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DAMPIER PORT AUTHORITY

Dampier Marine Services Facility

Assessment on Proponent Information

301012-01121

14-Mar-11

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EcoNomics™

[1] This document was originally submitted on 24 December 2009 as an Assessment on Referral Information (ARI). Following the implementation of the EPA's Environmental Impact Assessment Administrative Procedures 2010, this level of assessment is now identified as a Assessment on Proponent Information (API). The text of this document has been changed throughout to reflect this minor procedural change.

EXECUTIVE SUMMARY

The Dampier Port Authority is seeking approval under the State EP Act to undertake construction within the Dampier Port, adjacent to existing facilities. The proposal will involve dredging, land reclamation and the construction of a new jetty. Some terrestrial disturbance will be associated with the construction of access tracks around the reclamation area.

Capital dredging will be undertaken to remove 2.2 million m^3 parent sediments from the seafloor, thus providing safe depth for 65,000 DWT vessels to manoeuvre and berth. No new access channel, or increases to this channel width or depth are proposed.

The dredged sediment will be used to create a land reclamation area, forming a new land-backed wharf with a footprint of 22 hectares. Dredged material will be pumped directly from the dredge to the reclamation area via a cutter suction dredge. An outer bund wall will contain the reclamation area, which will be topped with road-base material in general laydown areas and an impervious surface (concrete and/or asphalt) within the roadways and on the heavy-load out facility.

A new jetty is also proposed, which will extend 300m north from the new land-backed wharf. Piling will be required to install the foundations of the jetty.

There are three principal drivers for the proposal. These are:

a) Age of existing infrastructure: The current facility will reach the end of its design life in 2021, and is currently experiencing elevated maintenance costs to maintain an operational state.

b) Market demand: the current facility is reaching full capacity and has limited ability to deal with increases in the size of incoming vessels. Industry standard is that 100% of practical berth capacity is reached when berth occupancy reaches 60%. This is because shipping is waiting to get onto a berth for significantly longer periods, and incurring demurrage costs that exceed wharfage costs. The current wait-time to get into the DCW is between 8 and 14 days. Current market demand to support the offshore oil and gas industry is for 90m+ vessels.

c) Additional Laydown area: wharf facilities only work efficiently where there is associated area for laydown and storage of equipment coming on and off vessels. This allows surge capacity to load and unload vessels quickly and reduce turnaround times, while the freight task of moving goods to a long-term storage or final destination can run independently. Currently DPA has less than 3 hectares of laydown area, which is 100% occupied.

The DPA has undertaken a wide variety of options assessment studies in the region, providing the basis for design detailed in the sections below. These studies include:

- Review of the Dampier Port Land Use Planning (Department of Resource Development 1989)

- Port of Dampier Development Study (Halpern Glick Maunsell 1989)
- Development Option Study (Port and Harbour Consultants 1996)
- Port of Dampier Development Strategy and Capacity Study (Halpern Glick Maunsell 1997)
- Berth Operability Assessment, Proposed Land Backed Wharf (WorleyParsons 2004)
- Concept Design of a Short Term General Cargo Wharf and Procurement of Design and Construction Services Options Study Report (WorleyParsons 2007)
- Dampier Port, General Cargo Wharf, Business Case (Evans and Peck 2007)

The key points of the final design are outlined below:

a) Construction can be undertaken while the existing Dampier Cargo Wharf (DCW) is operational, ensuring safety and minimal disruption;

b) The amount of required dredging is balanced with the land development area to allow the reuse of all material without requiring sea disposal;

c) The wharf is north-facing to minimise shut-down periods due to vessel movement during loading and unloading; and

d) The proposed location is between existing developments (the Dampier Cargo Wharf and Dampier Bulk Liquids Berth) and current developments (Woodside's Pluto Project), thereby consolidating projects and reducing the footprint along the Burrup Peninsula.

A photomontage of the proposed works is shown below. Stakeholder consultation has formed an integral role in the planning and design stages of the proposal. DPA has undertaken extensive consultation with representatives from local community groups, relevant local and state government bodies, local indigenous groups and neighbouring industry.

Early consultation with the Environmental Protection Authority and Services Unit (EPASU) has helped guide the ptroject and the speciliststudies undertaken. EPASU advice has been incorporated throughout this report.

This report has adopted a qualitative risk based approach to further identify and assess environmental impacts of the proposal. The environmental factors have been identified through existing studies, other published information and consultation with DEC, EPA, DoW and other stakeholders. The key environmental factors have been identified as:

1. Marine water quality; and

2. Marine habitat disturbance (corals).

The other environmental factors have been identified as:

1. Marine habitat disturbance (non-corals);
2. Megafauna;
3. Underwater noise;
4. Introduced marine organisms;
5. Disturbance to coastal processes;
6. Terrestrial flora and fauna;
7. Surface drainage;
8. Terrestrial noise;
9. Traffic;
10. Visual amenity;
11. Indigenous heritage;
12. Construction dust;
13. Waste management (solid and liquid);
14. Hydrocarbons; and
15. Hazardous wastes.

This document and its appendecies identifies all impacting processes and management and mitigation measures to bring impacts to an acceptable level. Accordingly, environment management strategies and commitments have been nominated throughout this document and its appendices.

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PROJECT 301012-01121 - DAMPIER MARINE SERVICES FACILITY

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for internal review	R Beaton R Beaton	H Houridis H Houridis	N/A	08-Dec-09	N/A	
0	Issued for use	R Beaton R Beaton	H Houridis H Houridis	P Mellor P Mellor	24-Dec-09	W Young W Young	
1	Issued for use	P Mellor	P Mellor	P Mellor	14-Mar-10	W Young	

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1. INTRODUCTION

1.1 Purpose

Dampier Port Authority (DPA) is proposing to construct and operate the Dampier Marine Services Facility (DMSF) (referred to from here on as “the proposal”) to serve as a centralised Port on the Burrup Peninsula for the loading and unloading of large vessels for major industry in the Pilbara region.

This document has been prepared as part of the formal referral of the DMSF proposal to the Environmental Protection Authority (EPA) for assessment under Section 38 of the *Environmental Protection Act 1986* (EP Act). This document has been prepared in accordance with referral guidelines and provides the key environmental information in relation to the proposal. A separate EPA referral Form has been completed for the proposal in which it is suggested that the appropriate level of assessment is an Assessment on Proponent Information (API). Advice received from the EPASU (Section 3.4.1) suggested a level of API was appropriate for this assessment.

The purpose of this document is three-fold:

a) To demonstrate that potential environmental impacts from both construction and operation of the proposed DMSF development, can be readily managed to meet the EPA’s environmental objectives;

b) To define DPA’s commitment as the proponent to manage the proposed DMSF development in an environmentally acceptable manner; and

c) To demonstrate that environmental impact of the proposed DMSF development will result in environmental impacts similar to or less than those already assessed by the EPA for other marine projects in the Pilbara Region , and as such can be readily managed to meet EPA’s objectives.

1.2 Scope

The scope of this document is to:

- Provide a description of the expanded facility, construction requirements and associated infrastructure proposed for the Dampier Marine Services Facility;

- Provide a summary description of the existing marine and terrestrial environments within the proposed footprint and area of influence predicted for the Dampier Marine Services Facility;

- Identify potential impacts associated with the proposal;
- Identify the extent of potential impacts; and
- Outline management strategies that will be applied to mitigate identified impacts.

1.3 Proposal Title

The title of the proposed project is: Dampier Marine Services Facility (DMSF).

The proponent is Dampier Port Authority (DPA), a state government owned corporation that operates under the *Port Authorities Act 1999*. Under this Act DPA facilitates trade and commerce within and through the port, and maintains several wharf and berth areas, shipping channels and swing basins within the Port.

Their office is located in Dampier, Western Australia:

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Further information on Dampier Port Authority can be found at their website, www.dpa.wa.gov.au.

1.4 Proposal Overview

The Dampier Port Authority (DPA) currently owns and operates the Dampier Cargo Wharf (DCW).

The DCW facility will reach the end of its design life in 2021, and is currently experiencing elevated maintenance costs to maintain its operational state. The facility is also experiencing problems with capacity, and demand is predicted to increase. Furthermore, the associated laydown area in the Port is beyond capacity, leading to a congested and inefficient work area.

DPA proposes to expand the current facilities (at DCW) to create a Dampier Marine Services Facility (DMSF). The proposed works will include:

- Capital dredging of 2.2 million m^3 to remove parent sediments from the seafloor adjoining the proposed extension of the existing cargo berth and new wharf area;
- A new land-backed wharf structure to create 17 hectares of reclaimed land, using all dredged sediment (as above) contained within an outer bund wall and topped with road-base material to provide laydown area for the Facility;
- Construction of a new 300m jetty extending from the land-backed wharf;
- Construction of a roll-on roll-off facility as part of the land-backed wharf; and
- Construction of a new access road.

The proposed project engineering design was developed using an Options Analysis undertaken by WorleyParsons (2007) and a series of design iterations that aimed to reduce environmental impact (discussed in Section 2.3). The final design has been independently reviewed by GHD (2009a).

1.5 Project Location

The Dampier Marine Services Facility will serve as an expansion to the existing Dampier Cargo Wharf on the western side of the Burrup Peninsula in the Pilbara region. A map is provided in Appendix 1.

1.6 Assessment Approach and Previous EPA advice

1.6.1 Overview

The EP Act is the principal statute that governs environmental protection in Western Australia. The EP Act is administered by the EPA, the Department of Environment and Conservation (DEC) and the Minister for the Environment.

Preliminary discussions and feedback held with the EPA indicated that an API level of assessment under the EP Act was likely for this proposal if the activities could be managed within the existing EPA policy framework. The API level of assessment is usually applied to proposed developments that raise one, or a small number of significant environmental factors which can be readily managed (EPA 2002a).

Existing information from other infrastructure developments in the region and nearby to the development has allowed potential environmental and social impacts to be well understood. Similar recent dredging projects involving dredging and reclamation have been assessed as an ARI (now changed to an API level of assessment) or lower level of assessment (Woodside Energy Limited 2007; BHPBIO 2008; FMG 2008; BHPBIO 2009).

Management and mitigation measures which have been used on previous developments in the area and the relative effectiveness of these measures are also well known.

An extensive literature review of existing reports and gap analysis of existing information for the area has been completed. In addition, extensive survey work of terrestrial flora, indigenous heritage, marine sediment quality, marine sediment acid sulfate soil potential, marine benthic habitat and a comparison of marine benthic habitat within a regional context has also been undertaken. This information, together with other social, heritage and engineering considerations, has been used to generate the final design.

1.6.2 Risk Based Approach

Biodiversity principles have been applied during the planning phase of the proposal to ensure that potential environmental impacts are identified and avoided as far as practicable. These principles form an integral part of the impact assessment approach outlined in this referral document and have been used to guide the preferred construction method and management of materials. A qualitative risk-based approach has been adopted to systematically determine the relevant environmental and social risks posed by the proposal. These risk factors have been identified through a review of existing information, findings of investigative studies and consultation with relevant stakeholders.

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

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

The key environmental factors identified for the proposal were:

- Marine water quality; and
- Marine habitat (corals).

Environmental factors, termed ‘other’ environmental factors, were determined to be non-key if they:

- had a moderate or low inherent risk to the environment if left unmanaged;

- required a less detailed assessment; and
- could be managed via existing controls and supporting procedures.

The other environmental factors for the proposal are:

- Other marine habitat (excluding corals);
- Marine megafauna;
- Light;
- Underwater noise;
- Introduced marine organisms;
- Disturbance to coastal processes;
- Terrestrial flora and fauna;
- Surface drainage;
- Terrestrial noise;
- Visual amenity;
- Indigenous heritage;
- Construction dust;
- Waste management (solid and liquid);
- Hydrocarbons; and
- Hazardous wastes.

The risk assessment approach applied to the proposal is outlined in Section 7. The residual risk associated with factors once management and mitigation strategies are applied is discussed in Sections 0 and 9. A Dredging and Reclamation Management Plan has been developed to address issues specifically related to dredging and reclamation, as presented in Appendix 2.

The proposed development is also subject to other state and Commonwealth legislation which have been listed in Section 1.7.

1.7 Applicable Legislation

Sections 1.7.1 and 1.7.2 provide a summary of the State and Commonwealth statutory requirements relating to the operation and development of the Dampier Port Authority and dredging and disposal of dredged material.

1.7.1 Commonwealth Legislation

Name: ***Environment Protection and Biodiversity Conservation Act 1999***

Overview: *The Commonwealth Environment Protection and Biodiversity Conservation Act, 1999*

(EPBC Act) applies to proposals that have, will have or would be likely to have a significant impact on one or more of the matters of national environmental significance specified in the Act. Proponents will be expected to consult with the Commonwealth DEWHA as required to determine what action(s), if any, would be necessary to meet the requirements of the EPBC Act. The EPA and DEWHA may consider undertaking a joint EIA for some dredging and dumping proposals. Proponents will be advised of decisions in this regard.

The objectives of this Act are:

e) To provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance; and

f) To promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and

g) To promote the conservation of biodiversity; and

h) To provide for the protection and conservation of heritage; and

i) To promote a co-operative approach to the protection and management of the environment involving governments, the community, land-holders and indigenous peoples; and

j) To assist in the co-operative implementation of Australia's international environmental responsibilities; and

k) To recognise the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity; and

l) To promote the use of indigenous peoples' knowledge of biodiversity with the involvement of, and in co-operation with, the owners of the knowledge.

1.7.2 State Legislation

Name: ***Port Authorities Act 1999***

Overview: This Act represents the main legislative instrument for defining management functions and powers of a port authority. It defines port areas and property, and responsibilities for environmental management.

Under Part 3 of the Act, the DPA is responsible for all areas of land, water and seabed that are vested in it.

Under Part 4 of the Act (Functions and Powers), the Act confers a responsibility upon DPA to protect the environment of the port and minimise the impact of port activities (Section 30), provides the DPA discretionary powers for how it manages the environment of the port and the timing of its management program.

DPA has a requirement to submit an annual report to the Minister (Section 68) that includes a summary of DPA's performance in relation to protecting the environment of the port and minimising the impact of port activities on that environment (Section 69, Clause 1(f)).

Name: ***Environmental Protection Act 1986***

Overview: This is the principal environmental management and pollution control legislation in Western Australia. The Act is administered by the WA Department of Environment (DoE) which has overall responsibility for the prevention, control and abatement of pollution, as well as, in concert with the Environmental Protection Authority (EPA), the conservation, preservation, protection, enhancement and management of the environment, including the assessment of development proposals. Part IV of the Act deals with Environmental Impact Assessments, while Part V addresses the control and abatement of pollution.

DPA is predominantly a management entity rather than an operator and as such its activities do not directly result in emissions and discharges. DPA have let five leases with operators whose activities have the potential to result in pollution. Those leaseholders who are prescribed premises as defined under the Act are licensed by DoE, and are bound by the conditions of those licenses. Under Schedule J of the EP Act, Bulk Material Loading or Unloading is defined as a Prescribed Activity (Category 58), although the licence conditions rest with the specific Port.

Other legislation relevant to the DPA

Environmental Protection Regulations 1987 — controlling the use of organotin antifouling paint;

Pollution of Waters by Oil and Noxious Substances Act 1987 - DPA has responsibility to respond to oil or oily water spills within the port limits;

Conservation and Land Management Act 1984 - permits the declaration of protected areas, including marine areas, and the establishment of management plans and regulations to preserve these areas;

Aboriginal Heritage Act - DPA has a requirement not to excavate, destroy, damage, conceal, alter, assume possession of, or deal with in a manner not sanctioned, any Aboriginal site or object;

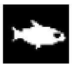
Aboriginal and Torres Straight Islander Heritage Protection Act 1984 - The purpose of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* is to preserve and protect places and objects of cultural significance to Aboriginal and Torres Strait Islander peoples;

Dangerous Goods Act and Dangerous Goods (Transport) (Dangerous Goods in Ports) Regulation 2001 - to apply the Australian Standard 3846-1998 Handling and Transport of Dangerous Cargoes in Port Areas to all Western Australian ports.

1.7.3 Environmental Values, Quality Objectives and Levels of Protection

The former Department of Environment (now DEC) completed a public consultation program that recommended a set of Environmental Values (EVs) (Table 1) and a set of levels for Ecological Protection to be developed for Pilbara coastal waters (Table 2). The EPA has given interim approval to this environmental quality management framework for guiding environmental impact assessment and regulation.

Table 1: Environmental values and environmental quality objectives

Ecosystem Health (ecological value)		This means maintaining the structure (e.g. the variety and quantity of life forms) and functions (eg. the food chains and nutrient cycles) of marine ecosystems.
Recreational and Aesthetics (social use value)		Water quality is safe for recreational activities in the water (eg. swimming).
Cultural and Spiritual (social use value)		Aesthetic values of the marine environment are protected. Cultural and spiritual values of the marine environment are protected.
Fishing and Aquaculture (social use value)	 	Seafood (caught or grown) is of a quality safe for eating Water quality is suitable for aquaculture purposes
Industrial Water Supply (social use value)		Water quality is suitable for industrial supply purposes.

Source: Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006).

Table 2: Levels of ecological protection linked to the maintenance of ecosystem integrity

Level of Ecological Protection	Environmental Quality Condition (Limit of acceptable change)	
	Contaminant concentration indicators	**Biological indicators**
Maximum	No contaminants – pristine	No detectable change from natural variation
High	Very low levels of contaminants	No detectable change from natural variation
Moderate	Elevated levels of contaminants	Moderate changes from natural variation
Low	High levels of contaminants	Large changes from natural variation

Source: Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006).

2. PROJECT DESCRIPTION AND JUSTIFICATION

2.1 Statement of Dampier Marine Services Facility Proposal

The Dampier Port Authority (DPA) is seeking approval under the State EP Act to undertake construction within the Dampier Port, adjacent to existing facilities. The proposal will involve dredging, land reclamation and the construction of a new jetty. Some terrestrial disturbance will be associated with the construction of access tracks around the reclamation area.

Capital dredging will be undertaken to remove 2.2 million m^3 parent sediments from the seafloor, thus providing safe depth for 65,000 DWT vessels to manoeuvre and berth at all stages of the tide. No new access channel, or increases to this channel width or depth are proposed.

The dredged sediment will be used to create a land reclamation area, forming a new land-backed wharf with a footprint of 22 hectares. Dredged material will be pumped directly from the dredge to the reclamation area via a cutter suction dredge. An outer bund wall will contain the reclamation area, which will be topped with road-base material in general laydown areas and an impervious surface (concrete and/or asphalt) within the roadways and on the heavy-load out facility.

A new jetty is also proposed, which will extend 300m north from the new land-backed wharf. Piling will be required to install the foundations of the jetty.

The key parameters for the proposal are listed in Table 3.

Table 3: Key parameters of the proposal

Element	Description
Dredging Area	46.78ha: including 40.40ha approach area, 4.08ha around the new jetty, and 2.3ha in the DCW berth.
Dredging Depth	Dredging depth ranges 0-9 m and resulting in depths of -8 m LAT in the DCW berth, -11 m LAT in approach areas and -14 m LAT in the new jetty berth.
Dredging Volume	Approximately 2.2 million m3.
Dredged Material	Sand – silty sand with some clay layers.
Reclamation Area	Approximately 22ha.
Jetty Construction	Extending 300m north of the new land-backed wharf.
Land Disturbance	Approximately 4.84ha.

2.2 Justification and Context of Proposal

The DPA currently owns and operates the Dampier Cargo Wharf (DCW). The facility is nearing its design life and is experiencing problems with capacity. The associated laydown area in the Port is also beyond capacity, leading to a congested and inefficient work area. Demand for the DCW is expected to increase in the medium to long term.

The DCW was constructed in 1980 to aid in the unloading of construction material for the Burrup Peninsular LNG Plant (Stage 1) and to load equipment and supplies for the North Rankin A gas platform. The estimated life of the cargo wharf was 8 years. The DCW was extended in 1993/94 to its current size, and in 1999 Woodside passed ownership of the wharf to the Dampier Port Authority.

The cargo wharf has become the major loading and service point for the rapidly expanding oil and gas production and exploration activities in the region. The demands of multiple users and major increases in tonnage have made the existing purpose built facility inappropriate for continued use or expansion. Since 2007, the DCW has been operating with a combined berth occupancy rate of 60% to 65%. Existing berth occupancy rate is expected to reach severe congestion levels (70% to 80% occupancy) by late 2012.

An overview of the current facility is shown in Figure 1.

Figure 1: Existing Dampier Cargo Wharf (right) and Dampier Bulk Liquids Berth (left), with project laydown area in foreground, in February 2009

2.2.1 Drivers for Development

There are three principal drivers for the proposal. These are:

d) Age of existing infrastructure: The current facility will reach the end of its design life in 2021, and is currently experiencing elevated maintenance costs to maintain an operational state.

e) Market demand: the current facility is reaching full capacity and has limited ability to deal with increases in the size of incoming vessels. Industry standard is that 100% of practical berth capacity is reached when berth occupancy reaches 60%. This is because shipping is waiting to get onto a berth for significantly longer periods, and incurring demurrage costs that exceed wharfage costs. The current wait-time to get into the DCW is between 8 and 14 days. Current market demand to support the offshore oil and gas industry is for 90m+ vessels.

f) Additional Laydown area: wharf facilities only work efficiently where there is associated area for laydown and storage of equipment coming on and off vessels. This allows surge capacity to load and unload vessels quickly and reduce turnaround times, while the freight task of moving goods to a long-term storage or final destination can run independently. Currently DPA has less than 3 hectares of laydown area, which is 100% occupied.

2.2.2 Current and Future Land Uses

The land use proposed is consistent with the Burrup Peninsula Land Use Plan and Management Strategy (September 1996). This plan identified the project area as Policy Area C, and identified the future use Industrial and Port uses, as shown below (extract from p 13 of Strategy).

BURRUP WEST (Policy Area C– 520ha)

Area Values

This Area, situated between the existing Woodside Supply Depot and the Woodside LNG Plant, has high value for major strategic industrial and port development sites. The proximity to the deep waters of Mermaid Sound ensures port potential. Holden Beach presently has recreation value. The Area also has environmental and heritage values.

Management Objectives

- To use the land for industries requiring adjacent port facilities.
- To preserve, as far as possible, the environmental values and significant Aboriginal sites.

Policy Statements

- Recreation at Holden Beach is inconsistent with the industrial use proposed for the Area.
- Construction and operation of land and port facilities should aim to minimise impacts on the marine environment.

This plan was endorsed by the West Australian State Government, and is the current Land Use Plan for the region (Figure 2).

The need to expand the Dampier Port facilities to meet continued strong growth in the region was identified by the Dampier Port Authority in the Port Development Plan 2004, which is a West Australian Government approved document.

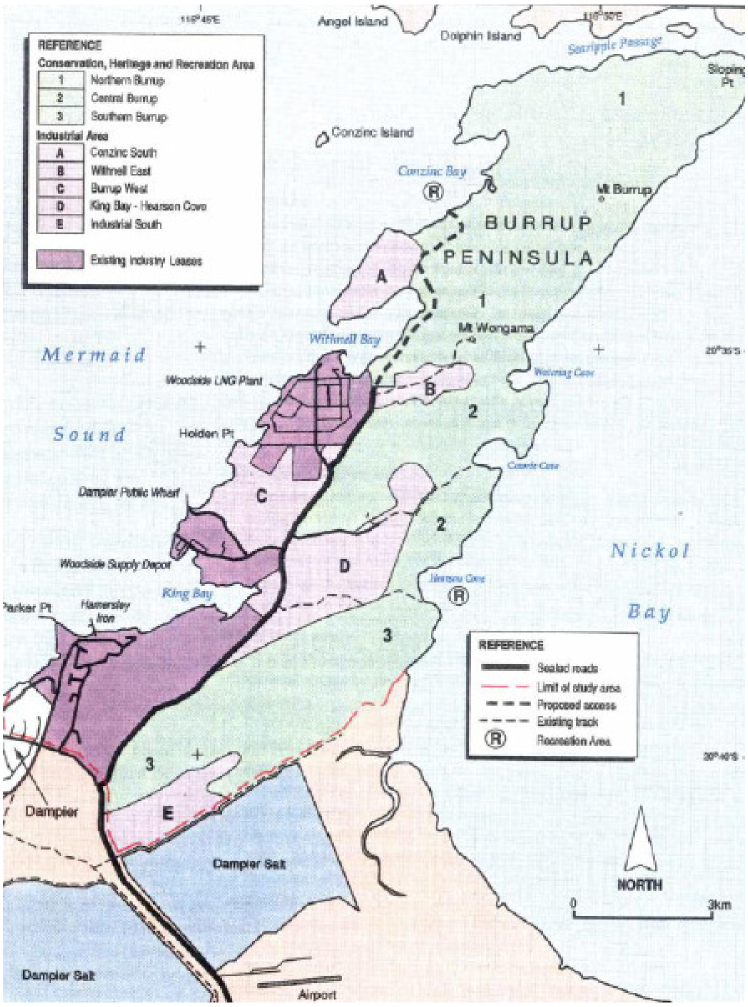


Figure 2 Burrup land use development plan

2.2.3 Land Ownership

The proposal covers three land lot areas, and the port waters of the Port of Dampier.

- Lot 472 is vested in the Dampier Port Authority;
- Lot 565 is vested with the Department of Planning and Infrastructure, with the lot leased to LandCorp on a 105 year lease term. LandCorp have obtained this lease to address the service corridor only. DPA has held discussions with LandCorp, and gained in principal support for the surrender of the remainder of the Lot 565 to DPI, and subsequent vesting with DPA.
- The seabed outside these land lots inside Port limits is vested in the Dampier Port Authority

The project footprint does not impact on existing or planned third party developments, or impact on conservation areas. There closest portions of the proposed Dampier Archipelago Marine Park are some 8km north, being outside Port Waters. The closest portions of the area listed as a National Heritage Place are some 600m east (lot 366), and the Burrup Conservation Area is some 7km north.

2.3 Alternative Options Considered

2.3.1 Options Assessment Studies

The DPA has undertaken a wide variety of options assessment studies in the region, providing the basis for design detailed in the sections below. These studies include:

- Review of the Dampier Port Land Use Planning (Department of Resource Development 1989)
- Port of Dampier Development Study (Halpern Glick Maunsell 1989)
- Development Option Study (Port and Harbour Consultants 1996)
- Port of Dampier Development Strategy and Capacity Study (Halpern Glick Maunsell 1997)
- Berth Operability Assessment, Proposed Land Backed Wharf (WorleyParsons 2004)
- Concept Design of a Short Term General Cargo Wharf and Procurement of Design and Construction Services Options Study Report (WorleyParsons 2007)
- Dampier Port, General Cargo Wharf, Business Case (Evans and Peck 2007)

2.3.2 No Development Option

The proposal has three principal drivers (Section 2.2.1), and these drivers are expected to increase with further economic activity in the North West.

The "No Development Option" is not preferred by DPA for the following reasons:

- Without the development of a suitable facility in Dampier, it is likely that individual proponents will develop a range of private facilities along the coastline. These private facilities are likely to have a larger environmental impact footprint than one consolidated development;
- Congestion of berths will continue to increase with a subsequent reduction in reliability and increased risk of accidents;
- Congestion also causes shipping delays, and associated demurrage costs currently exceed $1.5 million per annum for the existing DCW. Increased demand will lead to further increases in demurrage costs;
- Existing infrastructure maintenance is becoming excessive, and maintenance of the current facility has increased from $290k/year in 2004/05 to over $1,500k/year in 2008/09;
- Delays in materials delivery to major construction projects based out of Dampier will cause increased costs to major industry, and the 'No Development" option may result in the use of less convenient ports, thereby increasing costs for oil, gas and mining operators; and
- The DMSF will provide the adjoining towns of Dampier, Karratha, Roebourne and Wickham with strong employment and commercial development opportunities.

The Pilbara region is a major driver of state and national economic growth in employment (direct and indirect) and the development of secondary and tertiary industries, in addition to royalties and taxes resulting from the oil, gas and resources industries dependent on the Port of Dampier.

2.3.3 Land Backed Wharf – 2004 Design

The development of a land backed wharf was investigated during the development of the 2004 Port Development Plan, and subsequently represented in the 2005-2008 plans. While this design has been modified slightly over time, it is generally a land backed wharf facility constructed perpendicular to and east of the existing DCW (Figure 3).

Subsequent investigation has demonstrated that this design encountered hard rock at a depth to make infrastructure development and dredging challenging. This proposal also required significant drill and blast operations.

A Berth Operability Study was conducted upon this option in November 2004 (WorleyParsons 2004). The study indicated that the orientation of the facility perpendicular to the predominant wave direction may lead to significant periods where the wharf was inoperable. While bulk carriers and gas ships are able to tolerate significant swell and continue loading/unloading operations, the characteristics of the shipping more likely to use the facility (break-bulk shipping, often loading and unloading with fixed cranes) indicated issues with swell and sea influence.

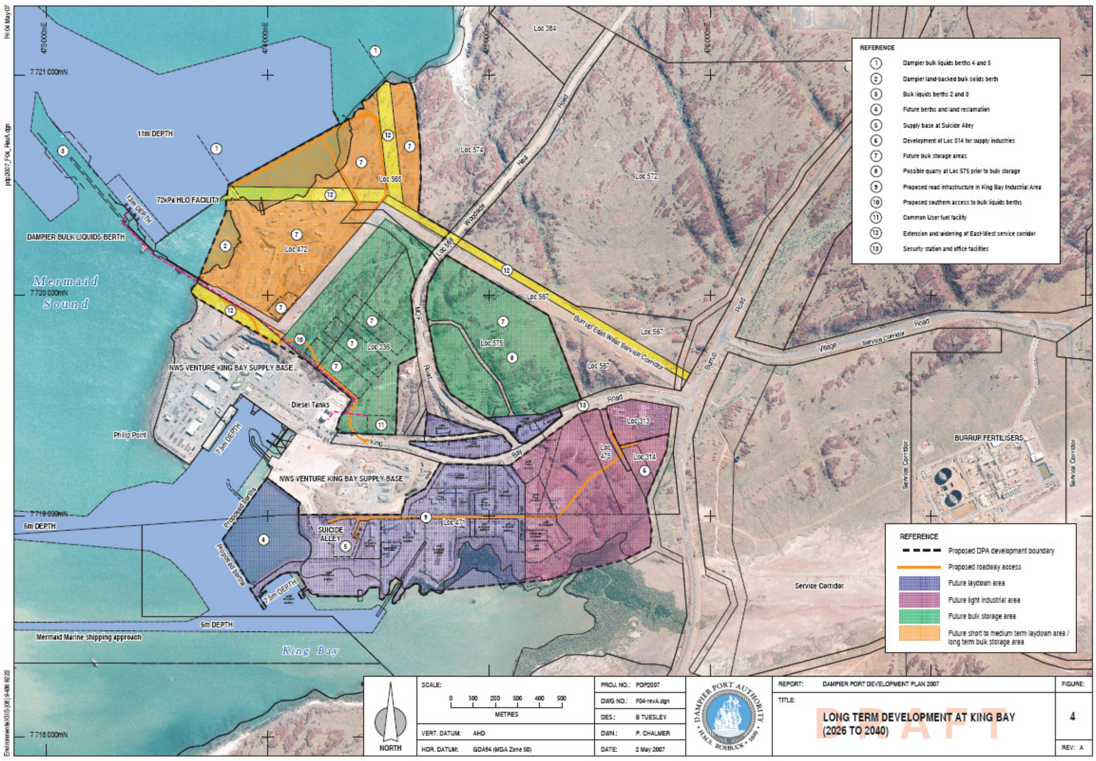


Figure 3: Concept 0

2.3.4 Offshore Harbour – 2006 Design

The Offshore Harbour design aimed to solve the operational issues identified in the above design. It attempted to develop a working area in a wave shadow, while maximising the advantages of the location in proximity to existing road and infrastructure networks. The design included the development of a significant offshore breakwater (Figure 4).

This proposal was compromised by the development footprint, environmental challenges and excessive construction costs (estimated at $1 billion). The Offshore Harbour option would also require the sea disposal of significant volumes of dredge material.

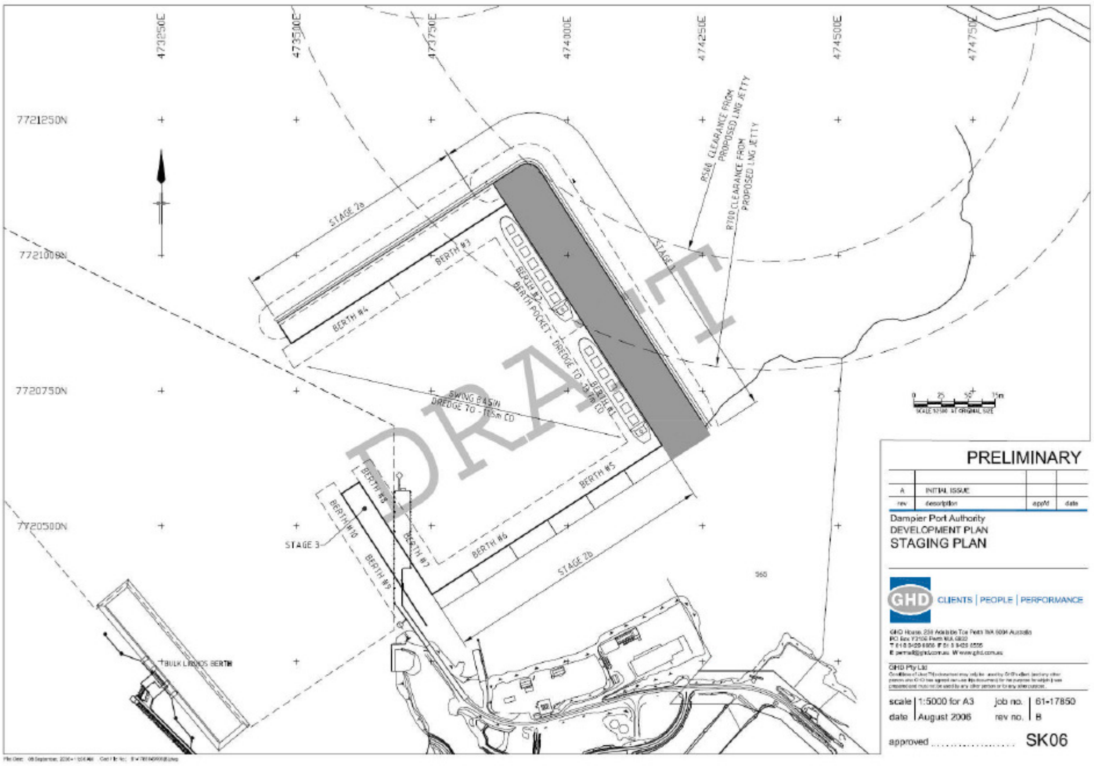


Figure 4: Concept 1

2.3.5 Option Assessment 2007

During 2007, WorleyParsons was contracted to undertake a comprehensive review of the options available to address the needs of the DPA for a facility, with a study scope to increase the potential coverage of the options. This study addressed options to include sites within the King Bay Industrial Estate, sites within the Dampier Salt berths and associated with the proposed Maitland Industrial Estate on West Intercourse Island (Figure 5).

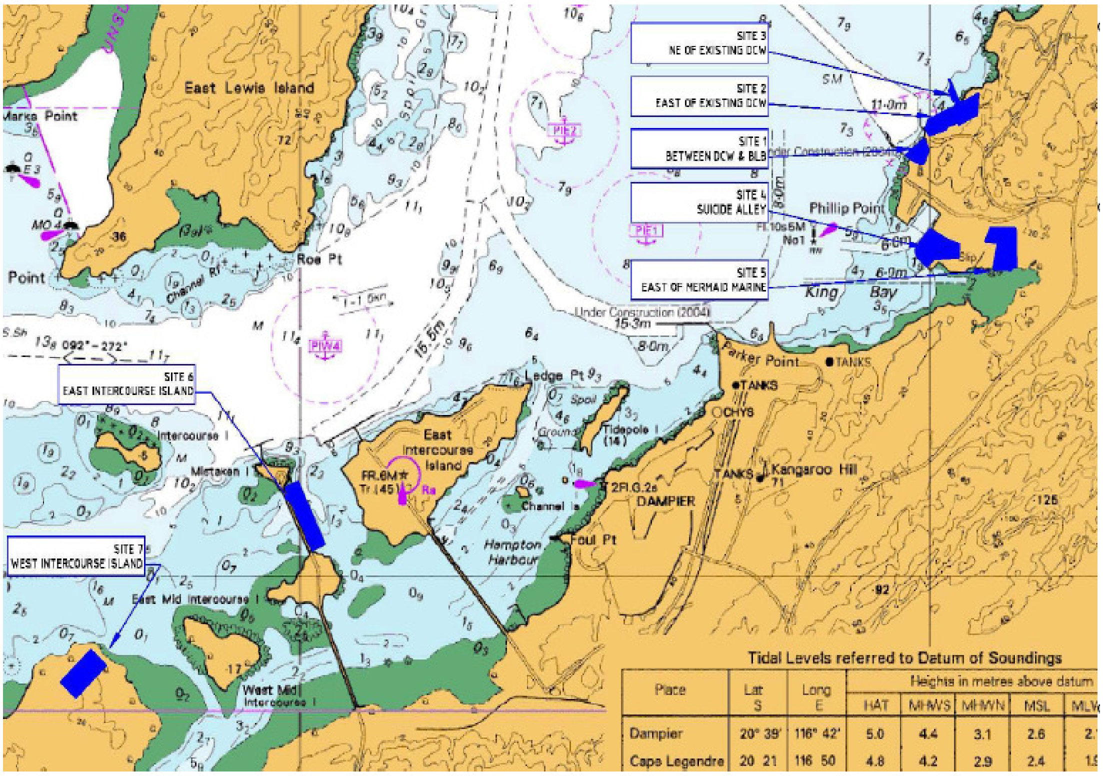


Figure 5: Potential development sites assessed as part of the Options Assessment Study (WorleyParsons 2007)

An initial assessment of the options reduced the scope to three sites (all located adjacent to the existing DCW facility) on the basis of proximity to deep water (and hence dredging requirements) and existing road networks (and hence infrastructure development requirements). These factors were felt to be a reasonable proxy for consideration of environmental impacts at this high level. This is borne out by consideration of the amount of dredging required to gain navigable depth at Site 7 (approximately 15 Mm^3), and the large areas of mangroves which would be impacted by Site 5. Options 4 -7 were discounted from further investigation on this basis.

The three remaining options were then subject to a rigorous assessment, investigating factors such as environment and heritage constraints, proximity to roads and services, amount of dredging required and suitability to address freight tasks.

The options were ranked, with Site 2 demonstrating a clear preference. It should be noted that this option is similar to that proposed in the 2004 study, with some minor changes to layout. As above, this design was compromised by the alignment to the predominant wave direction and likely presence of hard rock close to the surface within infrastructure areas. To address these issues, further investigations were undertaken through 2007 and early 2008 that resulted in the design currently proposed.

Table 4: Quantitative Analysis for Development Options (WorleyParsons 2007)

Criteria	Weighting (out of 5)	Option 1	Option 2	Option 3
Environmental and Heritage	4.3	3.0	3.0	3.0
Geotechnical Issues	4.0	2.7	2.3	2.0
Wharf Structural Types	3.0	3.7	3.7	3.7
Dredging, Reclamation and Seawalls	3.7	3.0	3.3	3.0
Road Access	3.7	2.0	2.3	2.3
Services	3.0	3.0	3.3	3.3
Vessel Handling	3.7	1.7	3.0	4.0
Rock Loadout Facility	4.7	3.0	3.7	2.7
Mud Plants	3.0	2.3	3.7	2.7
Operations including hazard identification	3.3	2.3	3.7	4.0
Schedule and Staging	5.0	2.7	3.7	2.7
Capital and Operations Cost Estimate	4.7	2.3	3.7	2.7
Total Weighted Score (out of 100)		51	85	59
Ranked Order		3	1	2

2.3.6 Detailed Design Iterations Leading to Current Design – 2008/09

CONCEPT 2

The above studies indicated that the most suitable location was to the east of the existing DCW. During 2008/09, further option assessment and preliminary design work was undertaken to better define this option. These works included an assessment of an option (Concept 2) to extend the existing DCW and develop a separate laydown area (Figure 6). However, this option was cost-prohibitive and could not be safely constructed while the eastern face of the DCW was operational, leading to unacceptable shipping disruptions.

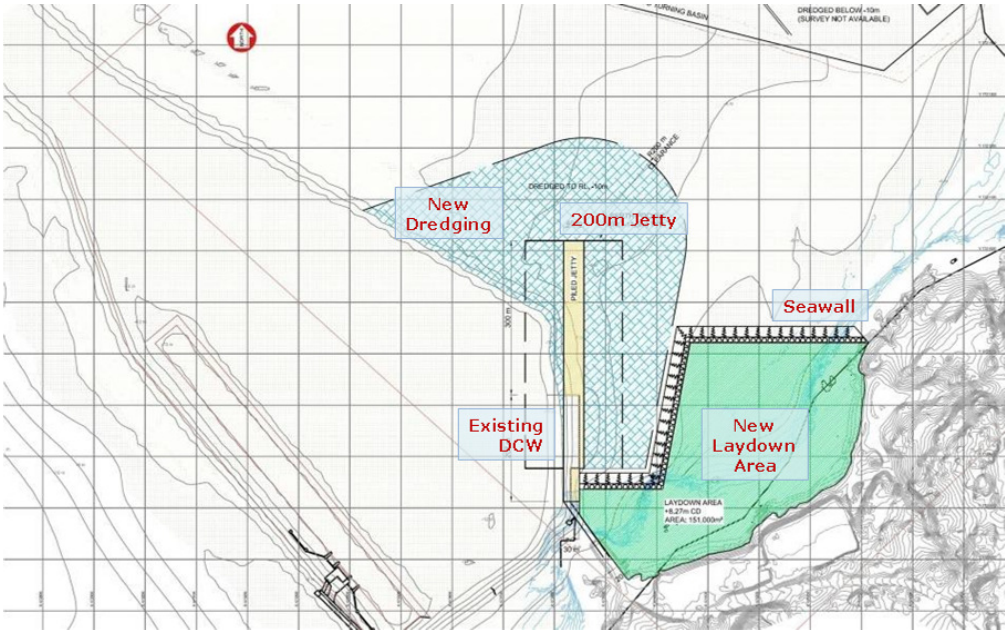


Figure 6: Concept 2

CONCEPT 3

Concept 3A was generated to combine the new wharf facility and the reclamation area. Detailed hydrographic survey and modelling indicated that Concept 3A would require dredging of some 1.75 Mm^3 of material, with disposal of some 300,000 m^3 of material to sea.

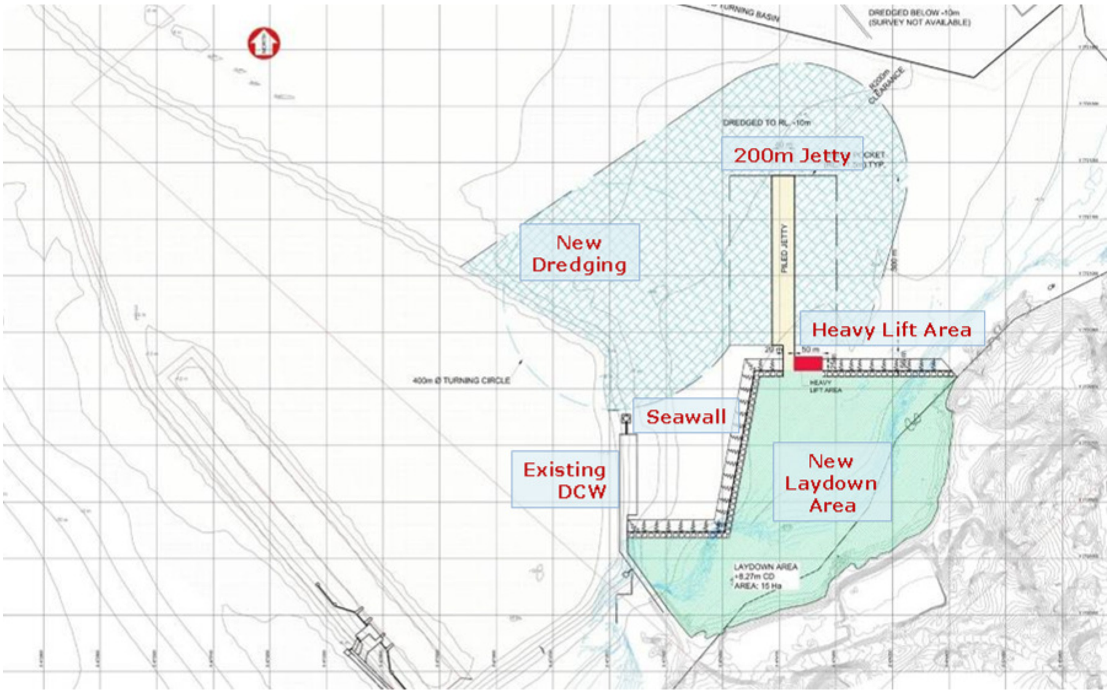


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Figure 7: Concept 3A

Concepts 3B and 3C were generated to address the dredging and disposal constraints of Concept 3A. Figure 8 presents the engineering design for Concept 3C, which was similar to 3B.

Further geotechnical investigations in 2007 (Coffey Environments Pty Ltd 2008) indicated the presence of hard rock in the upper layers. This would most likely necessitate the use of drill and blast operations to achieve design dredge depth, and to drive the sheet piling to the required depth in the Heavy Lift Out (HLO) area to achieve the required lateral strength. To avoid those drill and blast operations, Concept 3D (Figure 9) was developed.

Following several value engineering workshops to further refine and test the design, Concepts 3E (Figure 10) and 3F (Figure 11) saw the inclusion of sheet piling on the western face of the reclamation to make best use of this area, and the alignment of the wharf with this face to provided some 450m of continuous wharf face and a high degree of flexibility in berthing at the site.

Following two rounds of ship simulation modelling at the Broome Simulation Facility, the reclamation area and wharf was shifted slightly landward to ensure the safe passage of the design ship (65,000 DWT) to the eastern face of the wharf under all likely conditions. This included assessment under light and loaded draft, and needed to be achieved independent of the Pluto Swing basin and exclusion area. As a result of these studies, Concept 3G (Figure 12) was developed as the current preferred design.

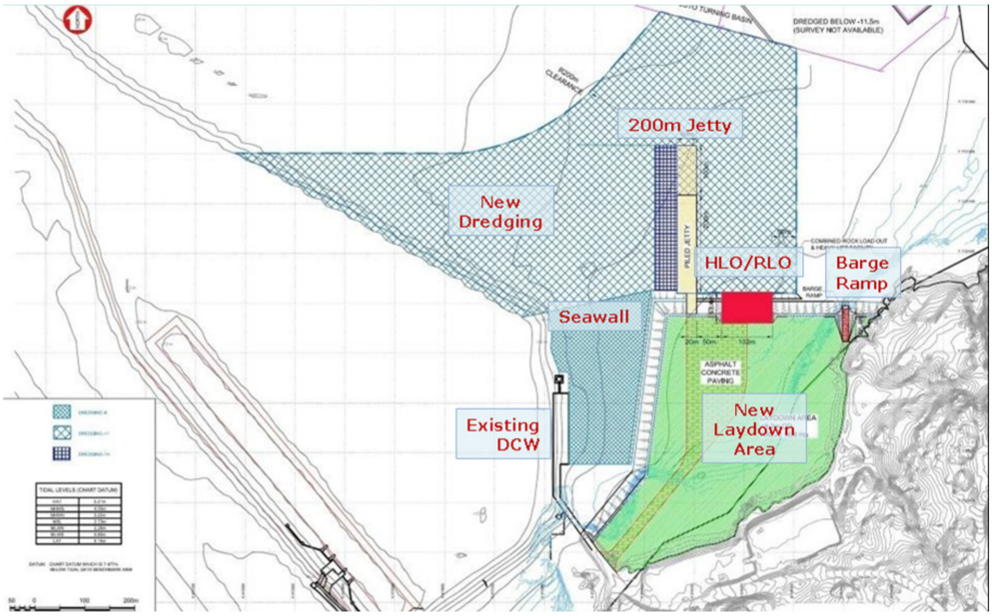


Figure 8: Concept 3C

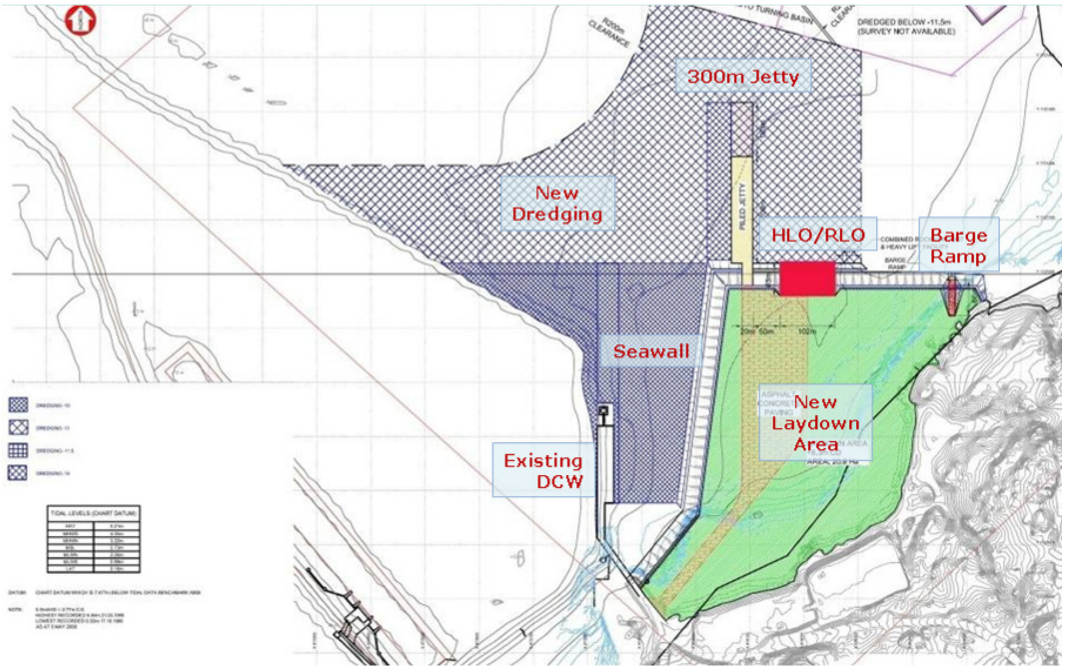


Figure 9: Concept 3D

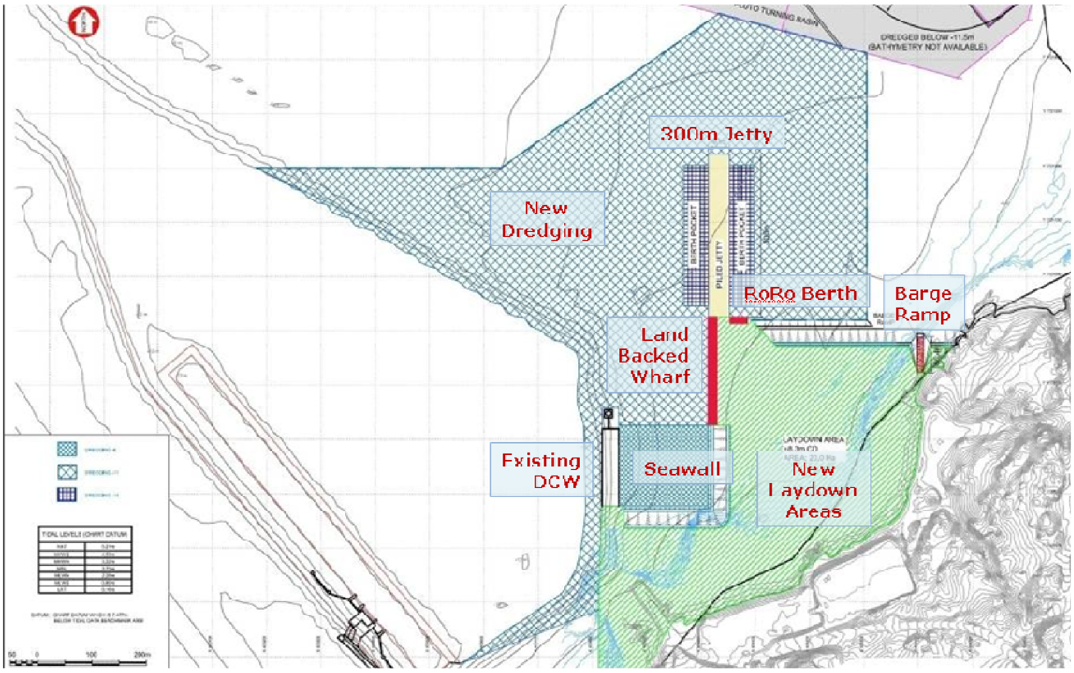


Figure 10: Concept 3E

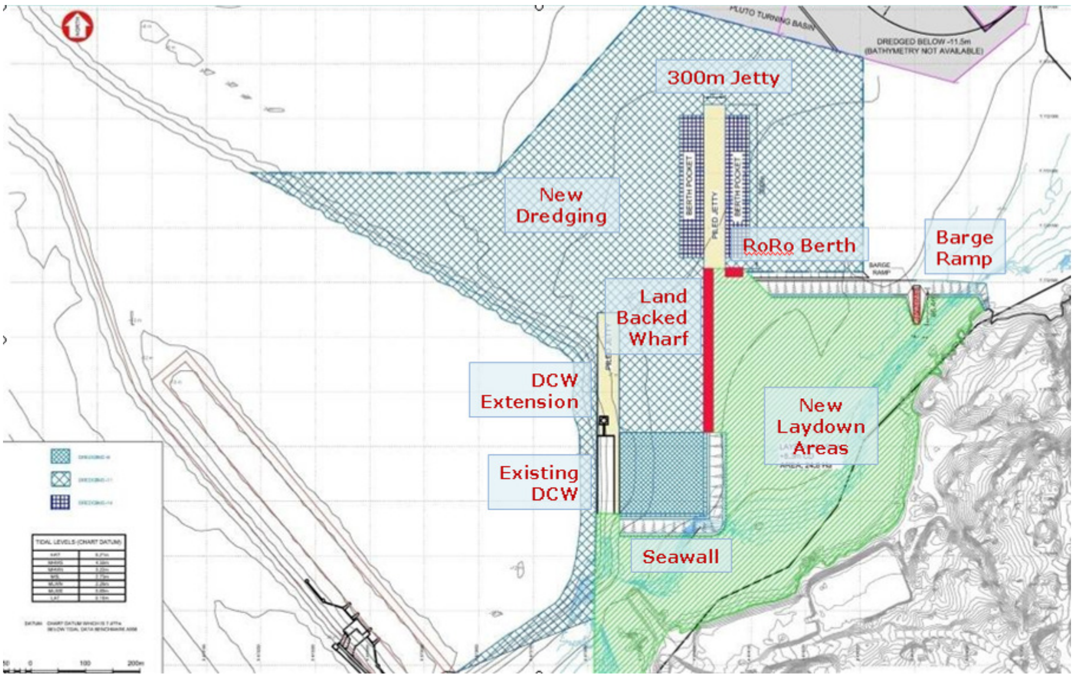


Figure 11: Concept 3F

2.3.7 Current Design

The final design (Concept 3G) is presented in Figure 12 and in Appendix 1. The final design was independently reviewed by GHD (2009a).

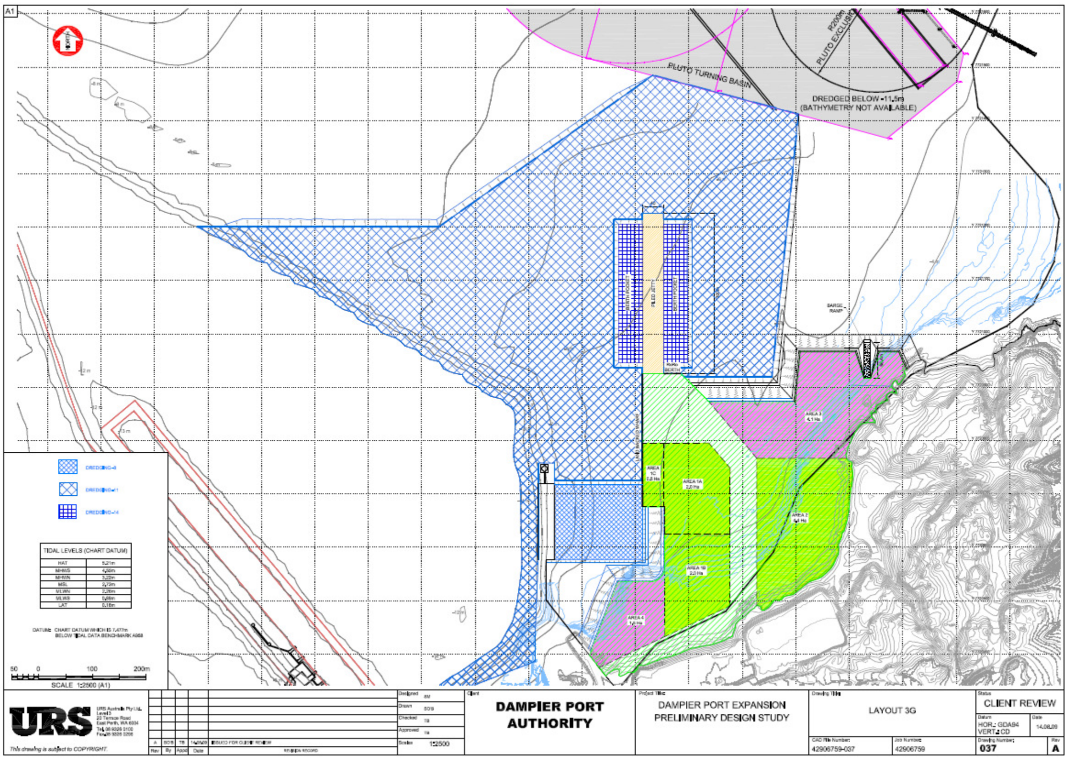


Figure 12: Concept 3G

The key points of the final design are outlined below:

- Construction can be undertaken while the existing Dampier Cargo Wharf (DCW) is operational, ensuring safety and minimal disruption;
- The amount of required dredging is balanced with the land development area to allow the reuse of all material without requiring sea disposal;
- The wharf is north-facing to minimise shut-down periods due to vessel movement during loading and unloading; and
- The proposed location is between existing developments (the Dampier Cargo Wharf and Dampier Bulk Liquids Berth) and current developments (Woodside's Pluto Project), thereby consolidating projects and reducing the footprint along the Burrup Peninsula.

A photomontage of the proposed works is shown in Figure 13 and a visual flythrough of the current and proposed project presented in Appendix 18.

Figure 13: Photomontage showing proposed DMSF, with a vessel docking at the proposed new jetty (centre), and the existing DCW jetty (right).

2.4 Construction Activities

2.4.1 Project Schedule

STAGE 1: SEAWALL, DREDGING AND RECLAMATION

- Seawall Construction: Q2 2010 to Q3 2010;
- Capital Dredging: Q3 2010 to Q3 2011;
- Reclamation: Q3 2010 to Q3 2011;
- Construction of Land Backed Wharf: Q2 2010 to Q3 2010;
- Construction of Laydown Area Civil and Drainage: Q2 2011 to Q1 2012; and

- Construction of Access road – Civil and Drainage: Q2 20011 to Q1 2012;

STAGE 2: JETTY, ROLL-ON/ROLL-OFF AND LAYDOWN AREA

- Construction of 300m Jetty: Q4 2011 to Q4 2013;
- Construction of Buildings in Laydown Area: Q1 to Q4 2012 (By future DPA Lessees. Beyond scope if this document); and
- Construction of Roll-on / Roll-off Facility: Q4 2012 to Q3 2013.

2.4.2 Construction Sequence

1. The first stage of construction will involve building the outer bund wall (seawall) of the land-backed wharf, which will contain the dredged material once dredging is underway. The outer bund wall is anticipated to take six months to complete.

- The rock will be back-tipped from trucks along the alignment of the bund wall. This will be pushed into location by a dozer at the tip face, and trimmed to design by a follow-up team of excavators. The wall will be developed to a level at or above highest astronomical tide, and most likely develop on two work fronts developing the bund wall out from the landward extent. This activity will take some 6mths to complete
- The material used to develop the rock wall will be graded rock sourced from an existing quarry, or residual material from the Pluto Site B site. The material will be screen to remove the fines fraction (less than 75mm). As a consequence it will be very clean going into the water, and produce a negligible plume from the tip face. Figure 14 illustrate the sequence of events from the recent Future Port Expansion at the Port of Brisbane (2001-2004).

Figure 14 - Aerial and ground level views of bund wall development similar to proposed method and material. Note that in these photographs, the core of the wall has been placed, with outer amour rock layers to be installed.

2. A section of the bund wall will remain open until the last stage of construction, when environmental surveys will remove any marine megafauna present within the enclosed area. The wall will then be completed to form a contained area for reclamation.

3. Dredging will commence after the completion of the outer bund wall and is expected to take 12 months to complete. Blasting will not be required. Material will be pumped directly from the dredge to the reclamation area as described in Section 2.4.4.

4. During this stage, the sheet pile wall will be installed along the southern project margins. The sheet piles will be installed through the bund wall into the sea bed, and thus provide some 150m of operational wharf area, predominately for use as a heavy load-out facility.

5. Following the completion of all of the above, the new wharf structure will be finalised. This is expected to be a deck-on-piles structure, similar to most wharves around Western Australia. Piles will be driven into the substrate, formwork established and headstocks/decks poured and set on-site.

6. The project schedule is outlined in Section 2.4.1.

2.4.3 Dredging

Capital dredging would be undertaken to remove parent sediments from the seafloor in the areas surrounding the proposed new land-backed wharf and 300m jetty. The areas traversed by vessels using the facility will be dredged to -11m LAT (below Lowest Astronomical Tide), thus providing safe navigable depth for a 65,000 DWT vessel at low tide. The berth pockets around the new 300m jetty will be dredged to -14m LAT, and the berth pocket within the existing DCW will be dredged to -8m LAT, thus providing safe depth for vessels to berth at all stages of the tide. No new access channel, or increases to this channel width or depth are proposed as part of these works.

The key parameters for the existing dredging proposal are as follows:

- Area of Dredging: The proposed dredging would cover an area of approximately 467,800 m^2. The dredging footprint is shown in Figure 2 of Appendix 1.

- Depth of Dredging: In the approach areas (403,978 m^2), dredging will range 1-6 m and result in a final depth of -11 m LAT. In the area around the jetty (40,786 m^2), dredging will be to a maximum depth of 7-9 m resulting in a final depth of -14 m LAT. Inside the existing berth area (23,000 m^2) dredging will range 0-3 m resulting in a maximum depth of -8 m LAT.

- Volume of Dredging: The calculated total volume of material to be dredged is approximately 2.2 million m^3 of material.

- Material to be Dredged: Geotechnical and sediment sampling investigations undertaken across the proposal area indicate that the material to be dredged is sand – silty sand with some clay layers. More detail on geotechnical investigations is provided in Section 5.2.3.

- Estimated Time for Dredging: the dredging is likely to commence as a single continuous operation in the third quarter of 2010, dependent on the availability of dredging plant and coordination with other projects within the region. It is expected that dredging would be completed within 12 months of commencement.

2.4.4 Reclamation

The reclamation footprint will form an area of 22 hectares. The extent of the footprint is shown in Figure 2 of Appendix 1.

The dredged sediment will be used for land reclamation of the land-backed wharf. The sediment will be contained within a seawall (outer bund wall) and topped with road-base material in general laydown areas. Within the roadways and on the heavy-load out facility, an impervious surface (concrete and/or asphalt) will be applied. Surface drainage is discussed in Section 9.7.

Dredged material will be pumped directly from the dredge to the reclamation area via a cutter suction dredge. The pump discharge will be 10-20% solids and 80-90% seawater. This mix will be decanted within the reclamation area, and the return water discharged via controlled weir boxes at several locations. The location of discharge and discharge volume will vary during construction, and will be determined according to prevailing conditions in order to maintain water quality.

It should be noted that while the majority of the water in the pump discharge will be drained from the reclamation area, the sediments within the reclamation area will always remain saturated though both tidal influence through the wall and capillary action.

Management of water quality during the dredging and reclamation process is addressed in detail in the Dredging and Reclamation Management Plan (Appendix 2).

2.4.5 Jetty

A new jetty will be constructed that extends 300 m north from the new land-backed wharf, to provide berthing space for large vessels. The jetty foundations will be constructed via pile driving using a hydraulic piling hammer, and sliding steel ramps will be laid progressively from the land-backed wharf to support the piling rig. The jetty will have a concrete surface for loading and unloading.

2.4.6 Roll-On Roll-Off Facility

The roll-on roll-off facility (RORO) (Figure 15) will be partially developed early in the construction schedule, and this work may commence before the reclamation activities are complete. Construction will be land based, with piles driven to the required depth. The vertical outer face will be the continuation of the sheet pile walls (Figure 16), the same as the land backed wharf area. The area behind this sheet piling will be compacted dredge material, capped with load-bearing running surface, such as concrete to form the RoRo ramp surface.

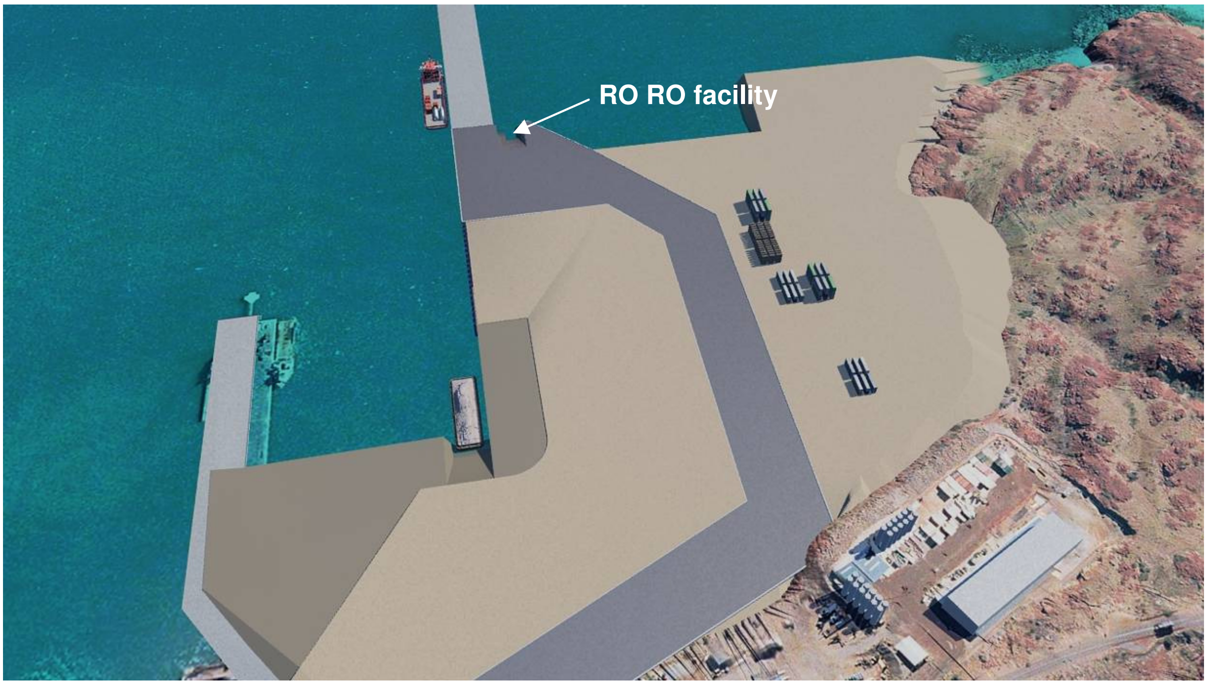


Figure 15 Photomontage of DMSF in particular the roll-on roll-off facility

Figure 16 Typical sheet piling

2.4.7 Laydown Area

The laydown area for construction purposes will be adjacent to the existing DCW and within the proposed terrestrial footprint of the DSMF.

2.4.8 Access Tracks

Access tracks for the purposes of construction and maintenance during operation will be constructed along the land adjacent to the reclaimed section of the coast. The proposed terrestrial footprint for these access tracks have been surveyed for indigenous heritage (Appendix 12) and native flora (Appendix 5). All known indigenous heritage items have been avoided by detailed design, and will not be disturbed by this project.

2.4.9 Construction Machinery

The machinery required during construction will include:

- Cutter suction dredge vessel and support vessels;
- Hydraulic piling hammer;
- Excavators, loaders and dozers;
- Articulated trucks, semi-trailers and water trucks;
- Graders and rollers; and
- Crawler cranes.

2.5 Operational Activities

Operational activities will be similar to those already undertaken at the existing facilities. The DMSF will primarily serve the oil and gas industry and will provide the only facility on the Burrup Peninsula for the loading and unloading of break bulk. The proposal will allow a maximum vessel size of 65,000 DWT to berth in the new DMSF, and (in contrast to existing facilities) the direct loading and unloading of vessels via the roll-on roll-off facility without the use of cranes.

Navigational aids, vessel movements and load out activities will be controlled by the DPA Harbour Master using the regulations and procedures already in place for existing facilities.

3. STAKEHOLDER CONSULTATION

3.1 Overview

Stakeholder consultation has formed an integral role in the planning and design stages of the proposal. DPA has undertaken extensive 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).

3.2 Methodology

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

- A brief history of the existing Dampier Cargo Wharf;
- A summary of a demands study on users of the Dampier 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 marine facility design, the planned construction approach and the primary dredging and reclamation footprint;
- 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.

3.3 Key Stakeholders

The following parties were identified as major stakeholders with a significant interest in the proposal:

- Dampier Salt Ltd
- Hammersley Iron (HI)
- Rio Tinto
- Pilbara Iron
- Coastal Communities Environmental Forum
- BHP
- Woodside WE, Pluto & NWSV partners
- Burrup Fertilisers (BFPL)

The following were also identified as stakeholders requiring consultation:

- Environmental Protection Authority (EPA) & Services Unit (EPASU)
- Dept Environment, Water, Heritage & Arts (DEWHA) (EPBC referral)
- Department for Environment & Conservation (DEC), including the Perth branch, the Pilbara branch, Marine Ecosystems, Air Quality, Environmental Management and Corporate
- Department of Water (DoW), including the Pilbara branch
- Water Corporation
- Department for Local Government & Regional Development
- Pilbara Native Title Service
- Department for Indigenous Affairs (DIA)
- Local Aboriginal groups
- Department of State Development
- Department of Mines and Petroleum
- Department of Transport (DoT)
- Department for Employment and Consumer Protection
- Shire of Roebourne

The following DPA leaseholders and service providers were also identified for consultation:

- Mermaid Marine Australia
- Woodside (King Bay)
- Patrick Stevedores (Western Stevedores)
- BIS Logistics
- Toll energy
- LandCorp
- North West Shelf Venture (NWSV)
- Chevron Australia Pty Ltd
- Schlumberger
- Oceanic Offshore
- BGC Contracting

3.4 Stakeholder Comments and DPA Response

3.4.1 Environmental Protection Authority and Services Unit

DPA and WorleyParsons Services Pty Ltd consulted with the Environmental Protection Authority and Services Unit (EPASU) between the 6th of July 2009 and the 9th of December 2009. Comments and responses are provided in Table 5. EPASU advice has been incorporated throughout this report.

Table 5: EPASU comments 10th August 2009 and DPA action or response

EPASU Comment	Response
The proponent needs to consider the results of previous dredging programs, determine the tolerance of sensitive organisms to suspended sediment and reduced light in the Zone of Influence and develop models to predict the likely impacts from the development. The proponent needs to develop management strategies to minimise or prevent predicted impacts of dredging and spoil disposal activities.	Refer to Dredging and Reclamation Management Plan (Appendix 2) and Impacts and Management – Marine Habitat (Corals) (Section 8.2). Tolerence of corals was validated in Appendix 8. Zones of influence a re developed in Appendix 13 and carried through the API as appropriate.

EPASU Comment	Response
Model outputs of predicted impacts should be presented in a format that spatially defines the zone of loss, zone of impact and Zone of Influence for key habitats, including Benthic Primary Producer Habitat (BPPH).	Refer to marine environmental modelling results (Appendix 13) and benthic habitat maps (Appendix 10). These were interrogated to produce Figure 39. Statistics for BPPH are presented in Table 24 and Table 25. Zones of Impact are illustrated in Figure 39.
The proponent will need to undertake an assessment of BPPH loss consistent with Environmental Protection Authority (EPA) Guidance Statement No. 29: Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment.	Refer to Section 8.2 and Appendix 15.
The concentrations of contaminants in the sediments to be dredged need to be characterised and the potential for toxic impacts on marine biota determined.	Refer to Baseline Sediment Quality Assessment and Acid Sulfate Soil Assessment (Section 5.2.7) and Appendix 9.
The concentrations and availability of toxic contaminants in the sediments to be dredged will need to be assessed within the context of the environmental values, environmental quality objectives and levels of ecological protection outlined in the Pilbara Coastal Water Quality Consultation Outcomes, Environmental Values and Environmental Quality Objectives (DEC 2006b).	Sediments within the primary footprint meet a Moderate to High Level of Ecological Protection (Table 2). Refer to Baseline Sediment Quality Assessment (Section 5.2.7) and Appendix 9.
The proponent should prepare and implement strategies to ensure development activities and on-going operations are managed to minimise potential impacts on marine mammals and turtles.	Refer to Management of Impacts on Marine Fauna (Section 9.2.5).
The introduction of marine pests is an issue that requires surveillance and management both during construction activities and regular operation of the new development. The proponent should seek advice from the Department of Fisheries when preparing the environmental impact assessment (EIA) documentation.	Refer to Management of Marine Pests (Section 9.4.5). Department of Fisheries were consulted see Section 3.4.3.

EPASU Comment	Response
The proposed development involves reclamation of seabed to a distance of approximately 500m offshore and jetty structures to > 600m offshore. These structures are likely to affect the natural currents in the area and should be investigated using the hydrodynamic model. In particular, the proponent should consider likely impacts on remaining benthic communities (e.g. corals) and coastal processes affecting stability of the beach just north of the proposal.	Refer to hydrodynamic modelling results (Appendix 13) and impacts and management of coastal processes (Section 9.5).
The proponent will need to develop a Marine Monitoring and Management Program that addresses both the construction phase and the operational phase of the new development. This program should be complementary to the Marine Environmental Quality Monitoring and Management Program required for the current Dampier Cargo Wharf facility (Ministerial Statement No. 643, Condition 12).	Refer to Key Factors Impacts and Management (Section 8) and Other Relevant Factors Impacts and Management (Section 9). The Proponent is in discussions with the DEC Marine Science Program: Science Division about developing a port wide management plan for operations. The concept has been supported by the Branch and DPA have committed to its development. Specific marine monitoring during construction is detailed in Appendix 2.
It is necessary for the proponent to assess/survey the distribution of seagrass within the Zone of Influence of the development on a seasonal basis. (Seagrass has a seasonal distribution in this area and is generally not present throughout the year.)	Refer to Macroalgal and Seagrass Communities (Section 5.3.5) and the Benthic Habitat Report (Appendix 10). The benthic habitats within the direct impact areas of the proposed DMSF do not appear to support seagrass communities.
The proponent needs to provide a detailed benthic habitat map that includes all benthic habitats, not just BPPH.	Refer to Benthic Habitat (Section 5.3.2) and Benthic Habitat Report (Appendix 10)

EPASU Comment	Response
The majority of the inshore coral communities of the Dampier Archipelago appear to be found in the inner sections of the Dampier Port and continue to be incrementally lost to development. Currently these communities are considered to be unique to this area; however this may be due to surveys and comparisons not having been undertaken in other similar habitats on the Pilbara coastline. It is recommended that the proponent consider the distribution of the inshore Dampier coral communities within a broader regional context.	Refer to Fringing Reefs: Regional Context (Section 5.3.4) and Appendix 11
Given that coral loss in this area has already exceeded the BPPH cumulative loss guideline, the proponent needs to establish the ecological function and value of the corals (and any other BPPH where the cumulative loss guideline will be exceeded) and discuss the likely consequence of the predicted BPPH loss to ecological integrity in the area.	Refer to Section 8.2 and Appendix 15
An investigation is required of the tolerance of sensitive indicator biota to elevated total suspended solids (TSS) and sedimentation.	Refer to Section 8.2, Appendix 2 and Appendix 8
In the preliminary information document the proponent has described two sediment habitats, mud and sand/shell. It is recommended that the proponent include observations of the sediment profiles (to depth) when undertaking the sediment contaminant survey and include discussion of these in its documentation. (MEB found extensive areas where recently deposited muds had covered the original sand/silt substrates of inner near-shore Mermaid Sound just after the completion of a dredging program.) The sediment profiles may give some insight into the potential extent and severity of sedimentation resulting from the current proposal.	Refer to Seabed Morphology and Geology (Section 5.2.3) and monitoring proposed in Appendix 2. Also refer to hydrodynamic assessment of potential siltation – Marine Environmental Modelling
In the preliminary information document the proponent discusses the coral loss limits from the Ministerial Conditions for the Pluto development as if they set a baseline from which coral losses associated with the Dampier Cargo Wharf expansion will be considered. This is not the case. The Pluto conditions set a limit for coral loss associated with that development, but it is anticipated	Refer to – Water Quality Impacts for the Pluto program in an area of intensive dredging - Appendix 8 which describes a new baseline. Monitoring detailed in Appendix 2 and the calculations of BPPH in Appendix 15

EPASU Comment	Response
that good management will ensure that actual losses will be substantially less than the limits.	
The proponent should consider whether offsets will be required for the predicted impacts on the marine environment.	The proponent has provided an assessment in accordance with EAG3 (Appendix 15).
The preliminary information documentation does not consider whether blasting will be required. The hardness of the substrate to be dredged should be determined through geotechnical investigations. The proponent needs to determine whether blasting is required, and if it is, provide management strategies for ensuring impacts on sensitive biota are prevented or minimised.	Blasting is not required. The DMSF was redesigned based on a geotechnical study (Appendix 7) to avoid dredging any hard or very hard material requiring drill and blast operations and provide sheet pile/pile penetration sufficient to obtain design loads by driving. Refer to Seabed Morphology and Geology (Section 5.2.3).
Stormwater treatment/management measures should be integrated into the design for the upgraded Dampier Cargo Wharf. Storm water should be directed away from the marine environment with marine discharges only occurring during extreme rainfall events.	Refer to Surface Drainage (Section 9.7) and Appendix 4.
The proponent will need to prepare and implement a contingency Oil Spill Management Plan to address potential oil spills during construction of the Dampier Cargo Wharf and for on-going operations of the wharf.	Refer to Oil Spill Management Plan (Appendix 14).

3.4.2 Department of Environment, Water, Heritage and the Arts

WorleyParsons submitted a Sampling and Analysis Plan (SAP) for sediment contamination assessment in the Dampier Port on behalf of DPA to the Department of Environment, Water, Heritage and the Arts (DEWHA) on the 29th July 2008. A reply was received on the 17th September 2008. DEWHA comments on the SAP and the WorleyParsons response are provided in Table 6.

Note that these comments are in reference to a SAP (now superceded) submitted for the purposes of offshore disposal. The proposed disposal method was changed to reuse for land reclamation, and therefore this document was superceded by the Preliminary Site Investigation Sampling and Analysis Plan (PSI SAP, Appendix 9) that was later submitted to the DEC. However, DEWHA's comments were also incorporated into the PSI SAP.

Table 6: DEWHA comments and DPA response

DEWHA Comment	Response
DPA should confirm there is a lack of potential sources for PCBs within the proposed dredge area, in order to approve the exclusion of PCBs from sampling.	Refer to Section 2.7.3 in PSI SAP (Appendix 9).
DPA should justify the exclusion of sampling for marine pests.	In April 2008 the National Introduced Marine Pest Coordinating Group (NIMPCG) accepted that the survey work undertaken within the Dampier Port by various proponents (principally Woodside-West Australian Museum survey works) was sufficient, and that Dampier did not have any Introduced Marine Pests (IMP) species on the NIMPCG Species of Concern list, or any other IMP of current concern. It is not anticipated that this project will have the potential to translocate IMP, and the existing levels of management and control are considered sufficient to address the key risks posed by the project. The dredging contractor will be required to address all State and Federal import controls for the entry of vessels (refer to Section 9.4).
If it was necessary to move the sampling positions to accommodate port operations, the new sampling positions should be recorded.	Sampling positions were not changed. Refer to PSI SAP (Appendix 9) for sampling locations.

3.4.3 Department of Fisheries

Advice was sought from the Department of Fisheries (DoF) regarding the prevention and management of marine pests and incorporated into Section 9.4.5 of this report. The prevention and management strategies provided by DoF are specific for dredging biosecurity and are based on experience gained as a result of recent large-scale dredging projects elsewhere in Western Australia (pers.comm. Bill Bardsley, DoF, 11 November 2009).

3.4.4 Department of Environment and Conservation

The Preliminary Site Investigation Sampling and Analysis Plan (PSI SAP) for sediment contamination and acid sulfate soil potential in the Dampier Port was developed by WorleyParsons Services Pty Ltd in correspondence with J Abrahams of the DEC during October 2009.

DEC comments and responses are provided in Table 7 below, and the completed PSI SAP is provided in Appendix 9. This document superceded the SAP for offshore disposal submitted to DEWHA and discussed in Section 3.4.2 above.

In addition the DPA met with the DEC to discuss the results and recommendations on the 9th December 2009. No further comments were provided

Table 7: DEC comments and response

DEC Comment	Response
DEC recommends that WorleyParsons increase the number of samples analysed for AVS and COD, and propose they be undertaken on 15 samples. This will provide further data and quantification that the disturbed dredged sediments will remain stable once encapsulated. The COD test procedure is based on the chemical-decomposition of organic and inorganic contaminants. The results of a COD tests will tell us the amount of dissolved oxygen consumed by the contaminants both dissolved and suspended forms in the dredged materials. This test carried out in the lab accelerates the decomposition process from a solution of boiling potassium dichromate; the higher the COD, the higher the amount of contaminants in the test sample that can be oxidised and remobilised. AVS test will compliment the SPOCAS analysis to give a better characterisation of the acidity risk.	AVS and COD were undertaken on 15 sediment samples at surface depth. Refer to sediment sampling results (Appendix 9).
Please note, in the ‘Plan’ you refer a number of times to the Draft Identification and Investigation of Acid Sulfate Soils (DEC. 2006). As of May 2009 this document has been finalised and can be sourced from DEC’s website. Also note that the main elements from the Draft guideline as referred to in your ‘Plan’ are consistent with the final guideline version.	The PSI SAP was updated to reflect the 2009 document. Refer to PSI SAP (Appendix 8).

3.4.5 LandCorp

DPA have met with LandCorp representatives on various occasions over 12 months regarding partial access to Lot 565, currently owned by LandCorp. LandCorp only use a corridor of the land currently leased, which does not include the area that may be affected by the DMSF. DPA wish to seek a formal arrangement for the use of Lot 565, preferably ensuring exclusive DPA access.

DPA have provided LandCorp with a description of the project and indicated that they plan to ensure access via one of the following options:

a) DPA will request that the LandCorp lease area is redefined by the State government to their existing corridor of use and that a new Lot is formed with the remainder, which DPA will then purchase from the State government;

b) DPA will request that the LandCorp lease area is redefined by the State government to their existing corridor of use and that the remainder of the lease is transferred to the DPA; or

c) DPA will sublease the required area from LandCorp.

LandCorp have indicated that they are satisfied with the above approach, and have not raised objections to the proposed use of the land providing there are no impacts upon existing LandCorp operations. DPA will continue to address this issue in consultation with LandCorp.

3.4.6 Other Stakeholders

A number of additional stakeholders (Section 3.3) were contacted during the design stage. Their comments and responses are summarised in Table 8 below.

Table 8: Other stakeholder comments and response

Stakeholder	Meeting date and attendees	Comment	Response
Dept Environment, Water, Heritage & Arts (DEWHA)	EPBC Referral	The proposed DMSF will not be subject to a Commonwealth level of assessment. DEWHA have advised that the project will not be a controlled action, and will be subject to a “Particular manner” approval.	None required. Refer to referral document, additional information request, DPA response and EPBC non-controlled action decision (Appendix 17).
Department of Environment and Conservation (Karratha Office)	4th June 2009, Shandell Smith and Alana Kidd	No prescribed activities are currently proposed. DPA must address the impacts and management of noise and dust during construction, although DEC notes that these are unlikely to be significant given the location of the project. DPA must also address the impacts of light on marine fauna and surface water controls.	All factors have been assessed for potential impacts, and management strategies are prescribed. Refer to Section 9.2 for light, Section 9.7 for surface drainage management, Section 9.8 for noise management and Section 9.12 for construction dust. A specific noise study was undertaken and is attached as Appendix 3
Department of Environment and Conservation (Marine Ecosystems Branch)	3rd July 2009. Ray Claudius (via e-mail) with MEB input. Meeting with Kevin Mcalpine 11 September 2009	Issues were identical to those discussed with the EPA Service Unit.	Refer to Table 5 of Section 3.4.1.

Stakeholder	Meeting date and attendees	Comment	Response
Department of Environment and Conservation (Marine Ecosystems Branch)	9th December 2009. Meeting with Cam Sim and Ron Tregonning	Assessment of impact of DMSF development on existing discharges from either Pluto or NWSV	Refer to Appendix 19
Department of Mines and Petroleum (Environment Division)	Ian Briggs	No specific issues were identified. DPA must apply EPA Guidance Statement 29 during the impact assessment.	Refer to Section 8.2 and Section 9.1 for the application of EPA Guidance Statement 29 to coral and seagrass, and Appendix 15 for proposed environmental offsets.
Department of State Development	Peter King	No specific issues were identified.	None required.
Department of Planning. Regional Planning and Strategy	Jim Kaucz	No specific issues were identified.	None required.
Water Corporation	Janice Landy 24 August 2009	DPA must ensure that project will not exceed their allowance (1080kL/day) during construction. No more water will be available within a 24 hour period if the allowance is exceeded. DPA must ensure they have sufficient water storage for fire fighting emergencies.	Refer to Section 6.3. Current and future forecast water demand for both construction and operation of the DPA facility will be comfortably within the 1080KL/day water allocation, and the two tank storage systems on the project site contain sufficient reserve to provide fire fighting capacity independent of supply rate.

Stakeholder	Meeting date and attendees	Comment	Response
Department of Indigenous Affairs	Robert Brock and Megan McCorry. 23 October 2009	A Section 18 approval will be required for impacts to any heritage items. DIA recommends avoidance where possible. If the proposed DSMF requires the disruption of heritage items, the existing surveys and consultation would not be sufficient to satisfy the requirements of a Section 18 application and further work would be required. DPA should contact relevant Aboriginal groups to inform them of the proposed works.	Refer to Section 9.11 for impacts and management of indigenous heritage. DPA does not anticipate that heritage items will be moved or destroyed during the construction or operation of the DMSF. DPA has contacted each of the nominated Aboriginal groups with interests in the Burrup. The letter (sent 15 December 2009) outlines the project, the proposed works and potential interaction with heritage items, and offers to arrange further consultation if required. DPA are awaiting responses, and further consultation will be undertaken outside the Environmental Assessment process.
Coastal Communities Environmental Forum (Rio Tinto community engagement Forum)	Rio Tinto managers, Department of Environment and Conservation, and community representatives	No specific issues were identified.	None required.

Stakeholder	Meeting date and attendees	Comment	Response
Dampier Community Association	DCA Committee (including Jenny Fox President) 27 July 2009	No specific concerns were identified. DPA must address dust and noise during construction and operation to ensure these won't impact Dampier residents. Marine heritage items may be present within the proposed DMSF footprint.	Dust and noise have been assessed for potential impacts, and management strategies are prescribed. Refer to Section 9.8 for noise management (and Appendix 3) and Section 9.12 for construction dust. Refer to Section 6.5 for European heritage.
Pilbara Sea Country Initiative	Pilbara Native Title Service and representatives of aboriginal groups. 6 November 2009	No specific issues were identified.	None required.
Shire of Roebourne	Bob Sharkey 21 July 2009	The Dampier Port is outside the Shire of Roebourne's planning jurisdiction. The Shire of Roebourne is aware of the proposed development and is satisfied with the progression of the planning and approvals process. DPA must consider impacts upon traffic, surface water management and potential noise impacts upon Dampier.	All factors have been assessed for potential impacts, and management strategies are prescribed. Refer to Section 9.7 for surface drainage management (and Appendix 4), Section 9.8 (and Appendix 3) for noise management and Appendix 16 for traffic.

Stakeholder	Meeting date and attendees	Comment	Response
Woodside	Eric Pegrium (7 July 2009), Neville Bryant (19 November) Ben Garwood	DPA should consider wave reflection from the proposed land reclamation area and its interaction with the Pluto berth. DPA should make a prediction of sedimentation levels inside the Pluto Berth as a result of the capital dredging program. If DPA sources rock material from the Pluto site, transport may need to occur at night to accommodate safety requirements of the operating site.	An assessment of wave reflection was undertaken by Coastal Engineering Solutions (2009). Refer to Section 9.5. Sedimentation levels inside the Pluto Berth were assessed by a specialist modelling study. Refer to Appendix 13. Refer to Section 9.7 for the noise implications of conducting operations at night. Wave study undertaken and demonstrated no significant impact. Details supplied to Woodside (Section 9.5).
Woodside (King Bay)	Peter Cowell, 1 December 2009	No specific issues were identified and the stakeholder was supportive of the project.	None required.
Burrup Fertilisers Pty Ltd	Summer Ali, Rajan Sinha, Bose John, 17 November 2009	Increases in large vehicle traffic on Mof Road, or the use of an alternate access route to the proposed DMSF, may result in increased risk to delivery routes. DPA should examine this risk.	A source for rock material will be selected during the next planning stage. DPA will then conduct traffic a risk assessment in conjunction with all port users, and implement management strategies as required to ensure that risk is minimised.

Stakeholder	Meeting date and attendees	Comment	Response
Mermaid Marine Australia (MMA)	Shaun Lee (11 December 2009)	MMA wish to be kept informed of the Project, including the source of rock material and potential traffic issues via the Port Notices. MMA has undertaken a smaller reclamation project and the project encountered issues with high turbidity levels in the discharge water near the end of dredging activities. The issue was managed by ceasing dredging operations until turbidity levels decreased and water could be safely discharged.	All relevant parties will be informed of relevant traffic planning (i.e. road closures) via the existing Port Notices distribution list. DPA will also issue a notification regarding the source of rock material once planning is complete. A detailed DRMP has been developed for the proposed dredging and reclamation activities (Appendix 2), including detailed water quality monitoring and contingency plans for high turbidity levels in discharge water.
Patrick Stevedores (Western Stevedores)	Steve Tesar	No specific issues were identified. DPA should inform Western Stevedores of traffic planning if the proposed development is expected to interact with existing operations.	All relevant parties will be informed of relevant traffic planning (i.e. road closures) via the existing Port Notices distribution list.
BGC Contracting	Elliott Warner, 20 November 2009	No specific issues were identified.	None required.

Stakeholder	Meeting date and attendees	Comment	Response
Rio Tinto	Peter Royce, Damon Newling and Mike Spreadborough, 15 December 2009	Rio Tinto is supportive of the project in general. DPA should consider noise and dust issues in the API document to ensure they don't impact nearby communities. DPA should consider increases to road traffic on existing road networks and keep Rio Tinto informed of potential changes or impacts. DPA should also ensure that the project will not impact Rio Tinto shipping movements or scheduling. Rio Tinto seeks assurance from DPA that the Rio Tinto Artificial Reef at Kings Bay will not be impacted by dredging or reclamation operations.	For potential impacts, management strategies and residual risk from construction noise and dust refer to Sections 9.8 and 9.12 respectively. Also refer to the Noise Assessment in Appendix 3. Road traffic considerations have been addressed in a separate report (Appendix 16). All relevant parties will be informed of relevant traffic planning (i.e. road closures) and any disruptions to shipping via the existing Port Notices distribution list. The artificial reef is outside the zones of impact and influence predicted by turbidity and sedimentation modelling.
BIS Logistics	David Taylor (Manager), 20 November 2009	No specific issues were identified. The traffic implications of rock haulage on Burrup Road and Mof Road were discussed.	All relevant parties will be informed of relevant traffic planning (i.e. road closures) via the existing Port Notices distribution list. DPA will also issue a notification regarding the source of rock material once planning is complete.

4. EXISTING TERRESTRIAL ENVIRONMENT

This section presents a description of the existing terrestrial environment in the area of the proposed DMSF on the Burrup Peninsula (Figure 17). It summarises information collected by desktop review, in addition to a terrestrial flora survey undertaken by Astron Environmental Services.

4.1 Physical

4.1.1 Geology

The geology of the Burrup Peninsula is described as primarily Fortescue Group granophyres and gabbros Archaean igneous rocks, with small exposures of granites (DEC 2006c). Regionally there exist two geological regions of the Burrup Peninsula, a low lying expanse of supra-tidal mudflat and sand dunes, separate from two elevated rocky areas. Ancient basalts have created large bare exposures on the Peninsula and these have evolved to the unique “rockpile” form, that is characteristic of the Burrup landscape (DEC 2006c).

4.1.2 Soils and Landforms

The distinct rusty colored soils of the Burrup Peninsula are typically shallow but persist up to 2 m in depth in the lower alluvial slopes (DEC 2006c). A coarser sandy soil occurs in the vicinity of coastal areas resulting from tides and storm surges contributing silts and shell fragments to these areas (DEC 2006c). The exposed environment has experienced weathering overtime, evidenced by substantial stony/clay colluvial infill within valleys across the predominantly elevated Peninsula (DEC 2006c). Around the beaches and tidal flats aeolian sands have accumulated. Intertidal mud flats commonly occur in sheltered embayments situated along the eastern and western coastlines.

4.1.3 Hydrology

Surface freshwater flows are limited and highly variable, influenced by intense rainfall typically during cyclonic events. Cyclone activity peaks between November and April with attendant storm surge and flooding of rivers and coastal plains. Significant flow periods can be followed by drought-like conditions over several years, eventuating in stagnant stream flows and deeper gorge waterholes drying out. The inherent unreliability of rainfall results in numerous ephemeral creeks and rivers (SKM 2006a). Similar to much of the Pilbara, some groundwater is found in fractured rock aquifers but overall groundwater supplies are limited. Groundwater recharge is dependent on rainfall which leads to water infiltrating the fractures of the surface rock or leaking from surface water flows. Fractured rock aquifers are characterised as highly localised systems with little regional flow (DEC 2006c).

Figure 17 Typical geology and overland rough surface water hydrology experienced at the current site

4.2 Biological

4.2.1 Vegetation and Flora

At least 383 native vascular plant species from 54 families occur on the Burrup Peninsula. Predominantly these are from the families; Papilionaceae (44 species), Malvaceae (31 species) and Amaranthaceae (29 species). The Poaceae was the most numerous native monocots (45 species), while the area is also well represented by Cyperaceae (15 species), (DEC 2006c).

The habitat diversity of the region is highlighted by the fact around 200 different vegetation associations have been described for the Burrup Peninsula many of which have limited distributions (Trudgen 2002). The vegetation is described as Pilbara coastal and near coastal groups, Eremaean groups, and of groups of species related to the Northern Botanical Province (Blackwell *et al.* 1979). Despite lacking true endemism the latter groups are particularly important due to their common occurrence on the Burrup Peninsula, maintaining a close association with the rock piles (DEC 2006c).

Overall flora communities of the Burrup Peninsular are considered to be in very good or excellent condition, except in areas of coastal sand (DEC 2006c). Disturbance from human activity (especially four-wheel-drives) has resulted in the introduction of invasive non-native species namely, buffel grass

(*Cenchrus ciliaris*) impacting on natural ecological values, principally through displacement of native vegetation. Disturbance of native vegetation has also been attributed to clearing for industrial development and altered fire regimes (Trudgen 2002).

While there are currently no known 'declared rare' (threatened) flora identified on the Burrup Peninsula, priority species have been identified in the area; one Priority 1 species (*Terminalia supranitifolia*) and one Priority 3 species (*Gymnanthera cunninghamii*) (CALM 2005).

Trudgen (2002) suggested that the vegetation of the Burrup Peninsula is unique in a regional context i.e. distinct from the vegetation of both the Fortescue Botanical District and the Abydos Plain. This was explained by the isolation of the area and the selection pressures attributed to the unique physical environment (see Section 4.1). It was therefore concluded that at the subregional level, the Burrup Peninsula has a very high value for the conservation of vegetation, and adds to the conservation value of the area at a regional level (DEC 2006c).

Vegetation studies have been undertaken for all the main development areas on the Burrup Peninsula. Studies undertaken for the Pluto LNG facility situated in close proximity to the DPA Cargo Berth Expansion Project have identified;

a) One priority flora species, *Terminalia supranitiflolia* (Priority 3) identified within the area;

b) 16 species of conservation interest as defined by Trudgen (2002); and

c) Four weed species, kapok (*Aerva javanica*), buffel grass (*Cenchrus ciliaris*), spiked malvastrum (*Malvastrum americanum*) and milk thistle (*Sonchus oleraceus*).

4.2.2 Flora Survey of Project Area

The flora and vegetation within the proposed DMSF site (Project Area) was surveyed by Astron Environmental Services on the 5th of August, 2009. The full report is included as Appendix 5.

A Total of 51 vascular species and one fern species from 29 families were recorded within the Project Area. The dominant families represented were *Poaceca* (grasses), *Papillionaceae* (peas) and *Mimosaceae* (wattles).

A total of four weed species were recorded within the Project Area: *Aerva javanica*, *Cenchrus ciliairs*, *Passiflora foetida var. hispida* and *Phsalis angulata* (Wild Gooseberry).

Five vegetation types were broadly described within the Project Area and vegetation condition was excellent.

Declared Rare Flora

No Declared Rare Flora was recorded within the Project Area.

SPECIES OF CONSERVATION SIGNIFICANCE

Two Priority 3 species were recorded: *Terminallia supranitifolia* and *Rhynchosia bungarensis*.

A total of 5 species identified as having conservation significance were also recorded within the Project Area: *Paspalidium tabulatum* (Burrup form), *Triodia angusta* (Burrup form), *Triodia epactia* (Burrup form), *Corchorus walcottii* (Burrup form) and *Triumfetta appendiculata* (Burrup form).

The Project Area contains one vegetation association that could be considered by Trudgen (2002) as having high conservation value. It is described as: Dwarf shrubland of *Pluchea tetranthera* (and annual *Streptoglossa decurrens*) over hummock grassland of *Triodia epactia* (Burrup form) with tall annual herbland of *Trichodesma zeylanicum* with scattered *Acacia colei*. This is the single occurrence of this Trudgen (2002) vegetation type on the Burrup Peninsula.

THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

No Threatened Ecological Communities were recorded within the Project Area.

One Priority Ecological Community was recorded: Burrup Rock Pile Communities, listed as a poorly known ecological community.

4.2.3 Fauna

The Burrup Peninsula supports a diverse terrestrial vertebrate fauna, comprising representatives of the Eyrean zoogeographic region (Heatwole 1987) with some Torresian species and arid-zone species that have adapted to high temperatures and intermittent rainfall.

The species diversity of the Burrup Peninsula is high compared with the Pilbara as a whole. As many as 47 species of mammal, 170 species of bird and 99 species of reptile may inhabit, or visit, the Burrup Peninsula, the surrounding area, and adjacent coastal fringes. Several species are restricted to the Burrup Peninsula alone. However, a number of key species, particularly reptiles and mammals such as the Little Red Kaluta (*Dasykaluta rosamondae*) and the Pilbara Ningaui (*Ningaui timealeyi*), are endemic to the Pilbara.

At least 300 vertebrate species have been described from the Burrup Peninsula. This includes introduced mammals (36 species), birds (186 species) and reptiles (78 species) and introduced vertebrates (four mammal species and one bird species), (SKM 2006a).

Avifauna on the Burrup Peninsula is diverse and is attributed to the diversity of habitats, including intertidal and marine environments. No species of bird are known to be restricted to the Burrup Peninsula (DEC 2006c). The intertidal flats surrounding the Burrup are locally important (DEC 2006c), and many of the species found on the flats are protected by the CAMBA and JAMBA international migratory bird treaties.

The mammals identified on the Peninsula are well represented by bats, with at least 14 species likely to occur in the region. Bats are commonly associated with relatively extensive ranges owing to their high mobility and are at least periodically distributed locally.

The mammal fauna of the Burrup Peninsula is comprised of species that are widely distributed across mainland Australia. This includes a variety of fauna with broad ranges across WA, in northern regions and species with central distributions (DEC 2006c). More specifically the northern quoll (*Dasyurus hallucatus*), delicate mouse (*Pseudomys delicatulus*) and common rock rat (*Zyzomys argurus*) occur in the northern parts of Australia, and the centrally distributed (Pilbara or western desert) species, Rothschilds rock wallaby (*Petrogale rothschildi*), little red kaluta (*Dasykaluta rosamondae*), Pilbara ningaui (*Ningaui timealeyi*), undescribed Planigale species, and Rory's pseudantechinus (*Pseudantechinus roryi*).

Three native species are known to have or are likely to have become locally extinct on the Burrup but remain distributed elsewhere, these include; the pale field rat (*Rattus tunneyi*), dingo (*Canis lupis dingo*) and western pebble mound mouse (*Pseudomys chapmani*).

The introduced animals present on the Peninsula namely foxes, the cat, black rat and house mouse are all common in the vicinity of Dampier, and around industrial areas such as King Bay and the port.

The frog fauna has been described as the same across the Dampier Archipelago and no species of reptile are known to be endemic to the Burrup Peninsula. A member of the Pygopodidae family *Delma borea* has been identified only on the Peninsula and surrounding offshore islands, however it has not been discovered on the mainland.

Reptile species on the Burrup Peninsula have a broad distribution. The dominant and most commonly encountered reptile species on the Burrup Peninsula include, the yellow-spotted monitor (*Varanus panoptes*), ring-tailed dragon (*Ctenophorus caudicinctus*), and two skink species (*Ctenotus pantherinus and C. saxatilis*), none of which are considered rare or threatened.

A species of conservation significance, the Pilbara olive python (*Liasis olivaceus barroni*), is currently listed under *Wildlife Conservation Act 1950* as 'fauna that is rare or likely to become extinct' is believed to exist on the Peninsula in good numbers (Figure 18). Therefore the species population on the Burrup Peninsula is of high importance to the Pilbara region.

Several species of Camaenid land snails are known to occur in the study area (Solem 1997). These species are of conservation interest Ponder (1997) suggests areas which have a concentration of narrow range endemics such as Camaenid land snails, should have a high priority for conservation.

DPA has carried out a Camaenid Land Snail desktop survey analysis of all populations known of significance. The analysis draws attention to the fact that their distributions area is widespread with endemic populations broadly within the environs. Figure 19 shows there are no endemic species have been recorded within or near the project footprint.

It was noted by the EPA in Bulletin 1065 that Camaenid Snails generally live in hills rather than on the lower plains (EPA 2002).

Figure 18 Pilbara olive python (*Liasis olivaceus barroni*) on the Burrup Peninsula

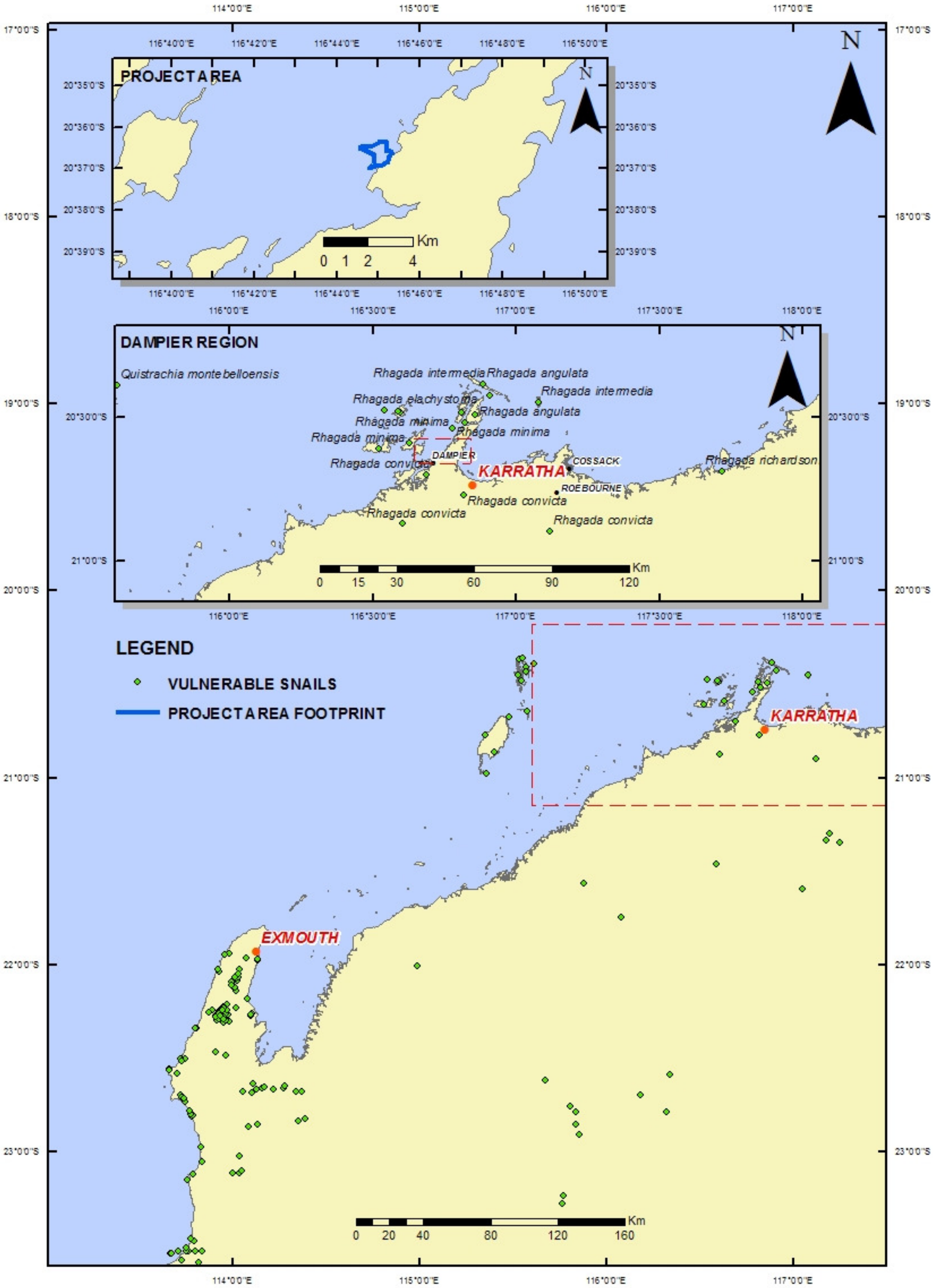


Figure 19 Recorded Camaenid snails from surveys undertaken in the Pilbara

5. EXISTING MARINE ENVIRONMENT

This section presents a description of the existing marine environment in the area of the proposed DMSF on the Burrup Peninsula. It summarises information collected by desktop review, in addition to the following specific studies and surveys:

- A baseline water quality assessment (MScience 2007c);
- A geotechnical investigation, undertaken (Coffey Environments Pty Ltd 2008);
- A sediment quality and acid sulphate soils investigation (WorleyParsons 2009e);
- A benthic habitat video camera survey (WorleyParsons 2009a) ; and
- A benthic habitat map (WorleyParsons 2009a).

5.1 Regional Setting

5.1.1 General Description

The Dampier Port is bounded by the western coastline of the Burrup Peninsula to the east and Dampier Archipelago to the west (Figure 1 of Appendix 1). The marine waters between both boundaries have a shallow in bathymetry with water depths ranging typically between 5-20m LAT (lowest astronomical tide). Mermaid Sound is the name given to the area of water between these two boundaries (Semeniuk *et al.* 1982). The area is described as a drowned coastal environment of plains which is interspersed by a number of small islands fringed often by limestone rock formations. Subtidal substrates generally consist of soft silt/sand sediments of terrestrial origin with occasional limestone rocky reef (Stoddart *et al.* 2004). Fringing and subtidal reef systems provide habitat for a range of species including diverse coral, fish and invertebrate communities. While there are no marine protected areas within the Dampier Port, an area of approximately 122,170 ha has been proposed as a marine reserve for the Dampier Archipelago based on the marine and coastal environment of the region. The unique combination of offshore islands, intertidal and subtidal reefs, mangroves, macroalgal communities and coral reefs, was identified by the Marine Parks and Reserves Selection Working Group report as having very significant conservation values (MPRSWG 1994).

The proposed reserve area is divided into three discrete areas intersected by the Dampier Port. The eastern portion of the proposed marine park extends from the boundary of the Dampier Port to include Delambre Island and waters adjacent to the eastern most limit of the proposed reserve (CALM 2005). The proposed marine park boundary in this area then extends along the coastline of

Nickol Bay to Dixon Island. The deeper waters of Nickol Bay are excluded from the proposed reserve. The western portion of the proposed marine park extends from Rosemary Island in the north to Enderby Island and also includes West Lewis, East Lewis, and Malus Islands. The proposed marine management area extends from Eaglehawk Island to the Fortescue River mouth in the south-west, and includes all waters up to approximately 20 km from the coast (CALM 2005).

5.1.2 Climate

The regional climate of the Dampier Archipelago is both arid and tropical, with hot dry summers with episodic heavy rainfall from tropical cyclone activity, and mild dry winters with limited rainfall (DPA 2007a). Compared to inland Pilbara the microclimate of the Burrup Peninsula features lower temperatures and higher humidity (DEC 2006c).

Annual rainfall is highly variable within the Archipelago with most rainfall received between January and May (Pearce *et al.* 2003). Summer rainfall events are often heavy and sporadic as a result rain-bearing tropical storms from the north while winter rainfall events are the result of passing depressions across the south-west of Australia (DPA 2007a).

Net annual evaporation is approximately 3500 mm which exceeds the average annual rainfall. Evaporation ranges between 200 mm per month during winter months to 400 mm per month during summer months (Pearce *et al.* 2003).

Wind prevails from a west to north-west direction with wind speeds often increasing to 35 km/hr for 3-4 days at a time (DPA 2007a). Tropical cyclones generally form between November and April and can generate wind speeds up to 260 km/hr, large swells and torrential rain. An average of two tropical cyclone events occur within the region annually (DPA 2007a).

5.2 Physical Marine Environment

5.2.1 Oceanography

Water circulation and currents in the Dampier Archipelago are determined by a combination of large scale ocean circulation, tides, local winds (including tropical cyclones) and non-tidal long period waves (continental shelf waves and meteorological effects) (Pearce *et al.* 2003). The magnitude of currents in the Archipelago are firstly influenced by localised bathymetry and secondly by the location of islands (Pearce *et al.* 2003). Consequently, strong currents flow along the axis of Mermaid Sound and in the channels between the islands due to the narrow passages and the shallow bathymetry (DPA 2007a).

Tides have the most influence on water movement within the Dampier Port. Tides are typically semi-diurnal which range from 1.0 m during neap tides to 3.7 m during spring tides (Australian

Hydrographic Service 2008). Tides contribute most to the instantaneous water movement, while other forces such as waves act to produce a net residual drift effect (Pearce *et al.* 2003).

Wave height and direction within port limits are heavily influenced by the sheltering effect of the Archipelago itself and is determined by oceanography, refraction and bottom friction (Pearce *et al.* 2003). The Archipelago shelters the port area from the Southern Ocean swell due to the shallow waters between Barrow Island to the west and the mainland. Wind generated waves are generally less than 1.3 m but topical cyclones (from December to April) may generate large waves and increase wave height to 10 m at the entrance to Mermaid Sound (Pearce *et al.* 2003).

5.2.2 Water Quality

PHYSICAL

Water temperature within the Dampier Archipelago ranges between 22.5°C during winter to 30.4°C during summer. While salinity remains relatively constant (34.6-35.6ppt) throughout the year, spatially, salinity generally decreases in concentration between nearshore and offshore areas (Pearce *et al.* 2003). Waters are generally well mixed with little stratification displayed temporally. Within Kings Bay adjacent to the proposed development, greater extremes of temperature and salinity are often displayed compared with temperature and salinity ranges observed further offshore.

Suspended sediment parameters are influenced primarily by natural circulation of water driven by localised hydrodynamics and bathymetric conditions. Turbidity and suspended solid concentrations display a distinct negative correlation with increasing distance offshore (Simpson 1988), while deeper offshore waters display relatively low turbidity. Nearshore coastal waters frequently display elevated turbidity and TSS concentrations due to:

a) Shallow bathymetry;

b) Fine sediment resuspension from wind induced wave action and tidal currents (Stoddart *et al.* 2005a)

c) Sediment transportation by terrestrial fluvial and erosion processes (Semeniuk *et al.* 1982);

d) Sediment resuspension from vessel propeller wash (Stoddart *et al.* 2005a); and

e) Tropical cyclone and rainfall events (Stoddart *et al.* 2005a).

Refractory sediment deposition rates have been recorded in the southern area of the Sound (Forde 1985). Sediment depositions rates range from 70 gfm^2/d (range 34-140 gfm^2/d) during winter to 120 g/red (range 33-211 g/m^2/d) in summer. Depositional rates in the mid to northern parts of Mermaid Sound have increased by 64-118 % following a cyclonic event (Forde 1985).

NUTRIENTS

The waters of the Archipelago are oligotrophic, and water quality characteristics are generally highly variable through the Archipelago (Pearce *et al.* 2003). High spatial and seasonal variability are evident in nutrient and chlorophyll-*a* distributions, with water quality generally displaying:

a) Low concentrations of inorganic nutrients with a high degree of variability for shallow inshore sites.

b) Seasonal spatial concentration gradients between nearshore and offshore locations

c) Nitrogen/Phosphate ratios (N:P) were generally low throughout the Archipelago indicating that under nutrient-limiting conditions nitrogen availability would be the most limiting to phytoplankton growth;

In contrary, water quality investigations within King Bay located to the south of the proposed development found total nitrogen and nitrate-nitrite, in the surface and bottom waters to exceed the ANZECC/ARMCANZ (2000) guidelines.

METALS AND ORGANICS

The coastal waters of the Dampier Archipelago generally display low metal and organic contaminant concentrations. Recent sampling investigations undertaken by Wenziker et al. (2006) identified that concentrations of cadmium, chromium, copper, lead and zinc, total mercury, polycyclic aromatic hydrocarbons (PAHs), phenols, BTEX chemicals and petroleum hydrocarbons were below the 99% species protection guideline for each respective contaminant and were comparable to water quality of the North West Shelf. While all contaminant concentrations were compliant to adopted 99% species protection guidelines, water samples collected from Kings Bay adjacent to DPA cargo wharf did display elevated cadmium and copper concentrations compared with all other sites (Wenziker *et al.* 2006).

BASELINE WATER QUALITY ASSESSMENT

Water quality investigations have been undertaken throughout the Dampier Archipelago, often as part of compliance monitoring in association with dredging and construction activities. The most relevant monitoring program within the proposed development area is the water quality monitoring undertaken for the Woodside Energy Ltd Pluto Project located immediately north of the development area (Figure 1, Appendix 1).

Several water quality monitoring sites were established adjacent to the proposed dredge area (Appendix 6). At each of these sites, *in situ* time series monitoring of turbidity has been undertaken over a period of 30 months, with seven months of data collected prior to the commencement of dredging. A detailed assessment providing summary statistics and time series graphs of turbidity recorded during the monitoring period is provided in Appendix 6.

Sites located adjacent to the proposed development displayed median turbidity ranging from 1.4 to 3.3 NTU at each of the impact sites prior to dredging commencing. These median values were comparable to reference site data. Summer median turbidity values were generally slightly higher (approximately 0.6 NTU) than median turbidity recorded during winter.

Temperature was also measured at identical sites to those described above to determine coral health response to water temperature. As expected, a distinct cycle was found with higher temperatures in summer compared with temperatures in winter. Mean water temperature ranged from 23°C in winter to 29°C in summer.

Detailed baseline water quality statistics are provided as a report in Appendix 6.

5.2.3 Seabed Morphology and Geology

The benthic substrate of the Dampier Archipelago features unconsolidated areas interspersed with outcrops of hard igneous rocks, fringing limestone coral reefs and subtidal limestone pavements. The basement rocks in the area comprise various heavily-dissected Archaean igneous rocks including basalt (various islands), granophyre (western Burrup) and gabbro (eastern Burrup) units, as well as more recent Quaternary limestones (including underwater reef features and Legendre Island); (Geological Survey of Western Australia 2008). A series of northeast-southwest (and east-west) trending faults control the basic shape of the shoreline of the Burrup, and also give rise to erosional features such as Searipple Passage and King Bay. Much of the seabed comprises flat, featureless limestone pavements and terraces with sand/gravel veneers, however it is unclear from the nautical charts which of the shoals in the Dampier Archipelago are coral reefs and which are sandbanks (Semeniuk *et al.* 1982). Bedrock outcrops dominate the shoreline of the development area, however these give way to marine sediments or poorly consolidated limestone within 100-200 m offshore.

The seabed of the Dampier Archipelago tends to drop off steeply from the bedrock shoreline of the Burrup Peninsula and various islands, and then assumes a more gradual gradient, sloping to the northeast. Water depths in Mermaid Sound range from 10-12 m, reaching greater depths in areas of current scour between islands. A raised limestone bank, trending northeast-southwest, stretches across the entrance of the Sound between Cohen Island and Nelson Rocks. Further offshore the seabed continues to slope gradually onto the North West Shelf, reaching 30 m 25 km from the shoreline (north of the Dampier Port area).

The seabed morphology in the vicinity of the development area is relatively smooth, with several subtle, long wavelength sediment dune features appearing in the north. Seaward of the development area, a small area of bedrock reef is apparent, beyond water depths of 8 m. All other reef is restricted to within 100 m of the shoreline. The region of previous dredging dominates the development area, having been dredged and maintained at depths of -11 m and -14 m CD.

5.2.4 Sediment

The sediments of the North West Shelf typically comprise sands to sandy muds inshore, grading to coarse carbonate sands and gravels offshore (McLoughlin *et al.* 1985; Dix 1989; Semeniuk V. 1993). These offshore sediments are typically derived from calcium carbonate (ranging from 40-100% of samples), the proportion of which increases both with depth and with sand content. These sediments are produced by organisms such as calcareous red algae, corals, molluscs, foraminifera and bryozoans, which are also mixed with terrestrial material sourced from onshore (Baker *et al.* 2008). Offshore from the 30 m isobath, the nautical charts indicate that the seabed comprises sand and broken shell with some fine sand and mud also present locally. Inshore, sediment grain size and composition, which is typically linked to wave energy and proximity to large rivers, contains finer, lower calcium carbonate sediments naturally occurring within sheltered bays and in mangrove creeks (Semeniuk *et al.* 1982).

Seabed sediment grain size in the Dampier Archipelago region is highly variable, due to the presence of strong tidal currents, periodic cyclones, protected embayments and sediment-producing organisms such as coral reefs (Talbot *et al.* 1985). A range of typical particle size distributions of sediments within the Dampier Port are provided in Figure 20, showing that clay and silt dominate the areas sampled, with sand fractions typically comprising 20-40% and gravel being relatively rare.

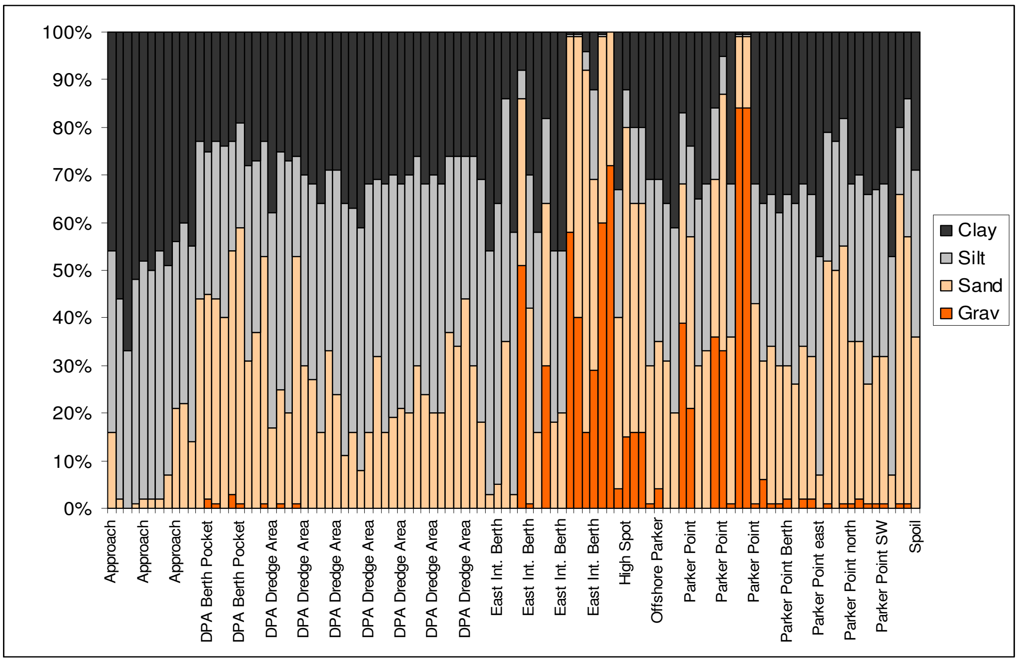


Figure 20: Relative proportions of clay, silt, sand and gravel for various areas sampled in the Dampier Archipelago (locations are shown in Figure 21).

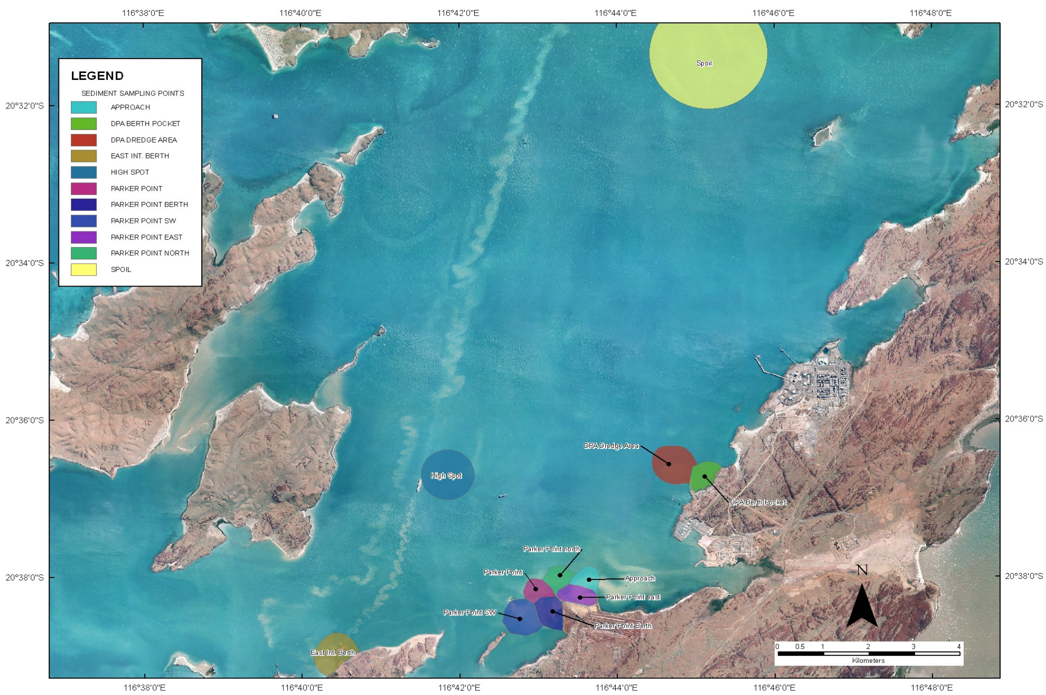


Figure 21: Locations of PSD results illustrated in Figure 20.

The spatial distribution of gravel, sand and mud fractions shown in Figure 22 indicates that most samples collected to date have been located in southern Mermaid Sound. This shows that in the southern portion of Mermaid Sound, sediments typically comprise fine muds and sandy muds, whereas north of the Pluto development the sediments generally become coarser (sand fraction) although this region is under-represented (very few samples collected). The seabed surrounding the outer islands also tends to be sand dominated, with gravel fractions also becoming more important (Figure 22).

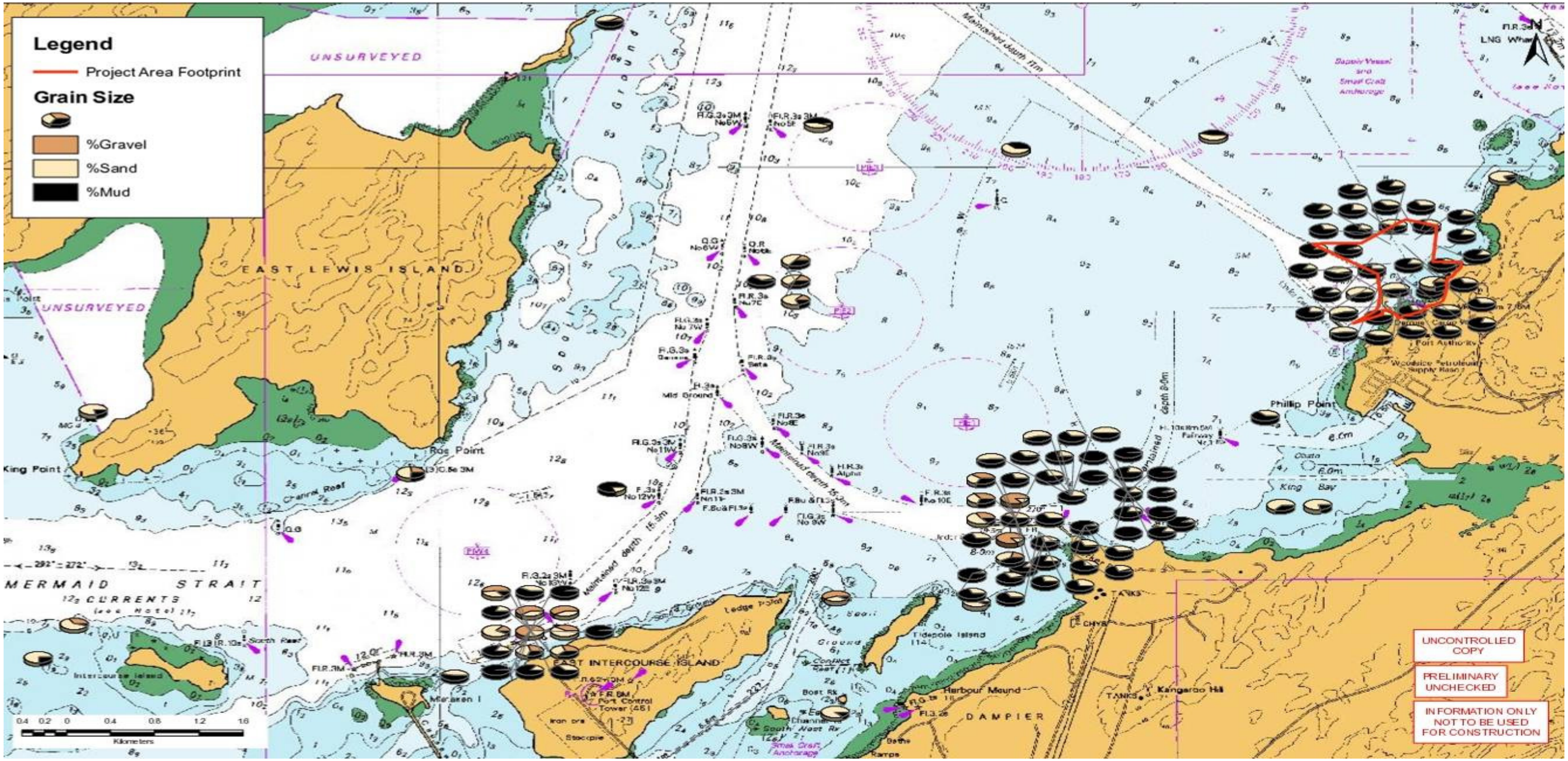


Figure 22: Spatial distribution of relative grain size of surface samples (gravel, sand and mud) for Mermaid Sound

Figure 23: Spatial distribution of relative grain size of surface samples (gravel, sand and mud) for the DMSF area

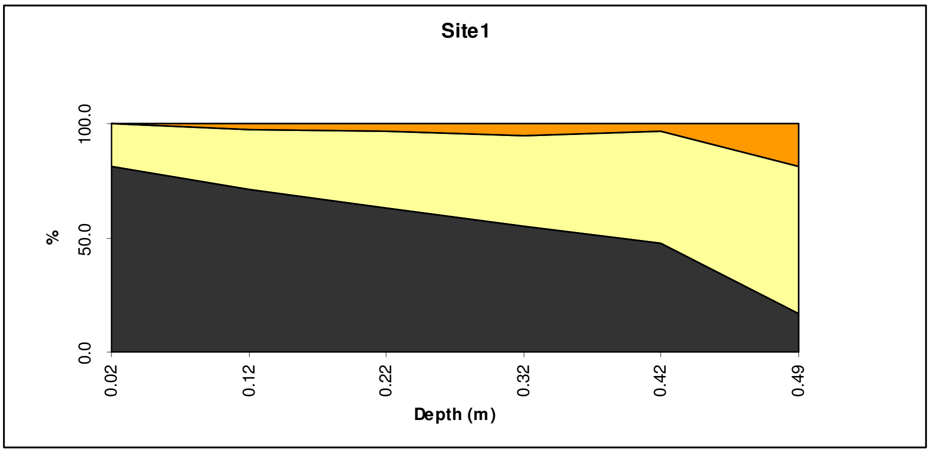
Coarser grains also occur off the exposed sides of the outer islands, whereas sediments become naturally finer adjacent to inshore islands (Harris *et al.* 1998), and within mangrove-fringed tidal channels to the south. Regions which experience strong tidal through-flow are generally floored by gravel or limestone substrates. Organic concentrations in sediments remain relatively low throughout the Dampier Port Area (rarely exceeding 15%), due to the lack of major riverine inputs (apart from the Maitland River to the southwest), and the generally low abundance of mangroves (MScience 2006).

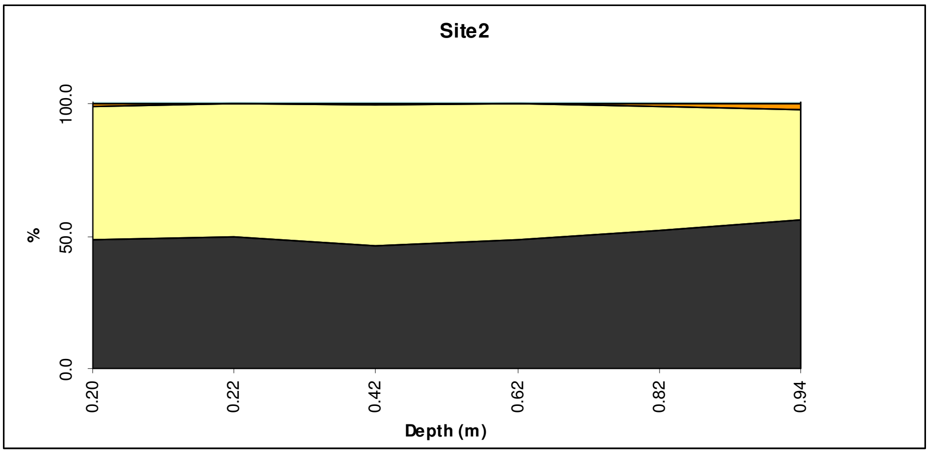
The substrate in the vicinity of the DMSF is dominated by fine sediments (Figure 23). Sediments located within the proposed development area are dominated by mud fractions, and observations show that these typically contain small amounts of clay and shell fragments (ranging from approximately 20-50% of samples). Gravel fractions represented <10% of each sediment sample, typically being shell fragments (MScience 2007a). Results from underwater video and push core samples obtained by WorleyParsons in 2009 provided similar results, showing fine sediments interspersed with shell material, and being relatively homogenous within the top layer of sediment (WorleyParsons 2009a; WorleyParsons 2009e).

5.2.5 Recent Sediment Accumulation

There have been a number of dredging campaigns in the southern end of Mermaid Sound in recent years which may have significantly affected the composition and grain size of surface sediments in adjacent areas. Stejskal (1992) noted that sediment resuspension by ship propeller wash may also be significant in redistribution of fine sediments. A 0.3-0.6 m thick layer of a yellowish, very soft, clay like material has also been observed on the seabed at the southeastern end of Mermaid Sound, which may be related to human activities (DEC 2006a).

A series of core samples acquired at locations away from dredging areas throughout Mermaid Sound (Figure 24) show that although mud proportions are high in the southern area (away from dredging regions), significant mud proportions persist down-core to a depth of 50-100 cm. A similar trend is shown by cores from the north of the Sound, with mud proportions being overall lower (~25%) and gravel proportions being correspondingly higher. These results show that southern Mermaid Sound is a naturally muddy environment, with similar mud proportions down core indicating little change in mud content over time. Water turbidity in the Sound is typically due to suspended particulate matter, organic detritus and plankton, the relative importance of each varying spatially and depending upon tidal cycle, wave action and season (Semeniuk *et al.* 1982).





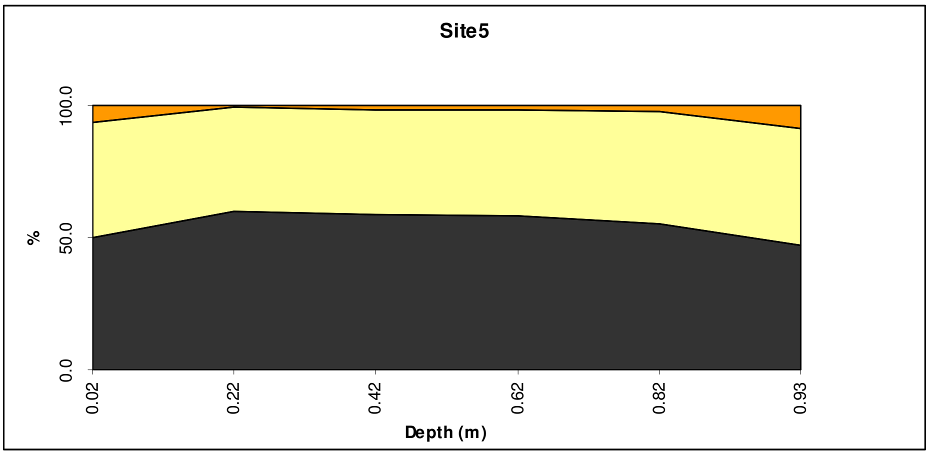


Figure 24: Sediment core logs from northern and southern Mermaid Sound, showing proportions of mud, sand and gravel with depth below the seabed

Borehole log results provided by Coffey Geotechnics in May-June 2008 (Coffey Environments Pty Ltd 2008) indicated that the near-surface sediment layer comprised either fine to medium-grained grey or brown sand with trace clay, or siliceous carbonate sand with trace clay and/or shell fragments, which reached between 0.5 to 6.0 m depth (Figure 23). It should be noted however that the surface layers (<0.5 m depth) may have been lost from these samples, as fine surficial sediments would not have been retained. The sub-surface layers become successively coarser with depth, grading to carbonate gravel and nodular limestones, overlaying bedrock. Coffey Geotechnics (2008) indicate that sediments within the proposed dredge area are relatively consistent within the project area.

As part of this study, short cores were obtained (Table 9) within the proposed DMSF dredging footprint which showed there is a difference between the proportion of fines in most surface samples compared to 1 m down-core, probably as a result of previous dredging activity. As a surface layer was not observed in any of the cores collected at the time, it is suggested that this finer surface material probably forms a very thin layer (e.g. < 2 cm) which has skewed the grain size results.

Table 9: Proportion of sand in surface samples and 1 m down-core, collected in the DMSF proposed dredging footprint

	BP1103	DA1607	DA2009	DA2304	DA2306	DA3006
% Sand Surface	37	8	11	30	16	16
% Sand 1m Depth	62	10	60	24	42	28

The generally fine nature of the surface sediments throughout the area (Figure 23) may be interpreted as an impact of dredging, specifically an increase in the thickness and/or the extent of fine muddy material overlaying areas of coarser sediment. However, the prevalence of broken shell material within the upper 1 m fine sedimentary layer (as evidenced by core photos and hand samples) shows that most of this material has been deposited slowly (as the mollusc shells are too large to be transported any significant distance as part of a dredge plume, they are therefore interpreted to have formed and accumulated *in situ*). Therefore, any dredge-plume related material present in the area likely forms a very thin surface layer as it was not readily distinguishable in core samples. This is consistent with modeling results recently undertaken by APASA (2009), which showed a maximum projected accumulation of approximately 30 mm for the DMSF region adjacent to the dredge. Furthermore, the lack of any observable infilling of nearby shallow (< 50 cm deep) dredging tracks on the seabed (as observed with repeat surveys of high resolution multibeam sonars) would appear to support this observation.

5.2.6 Sediment Quality

Numerous sediment quality investigations have previously been undertaken within the Dampier Port, often as part of sediment characterisation studies to determine suitability of material for dredging and offshore disposal (DEC 2006a). Most sediments within Dampier Port have been characterised as uncontaminated and suitable for offshore disposal while some areas have displayed elevated concentrations of tributyltin (TBT) and some metal species. These sediments have predominantly been located within existing berth areas where paint flakes become deposited in surface sediments. Other areas of elevated metal contamination have been identified adjacent to drainage points for surface runoff, sewage discharge outfalls and accidental spills of iron ore.

Sediment quality of sediments located within the proposed development area were most recently investigated in 2007 as part of proposed capital dredging of the general cargo wharf (MScience 2007a; MScience 2007b). The investigation considered contaminants including copper, nickel, nitrates, PAHs, hydrocarbons and TBT. Findings from the investigation concluded:

- No hydrocarbons, PAH or nitrates were detected in any sample. Metal values were all below nominated screening levels;
- Most sediment samples had low levels of TBT which when normalised to 1% TOC were above the National Ocean Disposal Guidelines for Dredged Material (NODGDM), (EA 2002) screening guidelines;
- TBT values showed a typical pattern seen in other surveys from the Dampier Harbour where TBT particles tend to be distributed unevenly around the berth areas. Low values of TBT were found generally in surface sediments, with no obvious spatial pattern, although at a finer scale (within a homogenised sample) TBT remained patchy and cores taken one metre apart varied by an order of magnitude;
- Further investigation of elevated TBT concentrations to determine level of TBT bioavailability within contaminated sediments resulted in TBT concentrations below adopted 99% level of species protection and therefore suitable for offshore disposal. It was also recommended that further testing of DCW sediments was not required due to the low probability of significant environmental consequences of disposing of a relatively small quantity of sediment which contained TBT at concentrations marginally above screening levels.

5.2.7 Baseline Sediment Quality and Acid Sulfate Soils Assessment

A sediment quality and acid sulfate soils assessment (Appendix 9) was undertaken by WorleyParsons Services Pty Ltd on the 12th and 13th of October 2009, based upon a Sampling and Analysis Plan developed in consultation with DEC (Section 3.4.4).

The results of the study can be summarised as follows:

- Of the metals tested, only chromium exceeded the Ecological Investigation Levels (DEC 2003). Australian Standard Leachate Procedure (AS 4439.3-1997) leachate analysis indicated that all results for chromium were below Practical Quantitation Limit (PQL) and that chromium present is in an immobile form. The DEC (2006a) found that natural levels of chromium were elevated in the Dampier Archipelago and similar to the results of this study (37.4 mg/kg predicted natural concentration, compared to 39.76 ±13.0 mg/kg this study);

- Nutrients, COD and BOD, Polynuclear Aromatic Hydrocarbons, Total Petroleum Hydrocarbons, and Organotins,normalised and individually did not exceed Ecological Investigation Levels (DEC 2003) or the NAGD (Commonwealth of Australia 2009) screening levels;

- Results from the acid sulphate assessment indicate the dredge material is self-neutralising and is suitable for disposal onshore as landfill in a bunded reclamation area, with no active ASS management required; and

- Reduced inorganic sulphur, measured as both acid volatile sulphur (AVS) and total reduced sulphur, including Chromium Suite (sCr) have shown no elevated levels of reduced inorganic sulphur and are deemed acceptable for onshore disposal.

Environmental Values and Levels of Ecological Protection

Based on the results of the baseline sediment quality and acid sulfate soils assessment (Appendix 9) it is expected that the water quality within the area will be maintained at a high level of ecological protection (Table 1) during dredging and reclamation operations, and that the DEC environmental values and environmental quality objectives (Table 2) will not be exceeded.

5.3 Biological Marine Environment

5.3.1 Overview of Benthic Habitats

A variety of subtidal habitats including coral, seagrass, macroalgae, mangrove, soft-sediment, rocky shore, mangroves, and mudflat communities occur in the Dampier Archipelago (CALM 2005). Intertidal areas generally contain mudflats and rocky shore type habitats (CALM 2005).

The following habitats have been identified throughout the Dampier Archipelago (Morrison 2004);

- Eight coral habitats (branching Acropora, corymbose Acropora, digitate Acropora, encrusting non-Acropora, massive non-Acropora and mushroom coral);

- Three soft coral habitats (alcyoniids, nephtheids and gorgonians);

- Three abiotic habitats (sand, rubble and rock);

- Macroalgae; and
- Five additional habitats (sponge, anemone, mollusc, echinoderm, ascidian).

5.3.2 Benthic Habitat Map

A benthic habitat map was compiled from the above reports and a variety of other data sources in order to quantify the spatial distribution of the main intertidal and subtidal environments within the Zone of Influence. Data sources included high resolution aerial imagery; previous maps; and video transect surveys undertaken by WorleyParsons in the direct footprint area and predicted plume extent. The benthic habitat map, and a report of the methods used, is included in Appendix 10.

5.3.3 Coral Reef Communities

Ecology and Distribution

Coral communities of the Dampier Archipelago provide support to diverse communities of fish and marine invertebrates. The majority of corals in the Archipelago occur at depths between 0-10 m (Jones 2004b). A total of 229 scleractinian coral species from 57 genera have been recorded in the Dampier Archipelago. Coral reef communities fringe the islands and coastline of Mermaid Sound. The structure of the reefs vary as the distance from the mainland is increases, and the water quality improves (EPA2003).

It is widely recognised that coral communities provide high ecological value to the marine environment. As such coral communities within the Dampier Archipelago have been researched to identify community structure/ecology and minimize/mitigate impacts associated with port development and other anthropogenic impacts. Historically taxonomic surveys and ecological research have concentrated on the outer Archipelago (Griffith 2004), while studies associated with monitoring potential impacts on coral from industrial development and port expansion have focused on nearshore areas (Blakeway *et al.* 2005).

The coral reefs found fringing the industrial developments along the western Burrup Peninsula (Figure 25) experience elevated levels of natural turbidity and suspended sediment almost all year, and coral communities appear to be relatively resilient in terms of the persistent turbidity (Blakeway *et al.* 2005). The *Turbinaria* and mixed coral assemblages found in this area are considered less sensitive to turbidity and sedimentation compared with the *Pavona*, *Porites* and *Acropora*-dominated assemblages found further offshore (Blakeway *et al.* 2005).

Figure 25: The fringing reefs of the Dampier Port and Reference sites were composed of a veneer of corals on rock and boulder substratum.

Coral reefs have been recorded in the vicinity of King Bay, and between Phillip Point and Dampier Public Wharf. The majority of coral habitat identified within the Dampier Port Boundary occurs in the immediate subtidal area – between approximately Spring Low Water and -4m LAT (MScience 2005).

Coral communities located within 2km of the proposed development are generally representative of nearshore coral communities found throughout the Dampier Archipelago and those identified within the proposed reclamation footprint. Densities are generally low to medium (5-20% cover) and consist predominantly of sediment tolerant species such as Faviid/Turbinaria and Porites species (MScience 2005).

RECRUITMENT AND SPAWNING

The ecology, particularly reproductive ecology, of corals in the Dampier Archipelago has been extensively studied (Simpson 1985b; Simpson 1985a; Simpson 1988; Heyward *et al.* 2000). Most of the major coral species are broadcast spawners and have their major peak of reproductive activity between March and April, about seven to ten nights after the full moon. A second, though less pronounced, peak occurs in October and November, coinciding with the major spawning on the Great Barrier Reef in eastern Australia. Brooding species tend to spawn more evenly throughout the year. Stoddard & Gilmour (2005b) investigated spawning behaviour of corals at the inshore Dampier Harbour. It was found that spawning was not uniform and appeared less synchronised than off-shore coral communities.

5.3.4 Regional Context (Fringing Reefs)

WorleyParsons (2009b) undertook a survey of fringing reefs in the Dampier Port location and at 12 surrounding reference locations for comparison (Appendix 11). The Dampier Port fringing reefs were also compared to fringing reefs at Cape Preston 60 km west of Dampier. The results are discussed briefly below and presented in more detail as Appendix 11.

The fringing reefs surveyed during this project in the Dampier region are not true coral reefs where the structure and substratum is formed by successive layers of dead coral. Instead the reefs are rock boulders with a veneer of living coral. Although some of the colonies are over a metre across and may be over 100 years old (Figure 27), corals have not yet provided a true reef structure. The reefs are narrow and fall quickly to a sand/mud substratum only a few metres below low tide level.

These reefs appear healthy with many large and long-lived coral colonies (Figure 26). Many small coral recruits of a wide range of species were observed on these reefs, also indicative of a healthy reef community (Figure 28).

Although grand mean coral cover was nominally lower at the three Port location sites compared with the mean from all the reference sites, these differences were not significant. Coral composition was similar at the Port sites to that in the Reference sites with the three coral groups Favidae, Poritidae and *Turbinaria* spp. accounting for about 70% of total hard coral cover. The major differences between the two locations were a slightly lower proportion of poritid corals at the Port location coupled with a lower proportion of acroporid corals. Some differences resulted from the significant site effects that are a distinctive feature of most fringing reefs (Ayling *et al.* 2006; WorleyParsons2009c).

Coral abundance and composition was also similar to Dampier reefs on the Cape Preston fringing reefs 60 km to the west of Dampier. Combined faviid, poritid and *Turbinaria* corals made up 73% of hard corals on the Cape Preston reefs with most differences resulting from significant site differences in the two regions.

The three coral groups that dominated the benthic communities at all three of these fringing reef locations are all relatively resistant to bleaching, able to withstand strong wave action and can cope with high levels of sedimentation (Berkelmans *et al.* 1999; Ayling *et al.* 2006; GHD 2008). The coral groups that are most susceptible to bleaching and wave impacts, acroporids and pocilloporids, are rare or absent on these reefs. These fast growing groups are usually dominant on many coral reefs but conditions on Dampier and Cape Preston region fringing reefs have not been suitable for their establishment and/or survival.

It is possible that the particularly low acroporid cover in the Port location has resulted from bleaching mortality of this susceptible group following port dredging and stress resulting from excessive sedimentation. The bleaching and partial mortality of a *Goniopora* (poritid) colony observed at the

Port location during this survey may also indicate that poritid cover has been reduced in the Port location by past dredging sedimentation and stress.

To surmise the inshore fringing reefs of the Dampier and Cape Preston region are a single community dominated by bleach, sediment and wave-resistant coral groups. Most of the small differences recorded are due to historically mediated site effects whereby a 50-100 m long local reef area becomes dominated by a single long-lived species of coral. It is possible that some of the small differences between the Port location and the Reference reefs result from selective mortality of a few susceptible coral groups caused by years of dredging impacts.

Figure 26 A large colony of the siderastreid coral *Psammocora digitata* on West Mid Intercourse Island

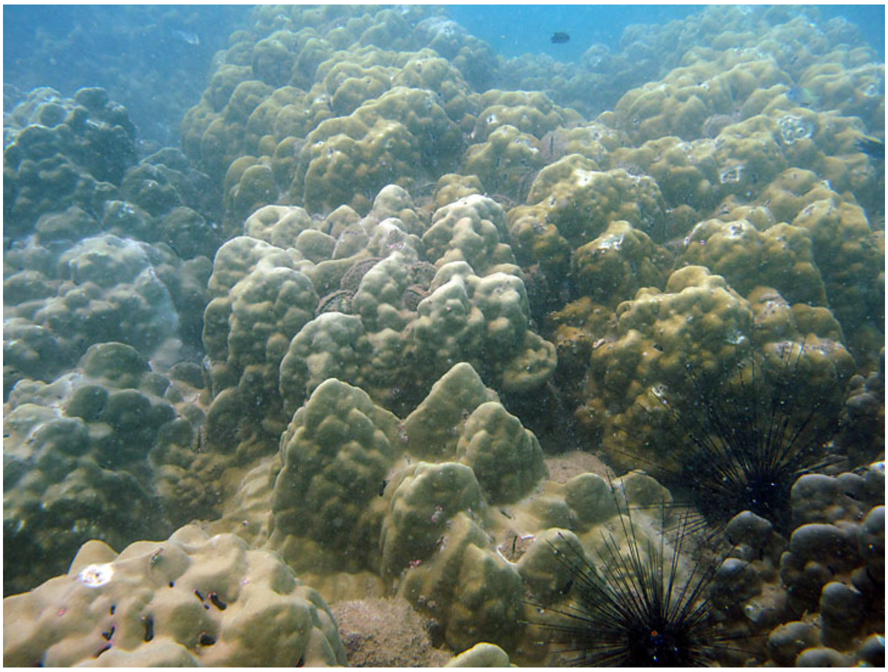


Figure 27 A large colony of the massive poritid *Porites lobata* on the inside of Conzinc Island

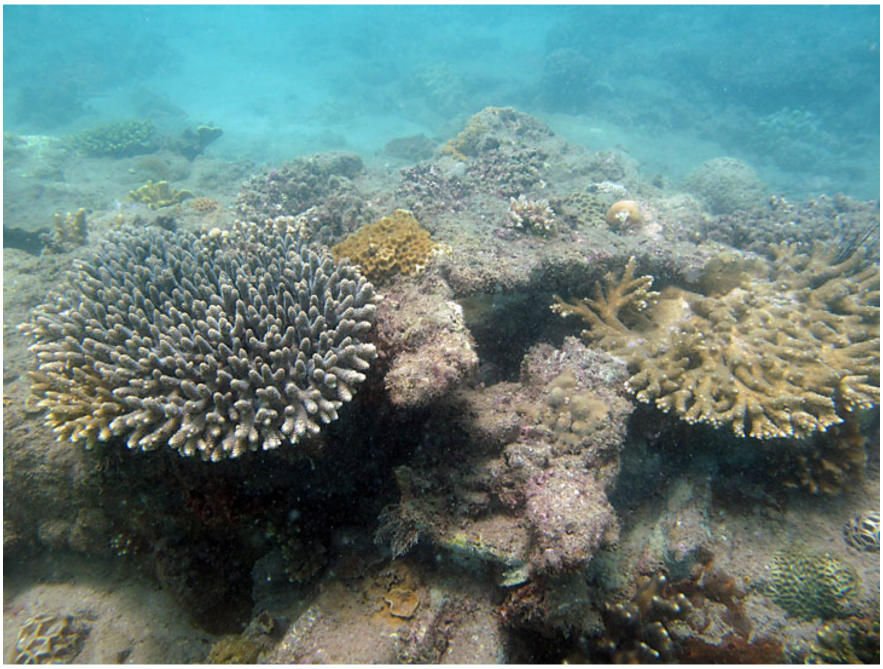


Figure 28 Corymbose growth form *Acropora* corals with small faviid corals on Angel Island

5.3.5 Seagrass Communities

Nine species of seagrasses occur in the Dampier Archipelago, but whilst they are diverse they tend to have reduced biomass compared to the dense meadows they form in southern Western Australia (Wells *et al.* 2003a).

The seagrass species found within the Archipelago and their distributions are as follows:

- *Cymodocea angustata* has been found to occur at depths of 1-17 m on sandy bottoms, growing together with or near patches of *Syringodium isoetifolium*, *Halophila ovalis* and *Halodule uninervis* (McMillan 1983). It grows in currents of 0-1 knots (Walker *et al.* 1988).

- *Enhalus acoroides* is found in coarse sediments on top and around the edges of raised reef platforms and near tidal channels where the plants are subjected to fast currents. It can also form meadows on sandy and muddy bottoms, where it traps fine particulates (Walker D.I. 1987).

- *Halophila decipiens* is widespread on the Western Australian coastline, and has frequently been found mixed with *Halophila ovalis* on rock with a thin sediment veneer or in pools. It is found at depths of up to 35m, and also in rock pools at the mid-tide level (Walker D.I. 1987). It grows in currents of 0-1 knots (Walker *et al.* 1988).

- *Halophila minor* grows in sand and mud on inter-tidal areas and mud flats (Western Australian Herbarium 2009)

- *Halophila ovalis* is dominant in intertidal systems, where it is often associated with mangroves. It has a very wide ecological tolerance and a high turnover rate, and is important for dugong grazing (Walker D.I. 1987). It can grow in white sand and mud, and is found in tidal pools, reefs and intertidal areas (Western Australian Herbarium 2009). It grows in currents of 0-1 knots (Walker *et al.* 1988).

- *Halophila spinulosa* is a deep-water species (up to 45 m depth), but has also been found at 8-15 m depth in coarse sediment in areas away from direct tidal streams. In shallower water in areas of rapid tidal movement, it occurs in patches between larger species or as sparse populations (Walker D.I. 1987). *H. spinulosa* was reported growing at depths of 3-14 m and in currents of 0-1 knots in Shark Bay (Walker *et al.* 1988).

- *Halodule uninervis* is found on sand or mud substrate in tidal pools and reef flats (Western Australian Herbarium 2009).

- *Syringodium isoetifolium* grows in sand and forms sparse colonies on reefs (Western Australian Herbarium 2009), and grows to depths of 0-14 m in Shark Bay (Walker, Kendrick & McComb 1988). It grows in currents of 0-1 knots (Walker *et al.* 1988).

- *Thalassia hemprichii* has been found in reef-associated habitats and is common around coral rubble with *Halophila ovalis* or *Halodule uninervis*. It accumulates sediment on raised reefs, as well as at depth (Walker D.I. 1987).

The key threats to seagrass communities are identified as habitat alteration, increasing turbidity and lower light regimes primarily attributed to increased dredging or port use (DPA 2007b). Species such as *Halophila sp*. and *Halodule sp*., occur within the macroalgal meadows, and are the dominant plants of some shallow sand flat areas near the coast. Seagrasses are the principal food of Dugongs (*Dugong dugon*) (DPA 2005). They are also consumed by other herbivores such as the Green Turtle (*Chelonia mydas*), which also grazes on the macroalgae beds found in the region.

5.3.6 Macroalgal Communities

Two hundred and one species of marine algae and cyanobacteria are found in the Dampier Archipelago (Wells *et al.* 2003a).

Macroalgae are most common on subtidal limestone pavements (Figure 29) on the south side of Legendre Island, and between Rosemary Island and Nelson Rocks outside the port limits. Other less dense macroalgae habitats occur on hard shallow substrates around Eaglehawk, Malus, Enderby and Angel Islands (DPA 2008). The most abundant species is *Sargassum sp*., members of this genus can grow to lengths of up to 3 m, typically breaking their holdfasts in early winter to form large floating agglomerations that are moved onshore and offshore by currents. Other common brown macroalgal species include *Dictyopteris sp.* and *Padina sp.* (CALM 2005). Macroalgae provides an important energy contribution to the ecosystem, being the primary producer and food source for turtles, dugongs, sea urchins, molluscs, sea stars, sea cucumbers, crabs and fishes (CALM 2005).

Figure 29 The algae *Padina* and *Dictyopteris* with several species of red finger sponges and a variety of hard corals on a Nickol Bay fringing reef

5.3.7 Algal Mats

In the Dampier region, many areas of the otherwise bare zone contain intertidal blue-green algal mats (Wells *et al.* 2003b). These have been studied by Paling (1986) and Paling and McComb (1994). The distribution of algal mats is controlled by tidal height, tidal current, sediment influx and sediment drainage (Wells *et al.* 2003b). The algal mat is a cohesive fabric consisting of cyanophyte filaments, stabilising the substrate to resist erosion. The mats are rich in organic matter, storing carbon, nitrogen and phosphorous. The nutrients from the algal mats provide a significant source of nutrient input to mangrove communities in the region (Paling *et al.* 1994).

5.3.8 Micropytobenthos

Subtidal sandy seabed areas that support benthic algae or microphytobenthos (MPB) are recognised as a major contributor to overall benthic primary productivity of ecosystems as well as providing habitat for short range endemic fauna (Murrell *et al.* 2009). Given the extent of subtidal sandy habitat within the project area, and the relatively shallow bathymetry of Mermaid Sound, it is likely that MPB occurs throughout the project area, although its abundance and distribution has not been previously described.

MPB generally consist of diatoms, dinoflagellates, cyanobacteria, and other microscopic primary producers that live on the soft seabed. As a group, MPB have a wide tolerance to variation in light climate and are found over a range of depths. In Port Phillip Bay (in south eastern Australia), it was found that MPB contributed about one-third of the total net primary productivity of the Bay (Harris *et al.* 1996). These values are consistent with estimates from a North American estuary where between 16–32% of total system productivity was attributed to MPB (Murrell *et al.* 2009).

MPB productivity is primarily light-dependent and is usually calculated in terms of chlorophyll-a concentration (as measured in the top 10 mm of sediment). As a result, this method of measurement does not consider differences in chlorophyll-a content due to different species or condition. For example, low-light adaptation can increase chlorophyll-a concentration in cells without a corresponding increase in organic carbon production. In Port Phillip Bay, most of the MPB is primarily in water less than 10 metres. Primary production is on average three times higher in 1 m depth than in 10 m depth (Beardall *et al.* 1997). Similarly, in Mermaid Sound the more environmentally significant MPB habitat is likely to occur in shallower areas, where more light is available on the seabed.

Regular fluctuations in biomass indicate that MPB respond rapidly to environmental variation. Monitoring (in Port Phillip Bay) has shown that MPB biomass is highly dynamic and capable of rapid recovery in shallow waters (Beardall *et al.* 1997; AME 2006). Biomass fluctuated by halving or doubling over periods of days to weeks – with rapid turnover of MPB communities evident. There were also longer-term trends which correlated with light and temperature, with biomass generally being higher in summer (CEE 2007).

5.3.9 Rocky Shore Communities

Rocky shores are the dominant shoreline habitat associated within the Dampier region (Semeniuk *et al.* 1982). Wells & Walker (2003b) described the fauna of the littoral zone as sparse, comprised predominately of littorinid snails and grapsid crabs while the intertidal zones are dominated by a diverse range of species including sponges (Figure 30), oysters, limpets, chitons, crabs, and barnacles. The biota becomes increasingly diverse in the lower intertidal, with a variety of sessile and motile invertebrates and benthic algae. Corals reach into the lowest portions of the intertidal zone (Jackson *et al.* 2006).

Figure 30 A selection of sponge species on one of the Nickol Bay fringing reefs

5.3.10 Mangroves

Mangroves are an important part of the coastal ecosystem, contributing to primary productivity and providing habitat for fauna species including fish, sea snakes, turtles and birds (Wells *et al.* 2003b). Six species of mangrove occur in the Dampier region: *Avicennia marina, Aegialitis annulata, Aegiceras corniculatum, Bruguiera exaristata, Ceriops tagal*, and *Rhizophora stylosa*. Most mangrove communities contain a number of species, and a variety of structures of zonation persist, dependent on the underlying sediment type, tidal height, and wave and current action (Semeniuk *et al.* 1987). *Avicennia marina* is by far the most abundant species, existing in some monospecific stands which range from forests down to stunted shrubs.

The nearest mangrove community to the DCW expansion proposal is located in King Bay and has been described as significant for the area. This mangrove community was the subject of studies by the WA Department of Conservation and Environment in the early 1980s when the main Burrup access road was constructed through its upper reaches (Semeniuk *et al.* 1982). A comparison of aerial photography from 1957 and 2001 show that the distribution of individuals and species within the Hamersley Lease have changed little over the intervening 44 years (MScience 2004). No mangrove communities have been identified within the zones of impact.

5.3.11 Megafauna

The waters of the Dampier Archipelago are highly diverse in range of vertebrate species. All marine mammals are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Dugongs (*Dugong dugon*) are common in the area. The humpback whale (*Megaptera novaeangliae*), false killer whale (*Pseudorca crasidens*), southern bottle nosed whale (*Hyperoodon planifrons*), Risso's dolphin (*Grampus griseus*), the bottle nose dolphin (*Tursiops tuncatus*) and the Indo-Pacific hump backed dolphin (*Sousa chinensis*) are all found in the Dampier Archipelago (Wells *et al.* 2003b).

While several species of turtle nest on the islands of the Dampier Archipelago (Prince 1993), none have been recorded nesting within the port limits (DPA 2007b). The nearest nesting site to the project area is Green Turtle site at the north-eastern tip of West Lewis Island (SKM 2006b). The beach adjacent to Holden Point on the Burrup Peninsula Industrial Estate has low flatback turtle and green turtle nesting activity, but is not considered to be an important local or regional nesting beach due to its small size and low nesting activity (SKM 2006a).

Sea snakes found in the Dampier region include; *Aipysurus laevis*; *Astrotia stokesii*; *Ephalophis greyi*; *Hydrelans darwiniensis*; *Hydrophis* and *Fordonia leucobalia* (Wells *et al.* 2003b). As many as 12 species of sea snake may occur in the area (Cogger 1979). Little is known of the size of their populations, distribution or status as they are not commonly seen within the Port (DPA 2007b).

The islands of the Dampier Archipelago provide breeding/nesting habitat for sixteen species of seabirds which includes migratory species protected by international agreements, the China Australia Migratory Bird Agreement and Japan Australia Migratory Bird Agreement (CAMBA and JAMBA) (DPA 2008).

The Dampier Archipelago is known to have approximately 736 fish species. This is comprised mostly of tropical species with a small number (6) of subtropical species and 31 species with uncertain distributions. The majority of the 736 species are wide ranging (75%), whereas smaller numbers occur only in northern Australia (10%), Western Australia (5%) and the Northern Territory (2%) (Hutchings 2003).

5.3.12 Benthic Invertebrates

Sand and silt dominated sediments of the Dampier Archipelago supports over 2226 species of marine invertebrates, including 1227 molluscs, 438 crustaceans, 275 sponges and 286 echinoderms (CALM 2005)

5.3.13 Introduced Marine Organisms

In the waters of the Dampier Archipelago, six species of macrobiota recognised as non-indigenous are currently recorded (Table 10). Many of the introduced species have been recorded as one or a few individuals on one or a few occasions only. Three of these introduced macrobiota (*Balanus amphitrite* Darwin, 1854*, B. cirratus* Darwin, 1854, *B. trigonus* Darwin, 1854) are well known, widely-distributed water fouling organisms, within Australian waters (Jones 2004a). *Balanus amphitrite* and *B. cirratus* occur commonly in the intertidal throughout the Dampier Archipelago and the adjacent mainland; *B. trigonus* is less widely distributed and is recorded from only two sites (Jones 2004a). No data are available as to whether the presence of introduced barnacles in the Dampier area have caused any ecological consequences, such as any adverse impacts on native species (Jones 2004a). In addition to the species listed in Table 10, a total of 22 zooplankton species and 45 other planktonic taxa, including crustaceans, molluscs, polychaete worms, arrow worms, sea squirts and coelenterates, have been introduced into Dampier Archipelago via vessel ballast water (Jones 2001).

Table 10: Marine Organisms Introduced into the Dampier Region

Species Name	Family	Method of Introduction	Possible Origin of Introduction
Botrylloides leachi	*Ascideacae* (Sea squirt)	Unknown	Europe, Atlantic
Balanus amphitrite	*Crustacea* (Barnacle)	Hull fouling	Cosmopolitan in tropical, subtropical and temperate waters. Species is a common fouler throughout Western Australia.
Balanus cirratus	*Crustacea* (Barnacle)	Hull fouling	Indo-west Pacific
Balanus trigonus	*Crustacea* (Barnacle)	Hull fouling	Cosmopolitan in tropical and warm temperate waters
Megabalanus rosa	*Crustacea* (Barnacle)	Hull fouling	Japan, China, Taiwan
Megabalanus tintinnabulum	*Crustacea* (Barnacle)	Hull fouling	Cosmopolitan

6. REGIONAL AND SOCIAL ENVIRONMENT

This section presents a description of the regional and social environment in the area of the proposed DMSF on the Burrup Peninsula. It summarises information collected by desktop review, in addition to the following specific studies and surveys:

- A desktop terrestrial traffic study (GHD 2009b);
- An analysis of current water use by Dampier Port;
- An indigenous heritage survey (Australian Cultural Heritage Management 2009); and
- A visual impact assessment (Section 9.9).

6.1 Regional Context

The Pilbara region covers an area of 507,896 km^2 including offshore islands (Department of Local Government and Regional Development 2006), which comprises around 20% of Western Australia's total land area.

The proposed DMSF is located on the Burrup Peninsula within the Shire of Roebourne, which is one of four local government areas in the Pilbara region.

6.1.1 Social Setting

The major centres in the Pilbara Region are Port Hedland, South Hedland and Karratha; other centres include Roebourne, Wickham, Point Sampson, Dampier, Onslow, Pannawonica, Paraburdoo, Tom Price, Yandeyarra, Marble Bar, Newman, Jigalong and Nullagine. The population totaled 39,282 people in 2005, the majority of which were residing in the western third of the Pilbara region (Department of Local Government and Regional Development 2006).

The Shire of Roebourne has the largest population of all four local government authorities in the Pilbara (15,350 people) (Department of Local Government and Regional Development 2006). The Shire includes the coastal towns of Roebourne, Karratha, Dampier, Wickham, Point Sampson and the Indigenous community of Cheeditha. A number of indigenous groups form part of the Shire community, including the Ngarluma/Yindjibarndi, Yaburarra/Mardudhunera and Wong-Goo-Tt-Oo groups.

6.1.2 Economic Setting

The Pilbara economy is dominated by the mineral and petroleum industries, and is considered to be the premier mining region of the State. The region has experienced considerable economic growth since the 1960s (Department of Local Government and Regional Development 2006). The Region's mineral and petroleum industries were valued at $20.6 billion in 2004/05, with oil and condensate valued at $7.2 billion, iron ore valued at $8 billion and gas valued at $4.8 billion. Other industries included salt, silver, gold, manganese and base metals (Department of Local Government and Regional Development 2006).

Commercial activities in the Pilbara primarily service the mineral and energy sector, particularly for services in engineering, surveying, personnel and equipment hire. Retail turnover was estimated at $344.9 million in 2004/05 and manufacturing at $309.1 million in 2001/02 (Department of Local Government and Regional Development 2006).

Tourism also contributed $225.9 million to the Pilbara economy (Department of Local Government and Regional Development 2006). Tourist industries in the Pilbara region are based around key attractions including the Karijini and Millstream-Chichester National Parks, the indigenous heritage of the Dampier Archipelago and the Ningaloo Reef.

The fishing and building industries also contribute to a significant portion of the regional economy (Department of Local Government and Regional Development 2006).

Industry activities based on the value of production, turnover and expenditure are shown in Figure 31.

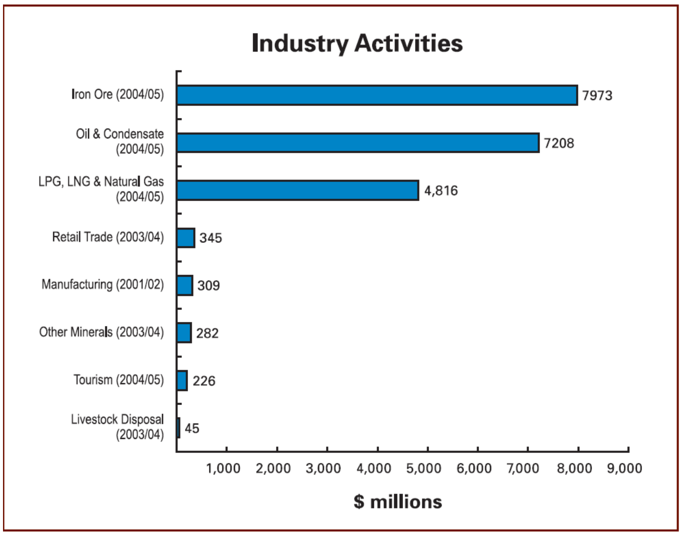


Figure 31: Summary of industry activities in the Pilbara region, by value (Department of Local Government and Regional Development 2006)

6.2 Infrastructure and Transport

A traffic study was conducted to identify the impacts on the Mof Road, King Bay Road, Burrup Peninsula Road and Dampier Highway from any extra traffic using the roads due to the construction of the proposed Dampier Marine Services Facility (DMSF). The study considered the Port itself, immediate surrounds and the broader area (Appendix 16).

The existing road characteristics and responsibility for each all local roads are outlined below:

Table 11 Existing Local Road Network Characteristics

Location	Road Geometry	Road Classification	Responsibility
Mof Road	Single carriageway, 1 lane each direction, steep grade up from King Bay Road	Local Distributor Industrial	Shire of Roebourne
King Bay Road	Single carriageway, 1 lane each direction	Local Distributor Industrial	Shire of Roebourne
Burrup Peninsula Road	Single carriageway, 1 lane each direction	State Road/Primary Distributor	Main Roads WA
Karratha – Dampier Road (north of Tip Road)	Single carriageway, 1 lane each direction (planned upgrade to duel carriageway, 2 lanes each direction)	State Road/Primary Distributor	Main Roads WA
Madigan Road	Single carriageway, 1 lane each direction	State Road/Primary Distributor	Main Roads WA
North West Coastal Highway (west of rail crossing)	Single carriageway, 1 lane each direction	State Road/Primary Distributor	Main Roads WA
North West Coastal Highway (west of Karratha – Dampier Road)	Single carriageway, 1 lane each direction	State Road/Primary Distributor	Main Roads WA

The main concern in the immediate surrounding roads to the site is Mof Road, which is the main access to the DPA Port and laydown areas. There are several limitations associated with the geometry and capacity of the road, and there is no alternative access road to the Port. The limitations include the width of the seal, the size of the vehicles able to use the road, the steep gradient and the lack of an emergency/breakdown lane.

The report recommended that an alternative access route into the Port be developed, either via Burrup Peninsula Road or parallel to Mof Road. An alignment adjacent to the service corridor from Burrup Peninsula Road is considered the best option and would require a detailed study to be completed in order to assess issues including grade, heritage and environmental impacts to the area.

The Dampier Port Marine Facility Traffic Study is included as Appendix 16.

6.3 Water Supply

Limited water supplies are available to industries operating on the Burrup Peninsula, and the current supply is fully allocated. DPA is constrained to a 1080kL/day allocation by the Water Corporation. Current operations are well within 1080kL/day, as shown in Figure 32. However, water limitations were considered during the design phase to ensure that DPA do not exceed their water allocation and are able maintain sufficient supply for fire fighting purposes during construction and operation of the proposed DMSF.

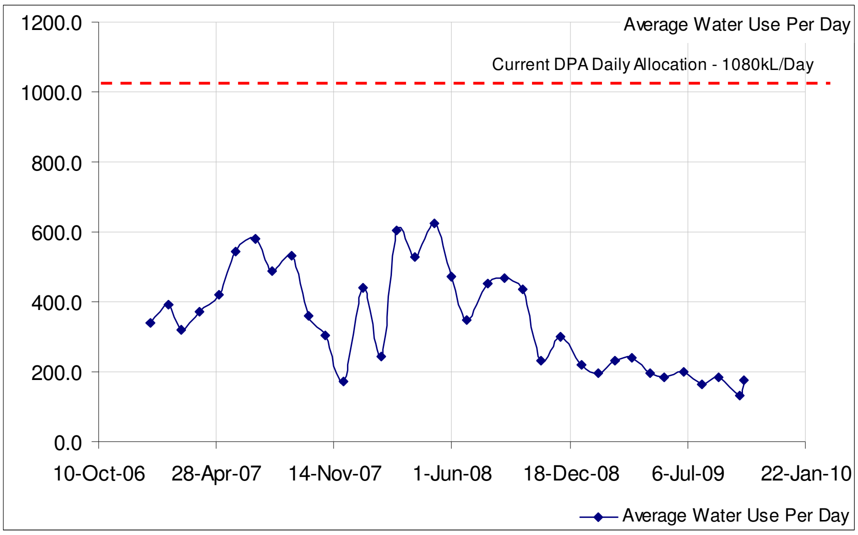


Figure 32: Current DPA average water use per day compared with the daily allocation

6.4 Indigenous Heritage

6.4.1 Aboriginal Heritage Values of the Burrup Peninsula

The Burrup Peninsula is world renowned for its petroglyphic art. The Dampier Archipelago, which includes the Burrup Peninsula, has now been included in Australia's National Heritage List for its outstanding Aboriginal heritage value. This means that the Commonwealth Government, under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), has identified it as an area of cultural heritage value to the country.

In addition to the petroglyphs, associated archaeological matter that is also found on the Burrup Peninsula includes artefact scatters, shell middens, stone structures and grinding stones (Australian Interaction Consultants. 2004; O'Connor 2005).

Aboriginal heritage in Western Australia is governed by the *Aboriginal Heritage Act 1972* (WA), Aboriginal Heritage Regulations 1974 (WA) and the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth). As indicated earlier, rock art located on the Burrup Peninsula is also protected by the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). These Aboriginal heritage provisions safeguard Aboriginal heritage through the protection of sites and objects that are of cultural significance to Aboriginal people.

6.4.2 Previous Surveys in the Vicinity

Between 2003 and 2005, the DPA commissioned a number of Aboriginal heritage surveys over the development area. These surveys indicated that there were sites of significance concentrated in the coastal part of the development area as well as the creek system that runs through it (O'Connor 2005). In order to comply with the *Aboriginal Heritage Act 1972* (WA), the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth) as well as the Objectives listed in Section 3.3 of the Dampier Port Authority Aboriginal Heritage Plan, further surveys involving the three Aboriginal groups in the area were undertaken in accordance with s18 Guidelines, as discussed in Section 6.4.3 below.

6.4.3 Heritage Sites within the DMSF Area

An Aboriginal Heritage Preliminary Investigation was undertaken by Australian Cultural Heritage Management Pty Ltd in November 2009. The full report is provided as Appendix 12. The investigation included a verification survey with DPA representatives in order to verify the location of Aboriginal sites in the DMSF.

The preliminary investigation and site verification survey confirmed that Aboriginal sites are located within the DMSF area (Figure 3.3). The five archaeological sites verified as within the DMSF are 'Aboriginal sites' pursuant to the *Aboriginal Heritage Act 1972*. The sites cluster into five discrete areas along the coastline.

All Aboriginal heritage sites within the project area are summarised in Table 12. Predicted impacts upon these sites and management strategies are detailed in Section 9.11. Modifications to the DMSF footprint will be made to avoid these sites wherever possible and practical

Figure 33 DMSF – Map of verified Aboriginal sites

Table 12: Aboriginal heritage sites within the proposed DMSF area (Australian Cultural Heritage Management Pty Ltd 2009)

Point Number	Easting	Northing	Height	Point Code
1000	474190.144	7720457.262	5.737	DPA34
1001	474193.583	7720458.498	5.812	DPA36
1002	474258.629	7720486.777	6.543	DPA09
1003	474268.918	7720487.946	8.17	DPA07
1004	474269.301	7720490.355	7.819	DPA06
1005	474268.522	7720492.108	7.702	DPA05
1006	474268.145	7720493.497	7.6	DPA04
1007	474267.689	7720493.52	7.533	DPA03
1008	474269.96	7720494.361	6.529	DPA08
1009	474379.098	7720603.584	6.245	DPA13
1010	474380.288	7720603.844	6.497	DPA14
1011	474380.491	7720602.326	5.054	DPA12
1012	474378.583	7720624.165	4.061	DPA15
1013	474379.061	7720624.018	4.35	DPA15
1014	474395.45	7720773.784	5.917	DPA20
1015	474403.627	7720779.289	6.987	DPA19
1016	474402.92	7720779.455	6.586	DPA19
1017	474403.343	7720778.669	7.037	DPA19
1018	474403.436	7720763.557	10.497	DPA17
1019	474404.667	7720779.103	7.326	DPA19
1020	474402.721	7720783.733	6.833	DPA37
1021	474408.01	7720791.256	7.959	DPA25
1022	474417.816	7720786.866	11.057	DPA21
1023	474409.904	7720785.631	9.789	DPA22

Point Number	Easting	Northing	Height	Point Code
1025	474405.991	7720788.297	7.34	DPA23
1026	474411.621	7720801.596	7.897	DPA29
1027	474417.123	7720805.543	8.501	DPA27
1028	474416.408	7720806.19	7.768	DPA27
1029	474415.214	7720805.563	7.693	DPA27
1030	474427.133	7720806.207	10.707	DPA30
1031	474424.235	7720803.591	11.192	DPA30
1032	474423.767	7720803.378	11.146	DPA30
1033	474423.297	7720803.605	11.042	DPA30
1034	474421.578	7720801.118	10.702	DPA30
1035	474421.917	7720801.632	10.838	DPA30
1036	474526.287	7720932.684	8.915	DPA32
1037	474529.25	7720937.284	8.606	DPA33
1038	474529.774	7720937.65	8.569	DPA33
1039	474478.722	7720890.88	4.346	DPA40
1040	474478.216	7720890.982	4.18	DPA40

6.5 European Heritage

European heritage sites on the Dampier and Burrup Peninsula area are registered on both the Environmental Protection and Biodiversity Conservation website, and the register of the Heritage Council of WA. Sites and buildings of heritage value are those that are connected to early European settlement and the historical development of Dampier and its surrounds.

A list of the historically significant sites can be seen in Table 13. None of these sites are within the footprint of the proposed DMSF.

A search for shipwrecks was conducted on the WA Maritime Museum database. No shipwrecks are registered in or near the Dampier Archipelago. An underwater video survey was also conducted over the proposed DMSF footprint for the purposes of identifying benthic habitats (Section 5.3.2) and no potential heritage items were identified during the survey.

Table 13: Registered Places of historical significance in the Dampier area

Place Name	ID Number	Location
Heritage Council of Western Australia		
Beagle Bay Mission Church	3630	Beagle Bay, Dampier Peninsula
Black Hawke Bay	8662	Hearsons Cove Rd, Burrup Peninsula, Dampier
Dampier Fire Station	14493	High St, Dampier
Dampier Police Station	17340	High St (Nielsen St), Dampier
Dolphin Island Grave Site	8667	West side of Dolphin Island off Burrup Peninsula, Dampier
Enderby Island	8668	Mermaid Strait, Dampier Archipelago
FT Gregory Camp Site	18634	Hearson Cove, Burrup Peninsula via Dampier
Lombadina Mission	690	Lombadina, Dampier Peninsula
Malus Island Whaling Site	4585	Mermaid Sound, Dampier Archipelago
West Lewis Ilsand Pastoral Settlement (Ruins)	8691	Mermaid Sound, Dampier Archipelago
EPBC Website		
Grave Site on Dolphin Island	10104	Watering Bay, west coast of Dolphin Island, NNE of Dampier
Legendre Island Lighthouse	19843	Cape Legendre, NW tip Legendre Island, NNE of Dampier
Malus Island Whaling Site	10105	Eastern side Whalers Bay, Malus Island, NNW of Dampier
Pearling Relics Blackhawk Bay	10108	Black Hawk Bay, E shore of Gidley Island, NNE of Dampier
West Lewis Island Pastoral Settlement	10107	SE shore of West Lewis Island, NW of Dampier

7. IMPACT ASSESSMENT

7.1 Introduction

The present DMSF design was chosen through a feasibility assessment as part of the Options Assessment Study (see Section 2.3 for options considered). The study assessed the feasibility of several possible options and selected the current design as the most suitable. Primary selection criteria were based on the overarching EPA Principles of Environmental Protection and also considered engineering constraints. The design was then subject to a number of design iterations to further address key engineering constraints. The EPA principles of supporting sustainability and biological diversity in the environment were also considered in this assessment phase.

This report has adopted a qualitative risk based approach to further identify and assess environmental impacts of the proposal. The environmental factors have been identified through existing studies, other published information and consultation with DEC, EPA, DoW and other stakeholders. The assessment follows the established methods and definitions of HB203:2006 Environmental Risk Assessment – Principles and Processes and AS/NZS4360:2004 Risk Assessment to systematically define and categorise the potential environmental impacts.

7.2 EPA Principles of Environmental Protection

The Principles of Environmental Protection as set out in section 4A of the EP Act and expanded upon in EPA Position Statement No. 7 follow:

- The precautionary principle;
- The principle of intergenerational equity;
- The principle of the conservation of biological diversity and ecological integrity;
- Principles relating to improved valuation, pricing and incentive mechanisms; and
- The principle of waste minimisation.

These principles are to be applied in undertaking the impact assessment for each environmental factor and is shown in Table 17. For each of these factors, the relevant issues have been addressed (and can be found at the reference stated in the table):

- Identify applicable legislation and standards;

- Identify relevant EPA Position Statements, Guidance Statements and criteria;
- Give attention to the principles of environmental protection;
- Consult with relevant government agencies;
- Consult relevant information databases;
- Consult key community members with particular relevant knowledge (eg. Aboriginal people);
- Undertake on-site surveys and investigations where appropriate;
- Review site specific information within a local, regional and cumulative context;
- Evaluate environmental significance; and
- Identify appropriate management approaches and mitigation measures.

7.3 Risk Assessment Methodology

The proposal and its environmental context have been established in Sections 1 to 6. This section and Sections 8 and 9 identify, analyse and evaluate the risks of the proposal and identify how DPA will manage the risks, and monitor and review the management process[2]. Each section reports the steps taken to communicate and consult during that phase. This forms the risk assessment process, and it is illustrated in Figure 34.

The following terms are used in the risk assessment:

- *Environment* means the surroundings in which DPA operates, including air, water, land, natural resources, flora, fauna and humans, and their interrelations and interactions;
- *Environmental aspects* are elements of the project that can interact with the environment;
- *Environmental factor* is the receptor of the project environmental impacts e.g. terrestrial fauna, air quality, heritage;

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[2] It should be noted that this process was used to systematically identify and outline risks for this project. Factors were not discounted on the basis of this assessment, and this project was not part of the EPA's Risk Based Approach trial to EIA's.

- *Environmental impact* is any change to the environment, whether adverse or beneficial, wholly or partially resulting from the environmental aspects of the project;
- *Consequence* is the outcome or impact of an event. There can be more than one consequence from one event and consequences can range from positive to negative and can be expressed qualitatively or quantitatively;
- *Likelihood* is a general description of the extent to which an event is likely to occur, similar to probability (usually expressed as a number between 0 and 1) or frequency (the number of occurrences per unit of time);

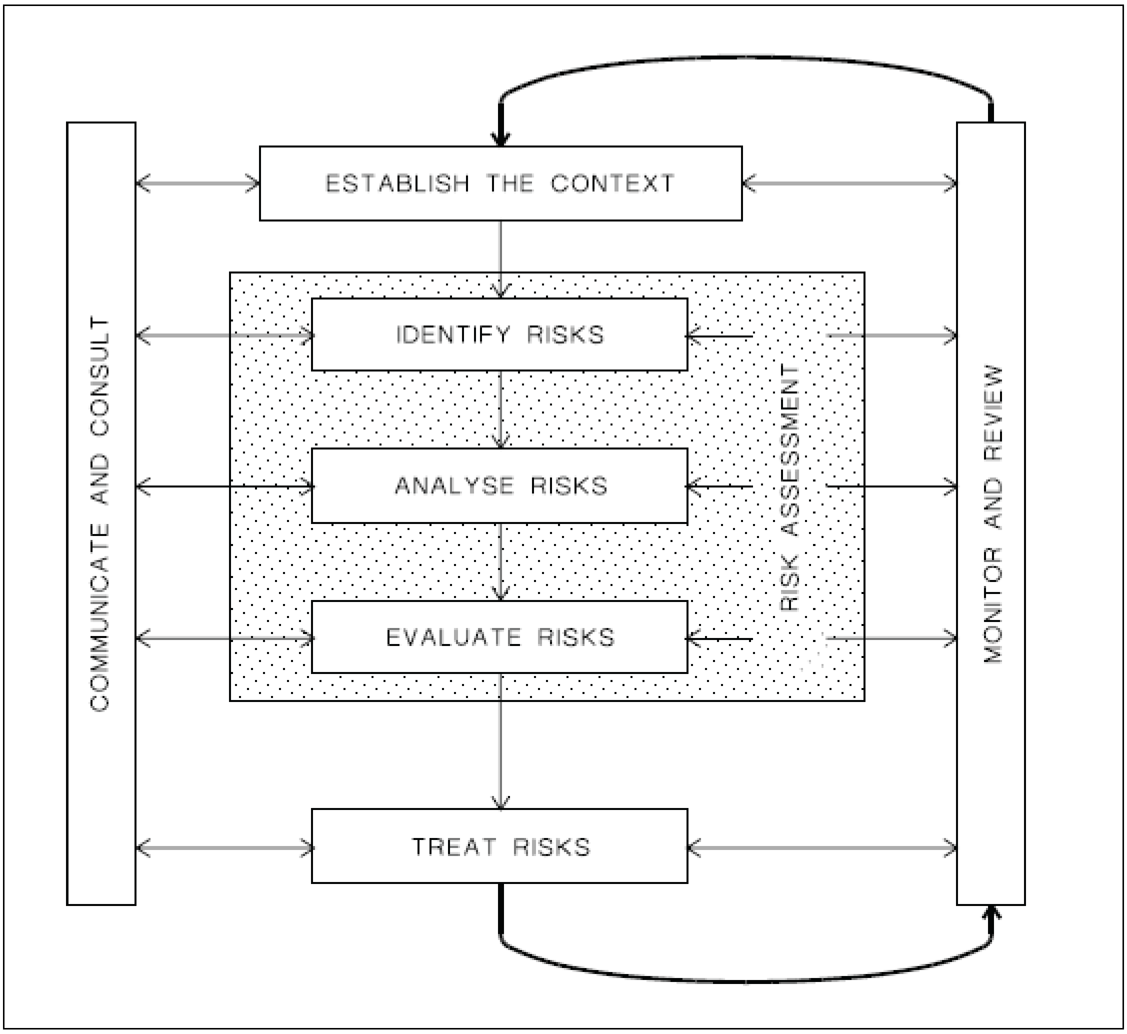

Figure 34: Overview of the risk assessment and management process (AS/NZS4360:2004)

7.4 Aspect and Hazard Identification

The overarching principles of sustainability and biodiversity have been applied to the DMSF proposal to ensure that it avoids, as far as practicable, hazards that could lead to potential environmental impacts. These principles form an integral part of the impact assessment approach outlined in this document and have been used to develop the engineering design and to select the preferred dredging method.

Based on detailed investigations, consultation with key stakeholders and review of similar dredging projects in the immediate environs, a number of environmental and socio-economic factors have been identified as being of relevance to this proposal. These factors are summarised below. A comparison of the proposal against the five principles of environmental protection is presented in Table 17.

The key environmental factors were defined as those:

a) Having a critical or major significance;

b) Requiring a more detailed assessment; and

c) Requiring a higher level of management measures and controls to ensure potential impacts are minimised.

Those factors not considered key are referred to as ‘other’ environmental factors. Other environmental factors are defined as:

a) Having high, moderate or low risk; and

b) Requiring less detailed assessment; and

c) Requiring a lower level of management measures and controls to minimise impacts and in general can be well managed using common procedures.

7.5 Characterising Environmental Risk

The next stage of the assessment was to assign the level of risk of the environmental impacts that could result from the project. This involved considering the consequence and likelihood of each event and these attributes are described in Table 14 and Table 15, respectively. Table 16 shows the resulting risk categories.

Table 14: Measures of Impact Consequence

Consequence Rating	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
People	No injuries or illness	First Aid Treatment	Medical Treatment Required	Extensive injuries or illness	Death
Environment	Limited damage to minimal area of low significance	Minor effects on biological or physical environment.	Moderate, short term effects but not affecting ecosystem function.	Serious medium term environmental effects	Very significant long term impairment of function or significant impacts on highly valued species/ecosystems
Production delay, loss or damage (to reputation)	Low financial loss. Less than $5000 delay/loss	Medium financial loss $5k to $500k delay/loss	High financial loss $500k to $1m delay/loss	Major financial loss $1m to $5m delay/loss	Huge financial loss, more than $5m delay/loss
Culture or Community Impact	No/temporary local impact; public concern limited to local complaints	Local short term impact; minor local public or media attention	Local/long term impact (manageable outcomes); medium public attention within Australia	Local/long term impact (unmanageable impacts); serious public or medium outcry	Long term/regional impact; irreparable damage to highly valued items of significance; serious public or medium outcry, international attention

Table 15: Measures of Impact Likelihood

Level	Descriptor	Description
A	Almost Certain	Is expected to occur in most circumstances, common or repeating occurrence
B	Likely	Will occur in most circumstances. Known to occur, or "it has happened"
C	Possible	Might occur at some time. Could occur or "I've heard of it happening"
D	Unlikely	Could occur at some time. Not likely to occur.
E	Rare	May occur only in exceptional circumstances. Practically impossible.

Table 16: Risk Matrix

Likelihood		Consequences 1 Low	2 Minor	3 Moderate	4 Major	5 Critical
A	Almost Certain	H - 15	H - 10	C - 6	C - 3	C - 1
B	Likely	M - 19	H - 14	H - 9	C - 5	C – 2
C	Possible	L - 22	M - 18	H - 13	C - 8	C – 4
D	Unlikely	L - 24	L - 21	M – 17	H - 12	C – 7
E	Rare	L - 25	L - 23	M - 20	H - 16	H - 11

C	Critical (extreme risk), immediate action required.
H	High risk, senior management attention required.
M	Moderate risk, management responsibility required.
L	Low risk, manage by routine procedures

The lower the risk rating number, the higher the risk. For example C-3 would have priority over C-7 or M-17.

Table 17 EPA Principles of Environmental Protection

FACTOR	ENVIRONMENTAL OBJECTIVE	DOC. REFERENCE
Marine water quality	To maintain the quality of water so that existing and potential environmental values are protected, including the environmental values and environmental quality objectives set by the Department of Environment (2006):	Section 8.1
Marine habitat disturbance (corals)	The environmental objective for the marine habitat (corals) is to limit the direct loss of corals associated with the dredging activities and the reclamation of DMSF and to ensure the protection of the coral ecosystem of the Dampier Archipelago from indirect impacts associated with the project.	Section 8.2
Marine habitat disturbance (non-corals);	The environmental objective for the marine habitat is to limit the direct loss of BPPH associated with the dredging activities and the reclamation of DMSF and to ensure the protection of the marine ecosystems of the Dampier Archipelago from indirect impacts associated with the project.	Section 9.1
Megafauna;	The EPA Environmental Objective for fauna is to maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Section 9.2
Underwater noise;	The EPA's Environmental Objective for noise only applies to noise receiving premises. Underwater noise will be considered in context of the EPA Environmental Objective for fauna, which is to maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Section 9.3
Introduced marine organisms;	The EPA does not have a specific Environmental Objective for introduced marine organisms. The EPA Principles of Environmental Protection include a "precautionary principle" and "the principle of the conservation of biological diversity and ecological integrity".	Section 9.4

FACTOR	ENVIRONMENTAL OBJECTIVE	DOC. REFERENCE
Disturbance to coastal processes;	To maintain the integrity, ecological functions and environmental values of the seabed and coast.	Section 9.5
Terrestrial flora and fauna;	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.	Section 9.6
Surface drainage;	To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.	Section 9.7
Terrestrial noise;	To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.	Section 9.8
Traffic;	To ensure that existing and planned uses are not compromised.	Section 9.9
Visual amenity;	To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.	Section 9.10
Indigenous heritage;	The EPA Environmental Objective for heritage is ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	Section 9.11
Construction dust;	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards	Section 9.12
Waste management (solid and liquid);	The EPA Environmental Objective for heritage is ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	Section 9.13.

FACTOR	ENVIRONMENTAL OBJECTIVE	DOC. REFERENCE
Hydrocarbons; and	To ensure that emissions to air do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	Section 9.14
Hazardous wastes.	The EPA's broad objectives for pollution are to ensure that land uses and activities that may emit or cause pollution are managed to maintain the physical and biological environment and the natural processes that support life, and the health, welfare and amenity of people and land uses; and to ensure that pollutants emitted are as low as reasonably practicable, and comply with all statutory requirements and acceptable standards.	Section 9.15

8. KEY FACTORS IMPACTS AND MANAGEMENT

The following section provides an overview of each of the identified 'key' factors including environmental objectives, potential impacts, management of impacts and predicted outcomes.

The key environmental factors have been identified as:

1. Marine water quality; and

2. Marine habitat disturbance (corals).

8.1 Key Environmental Factor 1: Marine Water Quality

8.1.1 Overview

The generation of a turbid plume is one of the most likely adverse environmental effects associated with dredging operations. The generation of dredge-induced turbid plumes generally results from the resuspension of existing fine sedimentary material from the seabed during the dredging process and from discharge of turbid water or high TTA from the reclamation area during the dewatering process. Turbidity at the dredge head is usually associated with sediments that are displaced by the operating cutter head that are not entrained by the suction system due to turbulence at the dredge head and local currents. Other significant sources of turbidity can be propeller wash as the dredge vessel is moved by attendant vessels into shallow waters.

8.1.2 EPA Objective

To maintain the quality of water so that existing and potential environmental values are protected, including the environmental values and environmental quality objectives set by the Department of Environment (2006):

8.1.3 Policy and Standards

- Pilbara Coastal Water Quality Objectives

- ANZECC 2000 Water Quality Objectives

8.1.4 Potential Impacts

ZONES OF IMPACT

Zone of Direct Impact was described as the seabed associated with the dredge and reclamation footprints. This includes the direct removal of benthic primary producer habitat.

Zone of Indirect Impact was described as anywhere a locality exceeded a coral threshold trigger (triggers are described below) in both the ambient (typical weather conditions) and energetic (cyclonic) scenario for either TSS or sedimentation. Corals are vulnerable to both sedimentation and light deprivation, and of the benthic primary producers found in the Dampier Archipelago, corals are the most susceptible to dredging, and these have been used as the proxy for the development of BPP tolerant triggers

Zone of Influence, was considered the area outside these two areas above were the plume was predicted to go but not exceed threshold levels set and no predicted losses to BPP is predicted in these zones.

TRIGGER VALUES

The objective in setting triggers is to set levels for TSS, sedimentation or other parameter which can act as a signal that potential impacts may occur. The exceedance of that initial level would then trigger a series of predetermined management responses. The underlying basis for the threshold is that a tangible risk of impact is evident once the threshold has been exceeded (based on McArthur et al (2002) and details in Section 8.2.4).

For this study, as discussed with the DEC, the thresholds employed during the Pluto Dredge Modelling Study have been utilised. Subsequent field monitoring programs have confirmed that these thresholds are conservative and substantially underestimate the levels of suspended sediment and sedimentation required to cause detectable mortality (MScience 2009b). Full documentation of these thresholds and the methodology used in their determination can be found in SKM (2007a). Application and implementation are described in Appendix 13 and Appendix 2 respectively.

BENTHIC PRIMARY PRODUCERS

Increased levels of turbidity in the water column cause a decrease in the levels of light available to benthic primary producers. Increased levels of sedimentation may also cause smothering, abrasion and stress to benthic organisms. The potential impacts upon coral and other benthic habitats are discussed in detail in Sections 8.2 and 9.1 respectively.

DISSOLVED OXYGEN (DO)

During dredging, the resuspension of organic matter and the subsequent increased levels of organic matter in the water column may stimulate the proliferation of oxygen-consuming microbes (particularly aerobic heterotrophic bacteria). These microbes consume oxygen and produce hydrogen sulfide as they decompose the organic matter, and therefore lower the available dissolved oxygen in the water column (ANZECC/ARMCANZ 2000). These impacts can have a detrimental effect on coral and other reef organisms.

Low DO concentrations can have adverse effects on aquatic organisms which depend upon oxygen for functioning. The oxygen requirements of fish and other aquatic organisms varies upon the species, life stages and different life processes (e.g. feeding, growth and reproduction) (ANZECC/ARMCANZ 2000). The USEPA (1986) recommends a minimum DO concentration of 6 mg/L and 5 mg/L for early and other life stages, respectively.

CONTAMINANTS

The dissolved oxygen concentration also has implications for contaminants. During anaerobic conditions (lack of dissolved oxygen), sediments generally release adsorbed nutrients, heavy metals and other compounds into the water column (ANZECC/ARMCANZ 2000). Many compounds, including zinc, lead, copper, hydrogen sulfide and ammonia also become more toxic at reduced DO concentrations.

A detailed sediment quality assessment was undertaken in the Dampier Port (Appendix 9), the results of which are discussed in Section 5.2.6. Background levels of contaminants were all below critical thresholds with the exception of chromium, which has been found to be elevated throughout the Pilbara region (DEC 2006a). Leachate analysis indicated that all results for chromium were below the laboratory practical quantification limit (PQL) and that chromium is in an immobile form.

Dredging is therefore not expected to cause any contamination release from sediment.

8.1.5 Predicted Impacts

The fate of sediments suspended by the proposed dredging operations has been simulated by APASA using the three- dimensional, sedimentation modelling system, SSFATE (Appendix 13). This model computes TSS distributions and sedimentation patterns by predicting the transport, dispersion and settling of suspended sediments released into the water column using a random procedure. The model calculated concentrations additional to background levels (‘above background’). The modelling assessed total suspended solids (TSS) concentrations and sedimentation against the thresholds employed for the Pluto Dredging Project. These thresholds were considered appropriate for the present study following monitoring work during and after the Pluto dredging operations that suggested that the thresholds represented substantially conservative levels for coral mortality (MScience 2009b).

The findings from the sediment fate modelling and analysis were (APASA 2009):

- The suspended sediment plume is predicted to be relatively close to the Dampier coast, with concentrations above 20 mg/l restricted to the immediate region surrounding the dredge zone.
- Results for the ambient and energetic simulations show that the sediment plume is expected to be dominantly transported north-east, with movement southwards towards King Bay stronger during the ambient run.
- Both scenarios indicated that the plume would extend only as far as 4 to 5 km from the dredge zone with concentrations in excess of 5 mg/l above background.
- The highest sustained plume concentrations were within 200 m of the outfall discharge point along the northern reclamation wall, with concentrations in excess of 25 mg/l observed here 6-7 % of the time during both scenarios.
- Exceedance of the nearshore TSS threshold of 35 mg/l was predicted to occur primarily within the immediate vicinity of the outfall discharge site, and to a lesser degree within the dredge zone and adjacent BLB turning basin.
- Offshore exceedances were predicted during the energetic scenario as a result of resuspension during cyclone events; however these are not expected to be significantly in excess of background rates.
- Exceedance of acute sedimentation thresholds are predicted to occur within the dredge zone and to a lesser extent within approximately 100 m of its perimeter.
- The most severe acute exceedances are predicted to occur within 200 m of the weir box, decanting excess tail water, where more than 50 days of exceedance was predicted during the dredging operations.
- Exceedance of the medium and chronic term thresholds are expected to be restricted to the extents of the dredge zone and predicted to be exceeded less than 15 days over the entire dredge operation.
- Areas more than 5 km from the DMSF development site are predicted to remain below the designated TSS and sedimentation thresholds for the entire dredging operation under ambient conditions.

Figure 35 and Figure 36 show the TSS levels and the sedimentation rates that the model predicted would exceed the thresholds adopted. The offshore exceedances is due to the change in trigger values for the inner and mid corals.

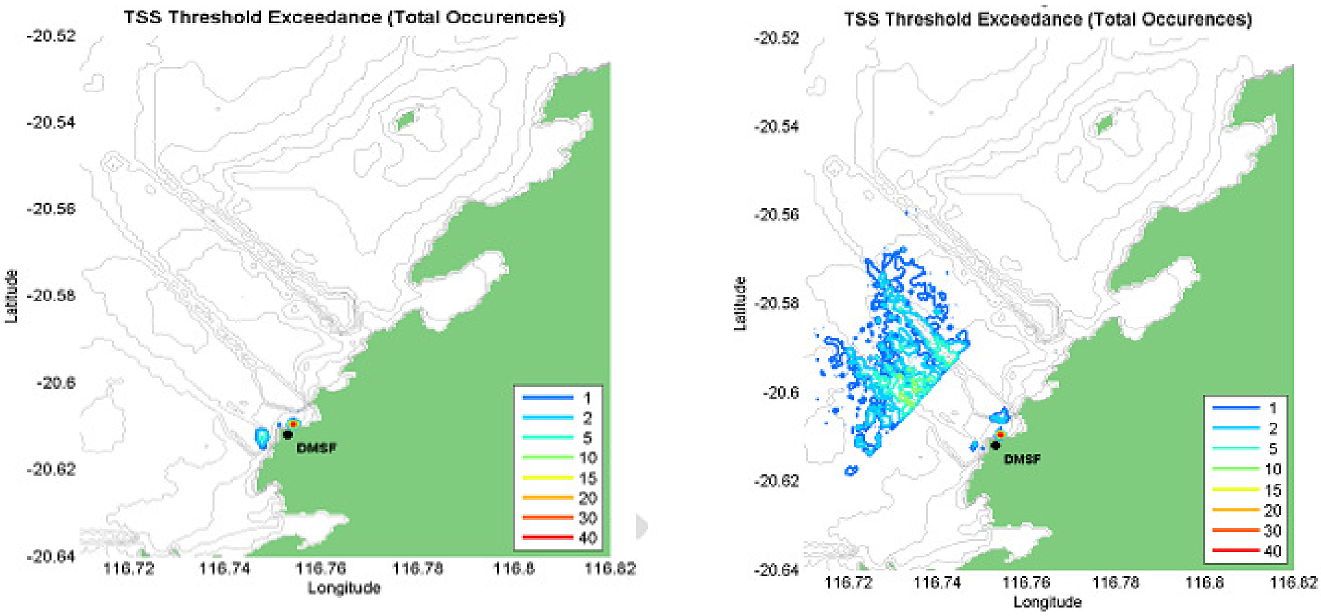

Figure 35: TSS threshold exceedance based on total number of events above allowable frequency of intensity-duration thresholds over the entire dredge period for the ambient (top) and energetic (bottom) modelled scenarios. Bathymetry contours are shown in grey (APASA 2009).

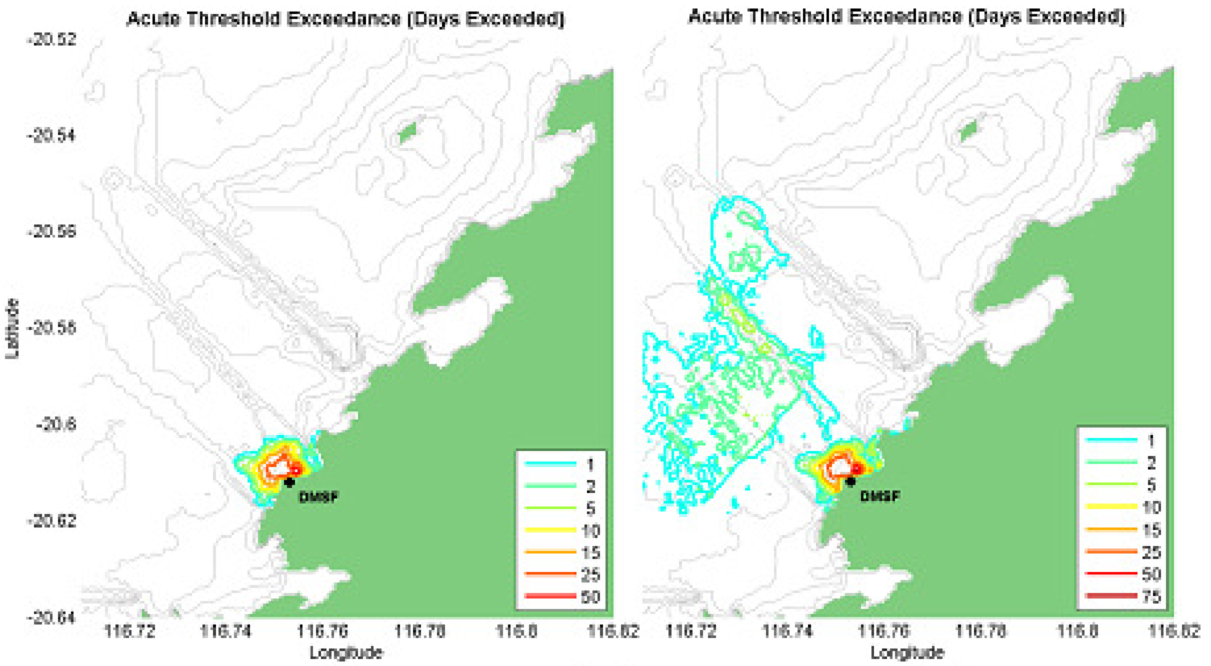

Figure 36: Acute sedimentation rate threshold exceedance based on total number of days exceeded over the entire dredge period for the ambient (left) and energetic (right) modelled scenarios. Bathymetry contours are shown in grey. Chronic and medium term sedimentation exceedances represent a much smaller footprint (APASA 2009).

8.1.6 Management of Impacts

The management, monitoring and reporting procedures to be followed during dredging and reclamation are presented in detail in the Dredging and Reclamation Management Plan (Appendix 2).

DREDGING MANAGEMENT

Management strategies that will be implemented during dredging include:

- Use of most appropriate dredge equipment, coupled with active management of a purpose built reclamation area. Previous projects have utilised Trailer Suction Hopper Dredges, cutter Suction dredges with unconstrained discharge and subsequent sea disposal of material. This project produces plumes and subsequent impact areas orders of magnitude smaller.

- Installation of a satellite-based vessel monitoring system on the dredge and track plot analysis to ensure maximum efficiency of the dredging effort and that no dredging occurs outside the required area;

- Use of the most suitable dredging equipment;
- Maintaining currency of calibration of hydrographic survey systems onboard the dredge:
- Avoidance of shallow areas during low tides to reduce plume generation by propeller wash;
- Use of submerged dredge pumps on the cutter suction dredge; and
- Monitoring of weather and sea conditions during dredging.

Reclamation Management

Management strategies that will be implemented during reclamation include:

- Real-time monitoring of reclamation pond discharge with associated active management of pond discharge.
- Adjusting the settlement time in the reclamation area to reduce the turbidity plume of decant (return) waters;
- Stop dewatering or move tail water within reclamation cells in the case of a trigger;

Monitoring Programs

DPA will implement three specific monitoring programs (Appendix 2) during and after construction. The proponent is responsible for ensuring that each of the monitoring programs is implemented. The following programs may be sub-contracted to a specialist sub-consultant:

- Water Quality Monitoring Program;
- Coral Health Monitoring Program;
- Surface Sediment Profiling Monitoring Program; and
- Onshore Reclamation Management Monitoring.

Further, the marine facilities construction contractor will monitor the operation on a continual basis and report any incidents that are likely to cause environmental harm to the environment officer DPA.

8.1.7 Outcome

A summary of the key potential impacts to existing turbidity levels and sedimentation rates and the associated management measures, consequence, likelihood and residual risk for each impact is provided in Table 18.

Table 18: Summary of potential impacts to existing turbidity levels and sedimentation rates and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Increased turbidity and sedimentation above predicted levels as a result of dredging and reclamation activities.	Implementation of DRMP, including the use of the most suitable dredging equipment and water quality monitoring.	3	D	M-17 (Moderate)
Changes to physio-chemical water quality parameters as a resulting of dredging and reclamation activities.	Implementation of DRMP, including water quality monitoring.	3	D	M-17 (Moderate)

8.2 Key Environmental Factor 2: Marine Habitat Disturbance (Corals)

8.2.1 Overview

Coral reef environments are considered sensitive to changing sediment regimes. However, corals colonising the near-shore fringing reefs north and south of the Dampier Cargo Wharf are likely to have evolved a natural tolerance to increased turbidity levels as a result of the natural background conditions in the Pilbara region.

A study of the Dampier region (Appendix 11) found that inshore fringing reefs of the Dampier and Cape Preston region are a single community dominated by bleach, sediment and wave-resistant coral groups. It is possible that some of the small differences between the Dampier Port and the reference reefs within the Dampier Archipelago have resulted from selective mortality of a few susceptible coral groups caused by years of dredging and port operation impacts.

Increased turbidity reduces light penetration, which reduces growth and over the longer term may even influence the survival of a community. Increased sedimentation as a result of dredging activities may smother corals, lead to increased energy consumption via cleaning processes, reduce fecundity and limit the viability of recruitment by reducing suitable substrate for colonisation. Depending on the scale of dredging and reclamation operations, proximity to coral habitats and operational processes, coral ecosystems can demonstrate a combination of lethal and sub-lethal effects from exposure to these stressors.

This section describes the key impacts anticipated from the proposed dredge and reclamation program on coral habitats within the vicinity of the proposed dredge and reclamation footprint. The possible risks to the short and long-term condition of these habitats are discussed, along with the significance of the likely impacts and proposed mitigation measures.

8.2.2 EPA Objective

The environmental objective for the marine habitat (corals) is to limit the direct loss of corals associated with the dredging activities and the reclamation of DMSF and to ensure the protection of the coral ecosystem of the Dampier Archipelago from indirect impacts associated with the project.

Further, EPA Environmental Assessment Guideline 3 for the Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (EPA 2009) provides guidelines for the assessment of damage or loss of BPPH and BPP within Development Areas (i.e. within the Dampier Port). The Guideline provides a Cumulative Loss Threshold within Development Areas (a 10% loss of BPPH).

8.2.3 Policy and Standards

EPA Environmental Assessment Guideline 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment

8.2.4 Potential Impacts

Excessive sedimentation from human activities constitutes one of the largest sources of coral reef degradation (Rogers 1990). Anthropogenic sources include construction activities, dredging, drilling at sea and runoff from river catchments through the removal of riparian vegetation. Primary responses of coral communities to elevated turbidity and sediment loads include:

- Changes in community composition (species distribution and abundance);
- Partial mortality (bleaching) or mortality as a result of smothering and light attenuation;
- Bacterial infection;
- Disturbed energy budgets (heterotrophy/autotrophy);

- Increased energy demand to maintain sediment rejection mechanisms; and
- Impact upon fecundity, fertilisation and recruitment/settlement.

Corals of the Dampier region are adapted to periodic elevation in turbidity and sediment deposition. The extent to which turbidity and sedimentation influences these stress responses relates to the temporal occurrence of the impacts. In the case of dredging and reclamation dewatering processes, extended changes in suspended sediment and deposition regimes have the capacity to affect coral community health.

TURBIDITY

High levels of turbidity limit reef development by decreasing light penetration and restricting the depth range at which corals can develop (Rogers 1990; Thamrongnawasawat *et al.* 1994).

Coral tolerance to varying light levels is generally thought to be species specific. Coral species of the Turbinaria and Faviid families are considered to be light tolerant while other species such as those associated with the Acropora family are considered light sensitive. Within the project area, Turbinaria and Faviids sp. are generally common in nearshore areas which tend to display higher turbidity while Acropora and other species such as *Pavona sp.* are found in areas further offshore which generally experience lower turbidity and increased light levels.

SEDIMENTATION

Various studies have recorded reductions in coral cover and diversity from increased sediment loads resulting from dredging and construction activities (Cortés *et al.* 1985; Brown *et al.* 1990). Amerson and Shelton (1976) recorded a 40% reduction in coral cover due to siltation resulting from airfield construction activities. Such impacts have the capacity to change coral community composition in the short term due to increased mortality, and also to produce chronic impacts, which favour the establishment of sediment tolerant species (Cortés *et al.* 1985).

Although most coral species can withstand low sedimentation rates, high sedimentation or extended turbidity events introduce sediment particles, which reduce available light for photosynthesis. Zooxanthellae, located within the coral polyps, provide the majority of energy for reproduction, feeding and growth in many coral species. Reduction in available light and the associated decrease in photosynthesis increase the overall respiration of coral polyps (Reigl *et al.* 1995; Yentsch *et al.* 2002). With increasing sedimentation, and increasing stress, growth, reproduction and the ability of colonies to maintain metabolic processes such as feeding decline. Dodge et al. (1974) recorded low growth rates of the hermatypic coral *Montastrea anularis* in areas of high resuspension of bottom sediments. Where elevated sediment and low light conditions remain for extended periods, zooxanthellae cells can be released from the polyp resulting in bleaching (Bak R. 1978; Lasker 1980; Rogers 1983).

Monitoring of corals in Mermaid Sound during construction activities such as dredging have generally reported limited impacts to coral communities in response to increases in sedimentation (MScience 2009b). Impacts have generally been associated with localised smothering close to dredging and spoil disposal activities and propeller wash from dredge vessels (Blakeway 2005).

Fecundity and Recruitment

Suspended sediment has been shown to affect coral fecundity (Tomascik *et al.* 1987) fertilisation, larval survival, and larval settlement in scleractinian (hard coral) species (Gilmour 1999). Decreased coral fecundity and larval survivorship subject to elevated suspended sediment loads is likely to result in decreased rates of recruitment for coral species (Gilmour 1999).

Increased turbidity, and associated deposition, either natural or anthropogenically derived, can affect the recruitment of corals. Gilmour (1999) identified during experiments, that increased sediment loads (100 mg/L – 50 mg/L) influenced successful fertilisation and subsequent larval settlement onto substrates. If dredging activities were to continue through the coral spawning and post spawning periods, the viability of local coral systems as successful donor and receiving sites for recruitment may be affected during dredging.

Intensity-Duration-Frequency Approach to Survival Thresholds

McArthur et al (2002) provide the following rationale for development of an intensity-duration-frequency approach to the setting of thresholds:

"Three factors were determined to be important aspects of coral and coral community effects of exposure to suspended sediments; intensity, duration, and frequency.

1. Intensity: High suspended sediment concentrations place stress on corals, therefore suspended sediment values near the high end of the normal range of concentrations to which South Florida coral communities are exposed are most likely to have adverse effects on community structure. Suspended sediment concentrations due to natural conditions plus dredged sediment disposal should not exceed the highest values to which South Florida coral communities are normally exposed. The highest allowable values have been selected as the 99th percentile observed concentration. A lower value, the 95th percentile observed concentration, has been selected as a threshold concentration. This threshold concentration can be exceeded only for specified durations and frequencies as discussed below. Concentrations below this threshold value are not considered to significantly affect coral communities because of their naturally higher frequency of occurrence.

2. Duration: The average suspended sediment concentrations that persist in the environment throughout the year can be considered "background" levels of continuous or near continuous duration. These typical concentrations are not expected to adversely affect coral

communities. High sediment concentrations may cause an adverse impact if the corals are exposed to these concentrations for sufficient time periods. Any significant increase in the time of exposure or duration of high sediment concentrations may result in excess stress in individual coral species and changes in community structure. Coral exposures to suspended sediment concentrations (dredged sediments plus native sediments) above the threshold value should not exceed the naturally occurring 95th percentile duration event.

3. Frequency: Suspended sediment concentrations that coral communities are most frequently exposed throughout the year are those to which corals are principally adapted and, therefore, are not expected to have an adverse impact. Higher values are those caused by storm events and other anomalies, which occur less frequently. Corals are able to tolerate occasional heavy sediment concentrations provided there is sufficient time for recovery between high sediment events. Any significant increase in the frequency of high sediment concentrations may cause a change in community structure due to the disappearance of those species with lower sediment tolerance. Suspended sediment concentrations above the threshold value due to dredged sediment disposal, for a specific duration, should not occur at a frequency such that the combined frequency of the dredging and natural events are significantly greater than would normally occur. The level of significance or frequency guideline has been selected as the upper 95th percent confidence interval."

For this assessment, as discussed with the DEC, the thresholds (intensity, duration and frequency) employed during the Pluto Dredge Modelling Study were used. Subsequent field monitoring programs during and after the Pluto dredging operations have since confirmed that these thresholds are conservative and substantially underestimate the levels of suspended sediment and sedimentation required to cause detectable morality (MScience 2009b). Full documentation of these thresholds and the methodology used in their determination can be found in SKM (2007b).

TOTAL SUSPENDED SEDIMENT THRESHOLDS

The suspended sediment thresholds are defined by TSS limits for three distinct zones, as illustrated in Figure 37. Table 19 indicates the maximum allowable concentrations of suspended sediments over a specified duration for the three given zones.

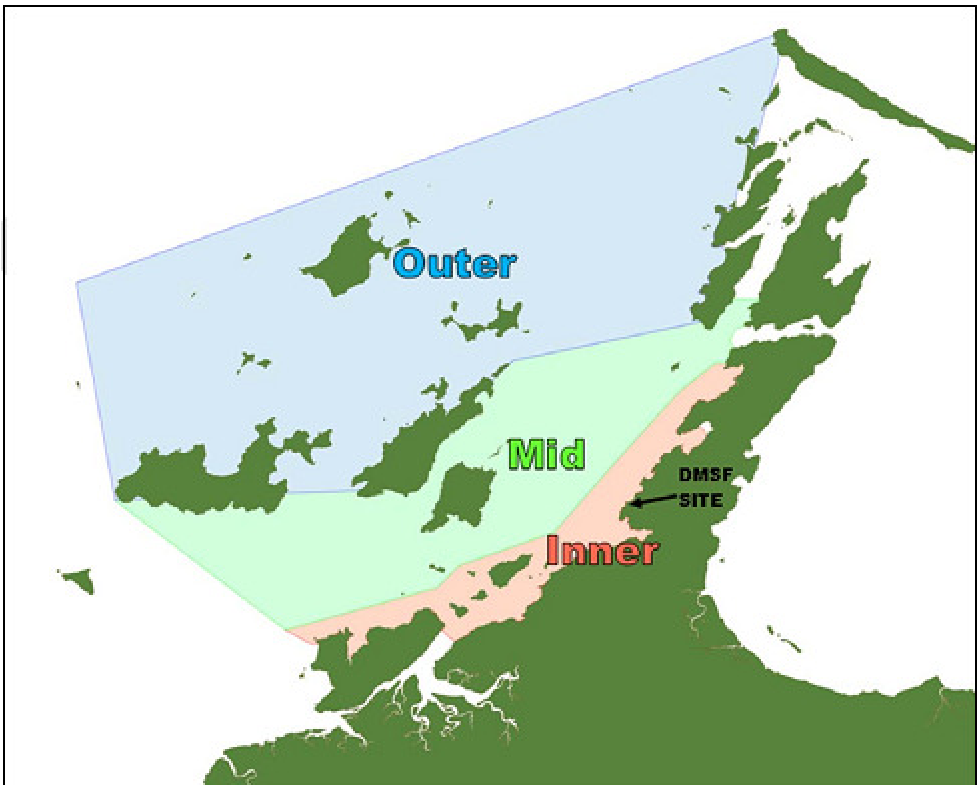

Figure 37 Map of ecological management zones defining separate threshold limits

Table 19 Adopted allowable frequency of intensity-duration events per month for model interrogation (SKM 2007b)

Threshold Concentration	Inner 35 mg/l	Mid 10 mg/l	Outer 10 mg/l
Max # of 1 hr events per month	16	10	4
Max # of 2 hr events per month	8	2	2
Max # of 3 hr events per month	5	1	2
Max # of 4 hr events per month	2	1	1
Max # of 5 hr events per month	1	1	1
Max # of 6 hr events per month	0	0	0

An allowance for background concentrations was included in the threshold analysis as the values in Table 19 relate to total in water concentrations of suspended sediments. Based on a recent turbidity monitoring program at the project site an appropriate level of background SSC was selected as 5.25 mg/l for the entire domain (MScience 2009a). This was based on the 80th percentile of a number of turbidity measurements. The 80th percentile was selected as a more conservative value to use than the mean.

For ease of comparison the same thresholds were applied to the energetic scenario. It should be noted, however, that these thresholds relate to ambient conditions. Exceedances due to cyclone events should be considered in the knowledge that natural resuspension rates would almost certainly lead to an exceedance of the SSC thresholds.

SEDIMENTATION THRESHOLDS

Sedimentation thresholds were defined using three different intensity-duration brackets as defined in Table 20. An allowance for background sedimentation rates was set based on those values used during the Pluto project. This was 2.3 mg/cm^2/day for the inner zone and 1.0 mg/cm^2/day for the mid and outer zones (Figure 37).

Table 20 Acute, Medium and Chronic Term Thresholds for model interrogation (SKM 2007b)

	Inner Zone	Mid - Outer Zone
Acute (for any day)	Flag if > 33 mg/cm^2/day	Flag if > 6.6 mg/cm^2/day
Medium Term (for any 5 days in a 15 day period*)	Flag if > 60 mg/cm^2/day	Flag if > 12 mg/cm^2/day
Chronic Term (for any 15 days in a 30 day period*)	Flag if > 36 mg/cm^2/day	Flag if > 9 mg/cm^2/day

*Days do not need to be consecutive.

These thresholds were applied to the energetic scenario in the same manner as the ambient case.

8.2.5 Predicted Impacts

DIRECT IMPACTS: PHYSICAL REMOVAL

The direct dredging and reclamation footprint of the proposed DMSF will remove 5,400m^2 of coral habitat greater than 10% coral cover. The direct impacts upon coral habitat are presented as the direct footprint (in red) in Figure 39 and summarised in Table 21. A description of the coral habitat within the development area is provided below, as summarised from Appendix 11.

Coral communities within the direct impact site include sparse cover (1-10%), moderate cover (10-50%) and limited areas of dense cover (>50%) as a thin veneer of living coral growing on a substratum of bedrock outcrop and large boulders. Hard coral cover is moderate in the areas surveyed, ranging from almost 25% to just over 40%. Massive faviid corals were the dominant hard coral group closely followed by *Turbinaria* spp. corals (family: Dentrophylliidae) and poritid corals. These three families made up 70% of all recorded hard corals. Agariciids (predominately the species *Pavona decussata*), pectiniids and mussids (mainly *Lobophyllia hemprichii*) were also present. Fast-growing acroporid and pocilloporid corals that often dominate coral reefs (and are susceptible to bleaching impacts) were rare or absent on these reefs covering a combined mean of less than 0.4% of the substratum. The coral assemblage was very similar to other inshore assemblages in Dampier Harbour, except that the areas of coral and hard substrate surveyed in this area were impacted by sedimentation. It should be noted that this project has adopted the management unit as established for the final Pluto ptoject assessment work, and shown in Figure 38.

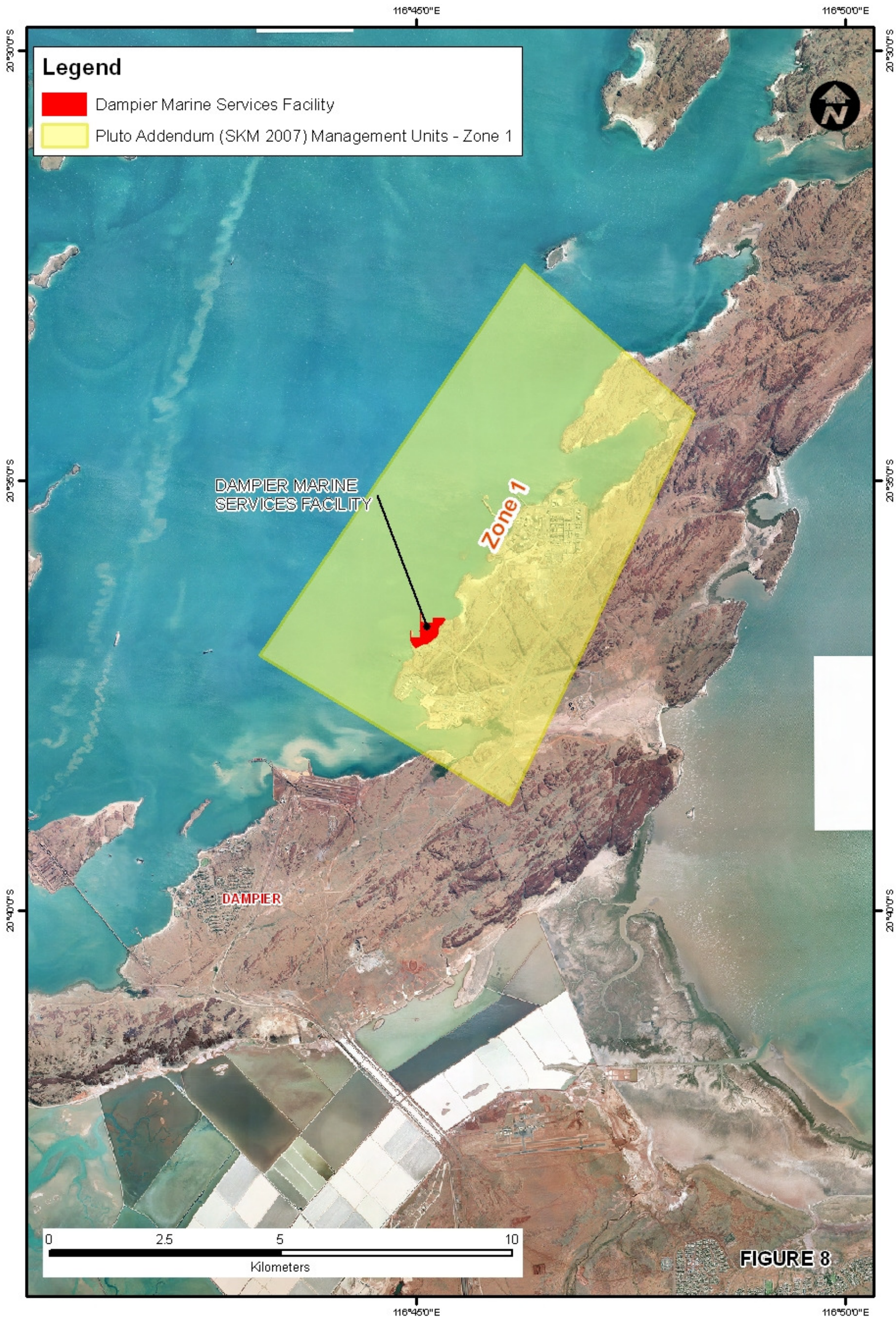

Figure 38 BPPH Managament Unit

Sponges were moderately common on these reefs, covering a mean of 3.4% of the substratum but algae and soft corals were rare. Live corals were restricted to depths ranging between 1 m and 5 m below CD.

Table 21: Direct impacts on coral habitat within the footprint of the DMSF

Coral Habitat	Description	Direct Impact Area (M^2)	% Total Area [1]
Rocky Reef with Sparse Corals	Rocky reef with 1-10% coral cover.	44,000	6.0
Rocky Reef with Moderate Corals	Rocky reef with 10-50% coral cover.	3600	0.5
Rocky Reef with Dense Corals	Rocky reef with >50% coral cover.	1800	0.2
Total		**49,400**	**6.7**

[1] Total area refers to the historical benthic primary producer cover within the management unit (73.72 ha)

For the study of impact a precedent has been accepted by the EPA that coral cover greater than 10% is considered BPPH – i.e. 5400m^2

INDIRECT IMPACTS: TURBIDITY AND SEDIMENTATION

The indirect effects (increased turbidity and sedimentation) of the proposed DMSF upon coral habitat are presented as a shaded area in Figure 39 and are summarised in Table 22.

Table 22: Indirect impacts on coral habitat outside the footprint of the DMSF

Coral Habitat	Description	Direct Impact Area (ha)	% Total Area [1]
Rocky Reef with Sparse Corals	Rocky reef with 1-10% coral cover.	3.57	4.8

[1] Total area refers to the historical benthic primary producer cover within the management unit (73.72 ha)

AREA OF INFLUENCE

The turbidity and sedimentation modelling undertaken by APASA includes an area of influence from the dredge plume (presented as a shaded area in Figure 39. No loss of benthic habitats is expected in this area.

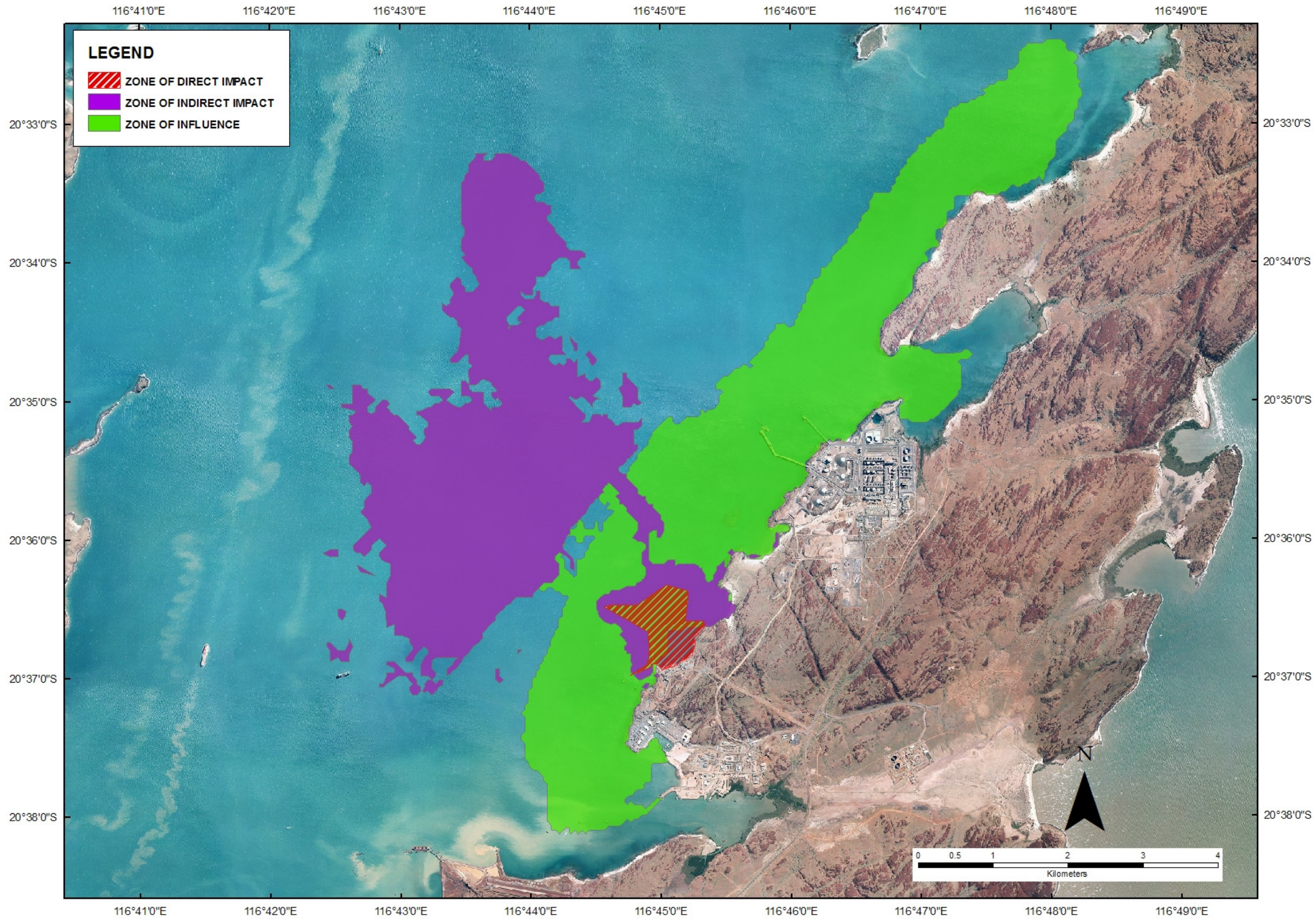

Figure 39: Direct and Indirect Impact and Influence Zones upon benthic habitat as a result of the proposed DMSF, in the immediate surrounds of the proposed site

8.2.6 Management of Impacts

DIRECT IMPACTS: PHYSICAL REMOVAL

Zone of Direct Impact was described as the seabed associated with the dredge and reclamation footprints. This includes the direct removal of benthic primary producer habitat.

Extents of direct impact will be managed during the construction of Marine Facilities by survey controls and construction design requirements.

MANAGEMENT OF INDIRECT IMPACTS: TURBIDITY AND SEDIMENTATION

The management of turbidity and sedimentation during dredging and reclamation activities is discussed in detail in the Dredging and Reclamation Management Plan (Appendix 2) and summarised in Section 8.1.6.

8.2.7 Outcome

A summary of the key potential impacts to coral habitat and the associated management measures, consequence, likelihood and residual risk for each impact is provided in Table 23.

Table 23: Summary of potential impacts to coral habitat and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Direct impact on coral habitat beyond that predicted within the project footprint.	Implementation of DRMP, including controls on vessel movements, anchoring and survey controls.	3	E	M-20 (Moderate)
Indirect impact to coral habitat, beyond that predicted, as a result of increased turbidity and sedimentation.	Implementation of DRMP, including the use of the most suitable dredging equipment and water quality monitoring.	3	D	M-17 (Moderate)

9. OTHER RELEVANT FACTORS IMPACTS AND MANAGEMENT

The following section provides an overview of each of the other relevant factors including environmental objectives, potential impacts, management of impacts and predicted outcome.

The other environmental factors have been identified as:

16. Marine habitat disturbance (non-corals);
17. Megafauna;
18. Underwater noise;
19. Introduced marine organisms;
20. Disturbance to coastal processes;
21. Terrestrial flora and fauna;
22. Surface drainage;
23. Terrestrial noise;
24. Traffic;
25. Visual amenity;
26. Indigenous heritage;
27. Construction dust;
28. Waste management (solid and liquid);
29. Hydrocarbons; and
30. Hazardous wastes.

9.1 Other Marine Habitat

9.1.1 Overview

The proposed DMSF dredging and reclamation footprint is located across a range of marine habitats other than coral, including subtidal and intertidal habitats. Benthic and intertidal habitats that may potentially be affected by the proposed dredging and reclamation activities (including macroalgae) have been described in the Biological Marine Environment (Section 5.3) and are illustrated in the benthic habitat maps in Appendix 10.

9.1.2 EPA Objective

The environmental objective for the marine habitat is to limit the direct loss of BPP associated with the dredging activities and the reclamation of DMSF and to ensure the protection of the ecosystem of the Dampier Archipelago from indirect impacts associated with the project.

Further, EPA Environmental Assessment Guideline 3 for the Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment (EPA 2009) provides guidelines for the assessment of damage or loss of BPPH and BPP within Development Areas (i.e. within the Dampier Port). The Guideline provides a Cumulative Loss Threshold within Development Areas (a 10% loss of BPPH).

9.1.3 Policy and Standards

- EPA Guidance Statement No 1: Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (2001);
- EPA Environmental Assessment Guideline 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment
- ANZECC/ARMCANZ Guidelines for Fresh and Marine Water Quality (2000);
- Pilbara Coastal Water Quality Consultation: Environmental Values and Environmental Quality Objectives (DoE 2006)

9.1.4 Potential Impacts

Potential Impacts on Seagrass

Shading

Shading of seagrass species inhibits photosynthetic capacity and prolonged light deprivation will eventually cause mortality, although the critical threshold is very species-specific. Changes in leaf physiology (e.g. amino acid content, chlorophyll content and $\delta^{13}C$) and morphological changes (e.g. biomass, shoot density, canopy height) may also result from decreased light attenuation.

Tropical seagrasses tend to be fast growing and are typically well adapted to disturbance (such as cyclonic events), which often result in large scale changes in the dynamics of seagrass meadows (Waycott *et al.* 2005). For example, two major floods and a cyclone in Hervey Bay, Queensland in 1992 triggered the loss of 1000 km^2 of seagrass meadows (*Halophila spinulosa* and *Halophila ovalis*). The cause was light deprivation from persistent elevated turbidity levels, and uprooting from extreme hydrodynamic conditions. Two years after the floods, deeper water areas (>10m depth) had recovered substantially, apparently by seed germination. There was almost no recovery in shallow areas, which was thought to be a result of either very heavy sediment deposition during the cyclone burying the seeds, or extensive physical abrasion caused by churning sediment (Preen *et al.* 1995). The recovering sites were dominated by *Halophila decipiens*, and also contained some original *Halophila spinulosa* and *Halophila ovalis* communities.

Halodule pinifolia, *Thalassia testudinum* and *Posidonea sinuosa* are considered to be tolerant species to shading, and can survive for more than 100 days in light conditions below their minimum requirements (Longstaff *et al.* 1999). *Halophila ovalis* is not a tolerant species, and was found to suffer complete plant mortality after 38 days of shading in a field study in the Gulf of Carpenteria, although it was able to quickly regenerate from seeds stored in the sediment (Longstaff *et al.* 1999).

Halophila ovalis and *Halophila decipiens* are fast-growing ephemeral seagrasses and are often the first species to colonise disturbed areas (Waycott *et al.* 2005). Their minimum light requirements are 14-16% surface irradiance (SI) (Longstaff *et al.* 1999; Schwartz *et al.* 2000) and 2.5-8.8% SI (Dennison 1987; Williams *et al.* 1990; Duarte. C.M. 1991) respectively.

Sedimentation

The critical threshold for sedimentation and the duration that seagrasses can survive periods of excessive sedimentation also varies greatly among seagrass species. Larger, slow-growing climax species with substantial carbohydrate reserves show greater resilience to such events than smaller opportunistic species, but the latter display much faster post-dredging recovery when water quality conditions return to their original state.

The critical sedimentation threshold for the seagrass *Halophila ovalis* is 2 cm/year (Vermaat *et al.* 1997).

Eutrophication

Organic material consists of particulate organic matter (POM), which is trapped as detritus within a seagrass meadow, and dissolved organic matter (DOM), which may be generated during the microbial breakdown of POM or released directly from seagrass roots (Kilminster *et al.* 2006). Concentrations of DOM are higher in sediment porewater than the water column and vary temporally and spatially (Kilminster *et al.* 2006).

Dredging can cause the release of organic material from sediment, which increases the available nutrients in the water column and can have a detrimental effect on seagrass growth. Kilminster et al. (2006) demonstrated that *Halophila ovalis* experienced decreased growth (up to 50% relative to control) when subjected to increased concentrations of particulate organic matter (POM) or dissolved organic matter (DOM).

However, in general, tropical seagrass ecosystems are nutrient limited, and their response to elevated nutrients is typically enhanced growth, in contrast with the negative effects reported on temperate species (Waycott *et al.* 2005).

POTENTIAL IMPACTS ON MACROALGAE

Benthic macroalgae are vulnerable to sedimentation and low light regimes, although tolerance varies between species. Macroalgae tend to have short life cycles with seasonal growth patterns, and therefore there is a strong potential for recolonisation of disturbed areas (Woodside Petroleum Limited 2006).

POTENTIAL IMPACTS ON MANGROVES

Mangroves are generally not vulnerable to turbidity and low light regimes, although they can suffer impacts from extremely high sedimentation levels, as shown by large scale spoil deposition in No Name Bay in Mermaid Sound (Woodside Petroleum Limited 2006).

POTENTIAL IMPACTS ON MICROPHYTOBENTHOS

The key factor effecting MPB is the response to turbidity and hence light. Requirements of MPB are dependent on a wide range of factors and can survive at very low light levels. MPB comprises a range of species, which are likely to have different light tolerances. There is likely to be a wide range of consequences for MPB depending on its exposure to turbid plumes (concentration, duration, frequency) and its depth (CEE 2007). Given the rapid turnover of MPB communities and their tolerance to reduced light levels, they are likely to survive over much of the shallow areas and areas with low exposure to turbid plumes (i.e within the Zone of Influence). Overall, any MPB that is affected will recover rapidly when the turbid plumes dissipate.

9.1.5 Predicted Impacts

AREA OF INFLUENCE

There are seagrass, micropytobenthos and mangrove communities present within the area of influence predicted by the dredging plume. However, impacts upon these communities are predicted to be minor and of a short duration, and therefore no significant loss of benthic communities is expected in this area.

The turbidity and sedimentation modelling undertaken by APASA includes an area of influence upon benthic habitats, as determined by the coral health thresholds discussed in the modelling report (Appendix 13) and in the DRMP (Appendix 2) these thresholds whilst developed for corals are considered conservative for seagrass and have been developed from baseline data which represents varying statistics of what the natural variation is. The area of influence is presented as a shaded area in

Figure 39.

DIRECT IMPACTS

Direct disturbance impacts to habitats other than the coral communities identified in Section 8.2 located within the reclamation and dredging footprint are presented as the project footprint (in red) in

Figure 39 and have been summarised in Table 24

Other habitats generally considered of less importance both ecologically and commercially are infauna communities found within surface sediments to a depth of approximately 0.5m. These communities are likely to be the most common within the Archipelago, given the distribution and extent of bare sediments within the area. Infauna is often able to recolonise relatively quickly following disturbance if suitable sediments are available for recolonisation. If sediments change between disturbance events, new species not previously present may colonise the area as they are better suited to the change in substrate type (Mori 2008). Community type may change several times following disturbance as pioneer species more adapted to disturbance events colonise first due to their ability to reproduce and grow more effectively followed by more progressive species. Eventually the community often stabilises, as long as other disturbance events do not occur. Where the habitat is subject to regular disturbance through maintenance dredging or disturbance from propeller wash or from a cyclone event, the infauna community is usually dominated by short-lived opportunistic species. It should be noted that no recolonisation will occur within the reclamation footprint as the removal of subtidal habitat will be permanent.

Table 24: Direct impact upon benthic habitats other than coral within the footprint of the DMSF

Habitat	Description	Direct Impact Area (ha)
Bare Sediment – proxy for microphtobenthos	Bare substrate comprising mainly silts, some areas of sand with sparse shells.	47.20
Previously Dredged Area	Bare substrate comprising mainly sandy muds with sparse shells; very low light conditions.	14.10
Intertidal Shallow Subtidal Rocky Shore	Intertidal to shallow subtidal bedrock/boulder reef with few colonizing organisms apart from macroalgae.	1.81

INDIRECT IMPACTS

The area of indirect disturbance impacts to habitats other than the coral communities identified in Section 8.2 are also presented as a shaded area in

Figure 39, and have been summarised in Table 25.

Table 25: Indirect impact upon benthic habitats other than coral outside the DMSF footprint

Coral Habitat	Description	Direct Impact Area (ha)
Bare Sediment – proxy for microphtobenthos	Bare substrate comprising mainly silts, some areas of sand with sparse shells.	295.65
Previously Dredged Area	Bare substrate comprising mainly silt or sand with sparse shells; very low light conditions.	53.54
Rocky Reef (No Coral)	Subtidal bedrock/boulder reef with few colonizing organisms.	2.23
Intertidal Shallow Subtidal Rocky Shore	Intertidal to shallow subtidal bedrock/boulder reef with few colonizing organisms apart from macroalgae.	1.18
Intertidal Mud/Sand Flats	Areas of unconsolidated sediments ranging from fine sand to gravel, occurring in the near supratidal zone.	1.20

IMPACTS ON SEAGRASS

The key threats to seagrass communities are identified as habitat alteration, increasing turbidity and lower light regimes (Section 9.1.4). Species such as *Halophila sp*. and *Halodule sp*., occur within the macroalgal meadows, and are the dominant plants of some shallow sand flat areas near the coast (Appendix 10 – Benthic Habitat Map). Seagrass is the principal food of Dugongs (*Dugong dugon*). They are also consumed by other herbivores such as the Green Turtle (*Chelonia mydas*), which also grazes on the macroalgae beds found in the region.

Whilst the literature suggests these species are perennial (McMillan 1983; Walker D.I. 1987; Walker *et al.* 1988; Western Australian Herbarium 2009), experience in similar projects has shown seagrass species are ephemeral and seasonal senescence occurs in some species The field survey (Appendix 10) subsequently investigated further the potential distribution of seagrass, the survey was timed to be at the end of the growing season for seagrasses in the area to capture the largest areal coverage of seagrass communities. A concurrent study being undertaken by WorleyParsons (WorleyParsons 2009e) identified a silty habitat which is typical in the south of Mermaid Sound and less preferential habitat for seagrasses (Figure 40).

A study undertaken by Bertolino (2006) further indicated seagrass species in the Dampier Archipelago are distributed in the coarser more compact sediments. In general, sites with sediments dominated by the larger grainsize fractions supported a larger biomass of seagrass than those dominated by clays and silts fractions (Figure 41). It is suggested that in the coarser, compact sediments resuspension is less likely to occur; therefore the water column is less likely to be turbid where light limitation and smothering of seagrasses could occur. Regardless, the sediments identified in the zones of influence were devoid of seagrass and appeared unsuitable for rhizome settlement.

Of further note was that BPPH<6mLAT was primarily rocky boulders unsuitable for seagrass. Bertollino (2006) study concluded that depths greater than 6m LAT (typically rocky BPPH in zones of impact) are not suitable for seagrass growth within the Dampier Archipelago.

This current study was executed in October or spring. Tropical species typically exhibit a 'bimodal' growth pattern, where the majority of their growth occurs during spring and autumn when the water temperatures are within their optimal growth range (Lee *et al.* 2007).

Based on the arguments above that geology, depth, habitat and the complete absence of seagrass (that was expected to be at its most abundant time of year if present) during this survey would indicate that seagrass does not occur in the impact zone.

IMPACTS ON MICROPYTOBENTHOS

Response to Turbidity (Reduced Light)

The light requirements of MPB are dependent on a wide range of factors and can survive at very low light levels. MPB comprises a range of species, which are likely to have different light tolerances. There is likely to be a wide range of consequences for MPB depending on its exposure to turbid plumes (concentration, duration, frequency) and its depth (CEE 2007). Given the rapid turnover of MPB communities and their tolerance to reduced light levels, they are likely to survive over much of the shallow areas and areas with low exposure to turbid plumes (i.e within the Zone of Influence). Overall, any MPB that is affected will recover rapidly when the turbid plumes dissipate. In Summary:

Reduced light will affect MPB productivity under the turbid plumes with decreasing effect with increasing distance from the source of the plumes

MPB will survive in most areas under the plume where there is sufficient light to balance photosynthesis and respiration

MPB populations in the affected areas will recover within weeks to months of a return to normal light conditions.

Areas that are subject to regular disturbance and occur in deeper areas e.g. shipping channels, are likely to contain lower MPB biomass and species diversity, than the adjacent seabed. The consequence of direct loss of MPB due to removal of sediment from existing channels is considered low. It is also likely that MPB removed from the seafloor will re-establish on the seabed within weeks of dredging completion as evidenced by the rapid fluctuations recorded in MPB biomass in other dredging campaigns (Beardall *et al.* 1994; AME 2006).

Sedimentation Effects

Shallow waters are frequently disturbed by wave action. MPB in general are capable of substantial burial and migration and withstanding burial or deposition at rates of at least millimetres per day if all other conditions (for example light and nutrients) are suitable (CEE 2007).

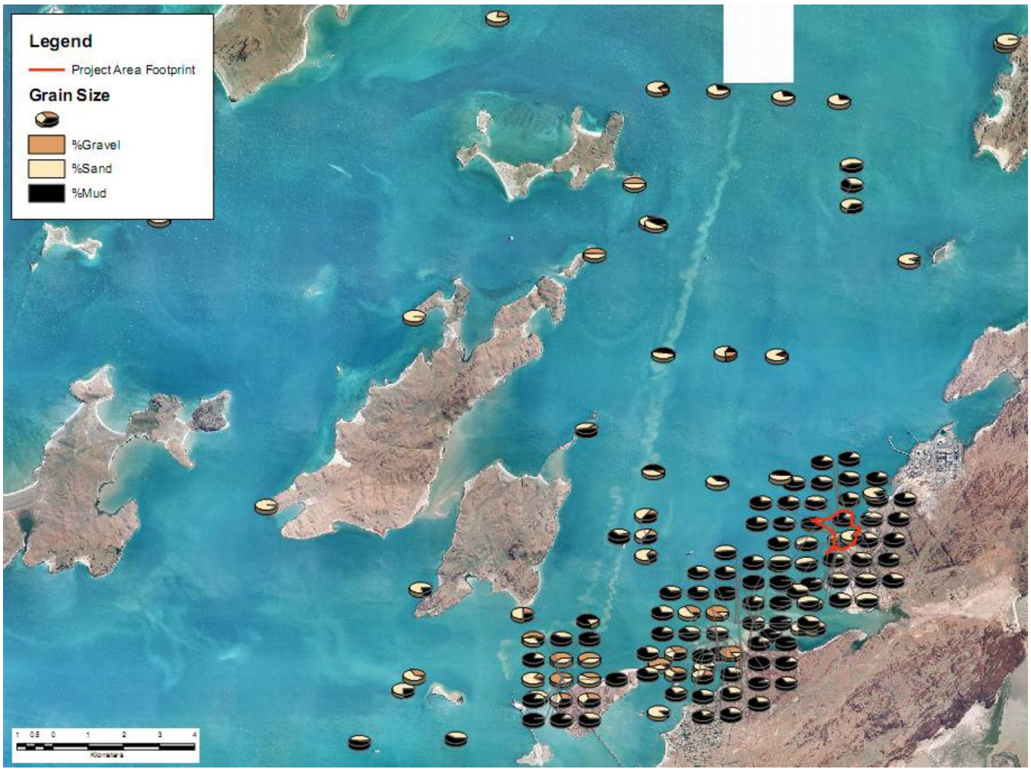

Figure 40 Surface sediment grain size Mermaid Sound

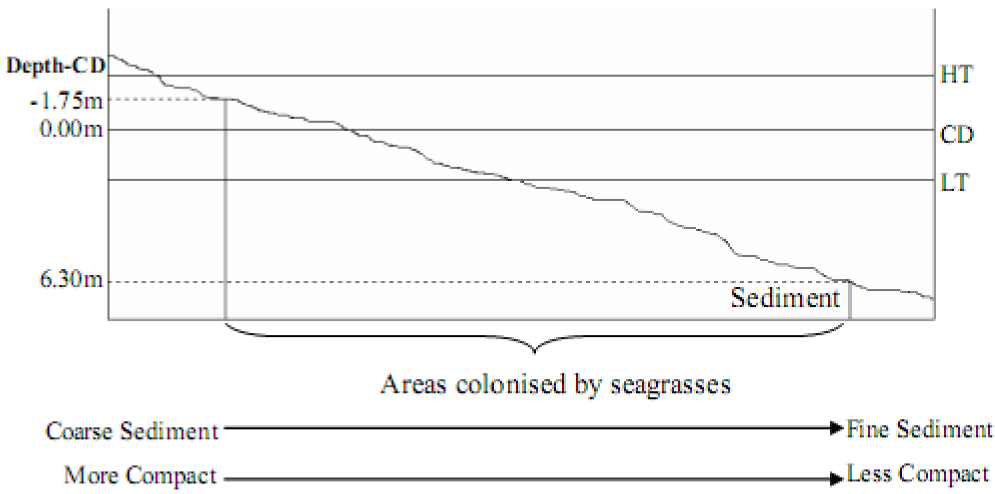

Figure 41 Diagrammatic representation of approximate seagrass distribution (maximum and minimum depth (CD) where seagrasses were found during survey, diagram not to scale with approximated depth of high (HT) and low (LT) tides) (Bertolino 2006).

9.1.6 Management of Impacts

The management of indirect impacts upon benthic habitats as a result of dredging and reclamation activities is discussed in detail in the Dredging and Reclamation Management Plan (Appendix 2), including the use of the most suitable dredging equipment and extensive water quality monitoring.

9.1.7 Outcome

A summary of the key potential impacts to marine habitat other than corals and the associated management measures, consequence, likelihood and residual risk for each impact is provided in Table 26.

Table 26: Summary of potential impacts to other marine habitat and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Habitat loss beyond that predicted within the direct impact areas.	Implementation of DRMP, including controls on vessel movements, anchoring and survey controls.	3	E	M-20 (Moderate)
Indirect impacts on marine habitats as a result of dredging and reclamation activities beyond that predicted.	Implementation of DRMP, including the use of the most suitable dredging equipment and water quality monitoring.	3	D	M-17 (Moderate)

9.2 Megafauna

9.2.1 Overview

The following section summarises the potential impacts upon marine megafauna as a result of the proposed DMSF, including the potential impacts of vessel collisions, underwater noise, light, increased turbidity and sedimentation, the physical presence of the land reclamation area and new jetty, potential entrapment within the constructed seawall and potential indirect impacts of the loss of benthic habitat.

The marine megafauna found within the Dampier Archipelago are discussed in Section 5.3.11. Vertebrate species include the dugong (*Dugong dugon*), three species of whale and three species of dolphin (Wells *et al.* 2003b). Approximately 736 fish species are found within the Archipelago, the majority of which are wide ranging (Hutchings 2003). Six species of sea snake have been found in the Dampier region (Wells *et al.* 2003b), and as many as 12 species may occur in the area (Cogger 1979). Little is known of the size of their populations, distribution or status as they are not commonly seen within the Port, although none have been recorded nesting in significant numbers within Port Limits (DPA 2007b).

Several species of turtle nest on the islands of the Archipelago (Prince 1993), although none have been recording nesting within the Port limits (DPA 2007b). The nearest nesting site to the project area is Green Turtle site at the north-eastern tip of West Lewis Island (SKM 2006b). Very low density nesting has been recorded on the beach to the east of the project (Holden Beach, Woodside Energy Limited 2006). The islands of the Dampier Archipelago also provide breeding and nesting habitat for sixteen species of seabirds (DPA 2008).

9.2.2 EPA Objective

The EPA Environmental Objective for fauna is to maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

9.2.3 Policy and Standards

The policies and standards relevant to marine megafauna are:

- EPA Guidance Statement No 1: Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (2001);
- EPA Environmental Assessment Guideline 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment
- EPA Guidance Statement No 8: Environmental Noise (Draft) (2007); and
- Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (DoE 2006c).

9.2.4 Potential Impacts

The proposed DMSF could have the following direct impacts upon megafauna:

- Entrapment within the constructed seawall;
- Vessel collisions or entrapment within dredging equipment;

- Underwater noise (discussed in Section 9.3);
- Light spill and disorientation (i.e. marine turtles) (see Appendix 2 for additional management);
- Increased levels of turbidity and sedimentation during dredging and reclamation;
- Physical presence of the construction workforce;
- Physical presence of the land reclamation area and new jetty; and
- Hydrocarbon spills (see Appendix 2 for additional management).

The loss of benthic habitat (discussed in Sections 8.2 and 9.1) could also have indirect impacts upon marine megafauna.

DIRECT IMPACTS

Seawall Construction

Land reclamation activities will involve the construction of a containing bund wall (seawall), which will be sealed to contain the dredged sediment. There is a possibility for some individual megafauna to become entrapped within the seawall at the point of final construction.

Vessel Collisions or Entrapment

Direct mortality of megafauna is possible via entrainment or strike by the cutter section dredge head during dredging. However, US Army Corps of Engineers experience has shown that turtle entrainment into cutter suction dredges is rare, and that all entrained specimens recorded were in a state of decomposition that suggests they were already deceased. Cutter suction dredges are used in preference to trailing suction hopper dredges for this reason (perscomm. D. Dickerson, US Army, 27 October 2009).

The presence of vessels during construction may increase the likelihood of a direct collision with megafauna, particularly turtles. Turtles are vulnerable to boat strike while surfacing 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.

Turtles are less likely to flee a vessel that is travelling at high speed, and will flee at shorter distances from a fast-travelling vessel (Hazel *et al.* 2007). The ability of the boat operator to see and avoid turtles is lessened in poor sea and/or weather conditions, water turbidity and safety restrictions for emergency stops (Hazel *et al.* 2007). Turtles will not reliably avoid a vessel travelling at greater than 4 km h^{-1} (2.2 knots) (Hazel *et al.* 2007).

Artificial Light Spill

Lighting sources during construction of the DMSF will include work lights, safety lights, navigational lights and vessel lighting.

Turtle hatchlings use lighting cues when they hatch and move down the beach to the waters edge. Some forms of artificial lighting have been found to disorientate hatchlings and reduce their ability to access the sea following hatching. Altered underwater light conditions in inshore waters may also change the levels of predation upon turtle hatchlings, by attracting fish and other predators.

Artificial lighting may have the potential to disorientate certain marine bird species.

Turbidity and Sedimentation

Increased levels of turbidity during dredging can smother food sources and reduce the foraging range of marine turtles, reduce their navigational ability or cause disorientation by impairing vision.

Increased levels of suspended particulate matter can cause direct mortality via abrasion and clogging of the gills of fish. Indirect effects include reduced feeding rates, particularly where species use visual clues to forage, and behavioural changes (avoidance). Changes in the population of prey species may affect food availability. Suspended particulate matter may also cause impaired respiration and development or smothering of eggs (ANZECC 2000). The biological effects of increased turbidity depend upon the species of fish, the nature of the suspended particulate matter, the dissolved oxygen concentration, water temperature and natural turbidity levels.

An increase in the level of suspended particulate matter in the water column during dredging may cause direct smothering of organisms in the first instance via sedimentation (ANZECC 2000). Macroinvertebrates may also suffer stress or mortality through clogging of their feeding mechanisms, especially in filter-feeding organisms such as mussels, oysters and other bivalves (Erftemeijer *et al.* 2006). Other possible impacts include behavioural responses such as increased invertebrate drift (avoidance); altered habitats (for example, the pore spaces of the benthic substrate filling with sediment matter); and an influence on the decomposition and availability of detritus and therefore food availability (ANZECC 2000).

Physical Presence (Construction Workforce)

Potential impacts from recreational fishing by the construction workforce include entanglement in fishing lines or hooks of foraging adult and immature turtles. No impacts are predicted upon nesting females or hatchlings due to the physical distance between the Port and any nesting beaches.

Physical Presence (Reclamation Area and Jetty)

The reclamation area and the jetty structure will act as a diversion for megafauna feeding on the fringing reefs either side of the existing port. The physical structures will divert turtles and other megafauna offshore, increasing the potential for vessel collision and predation.

Marine turtles have been observed in the general area of the existing port, but the closest significant turtle nesting beach is 4km from the Port and therefore the physical presence of the proposed structures is not expected to impact upon turtle nesting or turtle hatchlings.

Impacts of the DMSF upon coastal processes and the erosion or accretion of the beach to the north of the site are expected to be minimal, as discussed in Section 9.5.

Hydrocarbon Spills

Hydrocarbons used during the construction and operation of the future DMSF will include heavy fuel oil, diesel and smaller amounts of oil and grease in construction equipment. The fate of a potential hydrocarbon spill is discussed in more detail in Section 9.14.

Seabirds and intertidal organisms are at risk from spills of heavy fuel oil. Mortality rates for seabirds can be high where populations are concentrated (for example, during bird migrations), and shorebirds feeding in intertidal habitats are at risk of sub-lethal effects from contaminated or reduced prey populations (NOAA 2006a). Intertidal organisms can be smothered by beached oil, and long-term sediment contamination is possible (NOAA 2006a). Heavy fuel oils are typically not very toxic to water column organisms compared to lighter oils (U.S. Fish and Wildlife Service 1998).

Diesel is considered to be one of the most toxic oils to water column organisms, and direct mortalities are possible for fish, invertebrates and seaweed in direct contact with a spill (NOAA 2006b). 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 (NOAA 2006b).

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 2006b). 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 2006b).

INDIRECT IMPACTS

Loss of Coral Habitat

The loss of the fringing reefs along the shoreline within the direct impact area from the construction of the jetty and reclamation area is not expected to reduce the feeding areas for turtles, as a regional survey (Appendix 11) has shown that the fringing reef habitats present within the Port are well-represented around the Dampier Archipelago.

Loss of Other Habitat

As discussed in Section 9.1.5, there are no impacts predicted upon seagrass in the area and therefore impacts upon the feeding habitat of dugongs are predicted to be negligible.

9.2.5 Management of Impacts

DIRECT IMPACTS

Seawall Construction

Immediately prior to the final closing of the bund wall, surveys (eg Helicopter, vessel, land based) will be undertaken to determine if any dolphins or dugongs are present inside the reclamation area. While turtles can relatively safely and easily be caught and remove, dolphins and dugongs are much more challenging. If these fauna are present inside the bund wall, the wall will not be closed.

Once the wall is closed, additional surveys will be undertaken to determine if any turtles are present. If so, DPA will work with the DEC and DoF to conduct a program to safely catch and remove them. It should be noted that the two DPA environmental staff worked on the Future Port Expansion project in Brisbane (2001-2004) and would have the most experience in this context in Australia. There, some 42 turtles were captured and removed without injury to the turtles or staff.

During any removal programs, option to integrate research (such as tagging and/or biological sampling) would be investigated. This was also successfully integrated in the Brisbane works

Vessel Collisions or Entrapment

The following management strategies will be implemented to reduce the impacts of vessel movement upon marine megafauna:

- Dredge to minimise off-bed suction time
- All turtles to be removed from reclamation area as soon as possible as indicated in the API. Further controls on vessels designed to reduce noise impacts as in Section 9.3; and
- Further operational controls on the dredge vessel and dredging related vessels as provided in the Dredging and Reclamation Management Plan (Appendix 2).

Light Spill

The following management strategies will reduce the impacts of light on megafauna:

- 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.

- 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.

Turbidity and Sedimentation

Management strategies for maintaining water quality during dredging and construction, as discussed in Section 8.1.6 and in the DRMP (Appendix 2).

Physical Presence (Construction Workforce)

DPA has controls upon the movements of workers within the existing Port and these controls will be maintained during construction and operation of the proposed DMSF, including:

- Prohibiting recreational fishing during construction;

- Conducting inductions about marine fauna in the area; and

- Restricting coastal access except under a permit to work.

Physical Presence (Reclamation Area and Jetty)

The proposed reclamation area and jetty will form a physical barrier to turtles and other megafauna swimming along the coast. However, given that there are no turtle nesting beaches within or close to the Dampier Port negligible impacts are predicted upon turtles. The wharf structure will be piled, and hence minimise interference. The structure protrudes from the coastline in a similar fashion to the Pluto and North West Shelf venture infrastructure to the east, and the BLB structure to the west.

Hydrocarbon Spills

Management of hydrocarbons is discussed in Section 9.14.5 (see Appendix 2 for additional management).

INDIRECT IMPACTS

Management strategies for minimising impacts upon benthic habitat, as discussed in Sections 1.1.1 and 9.1.6 and in the DRMP (Appendix 2).

9.2.6 Outcome

A summary of the key potential impacts to megafauna and the associated management measures, consequence, likelihood and residual risk for each impact is provided in Table 27.

Table 27: Summary of potential impacts to megafauna and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	**Likelihood**	**Residual Risk**
Entrapment of individuals within the enclosed seawall, prior to land reclamation.	Megafauna will be netted and removed by Marine Scientists with experience in fauna handling after the completion of the seawall and before the commencement of reclamation.	2	E	L-23 (Low)
Vessel collision or entrapment within dredging equipment.	Controls on ship movements; the use of a cutter section dredge rather than a trailing hopper suction dredge; and controls on dredging activities as in the DRMP (Appendix 2).	2	E	L-23 (Low)
Disorientation of marine turtles or seabirds as a result of artificial light spill.	Artificial lighting will be minimised as far as practicable and light sources chosen will be designed for minimal impacts upon turtles and seabirds. Are no turtle nesting beaches close.	2	D	L-21 (Low)
Impacts as a result of increased levels of turbidity and sedimentation.	Management strategies for water quality as described in Section 8.1.6, including the monitoring detailed in the DRMP (Appendix 2).	2	D	L-21 (Low)
Impacts upon marine turtles as a result of recreational fishing by the construction workforce.	Controls on the movements of the construction workforce, including a ban on recreational fishing.	2	E	L-23 (Low)
Impacts as a result of hydrocarbon spills.	Management of hydrocarbons as discussed in Section 9.14.5.	3	E	M-20 (Moderate)

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Indirect impacts via benthic habitat loss.	Management strategies for benthic habitat as discussed in Sections 1.1.1 and 0, including the application of the DRMP (Appendix 2).	2	E	L-23 (Low)

9.3 Underwater Noise

9.3.1 Overview

Construction activities including dredging, vessel movement and piling activities can generate potentially harmful noise in the marine environment. The impacts will depend on the level and type of noise, the ambient noise conditions and the kind of marine fauna present in the area. The section below discusses the potential impacts of vessel movement, dredging and piling operations upon marine mammals, turtles, fish and sharks.

9.3.2 EPA Objective

The EPA's Environmental Objective for noise only applies to noise receiving premises.

Underwater noise will be considered in context of the EPA Environmental Objective for fauna, which is to maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

9.3.3 Policy and Standards

Noise generated "*whether transmitted through air or any other physical medium*" is controlled under Section 3 of the *Environmental Protection Act 1986*, and the *Environmental Protection (Noise) Regulations 1997*. However, the *Environmental Protection (Noise) Regulations 1997* are not relevant to dredging operations or marine fauna.

9.3.4 Potential Impacts

Potential impacts from artificially increased underwater noise levels include:

- An increase in organism stress levels, potentially instigating stress related illness;
- Disruption or masking of acoustic social cues;
- Behavioural changes and/or avoidance behaviour;
- A temporary but reversible shift in hearing sensitivity (TTS);
- A permanent shift in hearing sensitivity (PTS);
- Physical damage to auditory systems, organs and tissue.

Impacts are likely to be worse if there is no previous experience of the sound type and if the sound is sudden and unanticipated by the receiving animal.

Ambient Noise

Ambient noise is the overall background noise from natural and human sources such that a specific source cannot readily be identified. Sources of underwater ambient noise include weather effects, tectonic activity, ocean wave interactions ('microseisms"), thermal agitation and distant shipping traffic. Broadband ambient noise levels range from 45-60 dB in quiet areas to 80-100 dB for typical conditions and 120 dB during high winds, rain or biological choruses (URS Australia 2008).

Shipping and Vessel Traffic Noise

Vessel speed and size are the primary factors influencing the amount of sound generated. The majority of noise from a ship is from the propeller (URS Australia 2008). Intense cavitation noise (where the propeller blade forms gas-filled cavities, which collapse in a turbulent stream or against the surface of the propeller) is directly related to ship speed, and typically occurs above 7-14 knots. Cavitation occurs at speeds outside the 7-10 knot range for tugs and dynamically-positioned drilling ships (URS Australia 2008). Sound levels for a range of ships are shown in Table 28.

Table 28: Sound levels from a range of marine vessels (URS Australia 2008)

Source	Peak frequency or band	Peak source level/s (re 1μPa 1m)
Large tankers and bulk carriers (10-11 knots)	10-30Hz	193 dB
Tug towing barge	1000-5000 Hz	145-171 dB
20m Fishing vessel	(broadband)	168 dB
Supply vessel	1-500 Hz	182 dB

Noise Emissions from Dredging Operations

Large cutter suction dredges can emit strong tones from the water pumps that are audible to 20-30km ranges. The sound frequency typically depends on the phase of the operation, but the strongest source levels for a clamshell dredge are centred at 250 Hz (URS Australia 2008).

Noise Emissions from Piling Operations

The intensity and frequency spectra generated by pile driving activities varies according to the equipment used, the hammer drop height (1-7 m), the use of a shock-absorber, the design of the pile, the driven depth and the type and density of the seabed strata (Vagle 2003).

Traditional pile hammers use a piston as a drop-weight, lifted by either a diesel ignition or hydraulic system. A study by McCauley et al (2002), using the drop-weight method, found that each pile driving event had peaks of sound between 100 Hz and 1 kHz, and individual signals fell by 20-30 dB between the initial drop and last bounces. Signal duration ranged 10-200 milliseconds, and signals averaged 167 dB at 300 m from the operation and fell to 145 dB and 136 dB at 1.8 and 4.6 km respectively (McCauley *et al.* 2002).

Vibratory pile hammers, which mitigate noise, are powered by hydraulic motors and designed so that horizontal vibrations cancel out and vertical vibrations are amplified and transmitted into the pile.

Impacts of Noise upon Marine Mammals

There is evidence that some mammal species may abandon former breeding or feeding areas if heavy vessel traffic increases local background noise levels (URS Australia 2008). For example, grey whales avoided a breeding lagoon in Baja California during a period of intense heavy vessel traffic until noise levels decreased (Gard 1974).

However, some marine mammals can adapt to elevated local noise. Baleen whales have been observed to produce more calls, louder calls, longer calls and/or shifting call frequencies in response to elevated background noise: and bottlenose dolphins can echolocate louder and change the frequencies of their whistles and clicks (URS Australia 2008). Marine mammals almost always require quiet areas for calving and pupping (URS Australia 2008).

The existing Dampier 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, a temporary decline in hearing sensitivity, can occur in marine mammals in the same way as for land mammals. Recent studies reveal that pulsed sounds of above 200 dB re 1 µPa 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).

Impacts of Noise upon Turtles

Onshore noise and vibration may influence various life stages of turtle hatchlings and nesting females, whereas offshore noise may disrupt turtles from foraging areas or beach selection.

Several species of turtle nest on the islands of the Archipelago (Prince 1993), although none have been recording nesting within the port limits (DPA 2007b). The nearest nesting site to the project area is Green Turtle site at the north-eastern tip of West Lewis Island (SKM 2006b). It is therefore unlikely that operations will disrupt turtle nesting.

Marine turtles are sensitive to low-frequency sound (100-700 Hz) (McCauley 1994). McCauley et al (2000) reported that at 166 dB (re 1 µPa rms), one green and one loggerhead turtle exhibited a noticeable increase in swimming behaviour, presumed to be an avoidance response. At 175 dB (re 1 µPa rms) their behaviour became increasingly erratic, presumed to be an alarm response.

Adult turtles were sighted foraging within the Port during field investigations by WorleyParsons (2009b).

Impacts of Noise upon Fish and Sharks

It is well known that fish will actively avoid certain sounds or leave an area of intense sound production (McCauley 1998). Commercial north Atlantic fish species that were studied for their response to vessel noise were found to swim downwards or horizontally away from the vessel's path (Olsen 1990). There are studies of sharks being either attracted or repulsed by specific types of noise (Myrberg *et al.* 1976; Myrberg *et al.* 1978).

Fish respond to stress with a series of hormonal-induced changes to prime them to deal with potential threats: this is a normal process, but chronic stress creates physiological problems like immune suppression (Mazeaud *et al.* 1977).

Loud noises can cause direct physiological effects ranging from a temporary but reversible shift in hearing sensitivity, a permanent shift in hearing sensitivity or in extreme cases, gross physical damage to an organism's auditory system, other organs or tissues. At the volumes generated by dredging, fish in the area could suffer acute damage within distances of 100 m if they do not leave the area via an avoidance response from softer start-up noise (URS Australia 2008).

McCauley (2000) reviewed and studied the effect of pulsed sounds upon fish and other marine species. It was found that rockfish exhibited subtle behavioural changes at 149 dB (re 1 mPa rms) and a significant alarm response at 168 dB (re 1 mPa rms). At levels of 171 dB (re 1 mPa rms) or higher, a rapid increase in hearing stimulus occurred, and startle responses were elicited by noise levels between 182-207 dB (re 1 mPa rms). However, various finfish exhibited no significant physiological stress increase at levels of between 146-195 dB (re 1 mPa rms).

Vagle (2003) found that changes in fish movements and density are observed only above piling impulses of 30 kPa, and that fatal swim-bladder injuries to fish were observed at 120-150 kPa.

9.3.5 Management of Impacts

The following management strategies will be utilized in order to mitigate noise impacts upon marine megafauna:

- Occupational health and safety (OHS) noise limits and the *Environmental Protection (Noise) Regulations 1997* shall be complied with as a minimum standard;
- Piling and dredging equipment used for construction will be chosen to generate the lowest practicable noise emissions, and piling foundations shall be pre-drilled where necessary to reduce the temporal extent of noise impacts;
- Soft start-up noise pulses will be generated to create an avoidance response and remove megafauna from the area before the commencement of piling and drilling activities;
- An "avoidance boundary" will be defined and piling and/or 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. Marine monitors will be present during piling and/or drilling activities to enforce this boundary;
- Noise mitigating equipment will be used wherever practicable such as mufflers, sound-isolation mounts, tuned propellers and drive shafts and propeller shrouds;

- 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; and

- 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.

9.3.6 Outcome

Dredging activities are likely to reach noise levels in excess of 150 dB with a range of frequencies centred on 250 Hz, and tones from the water pumps of the cutter section dredge may be audible at 20-30 km from the source. Piling activities may reach peaks of 167 dB close to the source, with peak noise frequencies between 100-1000 Hz. There will be no blasting activities.

A range of marine species could be impacted by potential noise events including marine mammals, fish and reptiles. Some masking of communication between marine mammals is possible and avoidance behaviour is likely during periods of intense noise such as during piling activities. However, peak frequencies and noise levels are unlikely to reach threshold levels that cause permanent or even temporary hearing loss. Individuals are mobile and are likely to avoid potentially harmful noise sources, particularly when soft start-up procedures are employed.

Shipping activities may contribute to underwater noise levels as shown in Table 28; however the proposed construction area is currently a working port and noise from construction vessels is not expected to significantly increase underwater noise levels above those already experienced by megafauna in the area.

A summary of the key potential impacts to megafauna as a result of underwater noise and the associated management measures, consequence, likelihood and residual risk for each impact is provided in Table 29.

Table 29: Summary of potential impacts to megafauna as a result of underwater noise and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts upon marine fauna as a result of underwater noise from vessel movements and the dredge vessel.	Controls on movements of vessels and the dredge vessel within the Port as administered by the DPA Harbour Master.	2	D	L-21 (Low)
Impacts upon marine fauna as a result of intense underwater noise from piling activities.	Soft start-up procedures, an “avoidance boundary” and the use of marine mammal observers during piling activities.	2	D	L-21 (Low)

9.4 Introduced Marine Organisms

9.4.1 Overview

Construction and operation activities generate a potential risk for the introduction of marine species from international or state waters.

9.4.2 EPA Objective

The EPA does not have a specific Environmental Objective for introduced marine organisms. The EPA Principles of Environmental Protection include a “precautionary principle” and “the principle of the conservation of biological diversity and ecological integrity”.

9.4.3 Policy and Standards

- International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation D-1 Ballast Water Exchange Standard and Regulation D-2 Ballast Water Performance Standard

- ANZECC Code Practice for Antifouling and In-water Hull Cleaning and Maintenance

9.4.4 Potential Impacts

Vessels used during the construction phase of the project may have mobilised from international or State Waters, and there is therefore the potential to introduce marine species from other localities.

Marine pests are often introduced either by release of ballast water in water adjacent to the proposed port, or from biofouling species that become attached to the hulls of vessels or released from wet spaces such as sea chests and internal plumbing systems.

9.4.5 Management Strategies

The following management strategies were developed in consultation with the Department of Fisheries to minimise the risk of introducing any marine organism during dredging and construction.

It is important to note that the management strategies for vessels moving to the Damper Port require that the cleaning/inspection of dredges, equipment and associated vessels be undertaken immediately prior to departure for the Port. This provides some allowance for a possible delay in travel time to the Port. The intention is that the vessel must be cleaned/inspected as close as logistically feasible to the proposed departure date (preferably within 1-2 days of departure), i.e. it must not spend any extended period in water where it has been cleaned/inspected and it must travel directly to the Port.

VESSELS FROM OUTSIDE STATE WATERS

Where a dredge, associated equipment and vessels are to be brought to the Dampier Port from outside of State Waters (i.e. either inter-state or international) the following should apply:

a) Immediately prior to the departure of the vessel for the Dampier Port , the owner/operator of the vessel, associated equipment and vessels, should undertake dry dock cleaning of all vessels and associated equipment, followed by an inspection carried out by an appropriately qualified marine scientist/appropriately qualified expert, accompanied by a Department of Fisheries Officer if required, to ensure that:

    - There is no sediment in the dredging equipment, and
    - Any biofouling organism on or in any vessels or associated equipment have been removed or treated.

b) Any remaining organisms, which cannot be removed or treated, must not present any social, environmental or economic risk to the Marine waters and marine environments (ie. Not on the CCIMPE trigger list) within and surrounding the Dampier Port.

c) Where a proponent is of the view that the dredge and associated equipment and vessels represent a low risk of introducing marine organisms, then an exemption can be requested from the DEC/the Minister for Environment on advice from the Department of Fisheries. The request should be based on a thorough environmental risk assessment supported by documentation demonstrating the record of hull cleaning, antifouling treatment, ship activity profile and location of each vessel since the most recent out of water hull cleaning, etc., as well as other relevant details.

VESSELS FROM WITHIN STATE WATERS

Where a dredge, associated equipment and vessels, originate from ports within State Waters, DPA shall provide evidence to DEC through Department of Fisheries of:

a) The vessel, associated equipment and vessels, being fully cleaned of biofouling organisms and sediments immediately prior to departure for the Dampier Port, followed by an inspection carried out by an appropriately qualified marine scientist/appropriately qualified expert/Department of Fisheries Officer. Noting that under the ANZECC Code Practice for Antifouling and In-water Hull Cleaning and Maintenance: "In-water hull cleaning is prohibited, except under extraordinary circumstances and permission will not normally be granted"; or

b) Inspection of the vessel, associated equipment and vessels, at the point of departure for the Dampier Port, carried out by an appropriately qualified marine scientist/appropriately qualified expert/Department of Fisheries Officer, immediately prior to departure to ensure that:

   - There is no sediment in the dredging equipment, and
   - Any biofouling organism on or in any vessels or associated equipment have been removed or treated.

c) In the event that inspection indicates that these requirements are not met, appropriate management of the vessels and associated equipment should be implemented. It is recommended that any sediment, biofouling organisms (or ballast water) found as a consequence of any inspection should be managed by the proponent to the satisfaction of DEC/the Minister for Environment on advice from the Department of Fisheries - this would allow for dialogue between the proponent, Department of Fisheries and DEC to ensure that optimal management/treatment can be considered and approved as appropriate; or

d) An appropriate risk assessment (supported by relevant documentation) of the dredge, associated equipment and vessels, to demonstrate, to the satisfaction of DEC/the Minister for Environment on advice from the Department of Fisheries, that the vessels and associated equipment present a low risk in terms of the introduction of non-indigenous marine organisms e.g. in sediment, as biofouling (or in ballast water).

9.4.6 Outcome

A summary of the key potential impacts of introduced marine organisms and the associated management measures, consequence, likelihood and residual risk is provided in Table 30.

Table 30: Summary of potential impacts of introduced marine organisms and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Introduction of marine organisms to the waters of the Dampier Archipelago as a result of vessels originating from National or International waters, and associated environmental impacts.	Regular dry-docking, cleaning, inspection and reporting to DoF immediately prior to departure for the Dampier Port.	3	D	M-17 (Moderate)

9.5 Disturbance to Coastal Processes

9.5.1 Overview

Land reclamation and dredging activities may have impacts upon the currents, tides and waves as result of changes in bathymetry and the physical presence of the new land-backed wharf. In particular, changes to these processes may cause increased erosion or deposition of the beach immediately north of the project site. They may also cause changes to the wave height at the existing Pluto berth north of the site. The following section aims to assess the impact of the proposal upon coastal processes.

9.5.2 EPA Objective

To maintain the integrity, ecological functions and environmental values of the seabed and coast.

9.5.3 Policy and Standards

Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives.

9.5.4 Potential Impacts

Beach Dynamics

An assessment of the changes to the beach dynamics to the immediate north of the site was conducted by APASA (2009). The full report is available in Appendix 13.

Two scenarios were developed to represent both the proposed construction layout and existing layout, and currents and waves were modelled for both scenarios, forced with the same environmental conditions over the same hindcast modelling period. Three-dimensional currents and tides were simulated using the ocean/coastal hydrodynamic model HYDROMAP, and the SWAN (Simulating WAves Nearshore) model was used to represent the wave-induced component of re-suspension. The modelling period used was from September 2008 to August 2009 and is expected to depict the potential change over a typical year.

The key findings were:

- The proposed development will have only a minor effect on the current and wave conditions at the beach to the immediate north of the DMSF site, with effect on tides negligible.

- The reclamation zone construction and dredging is expected to marginally alter the current and wave energy at the beach zone, with an expected reduction in the overall magnitude at the southern extents of the beach. This effect on the beach dynamics is highly localised, and impacts north of the beach are expected to be negligible.

WAVE REFLECTION

Wave reflection from the proposed land-backed wharf could increase wave height at the Pluto wharf north of the project site, potentially leading to unsafe berthing conditions for large vessels. Coastal Engineering Solutions (2009) undertook an assessment of wave reflection from the sheet-pile and rock revetments for the proposed DMSF, including impacts on the existing Pluto Wharf, DCW and BLB. The study concluded that:

- In the absence of a cyclone, incident swell waves were unlikely to exceed 1m;

- At the western and eastern ends of Pluto Wharf, reflected waves could increase the wave height to 1.048m and 1.039m respectively for incident swell waves of 1m;

- The total increase in wave height at the DCW as a result of the proposed DMSF will be negligible; and

- At the BLB, reflected waves could increase the wave height to 1.020m for incident swell waves of 1m.

These increases are not considered to cause significant adverse impacts to berthing at the Pluto Wharf, DCW or BLB.

CHANGES TOEXISTING APPROVED MIXING ZONES

A study undertaken by APASA (Appendix 19) show that the alterations to the current velocity field are highly localised to the immediate region surrounding the DMSF project site. Regions over 1 km from the extents of the proposed dredge zone and reclamation area show a negligible effect on the current speed and direction as a result of the construction. This supports the results indicated in Figure 2 and Figure 3 (Appendix 19), as each of the sites analysed are over 1 km from the extents of the DMSF project site.

9.5.5 Management of Impacts

The key findings of the above indicate that the project will have no impacts at a local (1km) or regional (10's km) scale. As such, no active management is required.

9.5.6 Outcome

The impact of the proposed development on the integrity, ecological functions and environmental values of the adjacent coast is expected to be negligible.

A summary of the key potential impacts of the proposed development on the integrity, ecological functions and environmental values of the adjacent coast and the associated management measures, consequence, likelihood and residual risk is provided in Table 31.

Table 31: Summary of potential impacts to coastal processes and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Long term impacts on the current and wave conditions at the beach to the immediate north of the site.	None required.	2	E	L-24 (Low)
Impacts on the safety of large vessels berthing at Pluto Wharf, DCW or BLB.	None required.	1	D	L-24 (Low)

9.6 Terrestrial Flora and Fauna

9.6.1 Overview

The majority of the area impacted by the direct footprint of the proposed DMSF is marine or intertidal where any vegetation present is classified as benthic habitat. The terrestrial area impacted by the proposed DMSF is small, comprising approximately 4.84 hectares.

9.6.2 EPA Objective

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.

9.6.3 Policy and Standards

Key EPA Position Statements and Guidelines relevant to terrestrial flora and fauna include:

- EPA Position Statement No 2: Environmental Protection of Native Vegetation in WA (2000)
- EPA Position Statement No 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (2002); and
- EPA Guidance Statement No 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (2004).

9.6.4 Potential Impacts

Terrestrial flora and fauna will be impacted during construction by the clearing of vegetation; earthworks; the construction of bund walls; vehicle movements and inundation with dredged material.

The potential impacts upon terrestrial flora and fauna are:

- Direct loss of flora and vegetation communities within the terrestrial footprint;
- Modification to and loss of fauna habitat;
- Introduction and spread of weeds;
- Injury and mortality of individual fauna; and
- Indirect disturbance effects to fauna from construction e.g. noise and dust.

Direct Impact upon Flora and Vegetation Communities

The proposed DMSF will result in the loss of 1.92 hectares of native vegetation along approximately 725 metres of coastline along the Burrup Peninsula. The development site is currently a seaward margin, and would not bisect or fragment existing habitats. A vegetation survey was conducted by Astron Environmental Services (2009), the results of which are summarised below:

- There are no Declared Rare Flora or EPBC flora as listed under State or Federal legislation within the proposed clearing area.
- Two priority species as listed on the Declared Rare and Priority Flora list occur on the site.
- Five additional species with conservation significance were also recorded.
- The Burrup Peninsula rock pile Priority Ecological Community is represented within the proposed clearing area.
- One vegetation association on the northern end of the direct impact area has high conservation significance has high conservation significance (Trudgen 2004) because this is the only representation on the Burrup Peninsula. It should be noted that the species individually are common, secure and widespread. It is only that occurrence of these species growing together which is unique.

More information on these species and their distributions is available in Appendix 5.

IMPACTS UPON TERRESTRIAL FAUNA

A number of terrestrial species potentially use these areas for habitat and foraging. However, given the small size of the terrestrial area impacted by the proposed DMSF, it is unlikely that the project will impact upon significant areas of their habitat or their conservation status. The terrestrial fauna species present within the area are discussed in Section 4.2.3, and the species with conservation significance are summarised below:

- The Pilbara olive python (*Liasis olivaceus barroni*), is currently listed under *Wildlife Conservation Act 1950* as 'fauna that is rare or likely to become extinct'. The species is believed to exist on the Peninsula in good numbers, with a broad distribution;
- One species of lizard, a member of the Pygopodidae family *Delma borea*, has been identified only on the Peninsula and surrounding offshore islands but has not been discovered on the mainland; and
- Two Camaenid Land Snails, *Rhagada sp* and *Quistrachia legendrei*, are known to occur in the study area. A comprensive review of known recordings in Western Australia and habitat preferences (Section 4.2.3) shows that there is a low risk of one of these Camaenid snails occuring within or near the project footprint.

9.6.5 Management of Impacts

The greatest impacts to terrestrial flora and fauna will result from vegetation clearing (1.92 hectares in total). The following management strategies will be employed to minimise further losses to the greatest practicable extent:

- Vegetation clearing will be the minimum necessary for safe and efficient construction. The boundary will be marked by temporary fences and/or flags prior to the commencement of clearing to avoid unnecessary impacts. Clearing activities will be monitored to ensure clearing occurs only within marked areas. Vehicles and machinery will operate only within the marked areas and designated access tracks;
- DPA will notify all personnel involved in clearing activities of any nearby protected flora or fauna and the conditions that apply to those areas. DPA will ensure all employees are competent and able to manage the risks around those areas;

9.6.6 Outcome

A summary of the key potential impacts of the proposed development on terrestrial flora and fauna and the associated management measures, consequence, likelihood and residual risk is provided in Table 32.

Table 32: Summary of potential impacts to terrestrial flora and fauna and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Direct impacts on terrestrial flora or fauna habitat outside the approved construction footprints.	Application of the management strategies described above, including marked clearing areas and monitoring to ensure no clearing outside approved areas.	3	D	M-17 (Moderate)

9.7 Surface Drainage

9.7.1 Overview

Drainage is potentially a significant environmental issue on the DMSF project because of the intensity of rainfall that can occur, its proximity to the marine environment and the high silt content of the local soils. Site drainage must be designed to manage stormwater runoff to minimise the risk of pollutant transport to avoid:

- Sediment discharge to the marine environment; and
- Contamination of the marine environment

Site drainage must be carefully considered and designed appropriately to also manage flooding of the site to minimise inundation of infrastructure.

9.7.2 EPA Objective

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

9.7.3 Policy and Standards

- State Water Quality Management Strategy (Government of Western Australia 2001)
- *A State Water Strategy for Western Australia* (Government of Western Australia 2003)
- *Stormwater Management Manual for Western Australia* (Department of Water 2007)

- *Water Quality Protection Note: Industrial Sites Near Sensitive Environments – Establishment and Operation* (DoE 2004)

9.7.4 Potential Impacts

Contaminant Handling

Stormwater runoff has potential to transport a wide range of contaminants that may be sourced at the site including sediment, hydrocarbons, chemicals, faecal matter, pathogens, nutrients (phosphorous, nitrogen), pesticides, herbicides, saline water, heavy metals, surfactants and organic matter. The stormwater drainage system may become exposed to these contaminants through spillages, inadequate bunding, containment fracture, unstabilized surfaces, accident and so forth.

Water directed off site must be of adequate quality to avoid adverse effects to the downstream marine environment.

Flooding

Drainage water generated from the site will be managed to mitigate the risk of inundation of infrastructure which may lead to damage, mobilisation of contaminants and risk to safety of site staff.

Erosion

Erosion and sedimentation are natural processes that can be accelerated by construction activities. Erosion is destructive to the environment including the soil structure, vegetation, flora, fauna and fauna habitat. Water containing sediment is particularly erosive and can accelerate consequent downstream erosion.

Water flows may cause erosion due to increased runoff volumes and velocities, particularly when runoff flows are re-directed to areas which previously did not receive concentrated run-off.

Sedimentation

Erosion in one part of a development catchment results in sedimentation further downstream. This may result in contamination of marine water bodies. Sedimentation can cause significant changes in surface flow regimes, impact on the water column in marine environment and increase risk of contaminant loading.

Storm runoff that is contaminated with sediments can be treated using detention storage and infiltration to remove sediments using the sedimentation process.

9.7.5 Management of Impacts

CONSTRUCTION PHASE

During construction, stormwater runoff will be directed into the reclamation paddock, and managed as per reclamation discharge (refer DRMP Appendix 2).

OPERATIONAL PHASE

CONTAMINANT HANDLING

In accordance with section 4.11 of the Development Guidelines (DPA 2009) proponents planning to develop in the DMSF will be required treat stormwater prior to discharge into the DMSF drainage system. Source control will be a key management tool in reducing contaminant loads in the run-off generated from the site.

FIRST FLUSH DESIGN

The first rainfall event is often contains the highest contaminant and sediment loads due to the mobilisation of accumulated sediment over the dry season.

The NSW Department of Environment and Climate Change document Stormwater First Flush Pollution (2008) suggests a 15 mm rainfall be used for a first flush on industrial sites. Western Australian guidelines adopt a first flush volume equivalent to the 1-hour duration 1-year average recurrence interval storm (Better Urban Water Management, Western Australian Planning Commission, 2008). For the Project site, this equates to 24 mm of rainfall across the catchment.

The stormwater design measures proposed in the DMSF will retain sediment in infiltration swales in the perimeter of the site thus reducing potential for off-site sediment discharge.

FLOODING

Design Issues

The project is located in a sub-tropical region subject to high intensity precipitation at any time of the year, but especially during the tropical cyclone season from December through March. Drainage management needs to focus on:

a) The high intensity of rainfall that occurs during cyclones results in high runoff flows;

b) The Burrup soils have high silt and clay fractions which readily wash out, making runoff deeply coloured and highly visible, particularly as a sediment plume in the adjacent ocean;

c) Entrained sediment in runoff is highly erosive and promotes gully erosion in friable soils and embankments;

d) Entrained sediment may have contaminants associated with it polluting the marine environment;

e) The Burrup Peninsula is an environmentally sensitive area which has caused Government to apply stringent environmental conditions.

It is therefore important that drainage issues are carefully considered and managed by the Project.

Rainfall Intensity

Historical records indicate rainfall on the Burrup Peninsula is highly variable. The rainfall records from Karratha Airport show annual totals varying from 53 mm to over 855 mm per annum. Methods consistent with Australian Rainfall and Runoff were used in the design of the site drainage system.

Design of Structures

Stormwater design will be completed in accordance with the Stormwater Management Manual for Western Australia (Department of Water and Swan River Trust, 2004 - 2007) incorporating water sensitive urban design to mitigate contaminant transport and maintain a predevelopment water regime.

The general drainage design philosophy is to accommodate stormwater runoff via a network of lined/ un-lined open channels. Appropriate detention structures will be incorporated for the removal of suspended silt prior to discharge into the ocean. Pipes/ culverts will be required at road crossings. The follow design components have been considered in the development of the drainage plan.

Recurrence Interval	10-year ARI peak discharge contained within open channels. 100-year peak discharge released to the ocean in a controlled fashion via sea walls or floodways. Building minimum floor level 300 mm above 100-year ARI peak flood level. Laydown areas 100 mm above 100-year ARI peak flood level.
Sea level	Design has been considered to the highest sea level to the highest astronomical tide plus storm surge corresponding to design ARI.
Channels	Channels generally gravel surfaced. Rock pitching in high velocity areas.

	Minimum slope = 0.1% (where sediment trapping required), 0.3% where free drainage required. Maximum flow velocity = 0.8 m/s. Channel side slopes: 1:4 (V:H) where overland flow/ inflow occurs, 1:2 (V:H) otherwise.
Over land flow	Minimum slope = 0.5%. Surface: hardstand, bitumen or concrete.
Culverts/Crossings (where required)	Minimum culvert size = 450 diameter RCP Class 3. Minimum pipe size = 300 diameter RCP Class 3.
Detention/Retention Basins	No peak flow attenuation or flow retention except as required for sedimentation. 10-year ARI for overtopping.
Pollutant interceptors	Sedimentation in swales with controlled outlet for events up to 10-year ARI. Maintenance required to remove silt buildup. Treatment/containment at source for workshops and other oily/potentially contaminated areas and for spills.

The conceptual drainage design is shown in Appendix 4, the development site is partitioned into 6 sub-catchment areas. The direction of overland flow is, all run-off generated is directed towards lineal infiltration swales around the perimeter of the site. These will be rock lined to reduce run-off velocity and promote the deposition of sediment. Typical cross-section showing the design is provided in (Appendix 4) showing rock lined drain with rock sump contained within geotextile fabric. Flows are controlled and retained within the swale up to a 10 year ARI design storm event at which time overflow is discharged via controlled outlet to the receiving environment.

The infiltration swale will be maintained to remove accumulated silt and sediment to maintain design performance.

Runoff generated from retained natural catchments outside the development site will be diverted and separated from site runoff. A diversion drain will collect runoff generated from the south east and discharged via a controlled outlet in the north of development site.

The Dampier Port Authority has prepared a set of Development Guidelines for all proponents planning a new development in the DPA management area. The Drainage and Stormwater Management criteria and standards are listed in section 4.11 of the Development Guidelines (DPA 2009). The onus on providing sufficient stormwater storage i is on the proponents planning future development (such as storage sheds or alike) in the DMSF.

EROSION

New earthwork areas, particularly batter slopes and drain side slopes, are prone to rilling and other types of erosion. Earthwork surfaces will be treated to minimise exposure of erodible materials.

Erosion can be minimised or prevented by:

a) avoiding flow concentration;

b) dispersing flows;

c) reducing flow volumes;

d) stabilizing surfaces;

e) reducing slopes and flow velocities; and

f) constructing control banks and ridges.

The surface within the development area is a mixture of compacted hardstand, bitumen and concrete, the slope is also moderate set at a minimum of 0.5%. These factors will reduce the likelihood of erosion occurring within the site. There is potential for the high volume and velocity to increase erosion where the runoff is concentrated in the infiltration swales. To mitigate this risk, the infiltration swales are rock lined to reduce the velocity and thus erosion along with providing greater stability of the bed material.

SEDIMENT MANAGEMENT

Sediment loading in runoff may occur due to soil disturbance and where practicable shall be treated at source to minimise sediment transport. Runoff shall be treated to reduce sediment load prior to discharge off site or to the environment. As discussed above, future developments within the DMSF (beyond the scope of this document) will be required to meet the stormwater and drainage criteria detailed in section 4.11 of the Development Guidelines (DPA 2009). This stipulates minimum stormwater management practices required to mitigate against export of sediment from within the development areas.

As discussed above, the conceptual drainage design (Appendix 4) will incorporate the use of infiltration swales that will collect over flow from within the development areas. Any sediment entering the infiltration swales will be deposited within the swale as the velocity slows and infiltration occurs.

The surface of the development area will consist of compacted hardstand, bitumen and concrete thus the mobilisation of sediment will be limited to the sediment that accumulates on the surface during the dry season.

9.7.6 Outcome

A summary of the key potential impacts of the proposed development on surface drainage and the associated management measures, consequence, likelihood and residual risk is provided in Table 33.

Table 33: Summary of potential impacts on surface drainage and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Contaminant discharge	At source control	3	C	H – 13 (Moderate)
Flooding	Within lot storage and appropriately design site drainage to convey flood flows	3	D	M-17 (Moderate)
Erosion	The surface consists of compacted hardstand, bitumen and concrete. Rock line infiltration swales	3	C	H – 13 (Moderate)
Sedimentation	At source control, infiltration swales to detain flow and deposit sediment prior to controlled discharge	3	D	M-17 (Moderate)

9.8 Terrestrial Noise

9.8.1 Overview

Noise emissions must comply with the *Environmental Protection (Noise) Regulations 1997*.

9.8.2 EPA Objective

To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.

9.8.3 Policy and Standards

- *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 2004)
- 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)
- AS 2436:1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites (Standards Australia 1981)
- The EPA Aspirational Goal for Hearson Cove (EPA 2002b)

9.8.4 Potential Impacts

A Noise Screening Assessment and additional explanatory memo was prepared for the proposed DMSF (WorleyParsons 2009d), which is included as Appendix 3. The results are summarised below:

- The proposal is set in an existing industrial complex, between two existing wharves and adjacent to the Pluto Gas Plant, a major industrial complex;
- The proposal is not considered to be “particularly sensitive within the community” as defined within EPA Guidance Statement 8 (EPA 2007);
- The closest noise sensitive site is the town of Dampier, located approximately 6km south of the site, and located on the far side of Rio Tinto’s Parker Point facility, a major industrial complex. There are no other noise sensitive premises within 10 km. The town of Dampier is the closest “sensitive land use” to the site and is well outside the separation distance for bulk material loading and unloading under EPA Guidance Statement No 3 (EPA 2004);
- The only noise receiving premises within 4 km of the site are neighbouring industries (none of which contain dwellings), and the closest site is approximately 1km from the proposed DMSF;
- Hearson Cove (a swimming and recreation beach with amenity value and significance to the EPA, but not considered a noise receiving premises under the *Environmental Protection (Noise) Regulations 1997*) is located 5 km east of the site;
- Increases in traffic noise during construction and operation of the proposed DMSF are expected to have negligible impacts upon noise receiving premises;
- No blasting will be required on land or in the marine environment during construction;

- Noise levels are not predicted to exceed the maximum allowable assigned noise level in the worst case during construction or typical operation, either for neighbouring industry sites or for the closest noise-sensitive receptor (the town of Dampier); and

- Noise levels may exceed the non-mandatory EPA Aspirational Objective for Hearson Cove (EPA 2002b) by approximately 6 dB(A) during piling operations, which will only be undertaken during the day and during certain periods of construction as described in the Noise Assessment (WorleyParsons 2009d).

9.8.5 Management of Impacts

For construction work carried out between 7am and 7pm on any day which is not a Sunday or public holiday:

- The construction work must be carried out in accordance with control of noise practices set out in section six of Australian Standard 2436-1981 “Guide to Noise Control on Construction, Maintenance and Demolition Sites”;

- The equipment used for the construction work must be the quietest reasonably available; and

- The CEO[3] may request that a noise management plan be submitted for the construction work at any time.

For construction work done outside the hours shown above:

- The work must be carried out in accordance with Section 6 of AS 2436-1981;

- The equipment used must be the quietest reasonably available;

- The proponent must advise all nearby occupants of the work to be done at least 24 hours before it commences;

- The proponent must show that it was reasonably necessary for the work to be done out of hours; and

[3] The CEO refers to the chief executive officer of the Department of Environmental Protection. As this power is delegated under these regulations to the chief executive officers of all local governments in the state, any references to the CEO also means the Town Clerk, Shire Clerk or City Manager of the local council, unless otherwise noted.

- The proponent must submit to the CEO a noise management plan at least seven days before the work starts, and the plan must be approved by the CEO. The noise management plan must include details of -
  - need for the work to be done out of hours
  - types of activity which could be noisy
  - predictions of noise levels
  - control measures for noise and vibration
  - monitoring of noise and vibration
  - complaint response

If the proponent failed to comply with these conditions, or with the approved noise management plan, the noise from the construction site would be treated the same as noise from any other premises and would need to meet the assigned levels.

Best practice management strategies will be implemented during operation, particularly activities requiring the use of heavy vehicles, including:

- The work will be carried out in accordance with control of noise practices set out in section six of Australian Standard 2436-1981 “Guide to Noise Control on Construction, Maintenance and Demolition Sites”; and
- The equipment used for the work will be the quietest reasonably available.

9.8.6 Outcome

Noise emissions from the proposed DMSF are expected to comply with the *Environmental Protection (Noise) Regulations 1997*) during construction and operation of the proposed DMSF, without the application of management strategies. Best practice management will be used to further minimise terrestrial noise during construction and operation.

A summary of the key potential impacts of the proposed development on terrestrial noise and the associated management measures, consequence, likelihood and residual risk is provided in Table 34.

Table 34: Summary of potential impacts due to terrestrial noise and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts upon "noise receiving premises" as a result of construction and operation activities.	Noise levels will comply with legal limits during construction and operation. Noise levels will be minimised to an extent reasonably practical.	2	D	L-21 (Low)

9.9 Traffic

9.9.1 Overview

The main access to the site is along Mof Road, Burrup/King Bay Road and the route along Burrup Road, Karratha – Dampier Road, Madigan Road, NW Coastal Highway.

Mof Road is a sealed road that travels from Dampier Port to King Bay Road (Figure 42). The road is not heavily used and the majority of the traffic is from staff and contractors accessing the existing Dampier Port Operations.

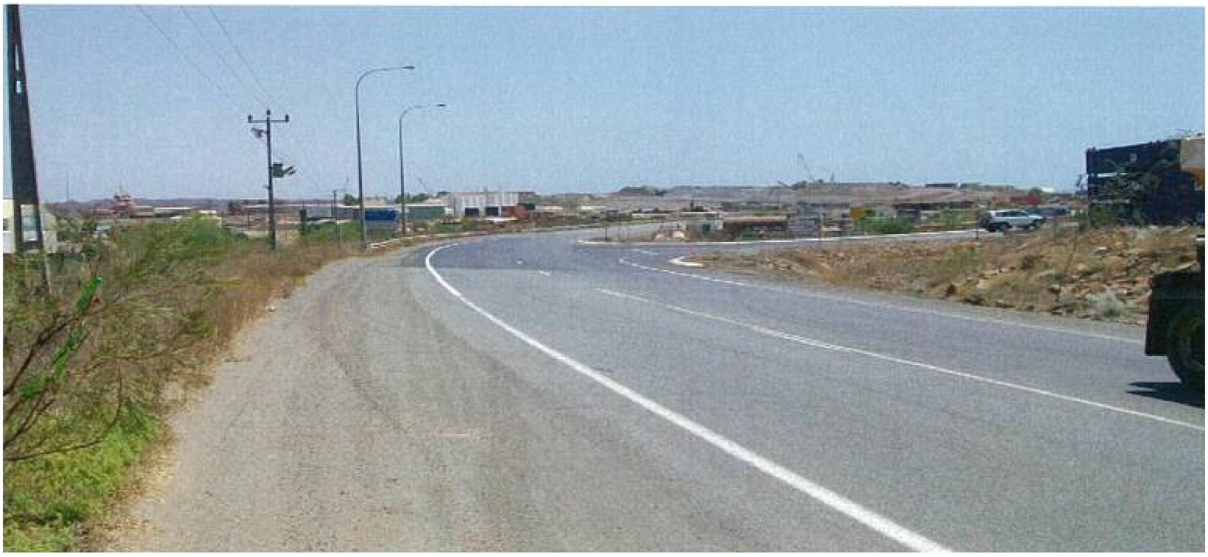

Figure 42 King Bay/Mof Road Intersection – view to west

9.9.2 Policy and Standards

- Road Traffic Act 1974
- Road Traffic Code 2000
- State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning (WAPC 2009a)

9.9.3 Potential Impacts

Based on the available traffic data (Appendix 16), most roads in the vicinity of the proposal have significant available capacity (daily) to accommodate additional traffic. However peak hour traffic volumes are high, particularly on Burrup Peninsula Road and Karratha — Dampier Road.

The following table (Table 35) summarises the ownership and responsibility of the roads likely to be impacted by the construction works traffic.

Table 35: Existing Local Road Network Characteristics

Location	Road Geometry	Road Classification	Responsibility
Mof Road	Single carriageway, 1 lane in each direction. Steep grade up from King Bay Road.	Local Distributor Industrial	Shire of Roebourne
King Bay Road	Single carriageway, 1 lane in each direction.	Local Distributor Industrial	Shire of Roebourne
Burrup Peninsula Road	Single carriageway, 1 lane in each direction.	State Road / Primary Distributor	Main Roads WA

The proposed works are likely to generate in the order of 153, 304 or 760 truck movements per day (two way) onto Mof Road depending on the source location of rock.

9.9.4 Management of Impacts

Management measures to limit impacts on traffic will include consultation and coordination with MRWA and the Shire of Roebourne on all activities that have potential to affect the local road network. In particular, road closures associated with the movement of any slow moving vehicles will take place outside peak traffic times for normal traffic. All relevant parties (Port users and industries on the Burrup Peninsula) will be notified of disruptions to normal traffic via the DPA Port Notices.

Other management measures that may be implemented include:

- Control using Traffic Management;
- Construct a truck staging/parking area on Burrup Rd (opposite the Hearson Cove intersection) and move vehicles up in convoy;
- Widen MOF Rd inside the Port;
- Widen MOF Rd outside of the Port; and
- Construct alternative access into the Port.

9.9.5 Outcome

A summary of the key potential impacts of the proposed development on traffic and the associated management measures, consequence, likelihood and residual risk is provided in Table 36

Table 36: Summary of potential impacts due to terrestrial noise and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts to the traffic flow of the area	Implementation of the management measures above, including traffic management and the construction of off-road parking	3	E	M-20 (Low)

9.10 Visual Amenity

9.10.1 Overview

Visual impact refers to changes in a view experienced by a person observing a landscape. A visual impact assessment compares the modification to a view resulting from a project with the visual sensitivity of the landscape. Visual sensitivity includes consideration of the nature and duration of a view. Figure 45 and Figure 46 show a photomontage prepared as part of the study.

9.10.2 EPA Objective

To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.

9.10.3 Policy and Standards

The standard most relevant to this assessment is the Guidelines for Landscape and Visual Impact Assessment (Wilson 2002) with some minor modifications to reflect the Australian context of the site.

9.10.4 Potential Impacts

A view of the existing facilities from offshore is shown in Figure 45 and a photomontage showing the proposed DMSF is shown in Figure 46. The visual flythrough (Appendix 18) shows the immediate adjacent terrestrial topography raises quickly within DPA lease limiting the publicly accessible terrestrial viewing points.

LANDSCAPE EVALUATION

A photomontage is most typically required for landscape evaluation of a proposed development in the context of its site. In this case, they have been created from an offshore location as it was perceived most traffic would be of a transient marine nature due to the topography (Figure 45 and Figure 46) of the DPA lease immediately behind the proposed reclamation area.

The photomontage is a very powerful visualisation tool. The photomontage is most easily read and therefore understood, in preference over the plans such as elevations etc. Also the photomontage can easily show the proposed colours, materials and landscape elements, combined with the comparison between existing and proposed photos. Note that there is no public access to the Port area or beach areas in King Bay. The nearest public access is Withnell Bay, some 4km to the NNE, and no direct line of site to the project.

The key elements of a photomontage are:

- Accuracy - There are no standardised techniques, and no scale is applicable, therefore some discrepancy and questioning of accuracy is very common.

- Colour - Colour accurate and photorealistic materials are important in the appearance and evaluation of the design.

- Shadows - The photomontage is modelled in true daylight conditions, no light modelling has been undertaken at this stage.

- Composition - The existing photo is masked (removed) and the proposed design inserted.

Photos of the infrastructure from immediately offshore (Figure 44) were merged and projected to create the photomontage (Figure 45). The original site photographs were then merged with the 3Ds Max renders in Adobe Photoshop (CS3). Areas obscured by terrain were masked from view and the colour of the render and photograph were adjusted to achieve a realistic match (Figure 46).

Maximum distance is a very important factor that has to be taken in consideration in a viewshed analysis, because the longer the distance the lower the visual impact that an object can bring to the landscape depending always on the size, form, texture, line and colour of it (Matos 2001). Visible distance has been calculated in nautical miles (nm) using the following equation (BHP 2006):

<u>Visible Distance (in nm) = 1.17 x the square root of the height (in feet)</u>

Therefore if we convert 6.5 m of infrastructure (approx reclamation height) height to feet (21 ft), we calculate that the port infrastructure could be viewed from 5.36 nm offshore (Figure 43). This is less than other nearby infrastructure (Figure 47).

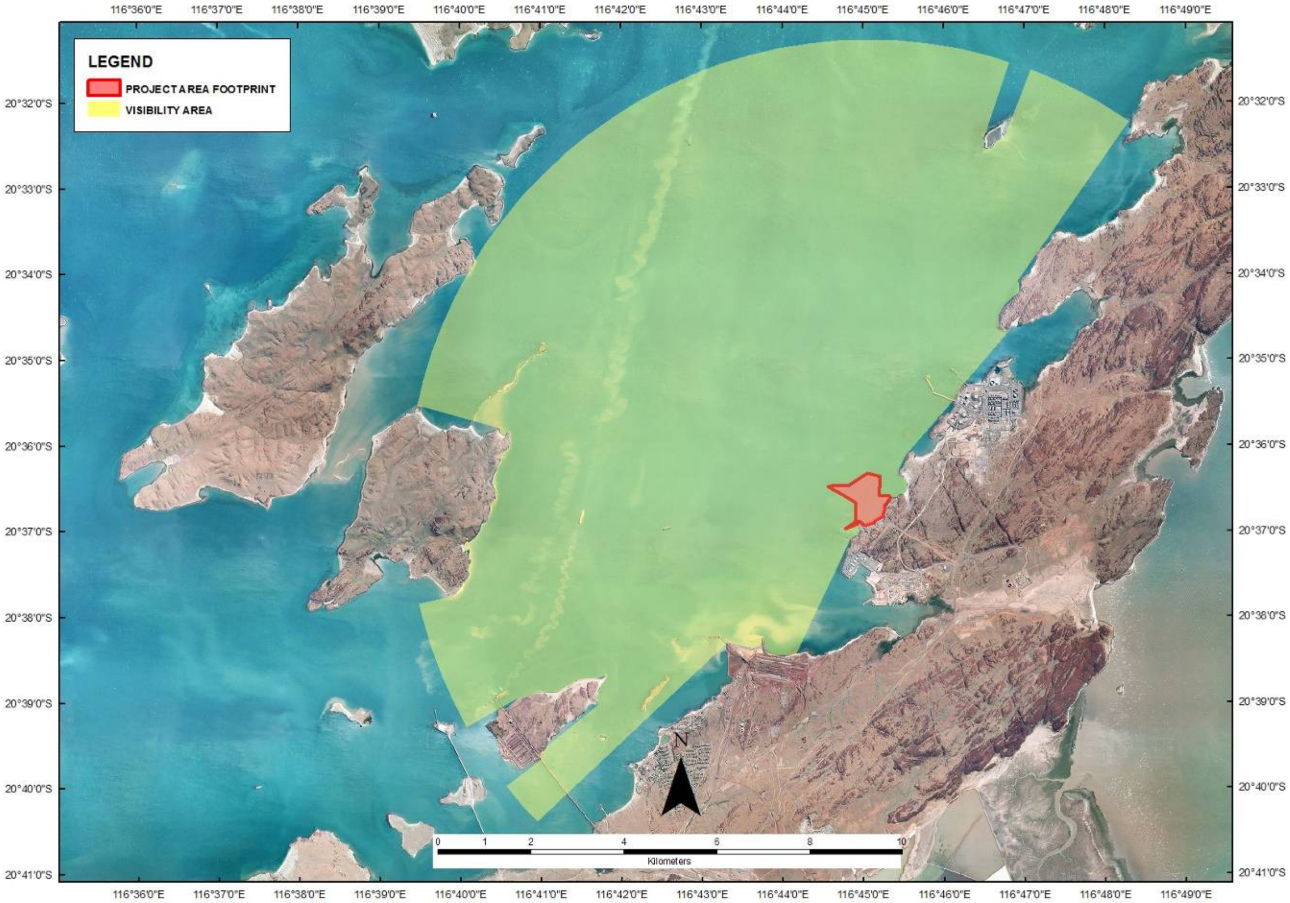

Figure 43: Viewable offshore distance of reclamation infrastructure

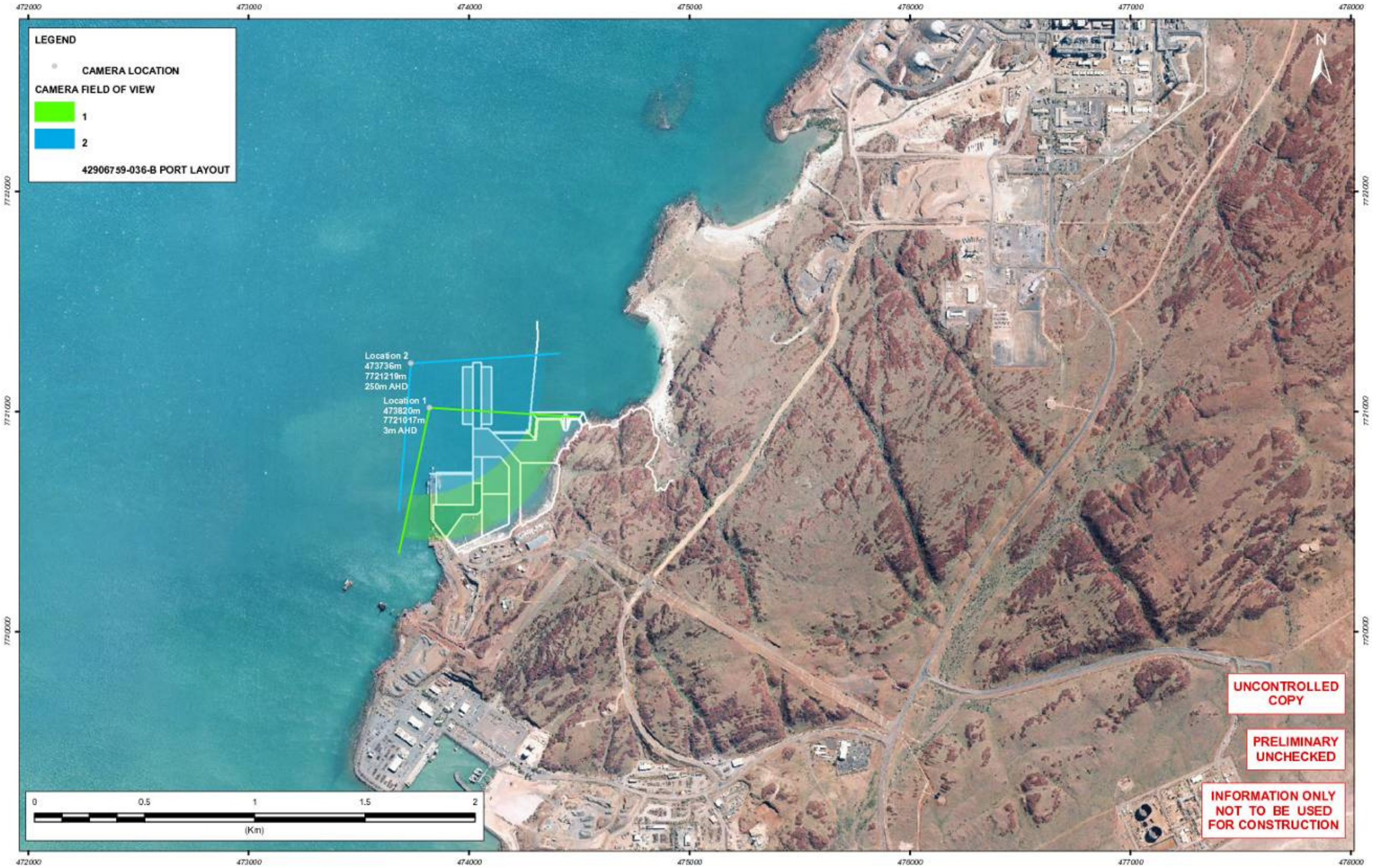

Figure 44: Visualisation camera locations

Figure 45: The existing view from sea, showing Woodside LNG gas plant facilities (left), DPA control tower (centre), existing DCW and two large vessels (right) and existing BLB (far right)

Figure 46: Photomontage of the view from sea after construction, showing Woodside LNG gas plant facilities (left rear), proposed DMSF jetty and land-backed wharf (left front), DPA control tower (centre), existing DCW and two large vessels (right) and existing BLB (far right)

9.10.5 Management of Impacts

Impacts on visual amenity associated with the proposed new port infrastructure are considered low. This is primarily due to the transient nature of boats in the area and the limited view from terrestrial locations. The potential visual impacts are likely to be limited to boats passing. The visual impact on these receptors will fit with current landuse (Figure 47a) and are consistent with existing operations in the Port (Figure 47b). Due to the limited identified impacts, no management is recommended.

Figure 47 a: Current operation activities at the Dampier Cargo Wharf and b: Woodside Pluto construction (400m east of the development) with NW Shelf Joint Venture in background

9.10.6 Outcome

A summary of the key potential impacts of the proposed development on visual amenity and the associated management measures, consequence, likelihood and residual risk is provided in Table 35.

Table 37: Summary of potential impacts to visual amenity and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts upon the visual amenity of the coastline as seen from offshore.	None required.	2	D	L-21 (Low)

9.11 Indigenous Heritage

9.11.1 Overview

The Burrup Peninsula is world renowned for its petroglyphic art. The Dampier Archipelago, which includes the Burrup Peninsula, has now been included in Australia's National Heritage List for its outstanding Aboriginal heritage value.

9.11.2 EPA Objective

The EPA Environmental Objective for heritage is ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

9.11.3 Policy and Standards

The major legislative documents applying to indigenous heritage in Western Australia are:

- Aboriginal Heritage Act 1972 (Western Australia)
- Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)[4]

State and Commonwealth legislative requirements are discussed in more detail in Appendix 12.

9.11.4 Potential Impacts

A preliminary investigation and verification survey was undertaken by Australian Cultural Heritage Management Pty Ltd (ACHM 2009). The full report is provided as Appendix 12. The results of the survey are summarised as follows:

- The preliminary investigation and site verification survey confirmed that Aboriginal sites are located within the DMSF area. The five archaeological sites verified as within the DMSF are 'Aboriginal sites' pursuant to the *Aboriginal Heritage Act 1972*. The sites cluster into five discrete areas along the coastline.

[4] It should be noted that DEWHA have advised that the referral of the project will not be a controlled action, and will be approved as a "Particular Manner" approval. The draft conditions supplied to DPA by DEWHA (21 Dec 2009) all relate to management of piling activities for marine fauna.

- All the Aboriginal sites on the northern headland are located above the required 8m height and will not be impacted.
- Aboriginal sites located on the cobble beach are sufficiently close to being above or below the 8m level, and therefore precise recording of these locations is warranted.

9.11.5 Management of Impacts

DPA will consult with the appropriate Aboriginal groups (Yaburara, Mardudhunera, Ngarluma, Wong-Goo-Tt-Oo and Yindjibarndi) regarding the development of the DMSF.

The DMSF is designed to avoid the Aboriginal sites verified as within the DMSF.

DPA adapt the existing Cultural Heritage Management Plan (as detailed in Appendix 12) and establish a dialogue with Aboriginal groups so a clear process is in place to manage any additional Aboriginal cultural material that should be located during the project.

If, during the designing of the DMSF, it becomes apparent is not possible to avoid these Aboriginal sites during the development of the DMSF, DPA submit an application under Section 18 of the Aboriginal Heritage Act 1972 to use the land proposed for the DMSF.

If consent to use the land under Section 18 is granted, the archaeological sites are salvaged by a qualified archaeologist and representatives of the Yaburara, Mardudhunera, Ngarluma, Wong-Goo-Tt-Oo and Yindjibarndi Aboriginal groups.

9.11.6 Outcome

There will be no impact upon indigenous heritage as a result of the proposed development.

9.12 Construction Dust

9.12.1 Overview

Construction activities may generate dust with the potential to impact on the health and welfare of nearby people and the surrounding environment. Site management strategies for the project, including dust suppression techniques, are able to minimise any potential impacts.

9.12.2 Objective

To ensure that emissions to air do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

9.12.3 Guidance

The following guidelines are relevant to air quality management:

- National Environmental Protection Goals as defined in the National Environment Protection (Ambient Air Quality) Measure (NEPM) (EPHC 2003);
- EPA Guidance Statement No 18 for the Prevention of Air Quality Impacts from Land Development Sites (Environmental Protection Authority 2000)

9.12.4 Potential Impacts

Dust emissions have the potential to impact on human health, visual amenity and the surrounding vegetation and fauna in addition to having a "nuisance value".

The following construction activities may generate dust emissions:

- Clearing and site levelling;
- Earthmoving;
- Vehicle movement on unsealed tracks; and
- Wind erosion from cleared areas of the terrestrial footprint; and
- Wind erosion from exposed areas of reclaimed land.

As the terrestrial footprint area of the project is small (4.84 hectares), the dust emissions from construction on land are not predicted to have a major impact upon human health, amenity or the natural environment.

Exposed areas of dredged sediment used for land reclamation will remain damp during reclamation and will be covered with an aggregate (e.g. gravel) or sealed with concrete after the area is compacted. Dust generation from this area is therefore expected to be minimal.

9.12.5 Management of Impacts

Standard construction dust management measures will be implemented through the duration of construction. Management strategies will include:

- Induction and training for all personnel on the need to reduce dust generation;

- Vegetation will be retained on land except where clearing is strictly required;
- Regular watering of unsealed roads, exposed surfaces and active construction areas;
- Alternate dust suppression methods where water is not available, including the chemical stabilisation of dust where required and where environmentally safe;
- Restricting vehicle speeds and minimising vehicular traffic as far as practicable;
- Reporting of community or neighbouring industry complaints regarding dust levels;
- Rehabilitating cleared areas no longer required for operations, future works, or right of ways;
- Daily monitoring of site conditions and the effectiveness of dust suppression; and
- Daily monitoring of weather and wind conditions.

9.12.6 Outcome

A summary of the key potential impacts of construction dust on air quality and the associated management measures, consequence, likelihood and residual risk is provided in Table 38.

Table 38: Summary of potential impacts of construction dust on air quality and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Excessive generation of dust during construction activities on land and from exposed land reclamation areas.	Personnel training, no excess clearing, dust suppression measures, restricting vehicle speeds, rehabilitation, monitoring and reporting.	1	C	L-22 (Low)

9.13 Waste Management (Solid and Liquid)

9.13.1 Overview

Construction and operation activities will generate solid and liquid wastes that have the potential to cause negative impacts upon the marine environment if not managed and disposed of correctly. Solid and liquid wastes may include packaging material, concrete, scrap metal, recyclable materials, general food packaging and scraps and domestic sewerage.

Refer to Sections 9.14 and 9.15 for the management of hydrocarbons and hazardous wastes. Appendix 2 – Dredging and Reclamation Management Plan provides additional management actions in relation to this environmental factor.

9.13.2 EPA Objective

The EPA's broad objectives for pollution are to ensure that land uses and activities that may emit or cause pollution are managed to maintain the physical and biological environment and the natural processes that support life, and the health, welfare and amenity of people and land uses; and to ensure that pollutants emitted are as low as reasonably practicable, and comply with all statutory requirements and acceptable standards.

9.13.3 Policy and Standards

- Environmental Protection (Controlled Waste) Regulations 2004 (WA)
- MARPOL 73/78, Annex IV: Prevention of pollution by sewage from ships
- MARPOL 73/78, Annex V: Prevention of pollution by garbage from ships
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972
- International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation D-1 Ballast Water Exchange Standard
- International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation D-2 Ballast Water Performance Standard

9.13.4 Potential Impacts

Although no discharge of waste to the marine environment within the 12 nm limit is to take place, the potential exists for accidental discharges of small quantities of solid or liquid wastes to the marine environment. Accidental discharges from vessels (not including hydrocarbons) could include:

- Deck drainage, which may comprise primarily rain water and washdown water, but may include small amounts of waste material;
- Potentially contaminated drainage, including drainage from machinery spaces and bilges;
- Engine cooling water; and

- Untreated sewage. Marpol Annex IV allows discharge or treated sewage.

The accidental discharge of waste material (without appropriate dilution or treatment) to the marine environment may:

- Impede the growth or cause mortality to BPP and fauna due to toxicity;
- Contaminate marine food sources; and
- Result in additional nutrients and pathogens in the water column (potentially leading to algal blooms or toxicity); and
- Cause death or injury of megafauna if ingested or entangled.

Solid wastes that may be generated during construction include plastics, materials packaging, scrap metal, containers, wood, and food waste.

9.13.5 Management of Impacts

Waste will be managed by DPA in a similar manner to existing Port operations, including the following strategies:

- Waste management requirements shall be communicated to personnel (i.e. through inductions, pre-starts and/or JHA's).
- Communition systems on vessels shall be capable of handling the volumes generated and maintained regularly so they efficient and fully operational at all times.
- 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 (MSDSs) for each substance carried.
- Controlled wastes shall be managed as per the Environmental Protection (Controlled Waste) Regulations 2004 (WA).
- Liquid wastes shall be stored in labelled drums, containers or tanks.
- 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 IMO Annex IV.

9.13.6 Outcome

A summary of the key potential impacts of the proposed development on waste generation and the associated management measures, consequence, likelihood and residual risk is provided in Table 39.

Table 39: Summary of potential impacts on waste generation and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts to the surrounding environment, the health and amenity of the area, local community and construction workforce as a result of incorrect management or disposal of solid and liquid wastes.	Implementation of the management measures above, including the segregation of waste types, recycling, workforce awareness and reporting. No wastes will be disposed of into the Port and no wastes will be disposed of into the marine environment unless approved.	2	E	L-23 (Low)

9.14 Hydrocarbons

9.14.1 Overview

Diesel fuel, oil and grease are regularly handled during dredging and reclamation operations. Potential sources of diesel include construction barges, construction support vessels and the dredge vessel. Heavy fuel oil will be used as fuel for bulk carrier vessels entering the Port during construction and operation. Consequently, also insert the following as a next sentence “There is no Heavy Fuel Oil bunkering available in the Port of Dampier however. Accidental spills have the potential to occur during accidents, collisions and refuelling.

Other hydrocarbons with the potential to be accidentally discharged during construction include droplets of grease, used lubricating oils and waste oil or hydraulic fluid, particularly from burst seals. The introduction of droplets of grease can occur through the activity of larger vessels such as tugs. Use of hydraulic equipment related to construction, drilling and piling also presents the risk of hydraulic fluid entering the marine environment, particularly in the event of burst seals.

Hydrocarbon spills can impact upon water quality, mangroves, fauna, recreational and aesthetic values. Heavy fuel oil spills can also impact upon benthic organisms.

The following section summarises the potential impacts, the associated management strategies and the residual risk to the environment from hydrocarbon spills.

9.14.2 EPA Objective

The EPA's broad objectives for pollution are to ensure that land uses and activities that may emit or cause pollution are managed to maintain the physical and biological environment and the natural processes that support life, and the health, welfare and amenity of people and land uses; and to ensure that pollutants emitted are as low as reasonably practicable, and comply with all statutory requirements and acceptable standards.

9.14.3 Policy and Standards

- Environmental Protection (Controlled Waste) Regulations 2004 (WA)
- Annex I: Prevention of pollution by oil, MARPOL 73/78
- International Convention on Oil Pollution Preparedness, Response and Co-operation 1990

9.14.4 Potential Impacts

HEAVY FUEL OIL

Heavy fuel oils (HFO) are not very volatile, and a spill typically spreads into thick, dark slicks, although the most viscous oils will break up into discrete patches. The oil can move hundreds of kilometres in the form of scattered "tarballs", varying in diameter from several meters to a few centimetres, by winds and currents (NOAA 2006a). These "tarballs" can be difficult to track or predict. HFO has a similar specific gravity to water and can sink, float or suspend in the water column depending on small changes in water density (NOAA 2006a). It could also adsorb to sand particles in the water column and sink (U.S. Fish and Wildlife Service 1998).

Emulsification (where water combines with the hydrocarbon and forms a stable mixture) can slow the degradation of the spill (U.S. Fish and Wildlife Service 1998), although this usually only occurs slowly and after a number of days (NOAA 2006a).

Beached oil tends to remain on the surface, forming a "bathtub ring" at the high-tide line or pools on the beach, rather than penetrate sediments (NOAA 2006a).

DIESEL

Diesel is a "light oil" and small spills of 2-20 kL 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. Diesel will not sink or accumulate on the seafloor, except as a result of adsorption to sediment, but is considered to be one of the most toxic oils to water-column organisms and fish kills are possible if large spills occur in non-readily mixing water.

Light oils contain moderate concentrations of soluble toxic compounds, and can leave a film or layer in the intertidal zone with the potential to cause long-term contamination (U.S. Fish and Wildlife Service 1998). Crabs and shellfish bioaccumulate oil but will also depurate it after several weeks of exposure (NOAA 2006b).

A very effective clean-up is possible for spills of light oil such as diesel (U.S. Fish and Wildlife Service 1998). 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 2006b). Complete degradation by naturally occurring microbes takes one to two months (NOAA 2006b).

OIL SPILL DISPERSION MODELLING

Oil spill dispersion modelling was conducted by APASA (2009) to assess the exposure risk of an accidental hydrocarbon release at the port. The full report is provided as Appendix 13.

The trajectory, dispersion and weathering of four oil spill scenarios were modelled, including a summer and winter simulation of both a 50,000 litre heavy fuel oil spill off the face of the wharf and 2,500 litre diesel fuel spill from alongside the wharf. A variety of thresholds were employed when examining the surface oil, shore stranded oil and entrained oil exposure with each set at conservative levels based on their documented environmental impacts.

The findings from the oil spill modelling were (APASA 2009);

- Weathering analysis of heavy fuel oil indicated only a 10% reduction in its mass would occur over a period of 5 days, whilst 40% of the diesel fuels mass will evaporate over the first two days of exposure.

- The heavy fuel oil would likely drift north-east against the Burrup Peninsula toward Angel Sound during summer and west toward East and West Lewis Islands during winter.

- Probabilities of surface oil thicknesses harmful to seabirds in excess of 40% were restricted to 5-6 km in a northeast direction from the spill site during summer and 3-4 km directly offshore during winter.

- The model predicts that the heavy oil will contact the shoreline somewhere within Mermaid Sound, with an 83% probability that this will occur to the immediate north of the release site during summer and 57% probability of contact to the eastern shoreline of East Lewis Island during winter.
- Simulations indicated there would be no build up of entrained heavy fuel oil underneath slicks.
- There were no slicks predicted to reach levels detrimental to seabirds for the diesel fuel spill, with exceedances of lower thresholds only moderate even in exposed areas.
- Prevailing winds during summer again moved the diesel slicks northeast along the Burrup Peninsula, with winter characterised by offshore movement as with the heavy fuel oil scenarios.
- During winter, shoreline exposure to the Burrup Peninsula near the release site has a probability of 60%, with a 30% probability of shoreline exposure for East Lewis Island.
- The highest probability of entrained diesel concentrations being above 1 ppb is predicted to be lower than 40%, relevant only for the waters in close vicinity of the release site and in Withnell Bay during summer.
- During winter, the predicted probability of entrained diesel concentrations above 1 ppb was below 20%.

9.14.5 Management of Impacts

The Dampier Port Authority is the First Strike Oil Spill organisation for Coral Bay to Balla Balla, including Dampier Port Waters. The DPA has developed a comprehensive Oil Spill Management Plan in accordance with this responsibility. The DPA has an large stockpile of oil spill response equipment in addition to being the North West AMSA stockpile custodian. The DPA has experienced and trained staff, and can draw on the experience and trained staff within stakeholder organisations, and the stockpiles of response equipment they hold if required.

A contingency Oil Spill Management Plan has been developed previously and is being implemented by the Dampier Port Authority, and this document is presented as Appendix 14 of this report. This document will be updated to incorporate this project.

9.14.6 Outcome

A summary of the key potential impacts of hydrocarbon spills and the associated management measures, consequence, likelihood and residual risk is provided in Table 40.

Table 40: Summary of potential impacts of hydrocarbon spills and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts to marine water quality, mangroves, fauna, recreation and aesthetic values as a result of spills and leaks of hydrocarbons.	Implementation of the Oil Spill Management Plan (Appendix 14).	3	E	M-20 (Moderate)

9.15 Hazardous Wastes

9.15.1 Overview

Construction activities may require the use of hazardous materials requiring specific management. The following section summarises the potential impacts upon the environment, the associated management strategies and the residual risk to the environment.

9.15.2 EPA Objective

The EPA's broad objectives for pollution are to ensure that land uses and activities that may emit or cause pollution are managed to maintain the physical and biological environment and the natural processes that support life, and the health, welfare and amenity of people and land uses; and to ensure that pollutants emitted are as low as reasonably practicable, and comply with all statutory requirements and acceptable standards.

9.15.3 Policy and Standards

- Environmental Protection (Controlled Waste) Regulations 2004 (WA)
- International Maritime Dangerous Goods Code (IMDG Code)
- MARPOL 73/78 Annex II *Regulations for the control of pollution by noxious liquid substances in bulk*
- MARPOL 73/78 Annex III *Prevention of pollution by harmful substances in packaged form*
- International Convention for the Safety of Life at Sea (SOLAS) Chapter VII *Carriage of dangerous goods*
- International Bulk Chemical Code (IBC Code)

- The Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol)
- International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances (HNS) by Sea (HNS Convention)
- The International Convention on the Control of Harmful Anti-fouling Systems on Ships

9.15.4 Potential Impacts

The accidental discharge of hazardous waste material (without appropriate dilution or treatment) to the marine environment may:

- Impede the growth or cause mortality to BPP and fauna due to toxicity;
- Contaminate marine food sources; and
- Result in additional nutrients and pathogens in the water column (potentially leading to algal blooms or toxicity).

9.15.5 Management of Impacts

- No residues containing noxious substances will be discharged within 12 miles of the nearest land, in compliance with MARPOL 73/78 Annex II.
- Vessels of 24 metres 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.
- Hazardous substances handling is to be carried out by suitably trained personnel only.
- 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).
- Incompatible products will not be stored together.
- Industry standards, port authority and pollution prevention regulations shall be adhered to during handling of hazardous materials (e.g. bunding, level gauges, overflow protection, drainage systems and hardstands).
- Volumes of stored chemicals will be limited.
- Hazardous materials (including hazardous waste) shall be stored in appropriately labelled drums or tanks.

- On-site spill clean up kits shall be provided. All personnel on the Marine Facilities will be familiar with the use of the clean up kit and dispose of waste in the prescribed manner.
- Installed 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.
- Empty liquid waste containers shall be segregated from other wastes and stored in designated, secure areas where the containers cannot fall overboard.
- 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.
- 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.

9.15.6 Outcome

A summary of the key potential impacts of hazardous wastes and the associated management measures, consequence, likelihood and residual risk is provided in Table 41.

Table 41: Summary of potential impacts of hazardous wastes and the associated management measures, consequence, likelihood and residual risk

Potential Impact	Management	Risk Assessment		
		Consequence	Likelihood	Residual Risk
Impacts to marine water quality, mangroves, fauna, recreation and aesthetic values as a result of spills and leaks of hazardous chemicals.	Implementation of the management procedures above, including appropriate storage and handling and clean-up procedures.	3	E	M-20 (Moderate)

10. PROPONENT'S ENVIRONMENTAL MANAGEMENT COMMITMENTS

DPA is committed to achieving or exceeding a level of environmental management performance consistent with national and international standards and statutory obligations. The proposed construction and operation program will be conducted in a manner that will minimise impacts on the surrounding environment. Accordingly, environment management strategies and commitments have been nominated throughout this document and its appendices and are summarised in Table 42 and Table 43.

10.1 Proponent Responsibilities

DPA takes a responsible and pro-active response to the environmental management of its activities. To this end its environmental responsibilities with respect to the dredging program will include:

a) Obtaining relevant approvals and permits to undertake the works;

b) Advising Marine Facilities Construction Contractors of significant environmental issues;

c) Appointing and managing suitably qualified Marine Facilities Construction Contractors;

d) Ensuring Marine Facilities Construction Contractors meet the obligations outlined in the Dredge and Reclamation Management Plan; and

e) Undertaking monitoring and reporting on the effects of dredging and reclamation on significant environmental issues.

10.2 Marine Facilities Construction Contractor Responsibilities

The environmental management responsibilities of the appointed Marine Facilities Construction Contractor relate to the specific dredging/reclamation works and include:

a) Complying with the relevant legislation, regulations and approval conditions;

b) Complying with the requirements of the Dredge and Reclamation Spoil Disposal Management Plan;

c) Compliance with DPA requirements, including Marine Pollution Plan, Cyclone Policy, Emergency Plan, etc;

d) Undertaking monitoring and other environmental management activities as specified;

e) Ensuring an Environmental Officer is engaged throughout the project;

f) Ensuring dredging equipment is in good condition and properly maintained for the duration of the works;

g) Taking all reasonable measures to protect the environment in and around the site and mitigate and/or protect the environment against impacts of the Works resulting from contaminants, turbidity plumes and reduced water quality; storage and handling of hydrocarbons and chemicals; waste and sewage disposal; and noise; and

h) Disposal off site of all rubbish, debris, scrap metals and redundant gear and the like, including implementation of a recycling program to minimise disposal to land fill.

In the event of any non-compliance with the approved Management Plans or breach of legislative requirements in respect of the environment the Contractor is obliged to report the type and extent of such non-conformance. The Contract allows for suspension of dredging operations until any and all deficiencies are addressed and corrected by the Contractor.

Table 42 Dampier Port Authority management commitments

Commitment No.	Section	Topic	Action	Objective	Timing	Advice
1.	8.1.6 of API	Dredging and reclamation management of impacts	Implementation of Dredge and Reclamation Management Plan	To reduce and manage environmental impacts caused by dredging and reclamation	Planning through to post dredging	EPA
2.	5.3.1 of DRMP (Appendix 2)	Marine water quality monitoring	Implementation of Water Quality Monitoring Program	To identify links between water quality and coral health	During dredging	EPA
3.	5.3.2 of DRMP (Appendix 2)	Marine water quality monitoring	Collection of water samples for total suspended solids (TSS) analysis and turbidity monitoring	To establish correlations between TSS and NTU	During dredging	EPA
4.	5.4.1 + 5.4.3 of DRMP (Appendix 2)	Coral monitoring	Implement coral health monitoring program	To ensure coral losses are within the areas predicted	Pre, during and post dredging	EPA
5.	5.5 of DRMP (Appendix 2)	Onshore reclamation monitoring	Implementation of Onshore Reclamation Management Monitoring	To ensure compliance with water quality objectives	During reclamation	EPA

Commitment No.	Section	Topic	Action	Objective	Timing	Advice
6.	5.6 of DRMP (Appendix 2)	Surface sediment profiling	Implementation of Surface Sediment Monitoring Program:	Assess the changes in surface sediment profiles due to dredging activities	Pre and post dredging	EPA
7.	9.2.5 of API	Megafauna management	Capture and relocation of megafauna from reclamation area	Avoid unnecessary loss of megafauna	Pre reclamation	EPA
8.	9.3.5 of API	Underwater noise management	Comply with OSH noise limits and Enviro. Protection (Noise) Regulations 1997	To ensure minimum impact upon marine megafauna from underwater noise	During construction	EPA
9.	9.4.5 of API	Introduced Marine Organisms	Comply with AQIS (Australian Quarantine Inspection Service) requirements, State and Federal legislation and particular provisions presented in the API document for dredges.	Ensure no marine organisms are introduced into the marine environment from vessels travelling to the port from interstate or international waters	Throughout construction and operation	Dep. of Fisheries, EPA
10.	9.6.5 of API	Flora and fauna management	Notify all personnel involved in clearing activities of the protected flora and fauna in the area	Minimise loss of protected flora and fauna in the area	Pre construction	EPA

Commitment No.	Section	Topic	Action	Objective	Timing	Advice
11.	9.6.5 of API	Flora and fauna management	Vegetation clearing will be the minimum necessary for safe and efficient construction.	Minimise loss of flora and fauna in the area	Pre construction	EPA
			Clearance boundary to be clearly marked	Minimise loss of flora and fauna in the area	Pre construction	EPA
			Vehicles and machinery to operate only within designated areas and tracks	Minimise loss of flora and fauna in the area	Pre construction	EPA
12.	9.6.5 of API	Weed Management	Weed management strategies	Ensure area is maintained as weed free	Construction	EPA
13.	9.6.5 of API	Terrestrial fauna management	Vehicle speed restrictions will be enforced within construction areas and approach roads to avoid injury and/or mortality of fauna	Minimise loss or injury to local fauna	Construction	EPA

Table 43 Marine Facilities Construction Contractor Commitments

Commitment No.	Section	Topic	Action	Timing	Advice
1	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Installation of a satellite-based vessel monitoring system on the dredge, allowing track plot analysis to ensure maximum efficiency of the dredging effort and that no dredging outside the required area occurs.	Ongoing During Construction	DPA
2	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Use of suitable dredging plant and equipment to minimise turbidity	Ongoing During Construction	DPA
3	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Maintaining calibration of the hydrographic survey systems onboard the dredge:	Ongoing During Construction	DPA
4	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Use of submerged dredge pumps on the CSD (Cutter Suction Dredge)	Ongoing During Construction	DPA
5	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Monitoring of weather and sea conditions	Ongoing During Construction	DPA
6	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Maximise the residence time in the reclamation area to reduce the turbidity plume of decant (return) waters.	Ongoing During Construction	DPA
7	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Stop dewatering or move tail water within reclamation cells when turbidity is excessive.	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
8	6.1.1 of DRMP (Appendix 2)	Turbidity and sedimentation during dredging	Install management measures to control decant water associated with reclamation:	Ongoing During Construction	DPA
9	6.2.2 of DRMP (Appendix 2)	Marine fauna management	Visual observations for whales, marine turtles, dugongs and dolphins must be undertaken to the extent of the exclusion zone for at least 15 minutes before the commencement of piling activities.	Ongoing During Construction	DPA
10	6.2.2 of DRMP (Appendix 2)	Marine fauna management	Dredge within nominated approved footprint.	Ongoing During Construction	DPA
11	6.2.2 of DRMP (Appendix 2)	Marine fauna management	All work-site personnel shall be inducted regarding the proper response to fauna interaction (including unexpected encounters).	Ongoing During Construction	DPA
12	6.2.2 of DRMP (Appendix 2)	Marine fauna management	During piling visual observations of the *exclusion zone* must be maintained continuously to identify if there are any *whales*, marine turtles, dugongs or dolphins present.	Ongoing During Construction	DPA
13	6.2.2 of DRMP (Appendix 2)	Marine fauna management	Soft 'fairy taps' start procedures: As far as practical, piling activities must be initiated at the soft 'fairy taps' start level and then build up to full impact force. The soft 'fairy taps' start procedures may only commence if no whales, marine turtles, dugongs or dolphins have been sighted within the exclusion zone during the pre-start-up visual observations.	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
14	6.2.2 of DRMP (Appendix 2)	Marine fauna management	During periods of low visibility (where a distance out to 2 kilometres cannot be clearly viewed), including night-time, pile driving activities may be undertaken provided conditions are met (see DRMP)	Ongoing During Construction	DPA
15	6.2.2 of DRMP (Appendix 2)	Marine fauna management	All turtles to be removed from reclamation area as soon as possible as indicated in the API.	Ongoing During Construction	DPA
16	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Hazardous substances handling is to be carried out by suitably trained personnel only.	Ongoing During Construction	DPA
17	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	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) in accordance with Australian Standards and Industry Guidelines.	Ongoing During Construction	DPA
18	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Incompatible products will not be stored together. Refer to MSDS sheets for appropriate storage information.	Ongoing During Construction	DPA
19	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Tanks and machinery shall be equipped with measurement and overflow protection (i.e. flow and level meters, relief valves, overflow protection valves and emergency shutoff).	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
20	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Industry standards, port authority and pollution prevention regulations shall be adhered	Ongoing During Construction	DPA
21	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Volumes of stored fuels and chemicals will be limited to day-use. No bulk fuel storage on-site. Use of appropriately licensed mini-tankers for refuelling.	Ongoing During Construction	DPA
22	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Hazardous materials (including hazardous waste) shall be stored in appropriately labelled drums or tanks.	Ongoing During Construction	DPA
23	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	The Marine Facilities Construction Contractor is to provide on-site spill clean up kits. All personnel on the Marine Facilities will be familiar with the use of the clean up kit and dispose of waste in the prescribed manner.	Ongoing During Construction	DPA
24	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Installed 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.	Ongoing During Construction	DPA
25	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Establish comprehensive vessel/ship refuelling procedures to avoid or reduce the possibility of a release.	Ongoing During Construction	DPA
26	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Controlled wastes shall be managed as per the Environmental Protection (Controlled Waste) Regulations 2004 (WA).	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
27	6.3.1 of DRMP (Appendix 2)	Hydrocarbons management and other chemicals	Empty liquid waste containers shall be segregated from other wastes and stored in designated, secure areas where the containers cannot fall overboard.	Ongoing During Construction	DPA
28	6.4.2 of DRMP (Appendix 2)	Direct marine habitat disturbance	The Marine Facilities Construction Contractor is to have an adequate understanding of the location and extent of those sensitive marine areas and areas of conservation significance that could potentially be impacted by the operation of vessels and equipment or where anchoring is required	Ongoing During Construction	DPA
29	6.4.2 of DRMP (Appendix 2)	Direct marine habitat disturbance	The location of moorings and large anchors outside the direct DMSF footprint and/or existing channels/swing basins shall only be approved in consultation with the DPA.	Ongoing During Construction	DPA
30	6.4.2 of DRMP (Appendix 2)	Direct marine habitat disturbance	Designated anchoring sites shall be used by vessels to reduce impacts on benthic fauna.	Ongoing During Construction	DPA
31	6.4.2 of DRMP (Appendix 2)	Direct marine habitat disturbance	All equipment onboard vessels shall be stowed securely to prevent solid objects from falling overboard.	Ongoing During Construction	DPA
32	6.4.2 of DRMP (Appendix 2)	Direct marine habitat disturbance	Construction of Marine Facilities will be guided by survey controls and construction design requirements.	Ongoing During Construction	DPA
33	6.5.2 of DRMP (Appendix 2)	Waste management	Waste management requirements shall be communicated to personnel (i.e. through inductions, pre-starts and/or JHA's).	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
34	6.5.2 of DRMP (Appendix 2)	Waste management	Communition systems on vessels shall be capable of handling the volumes generated and maintained regularly so they efficient and fully operational at all times.	Ongoing During Construction	DPA
35	6.5.2 of DRMP (Appendix 2)	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 (MSDSs) for each substance carried.	Ongoing During Construction	DPA
36	6.5.2 of DRMP (Appendix 2)	Waste management	Controlled wastes shall be managed as per the Environmental Protection (Controlled Waste) Regulations 2004 (WA).	Ongoing During Construction	DPA
37	6.5.2 of DRMP (Appendix 2)	Waste management	Liquid wastes shall be stored in labelled drums, containers or tanks.	Ongoing During Construction	DPA
38	6.5.2 of DRMP (Appendix 2)	Waste management	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 IMO Annex IV.	Ongoing During Construction	DPA
39	9.3.5 and 9.8.5 of API; Section 6.6 of DRMP	noise management	Ensure that all plant is maintained in operating order in accordance with industry best practice.	Ongoing During Construction	DPA
40	9.3.5 and 9.8.5 of API; Section 6.6 of DRMP	noise management	Ensure that all equipment meets equipment noise specifications and put in place action plan if requirements are not met.	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
41	9.3.5 and 9.8.5 of API; Section 6.6 of DRMP	noise management	Maintain and operate all equipment on board the dredge in a safe and efficient manner.	Ongoing During Construction	DPA
42	9.3.5 and 9.8.5 of API; Section 6.6 of DRMP	noise management	Switch off all equipment when not in use.	Ongoing During Construction	DPA
43	6.7.2 of DRMP (Appendix 2)	Air quality	Plant and equipment used during the works are maintained to comply with the relevant exhaust emission guidelines.	Ongoing During Construction	DPA
44	9.4.5 of API and 6.8 of DRMP	Introduced marine organisms	Comply with AQIS (Australian Quarantine Inspection Service) requirements, State and Federal legislation and particular provisions presented in the API document for dredges.	Ongoing During Construction	DPA
45	6.10.1 in DRMP (Appendix 2)	Artificial light spill	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.	Ongoing During Construction	DPA
46	6.10.1 in DRMP (Appendix 2)	Artificial light spill	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.	Ongoing During Construction	DPA
47	6.10.1 in DRMP (Appendix 2)	Artificial light spill	Only necessary artificial lights shall be used. ‘Unnecessary lighting’ includes lighting in unused areas, decorative lighting or lighting that is brighter than needed.	Ongoing During Construction	DPA

Commitment No.	Section	Topic	Action	Timing	Advice
48	6.11.2 in DRMP (Appendix 2)	Site access, safety and security	Safety Plan to be developed prior to construction works.	Ongoing During Construction	DPA
49	6.11.2 in DRMP (Appendix 2)	Site access, safety and security	DPA to issues a Marine Notice establishing an exclusion Zone around works area.	Ongoing During Construction	DPA
50	6.11.2 in DRMP (Appendix 2)	Site access, safety and security	Enforce and maintain an exclusion zone around dredge and construction vessels while in operation.	Ongoing During Construction	DPA
51	6.11.2 in DRMP (Appendix 2)	Site access, safety and security	Compliance with Safety Plan.	Ongoing During Construction	DPA
52	6.11.2 in DRMP (Appendix 2)	Site access, safety and security	All site staff engaged in work to undergo inductions which include site specific environmental issues.	Ongoing During Construction	DPA
53	6.12.2 in DRMP (Appendix 2)	Staff Environmental Training	Ensure that appropriate environmental induction and training is given to all personnel including crew, sub contractors, consultants etc that are involved in the Marine Facilities construction. Environmental training will include as a minimum instruction on the requirements of this DRMP and where personnel may access details of this DRMP	Ongoing During Construction	DPA

11. CONCLUSIONS

The proposed development of the Dampier Marine Services Facility to increase its throughput capacity and operational efficiency has been designed, and will be undertaken in a manner that will minimise impacts on the surrounding biophysical and social environments.

The proposal as described in this document has been developed to avoid, minimise, manage and mitigate environmental impacts. Some decisions made early in the project planning stage which significantly reduce both environmental and social impacts are as follows:

- A balanced cut and fill project making use of "spoil" as a resource and avoiding sea disposal
- Design iterations avoiding known limestone geology to avoid 'rock flour' and blasting impacts
- careful design in seeing the consolidation of port infrastructure, rather than the diffuse spread of development.
- Previous EIAs in the Archipelago have focussed on BPPH.

DPA decisions identified above have considered a proactive approach in managing the impact to an acceptable level.

This document describes the impacts of the proposal, and for each factor has discussed:

- The EPA objective for that factor;
- The potential impact;
- The management of impacts; and
- The outcome.

The following environmental factors were considered:

- Marine water quality
- Marine habitat disturbance (corals)
- Marine habitat disturbance (non-corals);

- Megafauna;
- Underwater noise;
- Introduced marine organisms;
- Disturbance to coastal processes;
- Terrestrial flora and fauna;
- Surface drainage;
- Terrestrial noise;
- Traffic;
- Visual amenity;
- Indigenous heritage;
- Construction dust;
- Waste management (solid and liquid);
- Hydrocarbons; and
- Hazardous wastes.

In addition, DPA has developed a dredging and reclamation management plan to specifically address environmental impacts associated with the key factors. Concurrently to this project, DPA has committed to developing a whole of port Marine Management Plan for all of DPA Port Waters. This would be a Multi User Marine Plan, detailing spoil grounds, marine park management and provide consistency to monitoring. This approach was endorsed by the DEC Marine Science Division who are now providing strategic advice into development of this Plan.

In the event that the Minister for the Environment considers the project to be environmentally acceptable, relevant management plans will be amended to incorporate any conditions of approval or additional project commitments.

For all factors assessed, and with implementation of the proposed management and mitigation measures, the EPA objectives can be met and environmental impacts will be minimised to ALARP.

12. ABBREVIATIONS

Acronym	Definition
ACHM	Australian Cultural Heritage Management Pty Ltd
ANZECC	Australian and New Zealand Environment and Conservation Council
API	Assesement on Proponent Information
AQIS	Australian Quarantine Inspection Service
ARI	Assessment on Referral Information
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid Sulphate Soil
AVS	Acid Volatile Sulphur
BFPL	Burrup Fertilisers Pty Ltd
BLB	Bulk Loading Berth
BOD	Biological Oxygen Demand
BPP	Benthic Primary Producer
BPPH	Benthic Primary Producer Habitat
BTEX	benzene, toluene, ethylbenzene, and xylene
CALM	Conservation And Land Management
CAMBA	China Australia Migratory Bird Agreement
COD	Chemical Oxygen Demand

Acronym	Definition
COPRI	Coasts, Oceans, Ports, and Rivers Institute
DCA	Dampier Community Association
DCW	Dampier Cargo Wharf
DEC	Department of Environment and Conservation
DEWHA	Department of Environment, Water, Heritage and Arts
DIA	Department for Indigenous Affairs
DMSF	Dampier Marine Services Facility
DOM	Dissolved Organic Matter
DPA	Dampier Port Authority
DRMP	Dredge and Reclamation Management Plan
DSMF	Dampier Marine Services Facility
DWT	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EPA	Environmental Protection Authority
EPASU	Environmental Protection Authority & Services Unit
EPBC	Environmental Protection and Biodiversity Conservation
EPHC	Environment Protection and Heritage Council
GSWA	Geological Survey of Western Australia
HFO	Heavy Fuel Oils

Acronym	Definition
HLO	Heavy Lift Out
HNS	Hazardous and Noxious Substances
IBC	International Bulk Chemical
IMDG	International Maritime Dangerous Goods
IMP	Introduced Marine Pests
IMS	Information Management System
JAMBA	Japan-Australia Migratory Bird Agreement
LAT	Lowest Astronomical Tide
MBS	Microphytobenthos
MEB	Marine Environmental Branch
MMA	Mermaid Marine Australia
MOF	Material Offloading Facility
MRWA	Main Roads Western Australia
NAGD	National Assessment Guidelines for Dredging
NEPM	National Environmental Protection Council
NIMPCG	National Introduced Marine Pest Coordinating Group
NODGDM	National Ocean Disposal Guidelines for Dredged Material
NWSV	North West Shelf Venture
OHS	Occupational Health and Safety
PAH	Polycyclic Aromatic Hydrocarbons

Acronym	**Definition**
POM	Particulate Organic Matter
PQL	Practical Quantitation Limits
PSI	Preliminary Site Investigation
PTS	Permanent Shift in Hearing Sensitivity
SAP	Sediment Analysis Plan
SOLAS	Safety of Life at Sea
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
SSC	Suspended Sediment Concentration
SWAN	Simulating WAves Nearshore
TTA	Total Titratable Acidity
TBT	Tributyltin
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift

13. REFERENCES

AME (2006). Port Phillip Bay Channel Deepening Project, Supplementary Environmental Effects Statement - Marine Ecology Specialist Studies Volume 2: Microphytobenthos, Report 351. Australian Marine Ecology. Kensington, Victoria.

Amerson, A. B. and P. C. Shelton (1976). "The natural history of Johnstone Atoll, central Pacific Ocean." Atoll Res. Bulletin **192**: 479.

ANZECC (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 2 - Aquatic Ecosystems. Australian and New Zealand Environment and Conservation Council, New South Wales.

ANZECC/ARMCANZ (2000). Water Quality and Monitoring Guidelines. National Water Quality Management Strategy.

APASA (2009). Dampier Port Authority: Marine Environmental Modelling.

Asia-Pacific Applied Science Associates (2009). Dampier Port Authority: Marine Environmental Modelling.

Astron Environmental Services (2009). Dampier Port Authority Project Margins Vegetation and Flora Survey 5th August 2009. Prepared for Dampier Port Authority.

Australian Cultural Heritage Management (2009). Aboriginal Heritage Preliminary Investigation - Dampier Port Authority, Dampier Marine Services Facility.

Australian Hydrographic Service (2008). "Australian National Tide Tables." http://www.hydro.gov.au/.

Australian Interaction Consultants. (2004). Report of an Archaeological Survey of Lots 471 and 475, Burrup Peninsula, Western Australia. Prepared for Worley Astron.

Ayling, A. M. and A. L. Ayling (2006). The dynamics of Cairns and Central Section Fringing Reefs. Unpublished report submitted to the Great Barrier Reef Marine Park Authority.

Bak R. (1978). "Lethal and sublethal effects of dredging on coral reefs." Marine Pollution Bulletin **9**: 14-16.

Baker, C., A. Potter, et al. (2008). Sedimentology and Geomorphology of the North West Marine Region of Australia. Geoscience Australia. Canberra.

Beardall, J. and B. Light (1994). Biomass, productivity and nutrient requirements of Microphytobenthos. C. P. P. B. E. S. Technical Report No.16. Canberra.

Beardall, J. and B. Light (1997). Microphytobenthos in Port Phillip Bay: distribution and primary productivity. Technical Report No.30,. CSIRO Port Phillip Bay Environmental Study. Canberra.

Berkelmans, R. and J. K. Oliver (1999). "Large-scale bleaching of corals on the Great Barrier Reef." Coral Reefs **18**: 55-60.

Bertolino, C. (2006). Seagrasses of the Port of Dampier: Distribution, Abundance, and Morphology. School of Plant Biology, The University of Western Australia **Honours:** 99.

BHP (2006). Cabrillo Port Liquefied Natural Gas Deepwater Port - Revised Draft EIR.

BHPBIO (2008). Environmental Referral Document: Port Hedland Finucane Island Dredging, October 2008.

BHPBIO (2009). Environmental Referral Document - Nelson Point Dredging, RGP6 Port Development, Port Hedland. Assessment on Referred Information.

Blackwell, M. I., M. E. Trudgen, et al. (1979). Vegetation and Floristics of the Burrup Peninsula. North West Shelf Development Project. Perth, Woodside Petroleum Development Pty. Ltd.

Blakeway, D. R. (2005). Patterns of mortality from natural and anthropogenic influences in Dampier corals: 2004 cyclone and dredging impacts. Corals of the Dampier Harbour: Their Survival and Reproduction During the Dredging Programs of 2004. Stoddart J.A. and Stoddart S.E. Perth Western Australia, MScience Pty Ltd**:** 65–76.

Blakeway, D. R. and B. Radford (2005). Scleractinian Corals of the Dampier Port and inner Mermaid Sound: species list, community composition and distributional data. Corals of the Dampier Harbour: Their Survival and Reproduction During the Dredging Programs of 2004. Stoddart. J.A and Stoddart. S.E. Perth Western Australia, MScience Pty Ltd**:** 1–12.

Brown, B. A., M. D. A. Le Tissier, et al. (1990). "Evaluation of the environmental impact of dredging on intertidal coral reeds at Ko Phuket, Thailand, using ecological and physiological parameters." Marine Ecology Progress Series **665**: 273-281.

CALM (2005). Indicative Management plan for the proposed Dampier Archipelago Marine Park and Cape Preston Marine Management area., CALM.

CEE (2007). Channel Deepening Project: Supplementary Environmental Effects Statement - Overview Impact Assessment on Sessile Soft Seabed Communities. Appendix 49.

Coastal Engineering Solutions Pty Ltd (2009). Dampier Cyclone Waves – Revised Layout URS Job No 42906759: Drawing No 028 Rev B.

Coffey Environments Pty Ltd (2008). Factual report, nearshore geotechnical investigation, Dampier Cargo Berth Expansion Project.

Cogger, H. G. (1979). Reptiles and Amphibians of Australia. Sydney, NSW, A.H. & A.W. Reed.

Commonwealth of Australia (2009). National Assessment Guidelines for Dredging. W. Department of the Environment, Heritage and the Arts. Canberra.

Cortés, J. and M. J. Risk (1985). "A reef under saltation stress: Cahuita, Costa Rica." Bulletin of Marine Science **66**(2): 339-356.

DEC (2003). "Contaminated Sites Management Series: Assessment Levels for Soil, Sediment and Water."

DEC (2006a). Background quality of the marine sediments of the Pilbara coast. Marine Technical Report Series 1.

DEC (2006b). Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives

DEC (2006c). Proposed Burrup Peninsula Conservation Reserve – Draft Management Plan 2006-2016., Department of Environment and Conservation.

Dennison, W. (1987). "Effects of light on seagrass photosynthesis, growth and depth distribution." Aquatic Botany **27**: 15-26.

Department of Environment (2006). Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives. Western Australia.

Department of Environment and Conservation (2006). Contaminated Sites Management Series - Community Consultation Guideline. Land and Water Quality Branch.

Department of Local Government and Regional Development (2006). Pilbara - Economic Perspective. Western Australia.

Department of Resource Development (1989). Review of the Dampier Port Land Use Planning.

Department of Water (2007). Stormwater Management Manual for Western Australia.

Dix, G. R. (1989). "High-energy, inner shelf carbonate facies along a tide-dominated non-rimmed margin, northwestern Australia. ." Marine Geology **89**(3-4): 347-362.

Dodge. R. E, Aller. R, et al. (1974). "Coral growth related to resuspension of bottom sediments." Nature **247**: 574–577.

DoE (2004). Water Quality Protection Note: Industrial Sites Near Sensitive Environments – Establishment and Operation.

DoE (2006). Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives. Western Australia.

DPA (2005). Port Development Plan 2004 (Planned Development 2004-2025). Dampier, WA.

DPA (2007a). Dredging & Spoil Management Plan.

DPA (2007b). Marine Management Plan. Dampier, WA, Dampier Port Authority.

DPA (2008). "http://www.dpa.wa.gov.au/Ecological.asp." accessed 5th May 2008.

DPA (2009). Development Guidelines

Duarte. C.M. (1991). "Seagrass depth limits." Aquatic Botany **40**: 363-377.

EA (2002). National Ocean Disposal Guidelines for Dredged Material. Canberra, ACT, Environment Australia.

Environment Protection and Heritage Council (2003). National Environment Protection (Ambient Air Quality) Measure. Canberra, Attorney-General's Department.

Environmental Protection Authority (2000). Guidance Statement 18: Prevention of air quality impacts from land development sites. Guidance Statements. Perth, WA, Environment Protection Authority.

Environmental Protection Authority (2001). Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act, 1986). Guidance Statement for protection of tropical arid zone mangroves along the Pilbara coastline No. 1.

Environmental Protection Authority (2002a). Environmental protection Act 1986 - Environmental Impact Assessment (Part IV Division I) Administrative Procedures.

Environmental Protection Authority (2002b). Methanol Complex, Burrup Peninsula - Report and recommendations of the Environmental Protection Authority.

Environmental Protection Authority (2003). Dampier Port Authority – Port Expansion and Dredging Program. Report and recommendations of the Environmental Protection Authority Bulletin 1116. Perth, Western Australia, EPA.

Environmental Protection Authority (2004). Guidance Statement 3: Separation Distances between Industrial and Sensitive Land Uses. Perth, WA, Environmental Protection Authority.

Environmental Protection Authority (2007). Guidance Statement 8: Environmental Noise (Draft). Guidance Statements. Perth, WA, Environment Protection Authority.

EPA (2002). Bulletin 1065: Ammonia-Urea Plant, Burrup Peninsula, Dampier Nitrogen Pty Ltd, Report and recommendations of the Environmental Protection Authority, Government of Western Australia

EPA (2009). Environmental Assessment Guideline 3: Protection of Benthic Primary Producer Haitats in Western Australia's Marine Environment. Perth, WA, Environmental Protection Authority.

Erftemeijer, P. and R. Robin Lewis III (2006). "Environmental impacts of dredging on seagrasses: A review." Marine Pollution Bulletin **52**: 1553-1572.

Evans and Peck (2007). "Dampier Port, General Cargo Wharf, Business Case."

FMG (2008). PORT FACILITY UPGRADE- ANDERSON POINT, PORT HEDLAND - Dredging and wharf construction-third berth.

Forde, M. J. (1985). Technical report on suspended matter in Mermaid Sound, Dampier Archipelago. . Department of Conservation and Environment. Perth, Western Australia.

Gard, R. (1974). "Aerial census of gray whales in Baja California lagoons, 1970 and 1973, with notes on behavior, mortality and conservation." California Fish and Game **60**: 132-143.

Geological Survey of Western Australia (2008). Published 1:250,000 and 1:100,000 scale geological maps, GSWA Record 2006/15.

GHD (2008). Report for Port of Hay Point Bed Leveling Environmental Monitoring Program: Post Bed-Leveling Coral Report. Unpublished report for Ports Corporation of Queensland**:** 35 pp.

GHD (2009a). Dampier Port Authority - Report for New Dampier Marine Services Facilities - Stage 1 - Preliminary Concept Design Review.

GHD (2009b). Dampier Port Authority - Report for New Dampier Marine Services Facility - Traffic Study.

Gilmour, J. P. (1999). "Experimental investigation into the effects of suspended sediment on fertilization, larval survival and settlement in scleractinian coral." Marine Biology **135** (3): 451-462

Government of Western Australia (2001). STATE WATER QUALITY MANAGEMENT STRATEGY - NO 1 - Framework for implementation.

Government of Western Australia (2003). Securing our water future : a state water strategy for Western Australia.

Griffith, J. K. (2004). Scleractinian corals collected during 1998 from the Dampier Archipelago, Western Australia. Report on the Results of the Western Australian Museum/Woodside Energy Ltd. Partnership to explore the Marine Biodiversity of the Dampier Archipelago

Western Australia 1998–2002. Jones. D. S, Records of the Western Australian Museum, Supplement No. 66**:** 101–120.

Halpern Glick Maunsell (1989). "Port of Dampier Development Study."

Halpern Glick Maunsell (1997). Port of Dampier Development Strategy and Capacity Study.

Harris, G., G. Batly, et al. (1996). Port Phillip Bay Environmental Study Final Report. Commonwealth Scientific and Industrial Research Organisation (CSIRO). Canberra.

Harris, P. and P. O'Brien (1998). Australia Ports Environmental Data & Risk Analysis Phase 1: Literature Review. Report prepared for Australian Quarantine Inspection Service (AQIS), Petroleum & Marine Division Australian Geological Survey Organisation.

Hazel, J., I. R. Lawler, et al. (2007). "Vessel speed increases collision risk for the green turtle Chelonia mydas." Endangered Species Research **3**(2): 105-113.

Heatwole, H. (1987). Major Components and Distributions of the Terrestrial Fauna in Fauna of Australia. General Articles. Canberra, Bureau of Flora and Fauna. **Volume 1A**.

Heyward, A. J., A. T. Revill, et al. (2000). Review of research and data relevant to marine environmental management of Australia's North West Shelf (TR1),. Report to the Department of Environmental Protection. Western Australian Institue of Marine Science and CSIRO Marine Research Branch. Perth, Western Australia, NORTH WEST SHELF JOINT ENVIRONMENTAL MANAGEMENT STUDY. **NWSJEMS Technical Report No. 1**.

Hutchings, J. B. (2003). Checklist of marine fishes of the Dampier Archipelago, Western Australia. The marine flora and fauna of Dampier, Western Australia. F. E. Wells, D. I. Walker and D. S. Jones. Perth, WA, Western Australian Museum.

Jackson, K. L., E. I. Paling, et al. (2006). Review of the Research and Data Relevant to the Marine and Terrestrial Environment of Dampier. Dampier, WA, Dampier Port Authority.

Jones, D. S. (2001). Introduced marine species in the Dampier Archipelago. Unpublished Report to Woodside Energy Ltd. Perth, WA**:** 13.

Jones, D. S. (2004a). Barnacles (Cirripedia: Thoracica) of the Dampier Archipelago, Western Australia. Records of the Western Australian Museum. D. S. Jones. Perth, Western Australia,, Western Australian Museum. **Supplement 66:** 121-157.

Jones, D. S. (2004b). "The Burrup Peninsula and Dampier Archipelago, Western Australia: an introduction to the history of its discovery and study,marine habitats and their flora and fauna." Records of the Western Australian Museum Supplement **66**: 27–49.

Kilminster, K. L., D. I. Walker, et al. (2006). "Limited nutritional benefit to the seagrass *Halophila ovalis*, in culture, following sediment organic matter enrichment." Estuarine, Coastal and Shelf Science **68**: 675-685.

Lasker, H. R. (1980). "Sediment rejection by reef corals: the roles of behaviour and morphology in Montastrea cavernosa." Journal of experimental Marine Biology and Ecology **47**: 77-87.

Lee, K. S., S. R. Park, et al. (2007). "Effects of irradiance, temperature, and nutrients on growth dynamics of seagrasses: A review. ." Journal of Experimental Marine Biology and Ecology **350**: 144-175.

Longstaff, B. and W. Dennison (1999). "Seagrass survival during pulsed turbidity events: The effects of light deprivation on the seagrasses *Halodule pinifolia* and *Halophila ovalis*." Aquatic Botany **65**: 37-62.

Matos, J. (2001). Fundamentos da informação geográfica. Lidel, Lisbon.

Mazeaud, M., F. Mazeaud, et al. (1977). "Primary and secondary effects of stress in fish: some new data with a general review." Transactions of the American Fisheries Society **106**: 201-212.

McArthur, C., R. Ferry, et al. (2002). Development of guidelines for dredged material disposal based on abiotic determinants of coral reef community structure. . Third Specialty Conference on Dredging and Dredged Material Disposal Coasts, Oceans, Ports, and Rivers Institute (COPRI) of ASCE Orlando, FL USA.

McCauley, R. (1994). The environmental implications of offshore oil and gas development in Australia - seismic surveys. Environmental Implications of Offshore Oil and Gas Development in Australia - The Findings of an Independent Scientific Review. J. M. Swan, J. M. Neff and P. C. Young. Sydney, Australian Petroleum Exploration Association**:** 19–122.

McCauley, R. (1998). Radiated underwater noise measured from the drilling rig Ocean General, rig tenders Pacific Ariki and Pacific Frontier, fishing vessel Reef Venture and natural sources in the Timor Sea, Northern Australia, prepared for Shell Australia**:** C98-20.

McCauley, R., J. Fewtrell, et al. (2000). "Marine Seismic Surveys – A study of environmental implications." APPEA Journal: 692-706.

McCauley, R., A. Maggi, et al. (2002). Analysis of Underwater Noise Produced by Pile Driving, Twofold Bay, NSW - Phase 11, Signal Measures. Prepared for Baulderstone Hornibrook Pty Ltd by the Centre for Marine Science and Technology, Curtin University.

McLoughlin, R. and P. Young (1985). "Sedimentary provinces of the fishing grounds of the North West Shelf of Australia: Grain-size frequency analysis of surficial sediments." Australian Journal of Marine and Freshwater Research **36**(5): 671 - 681.

McMillan, C. (1983). "The status of an endemic Australian seagrass, *Cymodocea angustata* Ostenfeld." Aquatic Botany **17**: 231-241.

Mori, N. (2008). THE IMPACT OF GRAVEL EXTRACTION ON HYPORHEIC ECOLOGY: A CASE STUDY OF THE BAČA RIVER (W SLOVENIA).

Morrison, P. F. (2004). "A general description of the subtidal habitats of the Dampier Archipelago, Western Australia." Records of the Western Australian Museum Supplement **66**: 51-59.

MPRSWG (1994). A representative marine reserve system for Western Australia: . Report of the Marine Parks and Reserves Selection Working Group. Perth, WA, Dept. of Conservation and Land Management.

MScience (2004). Dampier Port Upgrade Project: Coral Studies. MSA08R1. Unpublished Report to Hamersley Iron Pty Ltd. Perth, WA, MScience Pty Ltd.

MScience (2005). Coral Distribution in the Port of Dampier. Report Prepared for the Dampier Port Authority. Dampier, WA, MScience Pty Ltd.

MScience (2006). Pluto LNG Development: Marine Baseline Studies - Initial Sediment Characterisation. Report prepared for Woodside Energy Ltd by MScience Pty Ltd. Perth, WA, Woodside Energy Ltd.

MScience (2007a). Dampier Port Authority: DCW Capital Dredging: Sediment Quality Report. Report prepared for the Dampier Port Authority. Dampier, WA, MScience Pty Ltd.

MScience (2007b). Dampier Port Upgrade: Additional TBT Sampling: Area B3. Unpublished Report Prepared for Pilbara Iron (Services) Pty Ltd.

MScience (2007c). Pluto LNG Development, Baseline Water Quality Assessment Report April 2007. Prepared for Woodside Energy LTD.

MScience (2009a). Dampier Port Wharf Construction - Water Quality Descriptors.

MScience (2009b). Water Quality Impacts for the Pluto program in an area of intensive dredging. Dampier Marine Services facility - MSA142R2.

Murrell, M. C., J. C. Campbell, et al. (2009). "Effects of irradiance on benthic and water column processes in a Gulf of Mexico estuary: Pensacola Bay, Florida, USA." Estuarine, Coastal and Shelf Science **81**: 501-512.

Myrberg, A., C. Gordon, et al., Eds. (1976). Attraction of free ranging sharks by low frequency sound with comments on its biological significance. Sound reception in fish. New York, Elsvier.

Myrberg, A., C. Gordon, et al. (1978). "Rapid withdrawal from a sound source by open-ocean sharks." J. Acoust. Soc. Am. **64**: 1289-1297.

National Oceanic and Atmospheric Administration (2006a). No. 6 Fuel Oil (Bunker C) Spills.

National Oceanic and Atmospheric Administration (2006b). Small Diesel Spills (500-5000 gallons).

NSW Department of Environment and Climate Change (2008). Stormwater first flush pollution

O'Connor, R. (2005). An Aboriginal Heritage Survey of Lot 565 on the Burrup Peninsula Carried out with the Wong-Goo-Tt-Oo Group. Prepared for Worley Astron and the Wong-Goo-Tt-Oo Group.

Olsen, K. (1990). "Fish behaviour and acoustic sampling." Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer **189**: 147-158.

Paling, E. I. (1986). The ecological significance of blue-green algal mats in the Dampier mangrove ecosystem. . Department of Conservation and Environment. Perth, Western Australia

Paling, E. I. and A. J. McComb (1994). "Cyanobacterial mats: a possible nitrogen source to arid coast mangroves." International Journal of Ecology and Environmental Science **20**: 47-54.

Pearce, A., S. Buchan, et al. (2003). A review of oceanorgaphy of the Dampier Archipeligo, Western Australia. The marine flora and fauna of Dampier, Western Australia. Wells F. E, Walker D. I and Jones D. S. Perth, Western Australia Museum**:** 13-50.

Ponder, W. F. (1997). "Conservation status, threats and habitat requirements of Australian terrestrial and freshwater mollusca." Memoirs of the Museum of Victoria **56**: 421-430.

Port and Harbour Consultants (1996). Development Option Study.

Preen, A. R., W. J. Lee Long, et al. (1995). "Flood and cyclone related loss, and partial recovery, of more than 1000 km^2 of seagrass in Hervey Bay, Queensland, Australia." Aquatic Botany **52**: 3-17.

Prince, R. I. T. (1993). Western Australian marine turtle conservation project: an outline of scope and an invitation to participate. Marine Turtle Newsletter. **60:** 8-14.

Reigl, B. and G. Branch (1995). "Effects of sediment on the energy budgets of four scleractinian and five alcyonacean corals." Journal of Experimental Marine Biology and Ecology **186**: 259 - 275.

Rogers, C. S. (1983). "Sublethal and lethal effects of sediments applied to common Caribbean reef corals in the field." Marine Pollution Bulletin **14**: 378-382.

Rogers, C. S. (1990). "Responses of coral reefs and reef organisms to sedimentation." Marine Ecology Progress Series **62**: 185-202.

Schwartz, A., M. Bjork, et al. (2000). "Photosynthetic utilisation of carbon and light by two tropical seagrass species as measured in situ." Marine Biology **137**: 755-761.

Semeniuk, V., P. N. Chalmer, et al. (1982). "The marine environments of the Dampier Archipelago." Journal of the Royal Society of Western Australia, **65** (3): 97-114.

Semeniuk, V. and P. A. S. Wurm (1987). "Mangroves of the Dampier Archipelago, Western Australia." Journal of the Royal Society of Western Australia. **69**(2): 29-87.

Semeniuk V. (1993). "The mangrove systems of Western Australia 1993 : Presidential Address." Journal of the Royal Society of Western Australia. **76**: 99-122

Simpson, C. J. (1985a). Environmental factors affecting coral growth in the Dampier Archipelago, Western Australia. . Department of Conservation and Environment. Perth, Western Australia.

Simpson, C. J. (1985b). Mass Spawning of Scleractinian Corals in the Dampier Archipelago and the Implications For Management of Coral Rees in Western Australia. Perth, WA, Department of Environment and Conservation.

Simpson, C. J. (1988). Ecology of scleractinian corals in the Dampier Archipelago, Western Australia. Technical Series, Western Australian Environmental Protection Authority. **23:** 238.

SKM (2006a). Draft Public Environmental Report/Public Environmental Review. EPBC Referral 2006/2968, Woodside Petroleum Ltd.

SKM (2006b). Dredging and Dredge Spoil Disposal Management Plan Dampier Port Dredging. Perth, WA, Hamersley Iron Pty Ltd.

SKM (2007a). *Inner Harbour Nelson Point South Dredging - Selection Phase Study. Water Quality Monitoring.* Unpublished report prepared for BHP Billiton Iron Ore.

SKM (2007b). Pluto LNG Development. Addendum to public environmental report/public environmental review supplement and response to submissions.

Solem, A. (1997). "Camaenid Land Snails from Western and Central Australia (Mollusca: Pullmonata: Camaenidae) VII: Taxa from Dampierland through the Nullabor." Records of the Western Australian Museum **Supplement No. 50**.

Standards Australia (1981). Guide to Noise Control on Construction, Maintenance and Demolition Sites.

Stejskal, I. (1992). "THE ENVIRONMENTAL MONITORING OF NATURAL EVENTS AND INDUSTRY ACTIVITY IN MERMAID SOUND, DAMPIER ARCHIPELAGO." APEA **32**: 420-427.

Stoddart, J. A. and S. Anstee (2004). Water quality, plume modelling and tracking before and during dredging in Mermaid Sound, Dampier, Western Australia. Corals of the Dampier Harbour: Their Survival and Reproduction During the Dredging Programs of 2004. Stoddart J.A. and Stoddart S.E. Perth Western Australia, Mscience Pty Ltd**:** 13-33.

Stoddart, J. A. and S. Anstee (2005a). Water quality, plume modelling and tracking before and during dredging in Mermaid Sound, Dampier, Western Australia. Corals of the Dampier Harbour: Their Survival and Reproduction During the Dredging Programs of 2004. Stoddart J.A. and Stoddart S.E. Perth Western Australia, Mscience Pty Ltd**:** 13-33.

Stoddart, J. A. and J. P. Gilmour (2005b). Patterns of reproduction of in-shore corals of the Dampier Harbour, Western Australia, and comparisons with other reefs. Corals of the Dampier

Harbour: Their Survival and Reproduction during the Dredging Programs of 2004. Stoddart J. A. and Stoddart S.E. Perth, WA, MScience Pty Ltd**:** 53-64.

Talbot, V. and S. Creagh (1985). Mineralogical variation within the marine sediments of the Dampier region: a dynamic approach. . Department of Conservation and Environment Western Australia.

Thamrongnawasawat, T. and D. Hopley (1994). Digitised aerial photography: a new tool for reef research and management. 3rd ASEAN - Australia Regional Conference. Bangkok, Thailand.

Tomascik, T. and F. Sander (1987). "Effects of eutrophication on reef-building corals " Marine Biology **94**(1): 1432-1793.

Trudgen, M. E. (2002). A flora, vegetation and floristic survey of the Burrup Peninsula, some adjoining areas and part of Dampier Archipelago, with comparisons to the floristics of areas on the adjoining mainland. Prepared for the Department of Mineral and Petroleum Resources. M.E. Trudgen & Associates. Perth, Western Australia. **Volume 1**.

U.S. Fish and Wildlife Service (1998). Oil and Nature. 1 September 2009.

URS Australia (2008). Review of Literature on Sound in the Ocean and Effects of Noise and Blast on Marine Fauna. Prepared for Western Australian Water Corporation.

USEPA (1986). Quality Criteria for Water 1986. Washington: United States Environmental Protection Agency.

Vagle, S. (2003). On the impact of underwater pile driving noise on marine life. Vancouver, Canada, Ocean & Science Productivity Division, Institute of Ocean Sciences, Department of Fisheries and Oceans (Pacific Region).

Vermaat, J., N. Agawin, et al. (1997). "The capacity of seagrasses to survive increased turbidity and siltation: the significance of growth form and light use." Ambio **25**(2): 499-504.

Walker D.I., P. R. I. T. (1987). "Distribution and biogeography of seagrass species on the northwest coast of Australia." Aquatic Botany **29**: 19-32

Walker, D. I., G. Kendrick, et al. (1988). "The distribution of seagrass species in Shark Bay, Western Australia, with notes on their ecology." Aquatic Botany **30**: 305-317.

Waycott, M., B. Longstaff, et al. (2005). "Seagrass population dynamics and water quality in the Great Barrier Reef region: A review and future reseach directions." Marine Pollution Bulletin **51**: 343-350.

Wells, F. E. and D. I. Walker (2003a). Introduction to the marine environment of Dampier, Western Australia. In Proceedings of the Twelfth International Marine Biology Workshop, Western Australia.

Wells, F. E. and D. I. Walker (2003b). The Marine Flora and Fauna of Dampier; Western Australia. Proceedings of the Eleventh International Marine Biological Workshop: The Marine Flora and Fauna of Dampier, Western Australia. F. E. Wells, D. I. Walker and D. S. Jones. Perth, Western Australian Museum.

Wenziker, K., K. McAlpine, et al. (2006). Background quality for coastal marine waters of the North West Shelf Western Australia. North West Shelf Joint Environmental Management Study. Technical Report No. 18, CSIRO Marine and Atmospheric Research.

Western Australian Herbarium. (2009). "Florabase - the Western Australia Flora." Retrieved Thursday, 12 November 2009, from http://florabase.dec.wa.gov.au/.

Western Australian Planning Commission (2009a). State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning.

Western Australian Planning Commission (2009b). State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning - Implementation Guidelines.

Williams, S. and W. Dennison (1990). "Light availability and diurnal growth of a green macroalga (*Caulerpa cupressoides*) and a seagrass (*Halophila decipiens*)." Marine Biology **106**: 437-443.

Wilson, S. (2002). Guidelines for Landscape and Visual Impact Assessment. The Landscape Institute and the Institute of Environmental Management and Assessment.

Woodside Energy Limited (2006). Draft Public Environmental Report - PER.

Woodside Energy Limited (2007). Pluto Load Out Facility - Pluto LNG Development REFERRAL SUPPORTING INFORMATION.

Woodside Petroleum Limited (2006). Pluto LNG Development Draft Public Environmental Report / Public Environmental Review.

WorleyParsons (2004). Berth Operability Assessment, Proposed Land Backed Wharf.

WorleyParsons (2007). Concept Design of a Short Term General Cargo Wharf and Procurement of Design and Construction Services: Options Study Report.

WorleyParsons (2009a). Benthic Habitat Report. Submitted as an appendix of the DMSF API.

WorleyParsons (2009b). Comparison of the Dampier Port Fringing Reef Benthic Community with Nearby Reef Areas. Submitted as an appendix of the DMSF API.

WorleyParsons (2009c). Coral Condition Monitoring Survey, Cape Preston, Australia - First Construction Survey, October 2009.

WorleyParsons (2009d). Dampier Marine Services Facility - Noise Screening Assessment.

WorleyParsons (2009e). Dampier Marine Services Facility - Preliminary Site Investigation Sampling and Analysis Plan Implementation Report. Submitted as an appendix of the DMSF API.

Yentsch, C., J. Cullen, et al. (2002). "Sunlight and water transparency: cornerstones in coral research." Journal of Experimental Marine Biology and Ecology **268**(8): 171-183.

Appendix 1 – Figures

Appendix 2 – Dredging and Reclamation Management Plan

Appendix 3 – Noise Assessment

Appendix 4 – Drainage Management

Appendix 5 – Flora Survey

Appendix 6 – Water Quality Baseline

Appendix 7 – Geotechnical Investigation

See attached DVD

Appendix 8 – Water Quality Impacts for the Pluto program in an area of intensive dredging

Appendix 9 – Sediment Contamination and Acid Sulfate Soils Investigation

(See attached DVD)

Appendix 10 – Benthic Habitat Map

Appendix 11 – Dampier Port Benthic Community Comparisons

Appendix 12 – Indigenous Heritage Survey

Appendix 13 – Marine Environmental Modelling

Appendix 14 – Oil Spill Management Plan

(See attached DVD)

Appendix 15 – Benthic Habitat Losses within Dampier Archipelago and Implications of this Project

Appendix 16 –Traffic Study

Appendix 17 – EPBC Referral

Appendix 18 – Visual flythrough of DMSF

See DVD attached

Appendix 19 – MEM – DMSF Impact Assessment