have been sighted within Port Hedland Harbour, however no formal records are available. There is little likelihood of dugongs entering South West Creek as there are no preferential feeding habitats (seagrass) of the dugong in the Port Hedland harbour (Figure 4-14). Potential impacts on dugongs will therefore be limited as there will be little or no disturbance to potential dugong foraging areas.

While dolphins (such as the Indo-Pacific humpback dolphin and spotted bottlenose dolphin) are likely to enter Port Hedland Harbour to forage and rest during migration, they are expected to avoid the dredge due to the noise and vibrations generated. This avoidance behaviour together with the slow movement of the dredge in the harbour will minimise the likelihood of collisions.

The existing Port Hedland Port has been subject to increased levels of shipping traffic for some years, and it is possible that many marine mammals have either become accustomed to the elevated noise of the working port or that they avoid the area. Temporary Threshold Shift (TTS), (i.e. a temporary decline in hearing sensitivity), can occur in marine mammals. Recent studies reveal that pulsed sounds of above 200 dB cause mild TTS in dolphins and small toothed whales. Permanent threshold shift, or “hearing loss”, can occur as a result of repeated TTS without sufficient recovery time, or exposure to ~20 dB higher sound pressure levels than TTS (URS Australia 2008).

Spills and hydrocarbon leaks from the dredge vessel may cause disruption to dolphin foraging areas. Ingestion of hydrocarbons may adversely impact the health, and in severe cases may lead to mortality of dolphins.
7.3.3.2 Turtles

Potential impacts of the Project on flatback turtles and juvenile green turtles may include disturbance from noise or light generation by vessels, disorientation from increases in turbidity, disruption from spills and hydrocarbon leaks or collisions causing physical injury.

Certain frequencies of light can affect hatchling and juvenile animal activity (Pendoley 2007). There are no turtle nesting habitats within several kilometres of the proposed dredge footprint or Spoil Ground I (BHP Billiton 2009a), therefore light generated by the Project is not expected to have an impact on turtle nesting or hatchling orientation.

The discharge of return waters from the DMMAs may cause increases in turbidity which can disorientate turtles. This will only occur in the immediate vicinity of the dredge area, which turtles are expected to avoid. Spills and hydrocarbon leaks may also cause disruption to turtle feeding and foraging areas, toxicity to turtles, ingestion or mortality of turtles. PHPA’s Marine Oil Pollution Management Plan will be implemented to contain accidental hydrocarbon spills and reduce/avoid potential impacts to marine turtles.

Turtles are vulnerable to boat strike while surfaced to breathe or as a startle response to dredging noise or visual cues. They are also vulnerable to collision with boat propellers in shallow water, where there is little clearance between the keel and the benthos. However, due to the relatively low speed of the barges when travelling to and from the disposal area (≤ 12 knots), the risk of vessel strike is low (based on a TSHD) (Rick Morton, Port of Brisbane, pers comm.).

Marine turtles are sensitive to low-frequency sound (100-700 Hz) (McCauley 1994). McCauley et al. (2000) reported that at 166 dB, one green and one loggerhead turtle exhibited a noticeable increase in swimming behaviour, presumed to be an avoidance response. At 175 dB their behaviour became increasingly erratic, presumed to be an alarm response.

It is likely that some avoidance behaviour may be observed during dredging activities most likely during operation of barge and support vessel propellers and turtles may avoid areas of noise during dredging but would likely return once noise has subsided. Noise produced during dredging would not likely exceed noise generated within adjacent inner harbour areas associated with routine port activities.

7.3.4 Management and Mitigation Measures

The impacts of the Project to marine fauna will be managed in accordance with the DMP. Key management and mitigation measures in the plan include the following:

- Vessel Collisions or Entrapment:
Procedures for marine fauna interaction (including turtles and cetaceans) shall be developed for vessels to reduce the potential impacts to marine fauna. All work-site personnel shall be inducted regarding the proper response to fauna interaction (including unexpected encounters).

- The Dredge Contractor shall appoint an individual on each vessel to be responsible for undertaking marine fauna observations for the following:
  
  - Before commencement of dredging operations and offshore spoil disposal, a 15 minute visual inspection of the monitoring zone using binoculars from a high observation platform on the vessel must be undertaken by a person trained in faunal observation and distance estimation.
  
  - Where turtles, dugongs or cetaceans are observed within a 150 m radius of the dredge and are likely to be injured due to dredging, dredging must not commence until all individuals are observed to move outside the monitoring zone or have not been sighted for 20 minutes, or the dredge is to move to another area of the dredge site to maintain a minimum distance of 300 m between the dredger and any marine species.
  
  - Where turtles, dugong or cetaceans are observed within a 500 m radius of the hopper barge at Spoil Ground I, disposal of dredge material must not commence until all individuals are observed to move outside the monitoring zone of have not been sighted for 20 minutes, or the dredge is to move to another area of the dredge site to maintain a minimum distance of 300 m between the dredger and any marine species; and
  
  - The construction workforce and all vessels will be limited to designated areas. Recreational boating, fishing, diving, spear-fishing, fossicking, (i.e. collecting shells and any other biological or natural material e.g. animal’s bones), will be prohibited during the Project.

- Underwater Noise:
  
  - Equipment and vessels shall operate in accordance with appropriate industry and equipment standards including specifications for noise levels. Regular maintenance will be conducted to the manufacturer’s specifications. Equipment covers, mufflers and other noise suppression equipment shall also be maintained and in good working order at all times;
  
  - An ‘avoidance boundary’ will be defined and dredging activities will be ceased if a significant marine mammal or reptile is sighted within this boundary, and delayed until the creature has left the avoidance zone; and
o The use of thrusters and excessively noisy equipment will be avoided wherever practicable and engines, thrusters and auxiliary plant will not be left in ‘stand by’ or ‘running’ mode unnecessarily.

- Artificial Lighting:
  o Where practicable, vessel loading and unloading in nearshore areas shall be conducted during daylight hours. Where this is not practicable, artificial lighting shall be reduced to the minimum required for safe operations;
  o Outside artificial lighting on vessels will be kept to a minimum (i.e. navigational lights and where safety dictates necessary deck lighting). Lighting should be switched off when not in use and automatic timers/sensors installed where possible; and
  o Only necessary artificial lights shall be used. ‘Unnecessary lighting’ includes lighting in unused areas, decorative lighting or lighting that is brighter than needed.

- PHPA’s Marine Oil Pollution Management Plan will be implemented (see Appendix 2 of the DMP) and emergency spill response capability will be provided to reduce the chance of a hydrocarbon spill to the marine environment.
- Water quality monitoring and management will be implemented in accordance with the DMP (Appendix A) to mitigate impacts to marine fauna from high TSS concentration in DMMA return waters.

7.3.5 Predicted Outcome

The South West Creek Project is unlikely to have a significant impact on threatened or migratory marine species. Dredging will be managed to minimise the impact on marine fauna. Given the heavy industrial use of the harbour and the extensive history of modification, the Project is not considered to present a significant impact on marine fauna.

7.4 Introduced Marine Species

7.4.1 Overview

Introduced Marine Pests (IMP) pose a significant threat to Australia’s marine environment with the potential to seriously impact native ecosystems and biodiversity, maritime industries and coastal values and amenity.

In 1998 the CSIRO’s Centre for Research on Introduced Marine Pests (CRIMP) conducted an introduced marine organism survey in Port Hedland Harbour. This survey focused on habitats and niches within the port and its adjacent coastline with a high likelihood of being inhabited by
introduced species if they were present. In 1999, CRIMP released a document detailing this survey and the species recorded (CRIMP, 1999). The survey identified six introduced or cryptogenic biofouling species:

- the hydroid *Antennella secundaria*;
- the bryozoans *Amathia distans; Bugula neritina,* and *Bugula stolonifera,* and
- the barnacles *Balanus amphitrite* and *Megabalanus tintinnabulum.*

In addition to the biofouling species, this survey found cysts of two dinoflagellate species that were considered significant: one identified as a *Gymnodinium* sp. and the other *Coclodinium polykrikoides.* A review conducted by Huisman et al. (2008) examined introduced marine biota in WA waters. Of the 60 species identified by Huisman et al. (2008) as introduced into WA, 13 are documented as occurring in Port Hedland, 10 of which were additional to those identified in the CRIMP survey.

Although the existing records of introduced marine species in Port Hedland waters show that, although the particular species identified are not declared invasive marine pest species, the region should not be regarded as immune from marine pest introduction and establishment. A preliminary analysis of habitat biophysical parameters and National Introduced Marine Pests Coordination Group’s (NIMPCG) trigger list species intolerances excluded 19 of the 55 potential species from Port Hedland, however this still leaves 36 species that pose a potential risk to this region (McDonald unpublished).

A study by McDonald (2008) (using 2006 vessel data and examining Western Australian Ports only) ranked Port Hedland third out of 15 ports and assigned this Port a ‘high’ likelihood of receiving a marine pest introduction. This ‘high’ likelihood status means an introduction is likely to occur in the near future and regular comprehensive monitoring is recommended. The primary means of introduction of marine pest species are through entrainment and discharge in ballast water or vessel and equipment biofouling. Appendix G provides a detailed discussion of the presence of IMP in the Port Hedland area, potential impacts and management and mitigation measures.

### 7.4.2 Objectives, Applicable Standards and Guidelines

Minimise the risk of introduction of marine pest species consistent with the Australian Quarantine Inspection Services (AQIS) guidelines for ballast water management and the ANZECC/ARMCANZ code of practice for anti-fouling and in-water hull cleaning and maintenance.

The relevant policies and guidelines for the management of marine pest species include:

International standards and guidelines:
• International Convention for the Control and Management of Ships' Ballast Water and Sediments (adopted 13 Feb 2004; currently not ratified nor enforced); and

Commonwealth standards and guidelines:

• Australian Quarantine Act 1908;
• Australian Ballast Water Management Requirements (AQIS 2008);
• National Biofouling Management Guidance for Commercial Vessels (CoA 2009a);
• National Biofouling Management Guidance for Non-trading Vessels (CoA 2009b); and
• Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance (ANZECC/ARMCANZ 2000b).

WA standards and guidelines:

• Environmental Protection Act 1986; and
• Fisheries Resources Management Act 1994.

7.4.3 Potential Impact

Potential environmental impacts that may occur as a result of the IMP include the following:

• Establishment of non-indigenous marine pest species;
• Competition for food and space with native species;
• Removal of native species;
• Predation of native species; and
• Introduction of associated pests and disease.

Vessels are the primary vectors for introduction of IMP to the South West Creek area however the risk of IMP establishment goes beyond vessel movements. During the construction and operational phase of the South West Creek development there will be numerous potential stressors to native marine communities. Dredging will cause some direct loss of benthic habitat. Further, elevated total suspended sediment concentrations as a result of dredging and disposal activities may stress indigenous marine communities making them more susceptible to invasive species. The presence of new structures and disturbed areas could also provide new habitat for the establishment of potential IMP.

The primary species that would be of concern and cause the most impact if they were introduced to Port Hedland would be the Asian Green Mussel (*Perna viridis*) and the black striped mussel
Both species have the potential to cause physical impacts to vessels through hull fouling that reduce vessel speed, increase drag, cause damage to the hull and clog the cooling water intakes of boat engines. Other species include the Chinese mitten crab (*Eriochier sinensis*) which can cause extensive damage to stream banks through increased burrowing activity (see Appendix G).

The proposed Project provides opportunities for IMP to establish in two ways: on structures installed as part of the new facility infrastructure, and on Project vessels working in the harbour during the dredging program and those utilising the berths during operation. The former activity offers the highest chance of colonisation when first immersed, with likelihood decreasing with time as exposed surfaces are colonised by established native marine flora and fauna communities. The risk of Project vessels being colonised may increase during the project as antifouling systems age and become damaged during operation.

Of the seven pest species designated as the basis for management of domestic ballast water movements, none is currently listed as present in Port Hedland. Water taken up therefore as ballast or entrained in Port Hedland is deemed low risk for discharge in other Australian ports and coastal waters.

### 7.4.4 Management and mitigation measures

Successful marine pest eradications are rare worldwide and the costs are substantial. The goal therefore is to minimise the arrival of new species and through a rigorous monitoring regime detect and prevent them from becoming established should they get here. Effective management is based on:

- Robust risk assessment to help predict and mitigate any risk before it occurs;
- Preventative measures including understanding the pathways, through which introductions take place;
- Compliance with, and adherence to, existing regulatory procedures (e.g. AQIS ballast requirements);
- Rigorous targeted monitoring to facilitate early detection; and
- Timely eradication or containment measures.

The management of Introduced Marine Species is outlined in the DMP. Prior to mobilisation and during dredging the following measures are proposed to prevent or minimise the risk of marine pest introduction, establishment and/or translocation during the proposed PHPA development project:

- **International Ballast and Entrained Water:** any vessels coming to Port Hedland for the project from overseas that carry ballast or entrained water are required to manage that
water in accordance with AQIS requirements. This will include an inspection of the vessel hull and internal entrainment systems which may hold IMP species.

- **Domestic Ballast and Entrained Water:** any vessels coming to Port Hedland for the project from other Australian locations that carry ballast or entrained water are required to have the risk status of that water assessed, considering the location of uptake and time of year, and to manage the water in accordance with the requirements of the National System for the Prevention and Management of Marine Pest Incursions, if it is deemed to be high risk. This will include an inspection of the vessel hull and internal entrainment systems which may hold IMP species.

- **International Biofouling:** any vessels coming to Port Hedland for the project from overseas should be subject to a biofouling risk assessment following guidance within the National Biofouling Management Guidance for Non-Trading Vessels document. Vessels assessed as posing a risk should be inspected to ensure they are free of biofouling and preferably dry-docked for cleaning and repair/renewal of the antifouling system immediately prior to departure for Australia.

- **Domestic Biofouling:** any vessels coming to Port Hedland for the project from locations elsewhere in Australia should be subject to a biofouling risk assessment following guidance within the National Biofouling Management Guidance for Non-Trading Vessels document with risk determined on the basis of those marine pest species established in Australia but not yet widespread that have the potential to establish in Port Hedland. Vessels assessed as posing a risk should be inspected to ensure they are free of these pests and, if not, undertake mitigation measures prior to their departure for Port Hedland.

All vessels should have effective antifouling and other biofouling prevention systems in place to minimise the accumulation of biofouling before and during project activities to minimise any risk of further IMS translocation. Vessels should be re-inspected at the completion of the project and any established biofouling removed before departure to other domestic locations.

- **Internal Seawater Systems and other Contained Water:** internal seawater systems on any vessels coming to Port Hedland for the project from overseas or high risk Australia locations should be inspected for the presence of biofouling and mitigation measures undertaken before departure to prevent the translocation of any biofouling IMS Seawater tanks, wells etc should be drained, cleaned and dried, or filled with freshwater before arrival.

- **Mud, Sediments and Gear:** all areas where mud and sediments can collect, including anchor and chain lockers and hoppers, should be inspected and cleaned prior to a vessel’s departure for Port Hedland. Anchor chains, cables, and other gear that has been deployed overboard
should also be inspected and cleaned of any attached or entangled marine growth. These procedures should be repeated prior to departure from Port Hedland to prevent translocation of species away from this region.

If the need arises then suggested contingency management actions are outlined in Table 6.2 of IMP report (Appendix G).

### 7.4.5 Predicted Outcome

The Project aims for no introductions of IMP. It is envisaged that with the application of the proposed management detailed above and within the DMP, the potential risk associated with the introduction of an IMP during the dredging program is low and the objectives can be met.

### 7.5 Coastal Processes

#### 7.5.1 Overview

The coastal environment of South West Creek consists of low relief coastal flats and tidal creeks. The proposed dredging and construction of DMMAs may have impacts upon the hydrodynamics and coastal processes in Port Hedland Harbour due to changes in bathymetry and interruption of sediment transport pathways. Changes to these processes may cause increased erosion or deposition of sediments.

#### 7.5.2 Objectives, Applicable Standards and Guidelines

The management objective for coastal processes is to maintain the integrity and stability of the coast, seafloor and tidal creeks.

The relevant policies and standards for management of coastal processes include:

- *Environmental Protection Act 1986;*
- Protection of tropical arid zone mangroves along the Pilbara coastline- Guidance Statement No. 1 (EPA 2001);
- Coastal Zone Management Policy for Western Australia (WAPC 2001);
- Statement of Planning Policy No. 2.6: State Coastal Planning Policy (WAPC 2003); and
- Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006).
7.5.3 Potential Impact

Dredging may change the hydrodynamics and sediment transport processes through increased depths and creation of a sediment sink. Hydrodynamic modelling was undertaken using the Delft3D model system to assess the impact of dredging and construction of bunds on the hydrodynamic regime. The model was run for a 14 day tidal period (neap-spring-neap) for seven bathymetry scenarios representing each of the dredging stages. The model predicted relatively low current magnitude changes in the order of 0.2 m/s, with the greatest change in current velocity occurring during ebb tides, and the tidal flow out of South West Creek being modified due to the dredge pocket. The most notable change in currents between pre and post development occurred near Harriet Point, where some changes in small eddy patterns were predicted. Further details are provided in Appendix I.

Predicted changes in bed shear stress indicate that following the completion of dredging, areas of erosion and deposition are only likely to change in the immediate vicinity of the dredge area (Figure 7-5). There is predicted to be some erosion along the top of the dredge batter, particularly along the edge that intersects West Creek. Deposition is likely to occur within the dredge pocket due to a reduction in bed shear stress. These impacts are not considered to pose a high risk as they occur immediately adjacent to the disturbance envelope.

The DMMA sites may result in changes to tidal inundation and storm surge flooding over the tidal flats around South West Creek. The construction of bund walls for DMMA B-North and DMMA G are predicted to restrict the tidal excursion at Highest Astronomical Tide (Figure 6-20). However, the DMMA sites are not predicted to affect the currents immediately adjacent to the DMMA sites (Figure 7-5). Construction of the DMMA sites does not involve reclamation of areas that are usually underwater and does not require the construction of ‘hard’ engineering structures such as sea walls. Therefore, the potential impacts are not considered to pose a significant risk to coastal processes in South
West Creek.

- **Figure 7-5**  Difference in bed shear stress between the developed and existing cases

7.5.4 Management and Mitigation Measures

The DMMA B-North and DMMA G have been designed to minimise the impact on the hydrodynamic regime.

7.5.5 Predicted Outcome

Changes to hydrodynamics and coastal processes within the development area are predicted to be minor.

7.6 Potential Acid Sulfate Soils

7.6.1 Overview

Potential acid sulfate soils (PASS) have previously been identified in sediments to a depth of 2 m within Port Hedland Inner Port Area. Acid sulfate soils are generated when soils become acidic following oxidation of sulfates when exposed to the atmosphere. Consequently, runoff and leaching...
effects may cause impacts to species found within the receiving environment following change to the pH regime.

A preliminary site investigation of marine sediments identified for onshore disposal (below -6 m CD) were sampled and analysed for ASS. Of the 26 samples analysed, one sample indicated the potential for ASS in one of two methods used (Described in Section 4.3.6).

It is recognised through other studies completed on land areas adjacent to the Port Hedland Inner Harbour, that PASS are likely to occur in some locations within the proposed dredge footprint.

The potential risk for the generation of ASS is therefore considered low.

7.6.2 Objectives, Applicable Standards and Guidelines

The EPA objectives relevant to PASS are:

- To maintain the integrity, ecological functions and environmental values of landforms and soils; and
- To minimise the risk to receiving waters resulting from low pH discharge, runoff and groundwater caused by acid sulfate soils (ASS) that will ensure existing environmental values and ecosystem function are maintained.

The relevant policies and standards for management of PASS include:

- Identification and investigation of acid sulfate soils and acidic landscapes (DEC 2009);
- Planning Bulletin No. 64/2009 Acid Sulfate Soils (WAPC 2009);
- Draft Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes - Acid Sulfate Soils Guideline Series (DEC 2009b); and

7.6.3 Potential Impact

Previous ASS investigations undertaken within the inner harbour have identified potentially acid generating material within the unconsolidated sediment layer (the marine muds), which is typically associated with the mangrove communities.

Potential onsite and offsite impacts anticipated from the disturbance of ASS material during excavation and dredging works, based on a worst case scenario include:

- Contamination of surface water/ground water through disturbance of ASS material;
• Formation and accumulation of ASS material as a result of the separation of sulphuric fines found in marine sediments within the settlement cells;
• Loss of visual amenity from staining, scum, slime within local standing waters;
• Loss of biodiversity such as a deterioration of mangrove ecosystems;
• Mobilisation of heavy metals such as nickel and chromium;
• Corrosion of concrete, iron, steel and aluminium structures; and
• Acid and heavy metals leaching from stockpiled ASS material.

Paling (2002) found that few such impacts have been recorded in the marine environment where tidal exchange is an important component in reducing the impacts of acid drainage because:

• Tidal pressure maintains the water table above acid sulfate soils;
• The tide both dilutes and flushes acid from waterways; and
• The carbonate buffering of seawater helps neutralise acid.

Previous dredging operations completed by FMG at Anderson Point involved the separation and pumping of fines (of which a significant percentage was carbonate ‘red bed’ with high available Acid Neutralising Capacity (ANC)) and disposal of the dredge spoil into settlement areas. There were no reported environmental incidents associated with the acid runoff, indicating the dredging process was effective in neutralising any acid generating material (FMG, 2008).

An ASS investigation was undertaken by URS (2009b) in accordance with the Acid Sulfate Soils Guideline series to determine whether marine sediments in the proposed dredge footprint have the potential to generate acid if disturbed and to provide management recommendations if such materials are present.

URS concluded that potential ASS material in the vicinity of South West Creek is located predominately within the unconsolidated sediment layer (0.0 to -0.5 m), and is not present in the ‘red beds’ and/or carbonate material located below the sediment layer at shallow depths.

Based on investigations conducted by URS (2005; 2008b), Coffey (2005), Graeme Campbell and Associates (2005), and URS (2009b) concluded there was sufficient ANC within the ‘red bed’ and/or underlying carbonate material to neutralise the potential acid generating capacity of the sediment layer during dredging operations (Appendix C).

If ASS are identified and are not able to be neutralised or managed appropriately onshore, than they will be disposed of offshore.

Section 4.3.6 provides a summary of the acid sulfate soil investigation undertaken within the proposed dredge footprint associated with sediments identified for onshore disposal (Appendix C).
Acid sulfate soil analysis of 26 samples adopting the SPOCAS and SCr methods indicated one horizon, H3 sample with SPOCAS (Total Sulphur) concentrations exceeding the DEC (2009) action criteria and above the natural acid neutralising capacity of the sample. Comparatively, SCr concentrations for the same sample indicated that the concentration for SCr was below the Action Criteria.

SCr is often considered a more suitable determinant for PASS, than SPOCAS, within marine sediments. In conclusion, amalgamation of the material identified for onshore disposal would likely neutralise any small pockets associated with PASS within sediments.

### 7.6.4 Management and Mitigation Measures

#### 7.6.4.1 Offshore dredge disposal management

ASS material will be disposed of in Spoil Ground ‘I’. To ensure the effectiveness of this strategy the PASS material will be:

- Selectively cut using mechanical dredging methods; and
- Placed in barges and kept saturated during transport and disposal. The material will be kept saturated by placing seawater over the material using the dredging equipment or the deck wash on the barges. The expected maximum time between dredging the materials and sea disposal will be less than 14 hours, which is significantly less than the 70 hour limit recommended by DEC. Given the spoil’s saturated condition, it is unlikely that PASS oxidation and subsequent acid generation will result.

The bulk of the dredged material to be disposed of onshore is expected to be non acid sulfate soils (NASS). However, there is a low risk that some residual PASS present in the dredged material will be disposed of onshore. The operational procedures associated with dredging will ensure all material is well mixed prior to discharge into the land based reclamation cells.

A number of contingency plans have been developed for the treatment and handling of ASS in the event that ASS material is disturbed or in the event of a management procedure failure. The contingency plans address containment and treatment of marine mud, potentially acid runoff, additional analysis, treatment and management of material, management of newly formed ASS material in settling ponds and dredge spoil water containment and treatment (Fortescue 2009e).

Tailwater discharge from the reclamation cells will be monitored in accordance with the DMP (Appendix A). If a trigger level is exceeded, management actions will be implemented.
7.6.4.2 Onshore management of dredge material

The dredged materials disposed onshore are expected to be non-acid sulfate soil (NASS). There is a low likelihood of PASS occurring in the dredged material at levels requiring management or being oxidised, giving rise to actual acid sulfate soils.

Any residual PASS material will be mixed with the NASS material as a result of the dredging and spoil transport (via pipeline) process. It is likely that calcareous dredge material and seawater that will be present with ASS material in transport to the DMMA areas will also act to neutralise the effects of oxidation of any residual PASS, should this occur.

7.6.4.3 DMMA water discharge management

Excess water from the DMMAs will be discharged from nominated surface drainage discharge points. The discharge from DMMAs will be monitored to ensure it meets the action criteria outlined in Dewatering Effluent and Groundwater Monitoring Guidance For Acid Sulfate Soil Areas (DEC 2006b). Total Titratable Acidity (TTA), Electrical Conductivity (EC) and pH will be monitored weekly to ensure that water quality parameters are maintained at a pH >6 and a TTA <40 mg/L (see Section 7.14).

7.6.4.4 DMMA bund construction materials

Material proposed for use in the construction of the earth bunds surrounding the DMMAs will be subject to a detailed soil assessment. Material identified as PASS through the detailed assessment will not be used in the construction of bund walls.

7.6.5 Predicted Outcome

Potential marine ASS material in the vicinity of South West Creek is confined to the surficial sediment layer, and is not present in the ‘red beds’ and/or carbonate material located below the sediment layer at shallow depths. It was concluded there is sufficient ANC within the ‘red bed’ and/or carbonate material located below the marine sediment layer to neutralise the potential acid generating capacity of the sediment layer during dredging operations.

Any ASS materials encountered during the dredging program will be disposed of off shore and any acidity within the tailwater discharge will be managed in accordance with DMP (Appendix A). Given that previous dredging programs have not had any potential issues with acid-forming materials, it is considered the proposed management will minimise the risk to the environment from ASS and the environmental objectives can be met.

Any onshore PASS that could be oxidised by ground disturbing activities will be identified prior to ground disturbing activities and avoided wherever practicable.

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7.7 Hydrology and Hydrogeology

7.7.1 Overview

All dredged material below -6.0 m CD is intended for onshore disposal into the designated DMMAs. Following completion of dredging, the DMMAs will contain an estimated 14.5 Mm³ of unconsolidated dredge material (after dewatering) (see Table 2-4). The dredged material will be contained by means of perimeter bunds of up to 12 m AHD. Excess water will be discharged as required, up to 24 hours per day, with average volumes ranging up to 2,600 m³ per hour for the duration of the project. Residence time within the DMMAs will typically be 48 to 72 hours to allow fines to settle out, and ensure sediment within the water discharge is minimal. The DMMA design accommodates flexibility so extended settlement times can be achieved to ensure compliance with water quality criteria.

7.7.2 Objectives, Applicable Standards and Guidelines

The EPA objective relevant to hydrology is ‘to maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem function, are protected’.

The relevant policies and standards for management of hydrology and hydrogeology include:

- Environmental Protection Act 1986;
- Environmental Water Provisions Policy for Western Australia: State-wide Policy No. 5 (WRC 2000); and

7.7.3 Potential Impact

The construction of the DMMAs may change the local drainage and surface flows of the coastal flats, with the bund walls creating a barrier to natural water flows. Disruption to natural surface water flows and stormwater runoff may result in unnatural or accelerated erosion of the intertidal flats surrounding the DMMAs and increased mosquito breeding areas due to pooling of surface water.

Runoff, seepage or return water from the DMMAs also has the potential to pollute surface and ground water (with potential acidity, salinity or contaminants). Minor scouring or erosion of the creek bed may also occur near excess water discharge points.

Metals from the dredged material within the DMMAs have the potential to leach over time and impact on the ground water quality below. An assessment against EILs (DEC 2010) indicated the
geological material below -6.0 m CD in the dredge footprint is suitable for onshore disposal (Appendix C). The risk of leaching is consequently considered negligible.

7.7.4 Management and Mitigation Measures

DMMA B-North and DMMA G are located on the downstream side of the BHPBIO railway South West Creek diversion and do not intersect any major waterways. DMMA B-North is orientated across the direction of flow of one minor drainage line, but this is not expected to have a large impact on surface flows into South Creek as it is located on the upstream side of the BHPBIO railway line. Ponding of water in and around the DMMAs will be avoided where possible, and any ponding will be inspected for mosquitoes and larvae.

Return waters from the DMMAs will be channelled into South West Creek and South Creek via culverts or floodways, with discharge points especially chosen to minimise erosion, and controlled rates of discharge. The bund walls will be constructed with scour protection where risk of scour is a factor.

Water quality within the DMMAs and of the return waters will be monitored with discharge waters required to meet water quality objectives for parameters such as turbidity, dissolve oxygen, temperature, pH and contaminants, as described in DMP (Appendix A).

Potential leaching of metals from the dredged material into the ground water is not considered a risk given the geotechnical survey results, and no lining of the DMMAs are considered necessary.

7.7.5 Predicted Outcome

It is expected that the impacts associated with hydrology will be minor, with implementation of appropriate management as described above and the environmental objectives can be met.

7.8 Terrestrial Flora and Fauna

7.8.1 Overview

Two new DMMAs are included as part of the Project, DMMA B-North and DMMA G. A flora and fauna survey conducted in July 2010 recorded a low level of taxa richness in DMMA B-North and DMMA G (Appendix F). The other three DMMAs that will be used during the Project, namely, DMMA A, B and B-South, were not assessed as part of this referral given that they are already approved. The composition of flora and fauna assessed in the DMMAs was generally typical of the families and genera frequently recorded in the Pilbara coastal region. No Conservation Significant
Flora, Fauna or SRE Fauna have been recorded in DMMA B-North or DMMA G and thirteen conservation significant fauna were identified as potentially occurring in the DMMAs (Appendix F).

Based on the current July 2010 assessment, it was concluded that the scale of the Project has limited potential impacts on terrestrial flora and fauna resulting from disturbances involved in construction activities. However, a targeted, seasonally appropriate survey will be undertaken prior to any ground disturbance to determine whether any conservation significant fauna are present. In addition, a contingency plan will be prepared should any significant populations of conservation significant species be recorded.

7.8.2 Objectives, Applicable Standards and Guidelines

The EPA’s objectives for the Project with regards to flora and fauna management are to:

- Maintain the abundance, species diversity, geographic distribution and productivity of terrestrial flora and fauna;
- Protect Specially Protected (Threatened) fauna, consistent with the provisions of the *Wildlife Conservation Act 1950*; and
- Protect Declared Rare Flora and Priority flora, consistent with the provisions of the *Wildlife Conservation Act 1950*.

Applicable legislation and guidelines include:

- *Wildlife Conservation Act 1950*;
- Environment Protection and Biodiversity Conservation Act 1999;
- EPA Position Statement No 2 Environmental Protection of Native Vegetation in Western Australia (EPA 2000a);
- EPA Position Statement No 3 Terrestrial Biological Surveys as an element of Biodiversity Protection (EPA 2002d);
- EPA Guidance Statement No 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004d); and

7.8.3 Potential Impact

Potential impacts on flora and fauna that may arise from activities associated with the Project include:
• Direct loss of vegetation and habitat within the DMMAs and pipeline corridors through clearing and placement of dredge material and pipelines;
• Injury or mortality to individual fauna within the DMMAs through clearing construction and disposal activities;
• Reduced health of the vegetation and habitat surrounding the DMMAs due to dust deposition and/or changes in surface water flows;
• Reduced health of the vegetation and fauna habitats surrounding the DMMAs through hydrocarbon leaks and spills or incorrect disposal of liquid wastes;
• Sickness or mortality of fauna through accidental ingestion of spilt hydrocarbons or solid and liquid wastes that are incorrectly disposed of;
• Introduction or spread of weed species from increased vehicle movement in the area;
• Disturbance or stress to individual fauna through construction noise and lighting; and
• Blocking access of locally migrating fauna and reducing freedom of movement for local fauna, causing cut-offs from foraging, feeding, breeding or resting areas.

Terrestrial Flora:

Vegetation communities located within the dredge footprint and DMMA B-North and DMMA G will be impacted upon by direct clearing activities and onshore disposal activities. Likewise vegetation within access tracks and temporary pipeline corridors will be cleared.

The DMMAs consists of one land system, the Littoral land system (van Vreeswyk et al. 2004), much of which is made up of tidal flats, which support no vegetation. This land system occurs along much of the Pilbara coast line (approximately 50%), and covers a total of 0.9% or 1,577 km\(^2\) of the Pilbara bioregion (Appendix H). The most extensive vegetation associations identified in the DMMAs were the tidal flats vegetation associations. Table 7-1 presents the loss of vegetation for each vegetation association within the DMMAs.

An assessment of loss of mangrove vegetation that will be removed as a result of the Project has been presented in Section 6.2.3.1 and Appendix E.

- Table 7-1 Vegetation losses by vegetation association within DMMA B-North and DMMA C

<table>
<thead>
<tr>
<th>Vegetation Association Code</th>
<th>Description</th>
<th>Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>AmCi1</td>
<td>Open Shrubland to Shrubland of <em>Avicennia marina</em> and <em>Ceriops tagalove</em></td>
<td>DMMA B-North</td>
</tr>
<tr>
<td></td>
<td>Scattered Low Shrubland to Low Scattered Shrubbs of <em>Tecticornia</em> spp. and</td>
<td>12.4 ha</td>
</tr>
<tr>
<td></td>
<td><em>Muellerolimon salicorniaceum</em>.</td>
<td>5.8 ha</td>
</tr>
<tr>
<td>AbCiTs</td>
<td>High Open Shrubland of <em>Acacia bivenosa</em> over Low Open Shrubland of</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td><em>Corchorus incanus</em> subsp. <em>incanus</em> and <em>Gomphrena canescens</em> subsp.</td>
<td>3.3 ha</td>
</tr>
<tr>
<td></td>
<td><em>canescens</em> over Grassland of <em>Triodia secunda</em>, <em>Triodia epactia</em> and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Vegetation Association Code** | **Description** | **Extent**
--- | --- | ---
Am | Scattered Shrubs of *Avicennia marina* over Closed Low Shrubland of *Muellerolimon salicorniaceum* and *Tecticornia* spp. | 4.1 ha, n/a
AmCt2 | Closed Shrubland of *Avicennia marina* and *Ceriops tagal* over Low Open Shrubland to Scattered Shrubland of *Muellerolimon salicorniaceum*, *Suaeda arbusculoides* and *Tecticornia* spp. | 1.9 ha, 2.6 ha
Ts | Low Shrubland to Scattered Shrubs of *Tecticornia* spp. and *Muellerolimon salicorniaceum*. | 45.2 ha, 94.2 ha
TsSv | Closed Hummock Grassland of *Triodia secunda* with Scattered Tussock Grasses of *Sporobolus virginicus* and *Eragrostis falcata*. | 8.7 ha, n/a
TeTs | Closed Hummock Grassland to Grassland of *Triodia epactia* and *Triodia secunda*. | 8.1 ha, 9.4 ha

*Note: An asterisk (*) indicates the taxon is introduced.*

**Terrestrial Fauna:**

Terrestrial fauna species such as migratory bird and bat species could be potentially impacted during construction through habitat disturbance from direct clearing activities, or from noise impacts. These impact sources may result in a loss of habitat causing increased competition and loss of foraging, feeding, resting or breeding areas in the local region. Injury and mortality of individual fauna may result from vehicular activities associated with the Project.

Table 7-2 indicates the current fauna habitat types for the DMMAs and the area of disturbance.

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**Table 7-2 Predicted terrestrial habitat losses associated with Onshore Disposal activities**

<table>
<thead>
<tr>
<th>Habitat Type</th>
<th>Habitat Value</th>
<th>Habitat Loss in DMMA G (ha)</th>
<th>Habitat Loss in DMMA B-North (ha)</th>
<th>Habitat Loss associated with pipelines and access corridors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Flats</td>
<td>Low</td>
<td>94.2 ha</td>
<td>45.2 ha</td>
<td>2.5</td>
</tr>
<tr>
<td>Sandplain</td>
<td>Low</td>
<td>9.4 ha</td>
<td>16.7 ha</td>
<td>0.6</td>
</tr>
<tr>
<td>Limestone Hill</td>
<td>Low</td>
<td>3.3 ha</td>
<td>0 ha</td>
<td>0</td>
</tr>
<tr>
<td>Cleared/Developed</td>
<td>N/A</td>
<td>17.6 ha</td>
<td>0 ha</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>124.5 ha</td>
<td>61.9 ha</td>
<td>3.1</td>
</tr>
</tbody>
</table>

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### 7.8.4 Management and Mitigation Measures

The requirements of the *Wildlife Conservation Act 1950* and the *EPBC Act 1999* will be met by implementing management plans to reduce the impacts on terrestrial flora and fauna.
The disturbed footprint shall be minimise through the clear demarcation of vegetated areas marked for clearing;

- A dust suppression management programme shall be implemented during construction (see Section 7.9) to reduce the risk of dust deposition on vegetation or habitat;
- Surface water flows shall be managed to prevent flooding and erosion (see Section 7.7);
- A spill contingency plan shall be implemented (see Section 7.12) and emergency spill response capability shall be provided on site;
- Waste management measures shall be implemented (see Section 7.13) to reduce the risk of liquid wastes affecting vegetation health or being ingested by fauna;
- Speed restrictions, driver awareness and removal of road kill shall be enforced to minimise potential impacts arising from vehicular movement;
- Equipment and vehicles shall be washed down prior to arrival at the project site;
- Weed-free fill material shall be used; and
- Noise emissions and use of lighting during construction shall be minimised where practicable.

### 7.8.5 Predicted Outcome

All habitat removal will be confined to the dredge footprint, DMMA G and DMMA B-North and associated access tracks and pipeline corridors. No habitats within the DMMAs are spatially restricted or likely to support populations of significant species communities. All species of conservation significance that may be at risk from Project activities will be assessed and managed in accordance with the Wildlife Conservation Act 1950 and the EPBC Act 1999.

### 7.9 Dust

#### 7.9.1 Overview

The Port Hedland region has natural background levels of dust have been found to exceed the National Environmental Protection Measure (NEPM) standard level for PM$_{10}$ of 50 µg/m$^3$. Exposure to these small particulates has the potential to cause an exacerbation of respiratory problems, particularly in adults above the age of 49, and children under the age of five (PHDMT 2010). With background dust levels in the region that are naturally high and port operations that have dust

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$^\dagger$PM$_{10}$ refers to particles up to 10 micron in aerodynamic diameter
emissions, the ambient air quality measured in Port Hedland often exceed guideline levels. The Port Hedland Dust Management Taskforce recommended in March 2010 that an interim guideline measure for air quality in Port Hedland for particles measured as PM10 be established based on the following criteria (PHDMT 2010):

- 70 µg/m³ (24 hour average);
- 10 exceedences per calendar year;
- Applies to residential areas east of Taplin Street, Port Hedland; and
- Review five years after the commencement of the Plan.

7.9.2 Objectives, Applicable Standards and Guidelines

The EPA’s objectives for the Port Hedland region with regards to dust management are to:

- Ensure that atmospheric emissions (dust) do not impact on environmental values or the health, welfare and amenity of the population and land uses; and
- Use all reasonable and practicable measures to minimise airborne dust.

Applicable legislation and guidelines for the management of air quality include:

- EPA Guidance Statement No 18 Prevention of Air Quality Impacts from Land Development Sites (EPA 2000c); and
- National Environmental Protection Measure for Ambient Air Quality 1998.

Regulatory instruments for the management of dust include:

- The NEPM PM10 standard of 50 µg/m³ (24 hour average) used as the criteria to assess potential health impacts at sensitive receptors; and
- New South Wales EPA annual standard for Total Suspended Particulates (TSP).

It is noted that while the Port Hedland Dust Management Taskforce has recommended that an interim guideline criteria be applied to Port Hedland (Table 7.3), it is understood that this has yet to be established by the DEC.

Table 7.3 Ambient air standards and goals

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Period</th>
<th>Standard (µg/m³)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particles as PM10</td>
<td>1 day</td>
<td>50</td>
<td>NEPM</td>
</tr>
<tr>
<td>Particles as PM10 (Proposed Interim Guideline)</td>
<td>1 day</td>
<td>70</td>
<td>Port Hedland Air Quality and Noise Management Plan</td>
</tr>
<tr>
<td>Particles as PM2.5</td>
<td>1 day</td>
<td>25</td>
<td>NEPM</td>
</tr>
</tbody>
</table>
7.9.3 Potential Impact

The Project requires an estimated volume of 8.7 Mm³ of dredge material to be disposed onshore, and has the potential to generate significant volumes of slimes. Once the slime in the DMMAs dry out they have the potential to generate airborne dust in high wind conditions if no mitigation measures are put in place.

Modelling of dust generated from BHPBIO DMMA H, for the Nelson Point Dredging Program, found that uncontrolled dust\(^\dagger\) generated from DMMA H would not change the cumulative dust levels predicted at the Port Hedland Hospital monitoring location (BHP Billiton 2009 – Dust Assessment). DMMA H is a similar size, 204 ha, to the new construction footprint required for the South West Creek Dredging Program, 224 ha.

Construction activities, principally land clearing, the use of earth moving machinery for bund wall construction and vehicle and equipment traffic on unsealed roads and laydown areas has the potential to generate dust emission that is likely to have a limited and temporal impact on the ambient air quality.

7.9.4 Management and Mitigation Measures

Management measures which will be used to control dust generation, should visible dust be observed leaving the Project areas are:

- Application of regulator watering to unsealed roads and active unsealed areas;
- Use of environmentally safe dust suppression products;
- Restricting vehicle movements and speed limits, as appropriate;

\(^\dagger\)The emissions calculated for DMMA H assumed that the entire dredge spoil area was dry and that no emission reduction techniques had been applied.
• General housekeeping practices to ensure that there is no accumulation of waste materials within the construction site that may generate dust;
• Staff induction program to ensure all employees are made aware of the need to minimise dust generation; and
• Reporting of any community complaints regarding dust levels.

Due to the natural formation of a salt crust on the surface of the DMMA dust generation during and immediately post construction is likely to be limited. Management of the medium to long term stability of the DMMA surface is discussed in Section 7.14.

7.9.5 Predicted Outcome

Through the implementation of management measures for dust suppression, it is likely that the Project will have negligible impact on the air quality in the Port Hedland area.

It is anticipated that dust emissions from the Port Facility will be effectively mitigated and regulated through the application of licence conditions under Part V of the EP Act.

7.10 Terrestrial Noise

7.10.1 Overview

The Project is expected to generate noise associated with dredging equipment, barges, support vessel movement, construction of the DMMA’s and onshore disposal activities. Potential residential and commercial receptors that could be impacted by noise generated from dredging activities are located approximately 4 km from the Project. However, as the port is leased to over 40 tenants that use the facility for a range of industrial activities, noise generated from the Project is unlikely to impact on sensitive receptors above existing noise levels given the proximity of these receptors to existing port activities.

7.10.2 Objectives, Applicable Standards and Guidelines

The environmental objective is to protect the amenity of nearby residents from noise impacts resulting from activities associated with the Project by ensuring the noise levels meet statutory requirements and acceptable standards.

Applicable legislation and guidelines for the management of noise emissions include:
Environmental Protection (Noise) Regulations 1997, including the Assigned Noise levels specified in Regulation 7, and the special provision for construction work on construction sites provided in Regulation 13;

- EPA Draft Guidance Statement No 8 (Environmental Noise) (EPA 2007);
- EPA Guidance Statement No 3 (Separation Distances between Industrial and Sensitive Land Uses (EPA 2004c);
- State Planning Policy 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning (WAPC 2009a), and the associated Implementation Guidelines (WAPC 2009b); and

7.10.3 Potential Impact

The emissions from dredging operations and the construction of DMMAs will result in intermittent and incremental increases in ambient noise levels. Potential impacts include:

- Disturbance to residents in local townships;
- Disturbance to terrestrial fauna occurring in the DMMAs leading to potential behavioural changes (refer to Section 8.8); and
- Disturbance to marine fauna occurring within the inner harbour from underwater noise sources such as dredging equipment leading to potential behavioural changes (refer to Section 7.3).

The Environmental Protection (Noise) Regulations 1997 provide requirements on how noise emission from construction sites is to be controlled. These Regulations specify assigned noise levels, which are the highest noise levels that can be received at noise-sensitive premises, commercial and industrial premises. Assigned noise levels have been set differently for noise sensitive premises, commercial premises, and industrial premises. For noise sensitive premises, ie residences, an ‘influencing factor’ is added to the assigned noise levels. Penalties are also applied for noise that has tonal characteristics.

Previous BHPBIO dredging and construction projects undertaken at Harriet Point (directly adjacent to the proposed footprint and Nelson Point (RGP6)) assessed the impact of noise on a range of anthropogenic receptors within the area from proposed dredging activities. For the RGP5 and RGP6 projects noise modelling was undertaken to determine the impact of noise generated from five sources during dredging, namely, cutter suction dredge, backhoe dredge, excavator, dozer and pipe layer during dredging and construction. It was identified that only three sensitive receptors would be impacted during dredging namely, Laurentis Point, the Hospital and Police Station (BHP Billiton
2009). The assigned noise levels for these three sensitive receptors to the Project within Port Hedland are given in Table 7-5.

The extent of the noise impact on these three sensitive receptors has been calculated using the Australian Standard for Noise Control AS2436: 1981 (Standards Australia 1981). These standards provide guidance on noise control in construction, maintenance and demolition sites as it affects persons working on these sites and also those living and working in the locality. The standard includes guidance in investigation and identification of noise sources, measurements of sound and guidance in assessment with a view to planning measures for noise control and monitoring of their effectiveness.

The potential construction sound power levels emitted from the equipment used during the dredging process have been identified by applying the equipment type and specification to AS 1436-1981 (Standards Australia 1981) or manufacturer specifications.

The RGP5 project was modelled using five noise primary noise sources whereas this Project has three primary noise sources (i.e. two backacter dredges, one CSD and plant associated with construction of the DMMAs). Both projects have similar secondary noise sources e.g. from barge and support vessel engines.

The three noise receptors that were considered as sensitive to impacts associated by dredging activities as part of the RGP5 project have been adopted as part of the current noise assessment for this Project (Figure 7-6). Noise thresholds calculated for the RGP5 project identified a threshold of 46 dB at Laurentis Point and the Police Station (located 2 km away), while the hospital will be exposed to 42 dB (located at 3 km away) Table 7-4. A worst case scenario of the three primary project noise sources described above operating within the dredge footprint was used in a desk top assessment to estimate noise levels at the three sensitive noise receptors identified by the RGP5 and RGP6 projects. The estimated cumulative output sound power level from the proposed activities will not exceed 120 dB (SVT 2008).

- **Table 7-4: Predicted noise levels at 2, 3 and 4 km from 120 dB(A) noise source**

<table>
<thead>
<tr>
<th>Distance from Noise Source (km)</th>
<th>Predicted Noise Level at Receptor dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2km</td>
<td>46</td>
</tr>
<tr>
<td>3km</td>
<td>42</td>
</tr>
<tr>
<td>4km</td>
<td>40</td>
</tr>
</tbody>
</table>

Predicted noise thresholds were found to be compliant to assigned noise levels at Laurentis Point, the Police Station and the hospital during the day, the hospital and police station in the evening and
the police station at night. Assigned noise levels were exceeded at Laurentis Point in the evening and at both Laurentis Point and the hospital at night (Table 7-5).

- **Table 7-5: Assigned and estimated dredging noise levels at key threshold receptors**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Influencing Factor</th>
<th>LA10 Assigned Noise Levels dB(A) *</th>
<th>Predicted Noise Level at Receptor dB(A)</th>
<th>Assigned Levels Exceeded</th>
<th>Approximate Receptor Distance from Noise Source (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laurentis Point</td>
<td>5</td>
<td>Day: 50  Evening: 45  Night: 40</td>
<td>Evening: 46</td>
<td>Evening and Night</td>
<td>2</td>
</tr>
<tr>
<td>Police Station</td>
<td>17</td>
<td>Day: 62  Evening: 57  Night: 52</td>
<td>Evening: 46</td>
<td>None</td>
<td>2</td>
</tr>
<tr>
<td>Hospital</td>
<td>2</td>
<td>Day: 47  Evening: 42  Night: 37</td>
<td>Evening: 42</td>
<td>Night</td>
<td>3</td>
</tr>
</tbody>
</table>

* Note: Assigned noise levels taken from the Environmental Protection (Noise) Regulations 1997 and include a 5dB penalty for tonality.

- **Figure 7-6**  Predicted noise levels at distance from noise source, including primary receptors within Port Hedland
7.10.4 Management and Mitigation Measures

Measures that will be taken to reduce noise emissions during dredging and DMMA construction include:

- For construction work carried out between 7 am and 7 pm on any day which is not a Sunday or public holiday:
  - Construction work must be carried out in accordance with the control of noise practices set out in section 6 of the Australian Standard 2436-1981 ‘Guide to Noise Control on Construction, Maintenance and Demolition Sites’;
  - The equipment used for the construction must be the quietest reasonably available;
  - A noise management plan may be developed in order to undertake construction activities, in accordance with the Environmental Protection (Noise) Regulations 1997.
- Educating and training employees and contractors with respect to noise management;
- Ensuring noise emissions are considered when sourcing plant and equipment;
- Ensure that all plant is maintained in operating order in accordance with industry best practice;
- Ensure that all equipment meets equipment noise specifications and put in place action plan if requirements are not met;
- Switch off all equipment when not in use;
- Scheduled maintenance and monitoring of equipment with a view to minimising noise emissions; and
- Restricting high levels of noise emissions to appropriate daylight hours.

Additional measurements are applicable for construction activities at night time and will include:

- Consideration of acoustic enclosure of noise sources, i.e. CSD cutter drivers and engines;
- Need for work to be done out of hours;
- Types of activities which could be noisy;
- Predictions of noise levels;
- Control measures for noise and vibration;
- Procedures to be adopted for monitoring noise emissions; and
- Complaint response procedures to be adopted.

7.10.5 Predicted Outcome

Potential noise impacts from the Projects construction and dredging activities will be temporary and as Port Hedland is largely characterised by existing port infrastructure, noise impacts associated with
the Project are likely to be of minor concern. A noise management plan will be utilised to reduce the impact of noise emissions in the Port Hedland region and comply with *Environmental Protection (Noise) Regulations 1997*.

### 7.11 Visual Amenity

#### 7.11.1 Overview

The proposed development and construction of the Project has the potential to impact visual amenity at publicly accessible locations within the Port Hedland area. Port Hedland and its surrounding areas are however, characterised by port infrastructure and operations and during consultation with stakeholders, visual amenity has not been raised as an issue. Furthermore as the new DMMAs are located adjacent to and between existing DMMAs it is unlikely the presence of the new DMMAs will generate a significant impact.

#### 7.11.2 Objectives, Applicable Standards and Guidelines

The EPA’s objective for the Project is to reduce potential visual impacts associated with the project and its activities on the local communities and key users of the Project Area.

Applicable standards and guidelines for the assessment and management of visual impacts include:

- EPA Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2008);
- Guidelines for Landscape and Visual Impact Assessment (LI & IE MA 2002); and

#### 7.11.3 Potential Impact

The presence of the DMMA sites will have an impact on the visual amenity within the Project Area. The proposed total onshore disposal volume of dredged material is 8.7 Mm³ which will be deposited on the DMMA sites. The perimeter of the DMMAs will be surrounded by bunds that can be constructed up to 12 m AHD, depending on requirements. The DMMAs are in close proximity to existing DMMAs, to the west and northwest of Wedgefield and will be seen by local commuters and the workforce.

A detailed viewshed analysis and visual impact assessment has been undertaken for the nearby Nelson Point Dredging project (BHP Billiton RGP6) which included the construction of DMMA C which
in close proximity (within 100-200m of built up area) to Wedgefield (BHP Billiton 2009). This assessment concluded that most impacts to sensitive receptors were nil to slight with visual impact on Wedgefield lift industrial area rated moderate. Following implementation of management measures the residual risk was considered minor (BHP Billiton 2009).

The onshore disposal of dredge spoil from the South West Creek Dredging Project will require the use of existing and previously approved DMMAs (DMMA A, DMMA B and DMMA B-South) and the construction of two new DMMAs (DMMA B-North and DMMA G) which are adjacent to the existing DMMAs. DMMA B-North is over 1200m from the edge of Wedgefield and the DMMA G is on the opposite side of DMMA A from Wedgefield and as such largely obstructed from view by FMG iron ore stockyards and materials handling infrastructure and DMMA A.

FMG have approval under Part IV of the Environmental Protection Act 1986 to construct DMMA B to a height of 14 m AHD⁵ and DMMA B-South to a height of 12 m AHD¹ as described in Ministerial Statement 771.

Temporary and localised reduction in visual amenity may occur within the Port limits caused by the sediment plume generated from dredging operations and by the presence and movement of dredging and support vessels. Management of the dredge plume will focus on minimising impacts to mangroves and water quality as described the DMP (Appendix A).

During stakeholder consultation undertaken for the Project, visual amenity impacts of neither the DMMAs nor the dredging plume were identified nor raised by stakeholders as issues of concern.

### 7.11.4 Management and Mitigation Measures

Management measures which will be implemented to limit the impact from the South West Creek onshore disposal of dredged material are:

- Height of DMMAs not to exceed 12 m AHD;
- Dredge material management to keep the footprint and height of dredged material to a minimum; and
- Long term DMMA management as described in Section 7.14.

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⁵ It is assumed that the height datum for these limits is AHD, as it is not specified in Ministerial Statement 771.
7.11.5 Predicted Outcome

Given the location of the dredging operation within an existing port subject to regular maintenance dredging and a naturally high turbidity and the location of the onshore disposal locations within an area already developed with dredge material disposal facilities, the impact on visual amenity for the project is considered to be low and the environmental objectives can be met.

7.12 Hydrocarbons and Chemicals

7.12.1 Overview

The accidental release of hydrocarbons and chemicals has the potential to cause great harm to the surrounding aquatic and terrestrial environment. Accidental releases into the environment can be caused by spills, leaks and incorrect storage and disposal of hazardous materials. During Project operations, proper management is required to reduce the risk of hydrocarbons and chemicals from impacting the environment.

7.12.2 Objectives, Applicable Standards and Guidelines

The environmental objective is to minimise spills and impacts of hydrocarbons and chemicals in the marine and terrestrial environment, particularly with regards to hydrocarbon spillage during dredging operations.

Applicable legislation and guidelines include:

- *Pollution of Waters by Oil and Noxious Substances Act 1987*;
- International Convention for the Prevention of Pollution from Ships (MARPOL Convention) 1973/78; and
- Environmental Protection (Unauthorised Discharges) Regulations 2004.

7.12.3 Potential Impact

The risk from spillage of hydrocarbons or chemicals from shipping in the marine environment can be substantial. These spillages may result from ship collisions or grounding, discharge of oil in bilge water, during bunkering or deliberate discharge. In the event of such an incident resulting in spillage, PHPA carries the prime responsibility to take whatever action it deems appropriate to cope with that incident (PHPA 2008).

The most significant potential impact will be accidental spillage of the dredging vessels fuel in the event of a grounding or collision. Marine spills can also occur during bunkering. Hydrocarbons used during the dredging will include diesel and smaller amounts of lubricating oil and grease for dredging
equipment. Diesel is a ‘light oil’ and small spills of 2,000-20,000 L will usually evaporate and disperse within a day or less; for larger spills, a residue of up to one-third of the amount spilled will usually remain after a few days. Potential impacts associated with a major hydrocarbon oil spill from the proposed project during dredging is unlikely given the hydrocarbon storage capacity associated with the dredge vessels and associated vessels proposed to undertake dredging. A collision between dredge vessels or associated vessels or poorly maintained equipment during dredging could potentially increase the risk of a large oil spill. Other potential risks from a hydrocarbon spill are the risks associated with spillage of hydraulic oil. The volume associated with spillage of hydraulic oil is generally low and therefore unlikely to pose a high risk of impact.

Mangroves in the nearshore marine environment in the inner harbour are the BPPH most at risk from a hydrocarbon spill associated with the Project. The surface of these plants is in regular contact with the water's surface and therefore spilt hydrocarbons would be more likely to come into contact with these plants. The physical smothering of the pneumatophores causes damage to the mangals and the chemical composition of the hydrocarbon spilt may lead to leaf loss (Burns, Codi et al. 1999). The amount of oil in the soil is reduced by rain and tides which further reduces the toxicity of any residual oil, as does weathering of the oil where some of the more toxic volatile fractions evaporate. Diesel will not sink or accumulate on the seafloor, except as a result of adsorption to sediment. Diesel is not sticky or viscous in comparison to heavier oils, and tends to penetrate porous sediments on the shoreline but be washed off quickly by waves and tidal flushing, meaning that shoreline clean-up is usually not required (NOAA 2006). Complete degradation by naturally occurring microbes takes one to two months (NOAA 2006).

Direct mortalities are possible for fish, invertebrates and seaweed in direct contact with a spill (NOAA2006). However, small spills in open water are very rapidly diluted and fish kills have not been reported in these scenarios, although they have been reported in confined, shallow water (NOAA2006). Crabs and shellfish bioaccumulate oil but will undergo depuration after several weeks following exposure should individuals moves into areas that are not impacted by spill effects (NOAA2006).

Direct contact with diesel can affect marine birds by ingestion during preening and hypothermia from matted feathers, although the oil evaporates so rapidly that the number of birds affected is usually small (NOAA 2006). Small spills have the potential for serious impact if they occur close to a large nesting colony or are transported into an area of large bird population (NOAA 2006).

Given that there are no large seabird colonises near the proposed dredge footprint or DMMAs the risk to marine birds is negligible. Therefore it is likely that only invertebrates and fish may be exposed and subsequently affected by such incidents although area of spill extent is thought to be minimal given the small volumes of fuel that will be used during dredging activities.
Machinery and plant associated with the construction of the new DMMAs may present a risk in terms of hydrocarbon spillage. Spillages are likely most likely to occur during refuelling. Use of chemicals in dredging and settlement activities is however limited and the Project is unlikely to require significant volumes of hydrocarbons or chemicals to be either stored or used onsite.

7.12.4 Management and Mitigation Measures

The use of PHPA standard operating procedures will minimise the risk of a vessel collision or grounding occurring. All vessels must follow the PHPA standard operating procedures when working in the inner harbour.

The Dredge Contractor will adhere to the requirements of the DMP (Appendix A) and the PHPA Marine Oil Pollution Management Plan (see Appendix 1 of the DMP) will be implemented to minimise the risk to the marine environment from hydrocarbon or chemical spillage during the Project as dredging operations occur within the PHPA boundary. The PHPA Marine Oil Pollution Management Plan includes a procedure outlining the response plan and involved agencies in relation to the size of the spill.

Land based spills will be minimised by provision of bunded wash down areas, minimising storage of chemicals on site and implementation of the PHPA Marine Oil Pollution Management Plan (Appendix 2 of the DMP) throughout the life of the Project.

All hydrocarbons and chemicals will be stored and used in compliance with:

- relevant legislation and standards;
- PHPA Marine Oil Pollution Management Plan (Appendix 2 of the DMP); and
- Dredging Management Plan (DMP) (Appendix A).

Key management actions for the Project are:

- Training all Project personnel in spill prevention, management and clean-up;
- Providing appropriate spill kits at key locations;
- Providing designated areas for vehicle wash downs;
- Using oil/water separators;
- Industry standards, port authority and pollution prevention regulations shall be adhered to during:
  - Refuelling;
  - Transfer;
  - Storage; and
  - Handling of hazardous materials (e.g. bunding, level gauges, overflow protection, drainage systems and hardstands);
• Following PHPA standard operating procedures for bunkering, vessel movement and port safety; and
• Timely implementation of spill response procedures contained within the PHPA Marine Oil Pollution Management Plan and the DMP in the event of an accidental spillage.

In addition, as part of its responsibility for the management of hydrocarbon spillage in Port Hedland Port, PHPA will install quick response equipment in the harbour in 2010, which will include permanent booms throughout the harbour to protect mangrove areas. The Dredge Contractor will provide adhere to the requirements of the DMP and the PHPA Marine Oil Pollution Management Plan throughout the life of the Project.

7.12.5 Predicted Outcome

With management plans in place and close contractor liaison with PHPA, all reasonable actions to minimise the risk to the marine and terrestrial environments from hydrocarbon or chemical spillage will be implemented. Given existing management plans and emergency measures and proposed contractors management plans to prevent spillage and management of hydrocarbon and chemical wastes it is considered the Project will pose a low risk to the marine and terrestrial environments and it is expected that the environmental objectives can be met.

7.13 Waste Management

7.13.1 Overview

Dredging activities and construction of the proposed DMMAs may generate solid and liquid wastes (including hazardous wastes). These wastes include:

• Inert solid waste (non-putrescible wastes e.g. bricks, concrete, asphalt and sand);
• Putrescible solid waste (food waste, vegetative waste, timber, paper, plastics and packaging waste);
• Solid and liquid hazardous waste (waste oil, hydrocarbons, corrosives); and
• Domestic liquid effluent (sewage).

Waste management for the Project will be as for the existing port operations as set out by the DMP (Appendix A). The impacts associated with hydrocarbon and chemical spills and disposal are addressed in Section 7.12. Dredge material disposal is addressed in the DMP.
7.13.2 Objectives, Applicable Standards and Guidelines

The environmental objective for solid and liquid waste is to ensure that wastes do not adversely affect the health, welfare and amenity of people and land uses and is managed in accordance with the waste hierarchy outlined in DEC policy – Review of Waste Classification and Waste Definitions 1996 (as amended).

Applicable legislation, policies and standards include:

- *Environmental Protection Act 1986*;
- Environmental Protection (Controlled Waste) Regulations 2004 (WA);
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*;
- International Convention for the Prevention of Pollution From Ships 1973 (MARPOL 73/78);
- International Convention for the Control and Management of Ships Ballast Water and Sediments 2004;
- International Maritime Dangerous Goods Code 2008;
- Litter Regulations 1981; and
- Review of Waste Classification and Waste Definitions 1996 (as amended) (DoE, 2005).

7.13.3 Potential Impacts

Solid and liquid waste have the potential to impact on human health, pollute the environment and damage ecological communities if not managed appropriately. Solid and liquid wastes that may be generated during the Project include the following:

- Packaging material (plastic wrapping, pallets etc);
- Concrete;
- Scrap metal;
- Recyclable materials (paper, cardboard, aluminium);
- General food packaging and scraps; and
- Domestic sewage.

In addition, although vessels are not permitted to discharge waste such as sewage, bilge water or oily mixtures within the 12 nm limit, accidental discharges of small quantities of solid or liquid wastes into the marine environment may occur. Accidental discharges from vessels (not including hydrocarbons and chemicals) could include:

- Deck drainage, which may include small amounts of waste material;
- Engine cooling water; and
- Accidental discharge of liquid effluent.
Potential impacts from that could arise due to the generation of wastes during this Project include:

- Risk of harm or death to terrestrial and marine wildlife caused by ingestion or entanglement of waste;
- Increase in nutrients and pathogens in the water column (potentially leading to algal blooms or toxicity);
- Increased landfill requirements caused by unnecessary wastes; and
- Reduction in aesthetic value caused by solid waste.

### 7.13.4 Management and Mitigation Measures

HPA will ensure that the generation of waste is minimised and that any waste products are handled and disposed of in an acceptable manner. Key management actions for the reduction and management of wastes include:

- A waste hierarchy program;
- Waste management requirements shall be communicated to personnel (i.e. through inductions, pre-starts and/or Job Hazard Analyses (JHAs));
- Clear signage and coverage of wastes;
- Collection of rubbish in bins and recycled or disposed of by a licensed contractor;
- Contracting a local waste management and recycling contractor to collect and remove waste from the Project site, reusing and recycling waste, wherever practicable;
- Undertaking environmental awareness training for staff to encourage waste reduction, reuse and recycling;
- Disposing of waste that cannot be reused or recycled, at Port Hedland (or other) landfill facilities in accordance with relevant legislation and standards;
- Storing liquid wastes in labelled drums, containers or tanks;
- Return of empty chemical containers to the supplier for reuse and recycling where possible;
- There will be no discharge of materials, including liquid or solid wastes, into the marine environment unless approved. Any equipment or items that accidentally enter marine waters will be recovered as soon as practicable;
- All sewage treatment and grey water systems on vessels be frequently checked, maintained and monitored to ensure systems are efficient, fully operational and discharging treated water in accordance with MARPOL 73/78 Annex IV – Garbage;
- Collection of solid, non-hazardous waste or discharge of oily waste from vessels will be subject to Australian Quarantine and Inspection Service (AQIS) approval; and
- No residues containing noxious substances or sewage will be discharged within 12 nm of the nearest land, in compliance with MARPOL 73/78 Annex II - Noxious Liquid Substances carried in Bulk.
7.13.5 Predicted Outcome

By adhering to the waste management measures described in the DMP (Appendix A), the generation of waste will be minimised and there will not be a significant adverse impact on the health, welfare and amenity of people, the environment and land uses in the Port Hedland area.

7.14 DMMA Land Use Management

7.14.1 Overview

At the completion of the Project, temporary infrastructure (such as pipelines) and DMMA areas associated with the Project will be decommissioned. A degree of flexibility with respect to the ongoing management of the DMMAs and the corridors developed to support the DMMA use, following the completion of the dredging and reclamation activities is required so that the actual final land use can be optimised as necessary.

While the final land use of the DMMAs and the corridors has not yet been determined, the following options have been identified as potential uses:

- Reclamation and re-use of the dredge material within the DMMA;
- Development of the DMMA areas into future port facilities (e.g. material handling, stockpiling and ship loading facilities); and
- Rehabilitation of the DMMAs to provide stable and functioning landforms that are consistent with the surrounding landscape and other environmental values.

Following completion of the dredging program the project DMMAs will be made stable to ensure any emissions to air or water are minimised and within acceptable limits. If the DMMAs and corridors are not re-used or developed within five years of completion of the dredging program, the PHPA will rehabilitate these areas.

Any further development or re-use of the DMMAs (e.g. into future port facilities) will be subject to separate environmental impact assessment and, where applicable, regulatory approvals (including Environmental Protection Act 1986 approvals).

7.14.2 Objectives, Applicable Standards and Guidelines

The EPAs objectives regarding the land-use of DMMAs are to:

- Reduce potential visual impacts associated with the Project and its activities on the local communities and key users of the Project Area; and
• Ensure, as far as is practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.

Applicable legislation and guidelines include:

• EPA Guidance Statement No. 6: Rehabilitation of Terrestrial Ecosystems (EPA 2006); and
• EPA Position Statement No. 7: Principles of Environmental Protection (EPA 2004a).

7.14.3 Potential Impacts

Potential impacts associated with the DMMAs and corridors in the period between the transfer of dredge material and subsequent re-use, development or rehabilitation include:

• Potential increases in dust generation from DMMAs following completion of dredging;
• Introduction and establishment of weed species; and
• Modification of the landform resulting in altered local drainage which could lead to erosion and adjacent vegetation damage.

Potential impacts associated with the rehabilitation phase of the DMMAs and corridors include:

• Potential increases in dust generation from the DMMAs due to failure to establish a stable soil surface and/or effective vegetative cover;
• Introduction and establishment of weed species;
• Long-term visual impacts associated with failure to re-establish vegetative cover; and
• Changes in surface water flows and soil stability which could lead to erosion and adjacent vegetation damage.

7.14.4 Management and Mitigation Measures

To enable a degree of flexibility with respect to the management of the DMMAs and corridors following the completion of the dredging activities, management measures are proposed for an interim state following dredging and a longer term (post five years) rehabilitated state.

Short-term (up to five years post dredging, prior to re-use, development or rehabilitation):

• The DMMA surface will be stable so that dust generation from wind erosion is kept within acceptable limits. This is likely to be naturally achieved through the development a salt crust and if not, dust suppression techniques will be utilised as required;
• Surface water run-off from the DMMAs will be contained where appropriate and discharge controlled such that there are no significant, physical off-site impacts;
• Public access will be restricted and adequate signage and notification installed such that members of the general public could not inadvertently gain access to unsafe areas; and
• Declared Weeds and significant environmental weeds will be controlled (including regular inspection and treatment).

Long-term (greater than five years post dredging), if decision is made to rehabilitate (and not re-use or develop):

• Surface water run-off from the DMMAs will be contained where appropriate and discharge controlled such that there is no significant, physical off-site impacts;
• The external batters of the DMMAs will be intercepted by tidal flows intermittently and may periodically receive large storm surge flows. Rock armour will be placed on exposed wall surfaces to manage potential erosion impacts from intermittent tidal influence;
• Public access will be restricted and adequate signage and notification installed such that members of the general public could not inadvertently gain access to unsafe areas;
• Declared Weeds and significant environmental weeds will be controlled (including regular inspection and treatment);
• The surfaces of the DMMA will be rehabilitated using methods to be determined with key stakeholders at the time of rehabilitation. Initially following dredging, the dredged material is likely to be unsuitable for the establishment of vegetation due to high salt levels. Natural rainfall infiltration processes will assist the flushing of salts from the surface of the dredged material. Surface water will be collected and retained in settlement ponds within each DMMA to aid the natural salt flushing processes;
• Structural integrity of the DMMAs will be maintained during cyclonic rainfall events by maintaining a combination of suitable internal wall height free-board above the stored dredge material, combined with a suitably sized stormwater emergency overflow structure and suitable engineering design of the tidal intercept zone.; and
• A long-term systems-based monitoring approach will be used to track the trajectory of rehabilitated areas towards self-sustaining status.

Following cessation of dredging and reclamation activities, PHPA will implement a monitoring programme to evaluate the management of the DMMA and assess the effectiveness of management measures. The proposed monitoring is presented within the DMP (Appendix A) and broadly comprises the following:

• Visual inspection of wind-born dust during high wind periods;
• Surface water quality at points where surface water discharges from the DMMAs;
• Public safety;
• Rehabilitation performance, including weeds; and
• Stability of landforms.
7.14.5 Predicted Outcome

Through the preparation and implementation of the above management measures PHPA will ensure, as far as is practicable, that the DMMAs and corridors will achieve a stable and functioning landform consistent with the surrounding landscape and other environmental values.

7.15 Cultural Heritage

7.15.1 Overview

The proposed dredging activities are located within the Kariyarra native title claim area. MPL manages the conduct of Aboriginal heritage surveys for the Marapikurrinya family group on behalf of the Kariyarra native title claimants for the Port Hedland. On 30 May 2008 PHPA entered into an agreement with MPL that allows for a period of consultation by PHPA with MPL regarding any proposal to lodge a Section 18 Notice under the Aboriginal Heritage Act 1972.

A cultural heritage survey of the dredging area (excluding land and mangroves), undertaken in July 2010, identified one registered Aboriginal heritage site; site ID 22874 - Marapikurrinya Yintha. The Marapikurrinya Consultants undertook a Cultural Significance Assessment of this site and explained that they believe the kata katarra (the serpent) is present in the Port Hedland Harbour. Therefore, the waterways of Port Hedland Harbour are of high cultural significance to the Marapikurrinya Consultants and they do not support the proposed works in South West Creek.

Plans for cultural heritage surveys of DMMA B-North and DMMA G are underway, with the intention to submit a Section 18 Notice for the disturbance of any sites in the construction footprint.

On 20 August 2010 the PHPA lodged a notice under Section 18 with the DIA seeking to dredge areas of the inner harbour to enable construction and operation of additional berths and ship loading facilities in South West Creek. They are currently awaiting a decision. PHPA and FMG received Ministerial Consent for a Section 18 on 29 October 2009 to dredge areas of South West Creek covering approximately 95% of the water (by area) of the most recent application.

Fortescue has a whole of claim Land Access Agreement with the registered native title claimants over the Port Hedland area, the Kariyarra People. Fortescue and the Kariyarra people signed this agreement in 2005. The Land Access Agreement includes comprehensive provisions about the way that Fortescue and the Kariyarra People manage heritage. Fortescue conducts all heritage surveys and consultation over heritage issues in the Port with through the Kariyarra Native Title Claim in accordance with the Land Access Agreement.

Fortescue consulted with the Kariyarra People over the granting of a Section 18 application for the area of the South West Creek. Fortescue will continue to manage its operations in the Port Hedland
harbour in accordance with the *Aboriginal Heritage Act* 1972, the Land Access Agreement and the conditions of consent attached to any Ministerial approvals to impact heritage sites in the area.

### 7.15.2 Objectives, Applicable Standards and Guidelines

The Project’s objective is to comply with the *Aboriginal Heritage Act* 1972 and where practicable, to avoid or prevent adverse effects on the Project Area’s cultural associations due to Project-related changes to the biological and physical environment.

The Project and its operations must abide by the following legislation and guidance in relation to the use and construction on Native Title land:

- *Aboriginal Heritage Act* 1972;
- *Environmental Protection Act* 1986; and

### 7.15.3 Potential Impact

Potential impacts on cultural heritage that may arise from the Project’s operations include:

- Impacts on cultural associations to the site and surrounding areas;
- Loss/disturbance of culturally significant sites during construction;
- Restricted access to South West Creek for the *Kariyarra* people; and
- Unintentional disturbance of cultural heritage sites due to insufficient cultural heritage surveys of the terrestrial land to be disturbed during dredging and construction (e.g. DMMAs).

One registered Aboriginal heritage site was identified in the dredge area and disturbance of this site cannot be avoided. DMMA B-North, DMMA G and the land and mangroves in the dredge footprint have not yet been surveyed, but are likely to contain archaeological sites given the number of sites found in nearby areas (BHP Billiton 2009a).

### 7.15.4 Management and Mitigation Measures

PHPA have examined alternatives to the proposed construction of Berths located in South West Creek and associated dredging operations (see Section 2.4). However, no alternative options located outside of the registered Aboriginal site ID 22874 (*Marapikurrinya Yintha*) were considered to be viable.

PHPA will continue to consult with the MPL regarding the development of the Project on a regular basis, including half-yearly meetings. PHPA shall also allow at least two MPL consultants to be present when ground disturbing activity is occurring in order to monitor impacts on cultural values.
PHPA will provide the Kariyarra people with a continued right of access within registered Aboriginal site ID 22874 *(Marapikurrinya Yintha)*, where practical for health and safety reasons, in order to pursue and maintain their native title rights and interests including fishing, hunting and maintaining their sites and objects.

Aboriginal heritage surveys of DMMA B-North and DMMA G are currently underway with MPL and heritage surveys of the land and mangroves in the dredge footprint shall be undertaken prior to disturbance. If Aboriginal heritage sites are identified, a Cultural Heritage Management Plan shall be developed to help minimise disturbance to these sites.

On 20 August 2010 the PHPA lodged a notice under Section 18 with the DIA seeking to dredge areas of the inner harbour to enable construction and operation of additional berths and ship loading facilities in South West Creek. They are currently awaiting a decision. PHPA and FMG received Ministerial Consent for a Section 18 on 29 October 2009 to dredge areas of South West Creek covering approximately 95% of the water (by area) of the most recent application.

**7.15.5 Predicted Outcome**

PHPA is committed to ongoing consultation with the MPL and commits to developing the project in accordance with the requirements of the *Aboriginal Heritage Act 1972*. 
8. ENVIRONMENTAL MANAGEMENT COMMITMENTS

Table 8-1 presents a compilation of the environmental management commitments for the South West Creek Dredging and Reclamation Project.

*Table 8-1  Project Environmental Management Commitments*

<table>
<thead>
<tr>
<th>No</th>
<th>Environmental Factor</th>
<th>Commitment</th>
<th>Responsibility</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Quality and BPPH (mangroves and other BPPH)</td>
<td>Use of suitable dredging plant and equipment to minimise turbidity, including well maintained floating pipelines to be utilised to minimise leakage of turbid water during pumping of material to the DMMAs.</td>
<td>Dredge Contractor</td>
<td>During dredging</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Installation of a satellite based vessel monitoring system on the dredge, allowing a track plot analysis to ensure maximum efficiency of the dredging effort and that no dredging occurs outside the required areas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Maintaining calibration of the hydrographic survey systems onboard the dredge.</td>
<td>Dredge Contractor</td>
<td>During dredging</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Monitoring of weather and sea conditions.</td>
<td>Dredge Contractor</td>
<td>During dredging</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Implementation of the Tiered Monitoring Framework following a water quality trigger breach.</td>
<td>PHPA</td>
<td>During dredging</td>
</tr>
<tr>
<td>6</td>
<td>Water Quality and BPPH (mangroves and other BPPH)</td>
<td>Maximise the residence time in the reclamation area to reduce the turbidity plume of the tailwater discharge. Suitable controls (e.g. weir boxes) will be used at the discharge point to control the water level and the rate of discharge.</td>
<td>Shore Based Contractor</td>
<td>Prior to and during onshore disposal</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Cease dewatering or move tailwater within reclamation cells when turbidity is excessive.</td>
<td>Shore Based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Regular inspection and maintenance of erosion and sediment control structures particularly following heavy or prolonged rainfall.</td>
<td>Shore Based Contractor</td>
<td>During Onshore Disposal</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Stabilise uncovered areas of soil promptly.</td>
<td>Shore Based Contractor</td>
<td>During Onshore Disposal</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Install scour protection measures such as gabions where scouring is likely to occur.</td>
<td>Shore Based Contractor</td>
<td>Prior to and during onshore disposal</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Implementation of the Routine Water Quality Monitoring Program.</td>
<td>PHPA</td>
<td>Prior to, during and post dredging</td>
</tr>
<tr>
<td>No</td>
<td>Environmental Factor</td>
<td>Commitment</td>
<td>Responsibility</td>
<td>Timing</td>
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<tr>
<td>12</td>
<td></td>
<td>Implementation of the Routine Surface Sediment Profiling Monitoring Program.</td>
<td>PHPA</td>
<td>Prior to dredging and ongoing during onshore disposal</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Undertake the Reactive Coral Health Investigation and Reactive Mangrove Health Monitoring Program.</td>
<td>PHPA</td>
<td>On exceedance of water quality/sedimentation trigger levels</td>
</tr>
<tr>
<td>14</td>
<td>Marine Fauna</td>
<td>Delineation of clearance boundaries through the use of flagging or other suitable techniques prior to site clearing activities to avoid unnecessary disturbance of mangroves.</td>
<td>PHPA</td>
<td>Prior to commencement of dredging</td>
</tr>
<tr>
<td>15</td>
<td>Marine Fauna</td>
<td>Procedures for marine fauna interaction (including turtles and cetaceans) shall be developed for vessels to reduce the potential impacts to marine fauna. All work-site personnel shall be inducted regarding the proper response to fauna interaction (including unexpected encounters).</td>
<td>PHPA</td>
<td>Prior to commencement of dredging</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Before commencement of dredging operations and offshore spoil disposal, a 15 minute visual inspection of the monitoring zone using binoculars from a high observation platform on the vessel must be undertaken by a person trained in faunal observation and distance estimation.</td>
<td>Dredge Contractor</td>
<td>Prior to commencement of dredging</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Where turtles, dugongs or cetaceans are observed within a 150 m radius of the dredge and are likely to be injured due to dredging, dredging must not commence until all individuals are observed to move outside the monitoring zone or have not been sighted for 20 minutes, or the dredge is to move to another area of the dredge site to maintain a minimum distance of 300 m between the dredger and any marine species.</td>
<td>Dredge Contractor</td>
<td>During Dredging and disposal</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Where turtles, dugong or cetaceans are observed within a 500 m radius of the hopper barge at Spoil Ground I, disposal of dredge material must not commence until all individuals are observed to move outside the monitoring zone of have not been sighted for 20 minutes, or the dredge is to move to another area of the dredge site to maintain a minimum distance of 300 m between the dredger and any marine species.</td>
<td>Dredge Contractor</td>
<td>During Dredging and disposal</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>The construction workforce and all vessels will be limited to designated areas. Recreational boating, fishing, diving, spear-fishing, fossicking, (i.e. collecting shells and any other biological or natural material e.g. animal’s bones), will be prohibited from designated construction areas during the Project.</td>
<td>Dredge Contractor</td>
<td>Prior to commencement of dredging and during dredging</td>
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<tr>
<td>No</td>
<td>Environmental Factor</td>
<td>Commitment</td>
<td>Responsibility</td>
<td>Timing</td>
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<tr>
<td>20</td>
<td></td>
<td>Equipment and vessels shall operate in accordance with appropriate industry and equipment standards including specifications for noise levels. Regular maintenance will be conducted to the manufacturer’s specifications. Equipment covers, mufflers and other noise suppression equipment shall also be maintained and in good working order at all times.</td>
<td>Shore Based and Dredge contractor</td>
<td>During Dredging and disposal</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Dredging activities will be ceased if a significant marine mammal or reptile is sighted within the ‘monitoring zone’ of 150 m radius around the dredge and 500 m around the hopper barge at Spoil Ground I. The monitoring zone is defined as a 150 m radius around the backacter dredge and CSD and a 500 m radius around the hopper barge at Spoil Ground I.</td>
<td>Dredge Contractor</td>
<td>During Dredging and disposal</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>The use of thrusters and excessively noisy equipment will be avoided wherever practicable and engines, thrusters and auxiliary plant will not be left in ‘stand by’ or ‘running’ mode unnecessarily.</td>
<td>Dredge Contractor</td>
<td>During Dredging and disposal</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>Where practicable, vessel loading and unloading in nearshore areas shall be conducted during daylight hours. Where this is not practicable, artificial lighting shall be reduced to the minimum required for safe operations.</td>
<td>Dredge contractor</td>
<td>During Dredging</td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>Outside artificial lighting on vessels will be kept to a minimum (i.e. navigational lights and where safety dictates necessary deck lighting). Lighting should be switched off when not in use and automatic timers/sensors installed where possible. Only necessary artificial lights shall be used. ‘Unnecessary lighting’ includes lighting in unused areas, decorative lighting or lighting that is brighter than needed.</td>
<td>Dredge contractor Shore Based Contractor</td>
<td>During Dredging and disposal onshore disposal</td>
</tr>
<tr>
<td>25</td>
<td>Introduced Marine Pests</td>
<td>PHPA’s Marine Oil Pollution Management Plan will be implemented and emergency spill response capability will be provided to reduce the chance of a hydrocarbon spill to the marine environment.</td>
<td>Shore Based Contractor</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>Water quality monitoring and management will be implemented in accordance with the DMP (Appendix A) to mitigate impacts to marine fauna from high TSS concentration in DMMMA return waters.</td>
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<tr>
<td>27</td>
<td></td>
<td>Robust risk assessment to help predict and mitigate any risk before it occurs. Preventative measures including understanding the pathways through which introductions take place. Comply with AQIS (Australian Quarantine Inspection Service) requirements, State and Federal legislation and particular provisions presented in the ARI document for dredges. Rigorous targeted monitoring to facilitate early detection. Timely eradication or containment measures.</td>
<td>Dredge Contractor</td>
<td>Prior to dredging</td>
</tr>
<tr>
<td>28</td>
<td></td>
<td>Any vessels coming to Port Hedland for the project from overseas or domestically that carry ballast or entrained water are required to have the risk status of that water assessed, considering the location of uptake and time of year, and to manage the water in accordance with the requirements of the National System for the Prevention and Management of Marine Pest Incursions, if it is deemed to be high risk.</td>
<td>Dredge Contractor</td>
<td>Prior to dredging</td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>Any vessels coming to Port Hedland for the project from overseas or domestically should be subject to a biofouling risk assessment following guidance within the National Biofouling Management Guidance for Non-Trading Vessels</td>
<td>Dredge Contractor</td>
<td>Prior to dredging</td>
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<tr>
<td>No</td>
<td>Environmental Factor</td>
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<td>30</td>
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<td>document. Vessels assessed as posing a risk should be inspected to ensure they are free of biofouling and preferably dry-docked for cleaning and repair/renewal of the antifouling system immediately prior to departure for Australia.</td>
<td>Contractor</td>
<td>dredging</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>All areas where mud and sediments can collect, including anchor and chain lockers and hoppers, should be inspected and cleaned prior to a vessel’s departure for Port Hedland. Anchor chains, cables, and other gear that has been deployed overboard should also be inspected and cleaned of any attached or entangled marine growth. These procedures should be repeated prior to departure from Port Hedland to prevent translocation of species away from this region.</td>
<td>Dredge Contractor</td>
<td>Prior to and after completion of dredging</td>
</tr>
<tr>
<td>32</td>
<td>Hydrocarbon Management</td>
<td>Internal seawater systems on any vessels coming to Port Hedland for the project from overseas or high risk Australia locations should be inspected for the presence of biofouling and mitigation measures undertaken before departure to prevent the translocation of any biofouling IMS Seawater tanks, wells etc should be drained, cleaned and dried, or filled with freshwater before arrival.</td>
<td>Shore based and Dredge Contractor</td>
<td>During Dredging and Disposal</td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>Hydrocarbon spills will be managed in accordance with the requirements of PHPA’s Marine Oil Pollution Management Plan.</td>
<td>Shore Based and Dredge Contractor</td>
<td>During Onshore disposal</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>Dredge vessels: tanks and machinery shall be equipped with measurement and overflow protection (i.e. flow and level meters, relief valves, overflow protection valves and emergency shut-off).</td>
<td>Dredge Contractor</td>
<td>Prior to and during Dredging</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>Industry standards, port authority and pollution prevention regulations shall be adhered to during: • Refuelling; • Transfer; • Storage; and • Handling of hazardous materials (e.g. bunding, level gauges, overflow protection, drainage systems and hardstands).</td>
<td>Shore based and Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td>Volumes of stored fuels and chemicals will be limited to day-use. Use of appropriately licensed mini-tankers for refuelling.</td>
<td>Shore based and Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>37</td>
<td></td>
<td>Hydrocarbons (including hydrocarbon wastes) shall be stored in appropriately labelled drums or tanks and in bunded areas that can contain 110% of material stored within.</td>
<td>Shore based and Dredge Contractor</td>
<td>Throughout life of Project</td>
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<tr>
<td>No</td>
<td>Environmental Factor</td>
<td>Commitment</td>
<td>Responsibility</td>
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<td>38</td>
<td></td>
<td>Equipment will be designed and operated to prevent spills and leaks through the provision of in-built safeguards such as relief valves, overflow protection, and automatic and manual shut-down systems.</td>
<td>Shore based and Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
</tbody>
</table>
| 39 |                      | Establish comprehensive vessel refuelling procedures to avoid or reduce the possibility of a release include as a minimum the requirements for:  
  - adhering to all port authority and pollution regulations;  
  - refuelling during daylight hours where possible, depending on sea conditions;  
  - refuelling within established safety boundaries and during weather/sea/visibility conditions that will minimise potential release risk;  
  - training personnel involved with refuelling or fuel transfer in their roles, functions and responsibility, including emergency response;  
  - maintaining open communication channels;  
  - deploying spill prevention systems in accordance with established procedures and regulatory requirements; and  
  - maintaining emergency response equipment to ensure that it is readily available. | Shore based and Dredge Contractor | Throughout life of Project |
<p>| 40 |                      | All spills to land &gt;10 L will be communicated to the Environmental Superintendent. An incident report will be completed by the Shore based Contractor and submitted to PHPA’s Project Manager. | Shore based Contractor | Immediately following a spill |
| 41 |                      | All personnel will be familiar with the use of oil spill clean up kits and dispose of waste in the prescribed manner. | Shore based Contractor and Dredge Contractor | Ongoing during dredging and disposal |
| 42 |                      | Controlled wastes shall be managed as per the Environmental Protection (Controlled Waste) Regulations 2004 (WA). | Shore based Contractor and Dredge Contractor | Throughout life of Project |
| 43 |                      | Chemicals carried in packaged, solid or bulk form will comply with the regulations of Part A of SOLAS Chapter VII and the IMDG Code regarding the classification, packing, marking, labelling and placarding, documentation, stowage, handling and emergency response action of dangerous goods. | Dredge Contractor | Throughout life of Project |
| 44 | Waste Management     | All waste designated as hazardous/dangerous requiring disposal shall be packaged, stored and transported in accordance with IMDG (International Maritime Dangerous Goods) requirements. Vessel documentation shall include Material Safety Data Sheets (MSDS’) for each substance carried. | Dredge Contractor | Throughout life of Project |</p>
<table>
<thead>
<tr>
<th>No</th>
<th>Environmental Factor</th>
<th>Commitment</th>
<th>Responsibility</th>
<th>Timing</th>
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</thead>
<tbody>
<tr>
<td>45</td>
<td></td>
<td>All vessels will comply with the compulsory insurance and insurance certificate requirements of the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances (HNS) by Sea 1996.</td>
<td>Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>46</td>
<td></td>
<td>Vessels of 24 m or more in length but less than 400 gross tonnage engaged in international voyages will carry a Declaration on Antifouling Systems (prohibiting the use of harmful organotins in antifouling paints) in compliance with the International Convention on the Control of Harmful Antifouling Systems on Ships.</td>
<td>Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>47</td>
<td></td>
<td>All sewage and grey water treatment systems shall be frequently checked, maintained and monitored to ensure systems are efficient, fully operational and discharging treated water in accordance with MARPOL 73/78 Convention Annex IV (sewage) and Annex V (garbage).</td>
<td>Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>48</td>
<td></td>
<td>No residues containing noxious substances will be discharged within 12 nm of the nearest land, in compliance with MARPOL 73/78 Convention Annex II..</td>
<td>Dredge Contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>49</td>
<td></td>
<td>Waste management requirements shall be communicated to personnel (i.e. through inductions, pre-starts and/or Job Hazard Analyses (JHAs)).</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>Communion systems on vessels shall be capable of handling the volumes generated and maintained regularly so they efficient and fully operational at all times.</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>51</td>
<td></td>
<td>Solid and liquid wastes and hazardous materials shall be stored in appropriately labelled drums or tanks.</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>52</td>
<td></td>
<td>Hazardous substances handling is to be carried out by suitably trained personnel only.</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>53</td>
<td></td>
<td>Hazardous material storage areas shall be engineered and designed to handle the volumes and operating conditions (both normal and upset conditions) specifically required for each substance, including product identification, transportation, storage, control and loss prevention (e.g. bunding and drainage).</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>54</td>
<td></td>
<td>Incompatible products will not be stored together.</td>
<td>Dredge</td>
<td>Throughout life</td>
</tr>
<tr>
<td>No</td>
<td>Environmental Factor</td>
<td>Commitment</td>
<td>Responsibility</td>
<td>Timing</td>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td>55</td>
<td></td>
<td>Empty liquid waste containers shall be segregated from other wastes and stored in designated areas.</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>56</td>
<td></td>
<td>Incidents of waste entering the marine environment to PHPA as soon as possible (but within 48 hours) and implement appropriate clean up procedures.</td>
<td>Dredge Contractor and Shore based contractor</td>
<td>Throughout life of Project</td>
</tr>
<tr>
<td>57</td>
<td>Onshore Dredge Material Management</td>
<td>Material proposed for use for the construction of the earth bunds surrounding the DMMAs will not be sourced unless a detailed soil assessment is conducted and the proposed material does not contain PASS.</td>
<td>PHPA</td>
<td>Prior to bund construction</td>
</tr>
<tr>
<td>58</td>
<td></td>
<td>Monitoring of the DMMA discharge to ensure it meets the action criteria outlined in Dewatering Effluent and Groundwater Monitoring Guidance For Acid Sulfate Soil Areas (DEC 2006b). Total Titratable Acidity (TTA), Electrical Conductivity (EC) and pH will be monitored weekly to ensure that water quality parameters are maintained at a pH &gt; 6 and a TTA &lt; 40 mg/L.</td>
<td>PHPA</td>
<td>During DMMA development and onshore disposal</td>
</tr>
<tr>
<td>59</td>
<td></td>
<td>Regular watering of unsealed roads, exposed surfaces, active construction areas and stockpiles.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>Restriction of vehicle movements and vehicle speeds to reduce dust emissions and impacts to terrestrial fauna.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>61</td>
<td></td>
<td>Use of environmentally safe dust suppressants.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>62</td>
<td></td>
<td>General housekeeping practices to ensure that there is no accumulation of waste materials within the construction site that may generate dust.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>63</td>
<td></td>
<td>Staff induction program to ensure all employees are made aware of the need to minimise dust generation.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>64</td>
<td></td>
<td>Reporting of any community complaints regarding dust levels.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>65</td>
<td></td>
<td>A noise management plan will be developed in order to undertake construction activities, in accordance with the Environmental Protection (Noise) Regulations 1997.</td>
<td>Shore based Contractor</td>
<td>Prior to commencement of Project</td>
</tr>
<tr>
<td>No</td>
<td>Environmental Factor</td>
<td>Commitment</td>
<td>Responsibility</td>
<td>Timing</td>
</tr>
<tr>
<td>----</td>
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</tr>
<tr>
<td>66</td>
<td></td>
<td>Construction activities to be managed according to weather conditions and proximity to noise sensitive areas to minimise impact or noise and vibration emissions.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>67</td>
<td></td>
<td>Regular monitoring and maintenance of plant and equipment so that it remains in good working condition and noise emissions are kept to a minimum.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>68</td>
<td></td>
<td>Use of appropriate design during construction of the DMMA B-North and G, including configuration, landforming of berms and localised use of vegetative screening where applicable. The DMMA G bund walls directly adjacent to Finucane Road will be partially vegetated using vegetation suitable to the characteristics of the area.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>69</td>
<td></td>
<td>Vegetation screening and landscaping to reduce visibility of the DMMA’s will be considered. The height of the DMMA’s will not exceed +12 m AHD.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>All equipment and vehicles shall be washed down prior to arrival to Project site areas in order to minimise the spread of weeds.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>71</td>
<td></td>
<td>Surface water run-off from the DMMAs will be contained where appropriate and discharge controlled such that there are no significant, physical off-site impacts.</td>
<td>Shore based Contractor</td>
<td>During onshore disposal</td>
</tr>
<tr>
<td>72</td>
<td></td>
<td>The external batters of the DMMA’s will be intercepted by tidal flows intermittently and may periodically receive large storm surge flows. Rock armour will be placed on exposed wall surfaces to manage potential erosion impacts from intermittent tidal influence.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73</td>
<td></td>
<td>Public access will be restricted and adequate signage and notification installed such that members of the general public could not inadvertently gain access to unsafe areas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>74</td>
<td></td>
<td>The surfaces of the DMMA will be rehabilitated using methods to be determined with key stakeholders at the time of rehabilitation. Initially following dredging, the dredged material is likely to be unsuitable for the establishment of vegetation due to high salt levels. Natural rainfall infiltration processes will assist the flushing of slats from the surface of the dredged material. Surface water will be collected and retained in settlement ponds within each DMMA to aid the natural salt flushing processes.</td>
<td></td>
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</tr>
<tr>
<td>75</td>
<td></td>
<td>Structural integrity of the DMMA’s will be maintained during cyclonic rainfall events by maintaining a combination of suitable internal wall height free-board above the stored dredge material, combined with a suitably sized stormwater emergency overflow structure and suitable engineering design of the tidal intercept zone.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>76</td>
<td></td>
<td>PASS material will be placed in barges and kept saturated during transport and disposal. The material will be kept saturated by placing seawater over the material using the dredging equipment or the deck wash on the barges. The expected maximum time between dredging the materials and sea disposal will be less than 14 hours which is significantly less than the 70 hour limit recommended by DEC.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td></td>
<td>Provide the Kariyarra people with a continued right of access within registered Aboriginal site ID 22874 (Marapikurniya Yintha), where practical for health and safety reasons, in order to pursue and maintain their native</td>
<td>PHPA</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Environmental Factor</td>
<td>Commitment</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>title rights and interests including fishing, hunting and maintaining their sites and objects.</td>
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</tbody>
</table>
9. CONCLUSIONS

Port Hedland Port Authority considers that the Project, to support development of the Port and the creation of an additional eight berths, has been designed, and will be undertaken, in a manner that will minimise impacts on the surrounding biophysical and social environments.

The Project as described in this document has been developed to avoid, minimise, manage and mitigate environmental impacts. Some decisions which significantly reduce both environmental and social impacts are as follows:

- Design of the dredging footprint configuration to minimise the impact on sensitive habitats specifically mangroves, whilst allowing safe navigation of shipping vessels;
- Utilisation of results from planning studies to determine the location of the onshore DMMAs with an emphasis on avoiding disturbance to areas of high environmental value (such as mangroves) where possible;
- Disposal of PASS material offshore to ensure that ASS does not become an environmental legacy in the future; and
- Selection of Spoil Ground I as the preferred location for offshore disposal of dredged material due to factors including its existing use and the lack of benthic primary producer habitat within close proximity.

This document describes the impacts of the Project, and for each factor discusses the:

- objective for that factor;
- relevant guidance material;
- potential impacts;
- management of impacts; and
- outcome.

The key environmental factors were identified as:

- Marine Water Quality; and
- Mangroves.

The relevant environmental factors have been identified as:

- Coral Reef Communities;
- Other BPPH;
- Marine Fauna;
- Introduced Marine Pests;
- Coastal Processes;
- Potential Acid Sulfate Soils;
- Hydrology and Hydrogeology;
- Terrestrial Flora and Fauna;
- Dust;
- Noise;
- Visual Amenity;
- Hydrocarbons and Chemicals;
- Waste Management;
- DMMA Land Use Management; and
- Cultural Heritage.

PHPA is committed to minimising environmental impacts where possible and will ensure all impacts are managed through the implementation of management plans. PHPA has developed a project specific Dredging Management Plan (Appendix A) to specifically address the environmental impacts associated with the environmental factors assessed within this ERD.

PHPA believes that for all factors assessed and with the management and mitigation measures outlined, the EPA’s objectives can be met and the Project’s impacts will be minimised.
10. **LIST OF ACRONYMS AND ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHD</td>
<td>Australian Height Datum</td>
</tr>
<tr>
<td>ALARP</td>
<td>As Low As Reasonably Practicable</td>
</tr>
<tr>
<td>ANC</td>
<td>Acid Neutralising Capacity</td>
</tr>
<tr>
<td>APASA</td>
<td>Asia-Pacific Applied Science Associates</td>
</tr>
<tr>
<td>API</td>
<td>Assessment on Proponent Information</td>
</tr>
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<td>AQIS</td>
<td>Australian Quarantine Inspection Services</td>
</tr>
<tr>
<td>ARI</td>
<td>Assessment on Referral Information</td>
</tr>
<tr>
<td>ASA</td>
<td>Applied Science Associates</td>
</tr>
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<td>ASS</td>
<td>Acid Sulfate Soils</td>
</tr>
<tr>
<td>AVS</td>
<td>Acid Volatile Sulphur</td>
</tr>
<tr>
<td>BHPBIO</td>
<td>BHP Billiton Iron Ore</td>
</tr>
<tr>
<td>BPP</td>
<td>Benthic Primary Producers</td>
</tr>
<tr>
<td>BPPH</td>
<td>Benthic Primary Producer Habitat</td>
</tr>
<tr>
<td>CD</td>
<td>Chart Datum</td>
</tr>
<tr>
<td>CDOM</td>
<td>Coloured Dissolved Organic Matter</td>
</tr>
<tr>
<td>CRIMP</td>
<td>CSIRO’s Centre for Research on Introduced Marine Pests</td>
</tr>
<tr>
<td>CSD</td>
<td>Cutter Suction Dredge</td>
</tr>
<tr>
<td>DEC</td>
<td>Department of Environment and Conservation</td>
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<tr>
<td>DMP</td>
<td>Dredge Management Plan</td>
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<tr>
<td>DIA</td>
<td>Department of Indigenous Affairs</td>
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<td>DMMA</td>
<td>Dredge Material Management Area</td>
</tr>
<tr>
<td>DOC</td>
<td>Dissolved Organic Carbon</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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</tr>
<tr>
<td>DPI</td>
<td>Department for Planning and Infrastructure</td>
</tr>
<tr>
<td>DRF</td>
<td>Declared Rare Flora</td>
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<tr>
<td>EC</td>
<td>Electrical Conductivity</td>
</tr>
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<td>EIL</td>
<td>Ecological Investigation Levels</td>
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<td>EPA</td>
<td>Environmental Protection Authority</td>
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<td>EP Act</td>
<td>Environmental Protection Act 1986</td>
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<td>EBPC Act</td>
<td>Environmental Protection and Biodiversity Conservation Act 1999</td>
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<td>EQOs</td>
<td>Environmental Quality Objectives</td>
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<td>ERD</td>
<td>Environmental Referral Document</td>
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<td>ESAs</td>
<td>Environmentally Sensitive Areas</td>
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<tr>
<td>EVs</td>
<td>Environmental Values</td>
</tr>
<tr>
<td>FMG</td>
<td>Fortescue Metals Group</td>
</tr>
<tr>
<td>HAT</td>
<td>Highest Astronomical Tide</td>
</tr>
<tr>
<td>IMP</td>
<td>Introduced marine pests</td>
</tr>
<tr>
<td>IMS</td>
<td>Introduced marine species</td>
</tr>
<tr>
<td>ISQG</td>
<td>Interim Sediment Quality Guidelines</td>
</tr>
<tr>
<td>LAT</td>
<td>Lowest Astronomical Tide</td>
</tr>
<tr>
<td>MPL</td>
<td>Marapikurrinya Pty Ltd</td>
</tr>
<tr>
<td>NAGD</td>
<td>National Assessment Guidelines for Dredging</td>
</tr>
<tr>
<td>NEPM</td>
<td>National Environmental Protection Measure</td>
</tr>
<tr>
<td>NIMPCG</td>
<td>National Introduced Marine Pests Coordination Group</td>
</tr>
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<td>NASS</td>
<td>Non-Acid Sulfate Soil</td>
</tr>
<tr>
<td>N-PASS</td>
<td>Non-Potential Acid Sulfate Soils</td>
</tr>
<tr>
<td>NTU</td>
<td>Nephelometric Turbidity Units</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>NWIOA</td>
<td>North West Iron Ore Alliance</td>
</tr>
<tr>
<td>OEPA</td>
<td>Office of the Environmental Protection Authority</td>
</tr>
<tr>
<td>PAH</td>
<td>Polyaromatic Cyclic Hydrocarbons</td>
</tr>
<tr>
<td>PHPA</td>
<td>Port Hedland Port Authority</td>
</tr>
<tr>
<td>PASS</td>
<td>Potential Acid Sulfate Soils</td>
</tr>
<tr>
<td>PECs</td>
<td>Priority Ecological Communities</td>
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<td>RHI</td>
<td>Roy Hill Infrastructure</td>
</tr>
<tr>
<td>SAP</td>
<td>Sampling and Analysis Plan</td>
</tr>
<tr>
<td>DSEWPaC</td>
<td>Department of Sustainability, Environment, Water, Pollution and Communities</td>
</tr>
<tr>
<td>SCr</td>
<td>Chromium Reducible Sulphur</td>
</tr>
<tr>
<td>SGI</td>
<td>Spoil Ground I</td>
</tr>
<tr>
<td>SPOCAS</td>
<td>Suspension Peroxide Oxidation Combined Acidity and Sulfate</td>
</tr>
<tr>
<td>SRE</td>
<td>Short Range Endemic Fauna</td>
</tr>
<tr>
<td>TBT</td>
<td>Tributyltin</td>
</tr>
<tr>
<td>TECs</td>
<td>Threatened Ecological Communities</td>
</tr>
<tr>
<td>TOC</td>
<td>Total Organic Carbon</td>
</tr>
<tr>
<td>ToPH</td>
<td>Town of Port Hedland</td>
</tr>
<tr>
<td>TSP</td>
<td>Total Suspended Particulates</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>TTA</td>
<td>Total Titratable Acidity</td>
</tr>
<tr>
<td>TTS</td>
<td>Temporary Threshold Shift</td>
</tr>
<tr>
<td>UCL</td>
<td>Upper Confidence Limit</td>
</tr>
<tr>
<td>UDP</td>
<td>Port Planning Study and Ultimate Development Plan for Port Hedland</td>
</tr>
<tr>
<td>WAPC</td>
<td>Western Australian Planning Commission</td>
</tr>
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</table>
11. REFERENCES


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Appendix A

Dredge Management Plan
Appendix B

Baseline Water Quality Survey (WP)
Appendix C

Sediment characteristics for onshore disposal
Appendix D

BPPH survey report (Worley Parsons)
Appendix E

Mangrove survey report (Worley Parsons)
Appendix F

EPBC search
Appendix G

Marine Pest Species report (Oceanica)
Appendix H

Terrestrial Flora and Fauna report from DMMA G and B North (ENV)
Appendix I

South West Creek Dredge and Onshore Disposal Numerical Model Report (Cardno)