

R E P O R T

Darwin City Waterfront Redevelopment Project

Draft

Environmental Impact Statement

Prepared for

Department of Infrastructure, Planning and Environment

GPO Box 4000
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URS

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INTRODUCTION

The Department of Infrastructure Planning and Environment (DIPE) within the Northern Territory Government, proposes to redevelop the Darwin wharf area. The proposed **Darwin City Waterfront Redevelopment** (the Redevelopment) will transform an existing disused industrial area into a living precinct which captures the unique tropical character of Darwin for the use and enjoyment of the people of Darwin. The Redevelopment will create a community asset and attract Darwin residents and visitors with features including a Convention and Exhibition Centre, residential accommodation, commercial and entertainment, tourist and recreational facilities.

The Draft EIS was prepared to satisfy the requirements of the Northern Territory *Environmental Assessment Act* (1982). The document addresses issues noted in the *Guidelines for Preparation of an Environmental Impact Statement on the Proposed Darwin City Waterfront Redevelopment at the Darwin Wharf* issued by the Northern Territory Minister for the Environment in November 2003. The Draft EIS presents the findings of comprehensive studies of the existing environment and the potential impacts of the Redevelopment. The Commonwealth Minister for the Environment determined that the proposed development did not require additional approval under the *Environment Protection and Biodiversity Conservation Act*.

The Draft EIS has been based on the Concept Plan for the project. The Master Plan for the Redevelopment will be finalised in December 2004. If the Master Plan differs substantially from the Concept Plan and raises further environmental issues, additional environmental review will be undertaken through the normal environmental impact assessment processes.

Consultation about the Redevelopment has occurred over several years as the planning for the project has progressed. More recently, consultation has been carried out with business and tourism groups, Darwin City Council, specific interest groups, tenants and residents in and near the site and the general community.

OBJECTIVES OF THE PROPOSED PROJECT

The primary objectives of the project is to develop and invigorate a declining industrial site, to generate significant economic benefits for the Northern Territory and create an active precinct with new facilities and attractions that draw Darwin residents and visitors to the site and the Darwin Central Business District (CBD).

Specifically, the proposed project aims to:

- establish a world class waterfront development;
- revitalise and regenerate the Darwin waterfront area from its current form based largely on industrial and post-industrial land uses, including clean-up of areas of historic land contamination;

- establish a significant recreational and lifestyle resource for Darwin residents and intrastate, interstate and overseas visitors; and
- provide a significant stimulus to the business and tourism industries in Darwin and the Northern Territory.

PROJECT JUSTIFICATION

The Darwin City Waterfront site is currently a declining industrial area, which has become under utilised and semi-derelict. The project will reclaim valuable and strategically situated land, and utilise the site for the economic and social benefit of Darwin and the Northern Territory. The Redevelopment will create major financial/economic, social, urban design and environmental benefits for Darwin and the Northern Territory, including:

- the enhancement of the city environment;
- the potential to recognise and enhance the cultural and historical significance of the site;
- significant stimulation of Darwin business and the construction and tourism industries;
- \$600m in development value;
- \$550m economic benefit, over a 25 year period, from the conference and exhibition centre alone;
- significant increase in visitor nights to the Darwin area;
- the generation of employment during the construction and operation phases;
- the inclusion of residential housing within the development
- the provision of a major feature for the enjoyment of locals and tourists; and
- remediation of the contamination left by past industrial activities.

PROPOSED PROJECT

The Site

The site for the proposed Redevelopment is the Darwin Wharf and associated waterfront, which covers approximately 25 hectares immediately to the south of the Darwin CBD. The Northern Territory Government owns the site, and no land acquisition is required for the Redevelopment.

The Proposed Project

The Concept Plan shows that the Redevelopment will include:

- significant public open space to encourage a diversity of community-oriented activities;

- a continuous promenade along the length of the waterfront;
- community and tourist attractions such as a visitor centre and a cultural / heritage centre;
- the Darwin Convention And Exhibition Centre (DCEC);
- focal “landmark” feature to achieve orientation and create a sense of place;
- accommodation, including residential development, hotel(s) and serviced apartments;
- commercial and retail activities, such as cafes and kiosks;
- land reclamation in Kitchener Bay;
- construction of shoreline protection measures along Kitchener Bay such as a revetment structure or a sea wall constructed off-shore;
- leisure craft moorings and associated marina-oriented commercial and public transport facilities;
- a marina or jetties in Kitchener Bay and marine structures along the western side of Fort Hill;
- pedestrian and visual connections between the site and the CBD along the Smith Street axis; and
- improved road and pedestrian access to the site and its facilities.

The most significant single feature of the redevelopment will be the DCEC, which will comprise a 1,500-seat convention centre, 4,000 m² of exhibition space and cover approximately 10,000 m². The Northern Territory Government will commit \$100 million towards the DCEC and offsite support infrastructure.

Redevelopment of the site is anticipated to occur in stages over a 10 to 15 year period. Construction of the first stage of the development, including the DCEC, is expected to commence in early 2005. The timing of future stages of construction, particularly any residential developments, will be led by demand.

Remediation of the Site

The Redevelopment will remediate contamination at the site to appropriate health and ecological protection standards. The assessment of site contamination and the requirement for remediation will be carried out under the rigorous review and approvals of the Victorian EPA Contaminated Land Audit Process. An independent Victorian EPA Contaminated Land Auditor has been appointed to the project by the Territory Government.

Alternatives

The primary objective of this project is to revitalise a disused and contaminated industrial area close to the Darwin CBD and create a more valuable, environmental economic and social resource. Non-development will not realise these socio-economic, community and environmental benefits. Several options have been considered for the location of the DCEC. Of the nine assessed options, the current

wharf area was the most suitable on the set selection criteria and offered the greatest opportunities for integrated development linked to the Darwin CBD.

EXISTING ENVIRONMENT

Physical Environment

The site has been heavily disturbed by past activities with extensive importation of fill material for reclamation of Kitchener Bay, the leveling of Fort Hill and widespread industrial development. Stokes Hill is the only major topographic feature in the site and rises to about 25 m. The existing foreshore along the site consists of exposed fill material. The marine sediments in Kitchener Bay are relatively flat and are approximately 3-5 m lower than the adjacent reclaimed areas.

The catchment for the site extends above the escarpment into the southern CBD area. Drainage has been heavily modified, and no natural drainage lines remain. The quality of runoff is affected by the previous industrial land uses with elevated levels of sediment, metals and hydrocarbons. The groundwater movement under the site is generally towards the harbour and is slow.

Kitchener Bay lies near the main channel of Darwin Harbour with relatively deep water on the southern side of Stokes Hill and Fort Hill wharves. Broad intertidal mudflats cover much of the bay. Acid Sulfate Soil (ASS) materials occur in some areas of the marine sediments underlying the reclaimed areas. No AAS materials were found in the top 1 m of marine sediments of Kitchener Bay during recent testing.

As expected from the long history of industrial land use, the site contains some contamination from past activities which will be remediated and managed. Contamination of soils, groundwater and marine sediments varies across the site. Contaminants include:

- metals (arsenic, barium, cadmium, copper, lead, manganese, mercury, nickel and zinc), particularly from past mineral ore handling at the site; and
- hydrocarbons (total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and chlorinated hydrocarbons).

The site contains a mixture of existing industries that generate atmospheric discharges. These include particulate matter (PM), combustion products (carbon monoxide and dioxide [CO_x], nitrogen oxides [NO_x], sulfur oxides [SO_x]) and small amounts of organic compounds (including volatile organic compounds [VOC], methane [CH₄]), and possibly some air toxics such as polycyclic aromatic hydrocarbons (PAHs).

Until recently, the project site served as the primary wharf for Darwin with associated industrial development and activity. Loading conveyors, marine vessel noise, transportation vehicles and processing plants would have dominated the noise climate of the site at that time. With the transfer of a large proportion of significant port operations to East Arm, numerous industrial facilities across the site have been decommissioned with a corresponding reduction in noise levels.

Biological Environment

Past disturbance of the site has left little vegetation of significance. The coastal vine-forest on the escarpment immediately to the north is the most significant vegetation community nearby. As would be expected by the generally poor habitat quality offered by the vegetation, only two fauna species of significance were found on the site, and only few shorebirds were noted in Kitchener Bay. These species have extensive suitable habitat available within the region.

Biting midges do not breed in significant numbers at the site, but migrate from extensive breeding areas to the north-east. The site contains several mosquito breeding areas, however the mosquito problem in the area is minor. Development of the site will remove many current breeding sites.

The marine areas of the site support typical, but not exceptional, marine fauna. The project area does not contain habitats which could be considered critical for dugongs or other marine mammals, and the activities associated with the wharves discourage the presence of any noise-sensitive marine mammals. The closest marine area of sensitivity to potential impacts from the project site is 2 km away from the site and considered to be well beyond the potential influence of the Redevelopment.

Built Environment

Traffic access is adequate for current uses, although the road network is of a low standard.

The visual characteristics of the site in its current form are poor, reflecting the past industrial uses and the current semi derelict state. The road network will be upgraded as part of the Redevelopment.

The project site may contain Unexploded Ordnance (UXO) from wartime activities, particularly the bombings of Darwin in 1943. The UXO, if present, will be found embedded in landforms that remain unchanged since 1942, and are not considered likely in areas that have been subsequently filled. However, any UXO remaining in the area is unlikely to be readily detonated after such prolonged environmental exposure.

Cultural Environment

No archeological sites have been identified in the project area. Stokes Hill has been recorded as a Sacred Site, and a second Sacred Site lies within a kilometer of the site at Lameroo Beach. The portion of the Stokes Hill Sacred Site extending into the project area is a "Restricted Works Area" under the Aboriginal Areas Protection Authority Certificate.

The Darwin Waterfront area has been fundamentally linked to the establishment and development of Palmerston Town (to be renamed Darwin in the early 1900s) and its port from 1869. Three heritage sites within or near the project area are on the Northern Territory Heritage Register: the Oil Storage Tunnels, the Steam Pump House and the MV *Neptuna*. In addition, Goyder's Camp and Hughes Avenue were nominated recently for inclusion on the Heritage Register. Three sites within or in the vicinity of the project area on the Register of the National Estate: Oil Storage Tunnels (1, 5, 6, 10 and 11), the Steam Pump House and Traveller's/Chinaman's Walk (to be delisted). Four sites in or near the vicinity of the

project area are listed on the National Trust Register of Significant Places: Knight's Folly, the Oil Storage Tunnels (5 and 6), Traveller's (Chinaman's) Walk and the Burnett design "G" Type Residence.

Socio-economic Environment

The project site supports a range of commercial and tourism activities. These activities generate some economic and amenity benefits, however much of the area remains in a state that does not facilitate active commercial, tourism or recreational use. The project site is used by the Darwin community for a range of recreational activities focused on Stokes Hill Wharf and its surrounds. Community attitudes to the site indicate an interest in highlighting the connection between land and water, Darwin's tropical environment and lifestyle, and the history and culture of the site. The community also indicate an interest in greater recreational opportunities for local people and visitors, greater access to the site and enhancement of the aesthetics of the site with connection to the CBD.

ENVIRONMENTAL EFFECTS, MITIGATION AND MANAGEMENT

The following issues have been assessed as being significant potential impacts and will require appropriate mitigation and management controls to be implemented during the construction and operational phases of the project.

Site Contamination

Potential Impacts Disturbance and mobilisation of contaminants in soils and groundwater during various operations, including excavation, dewatering of contaminated groundwater from excavations, removal of existing infrastructure and erosion of exposed soils

Distribution of contaminated soil as dust

Mobilisation of metal contaminants through exposure to acidic groundwater or surface runoff generated from exposure or drying of Acid Sulfate Soils

Disturbance and mobilisation of contaminants from dredging of marine sediments from Kitchener Bay and disposal to a suitable land or offshore disposal area

Mitigation A thorough contaminated site assessment is being finalised, to characterise the sources, type, location and extent of contamination. This will allow determination of appropriate remediation and management actions. Health levels for some contaminants are exceeded in a number of areas. However, contamination can be dealt with satisfactorily through a combination of on-site remediation and management of any residual contaminants, that are determined to be present at acceptable levels. These actions will be undertaken to the requirements of the Contaminated Land Auditor. Remediation and on-site management of residual contamination will be carried out through a series of plans (Pre-remediation Site Works Environmental Management Plan, Remediation Action Plan and Site Management Plan for on-going post-remediation activities).

Sites for disposal of contaminated terrestrial soils and contaminated marine sediments are currently being investigated and options will be assessed through standard Northern Territory Government approvals processes and the Darwin Harbour Dredging Technical Advisory Committee.

Acid Sulfate Soils

Potential Impacts Exposure of ASS material by excavation, dewatering or dredging, and acidification of nearby groundwater or surface runoff, which can result in effects as described under Site Contamination.

Mitigation A detailed ASS Management Plan for minimising the impacts from the site works will be developed if significant quantities of ASS material are to be disturbed. This will address excavation, dewatering and stockpiling. This will achieve the desired outcome of containment, treatment or appropriate disposal of ASS material

Erosion and Sedimentation

Potential Impacts Soil erosion and sedimentation in near shore areas of Kitchener Bay, may result in effects as described under Site Contamination

Mitigation An Erosion and Sedimentation Control Plan will be incorporated into the Construction and Operational Management Plans which will be implemented to minimise soil erosion, sedimentation and dust generation.

Marine Environment

Potential Impacts Localised and temporary increase in water turbidity from dredging, spoil disposal, reclamation and foreshore engineering works which may also contribute to effects discussed in Site Contamination.

Mitigation Dredging and reclamation, if required, will be controlled to minimise water quality impacts through implementation of a Dredging and Reclamation Management Plan. Environmental specifications for activities will be defined to ensure that turbidity and contamination effects are minimised. Extensive monitoring will be undertaken and triggers included to stop work if certain criteria threshold are exceeded.

Unexploded Ordnance

Potential Impacts Detection of UXO during dredging and excavation activity is most likely in the remaining pre-1942 landform. Due to prolonged environmental exposure, the risk of UXO detonation is considered low.

Mitigation Operational procedures covering detection of UXO and contingency plans in the event of detection have been developed and will be integrated within Construction and Operational Management Plans.

European Cultural Heritage

Potential Impacts Heritage sites within the project area have been identified. There is the potential for damage to, or loss of, these heritage features and values.

Mitigation Wherever possible heritage sites will be incorporated into the Redevelopment as a “feature”, such as the Steam Pump House. Any identified heritage sites that are to be removed will be thoroughly documented, including photographs and video, to the requirements of the Office of Environment and Heritage before any works are undertaken.

Aboriginal Cultural Heritage

Potential Impacts Apart from the Stokes Hill Sacred Site, there are no archaeological impediments to the Redevelopment due to the extensive disturbance of the site. There are two areas of Aboriginal cultural value, at Stokes Hill, which is within the project area and Lameroo beach which is just outside the project area. Consideration within design and construction will help to minimise any potential for diminishing of Aboriginal cultural values for the site

Mitigation The cultural significance of the project site, particularly Stokes Hill, will be acknowledged as part of the Redevelopment. Aboriginal community will be consulted about any proposed uses of Stokes Hill, and guidance will be sought on possible cultural heritage interpretation.

Socio-economic Impacts

Potential Impacts Most socio-economic impacts from project will be positive. However, occasional, short-term impacts, which might inconvenience local businesses, are possible.

Mitigation Potential impacts on existing businesses will be mitigated through integration of the CBD and Redevelopment site in the Master Plan. Access will be maintained during

all construction activities for the existing businesses operators in and near the site and works will conducted during normal working hours unless required on special occasions.. Potential short term impacts will be countered by medium and long term significant commercial benefits as the Redevelopment progresses.

Air Quality

Potential Impacts Generation of dust and other emissions, may occur during site clearing and construction, which can result in effects as described under Site Contamination..

Reduced emissions of air pollutants are likely due to the replacement of current industrial sources, which will be a positive impact.

Fugitive emissions are predicted from the Naval Fuel Installations (NFI), which has the potential to affect future land uses in adjacent areas in the medium to longer term. Impacts will be dependant on future land uses, the lifespan of the NFI and future air quality standards.

Mitigation Construction, remediation and site management plans will be implemented to reduce dust and other emissions, and reduce risk from contamination

Once the future operational lifespan of the NFI has been confirmed, the details of the future adjacent land uses, an assessment of the dispersion of fugitive emissions from the NFI may be undertaken.

A program of dust monitoring will be implemented as part of the construction environmental management plan.

The following details summarise potential impacts and management controls for those issues assessed as of low to moderate significance:

- Surface water quality and stormwater flow management will improve significantly. The risk of storm surge flooding will be reduced.
- Groundwater impacts are not expected and can be managed if they occur.
- There is minimal native vegetation and no fauna habitat of significance in the site and the escarpment coastal vine-forest will not be disturbed in any significant way. Weed control is likely to improve.
- Measures will be incorporated to minimise biting insect breeding areas at the site.
- Traffic and transport impacts will be mitigated by improvements in road capacity and changes to the layout of various parts of the road network as required.

- Potential impacts on noise sensitive premises will be managed to comply with the requirements of Northern Territory Government regulators
- Visual characteristics and amenity of the site will be improved significantly.
- Construction and remediation wastes will be managed and disposed of in accordance with all Northern Territory Government requirements.
- All site works will be carried out under a Construction Environmental Management Plan, which will outline measures to deal with all relevant issues. Ongoing management of the redeveloped site will be carried out under an Operations Environmental Management Plan.

MONITORING PROGRAM AND REPORTING PROCEDURES

A comprehensive baseline environmental monitoring program has been either carried out for the preparation of the draft EIS or recommended as a future action to evaluate the pre-construction conditions at the site. On-going monitoring is also recommended to evaluate the iterative change in environmental conditions during the planned construction, post-construction and operational phases of the project. These will collectively form the Environmental Monitoring Program, which will test and validate the main predictions about the project effects which have the potential to adversely impact the environment. The monitoring program will also ensure that potential environmental effects are minimised and that the facility complies with any regulations governing particular activities.

The Draft EIS is provided in two (2) Volumes, which are available in CD ROM and Hard Copy version:

Volume 1 - The Executive Summary and Main Assessment Report

Volume 2 – Appendices, Including Specialist Research Reports and Environmental Management Plans

Copies of the draft EIS may be purchased from: URS Australia, Level 1 Arkaba House, 13 The Esplanade, Darwin, NT, 0801 or ordered by email darwin@urscorp.com or phone 08-8980-2900.

1.1 Background

1.1.1 Vision for the Redevelopment of Darwin City's Waterfront

The Darwin Waterfront is currently a declining industrial area, with popular community activities at its fringe, such as the Stokes Hill wharf and fishing spots. The aim of the redevelopment project is to create a community asset, transforming the landscape from its current industrial focus, to a living precinct which captures the unique tropical character of Darwin for the use and enjoyment of the people of Darwin and to enhance Darwin as a destination. The Development will incorporate a Convention and Exhibition Centre (DCEC), residential accommodation, commercial and entertainment facilities, and tourist and recreational facilities.

1.1.2 The Draft Environmental Impact Statement

This document is a Draft Environmental Impact Statement (EIS) for the proposal to redevelop the Darwin City Waterfront. This Environmental Impact Statement presents the findings of a comprehensive and wide-ranging study of the potential environmental impacts of the Redevelopment project. The EIS document is submitted to provide the Northern Territory Government and the public with the information necessary to allow an informed appraisal of the environmental acceptability of the proposed project.

The environmental impacts of the Redevelopment have been assessed, and the draft EIS written, against information provided in the Darwin Waterfront Revitalisation Concept Plan (Northern Territory Government Department of Infrastructure, Planning and Environment July 2003). At the time of the preparation of the Draft EIS (May 2004) the final development Master Plans have not been completed and released. Master Plans are expected to be finalised in December 2004 when the developer is selected, and will confirm the components of the redevelopment and their locations. The Master Plan is not expected to differ substantially from the Concept Plan, but if changes occur due to the addition or revision of project plans, details will be provided to the Office of Environment and Heritage of the Northern Territory Government for review to determine if any further assessment will be necessary.

1.2 Scope, Purpose and Structure of the Draft Environmental Impact Statement

This Draft Environmental Impact Statement (EIS) has been prepared to satisfy the requirements of the Northern Territory *Environmental Assessment Act (1982)* [Refer Table 1.1, Page 1-8]. The document addresses issues noted in the *Guidelines for Preparation of an Environmental Impact Statement on the Proposed Darwin City Waterfront Redevelopment at the Darwin Wharf* (the EIS Guidelines) (**Appendix A**) issued by the Northern Territory Minister for the Environment in November 2003. The Draft EIS presents the findings of comprehensive studies of the existing environment and the potential impacts of the Darwin City Waterfront Redevelopment (DCWR).

As required by the EIS Guidelines, the Draft EIS has been prepared to:

- describe the existing environment of the proposed redevelopment site and adjacent areas;
- describe the proposed project;
- identify and clarify potential environmental impacts from the proposed development;
- describe actions proposed to prevent, minimise and mitigate the identified potential environmental impacts;
- provide a source of information to government agencies and the community about the proposal;
- facilitate public consultation about the proposal; and
- establish a framework for considering the environmental acceptability of the proposal and determining environmental management measures that may be necessary for the proposal to proceed.

The EIS comprises the following main sections:

Section 1 Introduction

This section introduces the existing Darwin Wharf Precinct, the key elements of the proposed redevelopment, and provides background information on the proponent.

Section 2 Objectives and Benefits of the Project

This section outlines the key objectives for the redevelopment, and discusses the local and regional benefits anticipated from the development.

Section 3 Alternatives

This section considers alternative proposals that may still allow the objectives of the project to be met, detailing the reasons for the selection and rejection of particular options.

Section 4 Project Description

This section describes the location, major components of the proposal and details of the preparation phase of the proposed project. It also outlines associated headworks that are proposed to be provided by the Northern Territory Government (NTG).

Section 5 *Existing Environment*

This section describes the existing physical, biological, built, cultural and socio-economic environments at and in the vicinity of the project site.

Section 6 *Potential Environmental Impacts*

This section predicts the potential environmental impacts arising from the redevelopment of the Wharf Precinct.

Section 7 *Preliminary Hazard Analysis*

This section identifies hazards associated with the redevelopment and assesses the level of risk to the public, the environment and nearby facilities.

Section 8 *Mitigation, Management and Monitoring*

This section outlines proposed management strategies and monitoring commitments to ensure the actual and potential adverse impacts on the environment are minimised to the extent practicable.

Section 9 *Public Involvement and Consultation*

This section summarises the outcomes of extensive consultation with local and regional stakeholders during preparation of the Draft EIS.

Sections 10, 11 and 12 *Acknowledgements, Glossary and References*

These sections acknowledges all authors, co-authors and sub-consultants who contributed to the report, provides an explanation of technical terms used in the body of the EIS and specific references consulted and researched during the preparation of the EIS. It also provides a Glossary of terms and abbreviations used in compiling the report.

1.3 The Proponent and the Proposed Project

1.3.1 The Proponent

The proponent for the DCWR is the Department of Infrastructure Planning and Environment (DIPE) within the Northern Territory Government. One of the key functional responsibilities of DIPE is the delivery of the Northern Territory Government's capital works, repairs, maintenance and minor new works programs.

The primary contact person for the proponent is:

Mr Phill Piper

Infrastructure Consultant

Land Administration Division

Department of Infrastructure Planning and Environment

GPO Box 1680, DARWIN NT 0801

Telephone: (08) 8999 7019 Fax: (08) 8999 7452

1.3.2 The Proposed Project

Description of Site

The site for the proposed DCWR is the existing Darwin Wharf Precinct, which covers approximately 25 hectares on the southern end of the short peninsula supporting the Darwin CBD, Northern Territory (**Figure 1.1**). This area includes a significant portion of Kitchener Bay (**Figures 1.2 and 1.3**). The site does not encompass Stokes Hill and Fort Hill wharves.

The site is located immediately to the south of the Darwin Central Business District (CBD), approximately 2 km from the entrance to Darwin Harbour, at the head of Frances Bay on the north-east shore of the harbour. The site is bounded to the south and west by the Port of Darwin, to the east by Frances Bay and to the north by the city of Darwin.

The redevelopment site includes:

- the former Deckchair Cinema site to the north-east;
- the former Stokes Hill power station site;
- the southern portion of Stokes Hill;
- land formerly or currently occupied by industrial activities to the south of the base of the escarpment, including Kitchener Drive, the Fort Hill area and the bitumen plant;
- a portion of the escarpment along the Smith Street axis; and
- the tidal areas of Kitchener Bay.

The site does not include Stokes Hill and Fort Hill wharves, the southern portion of the Fort Hill Wharf cargo handling area, the freehold portion of land occupied by *The Jetty* restaurant (Lot 6605) and the Steam Pump House.

The site is currently used for industrial purposes associated with bulk cargo operations and tourism.

Overview of the Proposed Darwin City Waterfront Redevelopment

The Darwin Waterfront Revitalisation Concept Plan (**Figure 1.4**) depicts a notional range of land use activities, and specifically excludes any industrial or related incompatible uses of the land. The specific nature of the redevelopment will be defined by the final Master Plan for the site. This final Master Plan will define the components of the redevelopment, their locations across the site and the likely staging and timeframe of the redevelopment. Details of the proposed project are provided in Section 4.

Possible components of the redevelopment are likely to include:

- significant public open space to encourage a diversity of community-oriented recreation, activities and functions;
- community uses and tourist attractions such as a visitor centre, cultural / heritage centre, and public buildings;
- convention and exhibition centre;
- residential development;
- commercial and retail activities, such as cafes and kiosks;
- hotel(s);
- serviced apartments;
- leisure craft moorings and associated marina-oriented commercial and public transport facilities;
- focal “landmark” feature to achieve orientation and create a sense of place;
- construction of shoreline protection measures along Kitchener Bay such as a revetment structure (comprising rock armour, sheet piles, precast concrete retaining wall sections or similar) or a sea wall constructed off shore;
- land reclamation in Kitchener Bay requiring dredging of marine mud;
- construction of a marina or jetties in Kitchener Bay including dredging of marine mud;
- minor reclamation and/or marine structures such as a jetty adjoining the western side of Fort Hill;
- pedestrian and visual connections between the site and the CBD along the Smith Street axis;
- continuous promenade access along the length of the waterfront to maximise public accessibility; and
- road upgrading of McMinn Street and Frances Bay Drive to improve direct vehicle and public transport access, and pedestrian accessibility.

Various existing buildings and infrastructure will be demolished. The original (inner) Fort Hill Wharf is expected to be demolished during the redevelopment. The Iron Ore Wharf may be either decommissioned and refurbished for a future use related to the redevelopment or demolished if no appropriate use can be identified. The buildings in the Pump House heritage area are to be retained.

It is expected that the level of low-lying land across the site on which buildings are to be constructed will be raised to RL 6.5 m Australian Height Datum (AHD) above the storm surge level for a 1 in 1000 year average occurrence interval event [0.1 % Annual Exceedance Probability (AEP)], which includes a 0.3 m allowance for rise in sea level to take account of long term global warming.

Scope of the Proposed Project

The Northern Territory Government will commit \$100 million to the project that will contribute towards the Darwin Conference and Exhibition Centre and associated infrastructure. The Northern Territory Government will also contribute to the necessary offsite support infrastructure.

The redevelopment will include the following component activities.

- Demolition of existing infrastructure

Most industrial activities have relocated from the site over the last five years. The exception is the Bitumen Plant which is currently being decommissioned in preparation for demolition. Much of the remaining disused and redundant above- and below-ground infrastructure remains *in situ* across the site, and this will be removed.

- Site preparation and construction

The waterfront redevelopment work will be undertaken in line with demand and is likely to be staged over a period of ten to fifteen years. Likely staging of site preparations and construction are:

- Construction of the Darwin Conference and Exhibition Centre;
- Construction of public infrastructure; and
- Construction of residential developments in one or more stages depending on demand.

The site has historically been utilised for a broad range of industrial purposes, and significant remediation works and management will be necessary to ensure the site is suitable for the range of proposed land uses. The first phase of works to be completed will be the demolition of various existing buildings and infrastructure. The works is required to prepare the site for the remediation phase of the project which will clean-up contamination on the site to the appropriate level to allow the development to proceed. These early works while part of the project, are being separately assessed by an Independent Victorian EPA Contaminated land Auditor and will be managed through and Environmental Management Plan and a Remediation Action Plan (RAP). These management documents will be reviewed and assessed by the Office of Environment and Heritage and will be subject to rigorous compliance assessment.

The interrelationship between the Environmental Impact Assessment and the Contaminated Site Assessment processes is detailed in Figure 8.1.

Objectives of the Proposed Project

The proposed project aims to:

- establish a world class waterfront development;
- remove disused and unnecessary infrastructure from the site to allow expanded use of the area;
- revitalise the Darwin waterfront area from its current form based largely on industrial and post-industrial land uses;
- establish a significant recreational and lifestyle resource for Darwin residents and intrastate, interstate and overseas visitors; and
- provide a significant stimulus to the business and tourism industries in Darwin and the Northern Territory.

Net Benefit

The project will generate a broad range of social, commercial and environmental benefits. These benefits include:

- revitalisation of the CBD and enhancement of the city environment;
- significant stimulation of Darwin business and the construction and tourism industries;
- \$600m in development value;
- \$550m economic benefit from the DCEC over a 25 year period;
- significant increase in visitor nights to the Darwin area;
- the generation of employment during the construction and operation phases;
- the provision of a major feature for the amenity of locals and tourists; and
- remediation of the contamination from past industrial activities, where required by the independent auditor.

The integrated redevelopment of the site with compatible residential, tourist, retail and recreational objectives will ensure the waterfront develops to be a central long-term asset to Darwin and the Northern Territory.

1.4 The Impact Assessment Process

1.4.1 Northern Territory Environmental Assessment Process

The environmental impact assessment (EIA) process in the Northern Territory is controlled by the *Environmental Assessment Act* 1982 and the Environmental Assessment Administrative Procedures 1984, which are administered by the Office of Environment and Heritage. An overview of the Northern Territory EIA process is shown in **Figure 1.5** and **Table 1.1**. The primary purpose of the process is to:

Table 1.1: Timeframe for the Northern Territory Environmental Impact Assessment Process

Stage Of EIA Process	PER	EIS
The proponent notifies the responsible Minister of a proposal including details (NOI).	Open	
The Responsible Minister notifies the Minister for the Environment and Heritage (the Minister) of the proposal.	Open	
The Minister may require further information from the proponent to assist in determining the level of environmental significance.	Within 14 days	
The Minister determines the level of assessment and notifies the responsible Minister and the proponent if a PER or EIS is necessary. The Commonwealth Government involvement may be required at this stage, depending on the nature of the proposal and the expected impacts.	Open	
Draft Guidelines for a PER or EIS are prepared.	Open	
Draft Guidelines are made available for public comment and referred to advisory bodies.	Within 14 days	
The Minister finalises the Guidelines, issues them to the proponent and directs the preparation of a PER or a draft EIS, if required	Within 14 days	
The proponent prepares the PER or draft EIS and submits it to the Minister.	Either determined by the Minister, or at the proponent's discretion	
The PER or draft EIS is advertised for public comment and circulated to advisory bodies for comment.	Max 28 days	Not less than 28 days
Public and advisory body comments are forwarded to proponent	-	ASAP
Proponent prepares the Supplement to the draft EIS and submits the Supplement to the Minister.	-	Open (usually)
The Supplement to the draft EIS is circulated to advisory bodies for comment	-	Within 14 days

**Table 1.1: Timeframe for the Northern Territory
Environmental Impact Assessment Process**

Stage Of EIA Process	PER	EIS
The Minister can request further information.	Within the above 28 days	Within 21 days of delivery of the Supplement
The report and recommendations on the PER is prepared. The Minister forwards the report and recommendations to the responsible Minister	Within 14 days of expiration of above 28 days	-
The assessment report and recommendations are prepared based on the draft EIS, the Supplement and comments received.	-	Within 35 days of delivery of the Supplement
Incorporation of recommendations in lease or license conditions, and relevant management procedures	Open	Open

- provide adequate information to allow appropriate examination of proposed projects which may cause significant environmental impact; and
- prevent unacceptable or unnecessary harm to the environment.

The legislation applies to both public works and private projects, and the EIA process may be triggered when an existing proposal or project is modified or expanded with a likely significant effect on the environment.

The detail of information required from a proponent and the level of assessment varies depending on the extent or significance of potential environmental impacts from the proposed development. This is affected by issues such as the sensitivity of the local environment and the scale of the proposal. The Northern Territory EIA process is described below.

Notice of Intent (NOI)

The initial notification of a proposed development is made to the Minister for the Environment and Heritage through a Notice of Intent (NOI). The NOI provides sufficient information to allow the Office of Environment and Heritage to determine if the proposed development could have a significant impact on the environment and the appropriate level of assessment needed for the proposal.

Determination of the Level of Assessment Required

If a proposal is considered to have a significant environmental impact, the Minister for the Environment and Heritage will direct the proponent to prepare and submit a Public Environment Report (PER) or an EIS. These documents are required to assist in assessing the environmental impacts of the proposal. A PER is called for to assist in assessing environmental impacts which are considered significant but limited in extent. An EIS is called for to assist in assessing environmental impacts which are considered significant either in terms of site specific issues, offsite issues and conservation values and / or the nature of the proposal.

Preparation of the EIS Guidelines

After consultation with relevant advisory bodies, the Minister prepares draft guidelines outlining the matters to be addressed in the PER or EIS. The draft Guidelines are open to public and government agency review for a 14 day period. The comments from this review period are used to finalise the EIS Guidelines, which are then forwarded to the proponent.

Preparation of the Draft EIS

The proponent prepares the Draft PER or EIS to address all issues noted in the final Guidelines. The Draft EIS is submitted to the Office of Environment and Heritage.

Public and government agency review of the draft EIS

The draft PER or EIS prepared by the proponent is exhibited for public review and comment for a defined period. The period for public review on a Draft EIS is a minimum of 28 days. Government agencies and advisory bodies also review the document over this period.

Assessment of the Proposal through the Draft EIS

After the public exhibition period, the proponent addresses comments and issues raised during the public and agency review by preparing a Supplement to the Draft EIS. The Supplement is circulated to advisory bodies for review and comment, and within 35 days the Office of Environment and Heritage prepares an Environmental Assessment Report and Recommendations for consideration by the Minister for the Environment and Heritage. The Minister liaises with other relevant Ministers to formulate recommendations on environmental safeguards as permit or licence conditions to minimise any adverse impacts on the environment arising from the project.

1.4.2 Commonwealth Environmental Assessment Process

Under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Environment and Heritage Legislation Amendment Act (No 1) 2003*, developments require assessment if they have the potential to affect any matters of National Environmental Significance (NES), namely:

- World Heritage properties;

-
- National Heritage places;
 - Ramsar wetlands of international importance;
 - listed threatened species and ecological communities;
 - listed migratory species;
 - Commonwealth marine areas; and
 - nuclear actions.

The EPBC Act also provides that:

- a person must not take an action on Commonwealth land that has, will have or is likely to have a significant impact on the environment;
- a person must not take an action outside Commonwealth land that has, will have or is likely to have a significant impact on the environment on Commonwealth land; and
- the Commonwealth (including a Commonwealth agency or corporation) must not take an action which has, will have or is likely to have a significant impact on the environment anywhere in the world.

Proponents of developments that may have an impact on a matter of NES, are required to submit a referral under the EPBC Act to the Commonwealth Minister for the Environment to enable the Minister to determine if the proposed development is a “controlled action”. If a proposal is deemed to be a “controlled action” then the subsequent EIA must satisfy Commonwealth concerns and Commonwealth approval is required for the project to proceed.

The level of environmental assessment applied to each referred action depends on the likelihood of significant impacts on the environment. The Commonwealth Minister of the Environment has a number of options, including:

- assessment of preliminary documentation;
- PER;
- EIS;
- public enquiry; or
- an accredited process (i.e. accreditation on a project-by-project basis).

1.4.3 Status of the Proposed Project in the EIA Process

Notice of Intent

An NOI for the proposed DCWR was submitted to the NT Government on 30 September 2003. The NOI documented the intention of DIPE to pursue the redevelopment, and enabled the Minister for the Environment and Heritage to determine that the proposal required an EIS to be prepared by the proponent. The Minister advised the proponent of this requirement in October 2003. The information within the NOI and consultation with relevant agencies assisted the preparation of EIS guidelines.

Public Review of Guidelines

Draft Guidelines covering issues to be addressed in the EIS were released for public and government agency review in mid October 2003. The final Guidelines (**Appendix A**) were issued to the proponent on 24 November 2003 and took into account comments received from the community and Government agencies.

Preparation and Submission of the EIS

The Draft EIS was developed between October 2003 and May 2004 using the information available at the time of preparation. Substantial consultation with the community, special interest groups and government agencies was undertaken. Extensive investigations covering specific areas of interest were also undertaken. The consultation and investigations carried out in the preparation of the Draft EIS are outlined in Section 9 and Section 1.5, respectively.

The Draft EIS was submitted to the Office of Environment and Heritage on the 28th of May 2004 and will be on public exhibition for 6 weeks.

Commonwealth Environment Protection and Biodiversity Conservation Act

The Proponent submitted a referral for the proposed project to the Commonwealth Minister for the Environment on 20 October 2003. On 13 November 2003 the Commonwealth Minister decided that the proposed development was not a controlled action. Approval is therefore not required under Part 9 of the EPBC Act before the action can proceed.

1.4.4 Relevant Government Legislation and Policies

Northern Territory Legislation

The Northern Territory Government has jurisdiction over environmental and other legislation relating to the siting, construction and operation of the DCWR. The *Environmental Assessment Act* 1992 and its

implications for the development are discussed in Section 1.3.1. The following is a list of the primary Northern Territory legislative requirements that may have a bearing on the proposed project.

- *Environmental Assessment Act 1992*

Outlined in Section 1.3.1.

- *Environmental Offences and Penalties Act*

The Act defines levels and penalties for environmental offences.

- *Planning Act 2003*

Provides for the planning and control of the use and development of land, which may or may not be subject to a planning instrument. The planning instrument is the NT Planning Scheme which consists of Development Provisions (town plans which specify land zoning), Land Use Objectives (planning policy) and Incorporated Documents. The Darwin Town Plan and the Central Darwin Planning Concepts and Land Use Objectives apply to the proposed development area. The Planning Scheme is supported by Town Plans in metropolitan areas that specify the development and use conditions for different zones. The Planning Act is in the process of being revised.

- *Heritage Conservation Act 1991*

The Act provides for the recording, declaration, conservation and protection of heritage and archaeological places and objects. The Heritage Conservation Regulations stipulate that prehistoric or protohistoric occupation places are prescribed archaeological places, and Aboriginal artefacts are protected also.

- *Water Act 2004*

The *Water Act* provides for the investigation, use, control, protection, management and administration of water resources within the NT. It provides a strategy for the management of the NT's water resources including tidal waters. Under this Act, "beneficial uses" have been declared in several coastal areas of the NT. The waters of Darwin Harbour (and the marine reaches of rivers draining into it) were declared to have beneficial uses for the protection of aquatic ecosystems, recreational water quality and aesthetics. It is an offence under this Act to pollute the declared waterways and impact on the beneficial uses. An information sheet from DIP describes the various beneficial uses (<http://www.ipe.nt.gov.au/whatwedo/water-resources/facts/pdf/BeneficialUses.pdf>).

- *Waste Management and Pollution Control Act 1999*

The Act places general environment duties on persons to not undertake an activity that pollutes or might pollute the environment unless the person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm. The Act provides for implementation of Commonwealth National Environmental Protection Measures (NEPMs) in conjunction with the *National Environment Protection Council (Northern Territory) Act*.

-
- *Soil Conservation and Land Utilisation Act 2001*

Provisions under the Act may be used to assist in protecting sensitive areas and assist in reducing impact of sediment on downstream areas. Under the Act, DIPE may request Erosion and Sediment Control Plans (ESCP) as part of the development approvals process.

- *Weeds Management Act 2001*

The Act classifies weeds and requires specific weeds to be dealt with under the provisions of the Act.

- *Marine Pollution Act 2003*

The objective of the *Marine Pollution Act* is to protect the marine and coastal environment from ship/boat (including dinghies) sourced pollution. This includes litter/ rubbish, hydrocarbons and substances that may be hazardous to the marine environment (including substances that may be in ballast water).

- *Parks and Wildlife Commission Act 2000*

This Act creates and gives powers to the Northern Territory Parks and Wildlife Commission, under the general mandate to promote and enforce where necessary the protection, conservation and sustainable use of wildlife, whether on parks, reserves or elsewhere in the Territory.

- Public Health (General Sanitation, Mosquito Prevention, Rat Exclusion and Prevention) Regulations 1998

This Regulation empowers the Chief Health Officer to issue directives on mosquito prevention such as drainage works and maintenance of drainage systems to avoid ponding of water and reed growth. Public lakes may require regular dosing with bacterial agents to control mosquito larvae.

- *Northern Territory Aboriginal Sacred Sites Act 2000*

This Act creates the Aboriginal Areas Protection Authority, which issues (Sacred Sites) Certificates for specific areas. These certificates advise of sacred sites within an area.

- *Crown Lands Act 2000*

This act prohibits the removal of timber and minerals including extractives (sand, soil or other) without a permit.

- *Fisheries Act 2004*

This Act makes illegal the polluting of waters where the effect of the substance is that fish or aquatic life are injured, detrimentally affected or the habitats, food or spawning grounds are detrimentally affected.

- *Litter Act 1999*

This Act prohibits littering and allows Council Officers to fine/prosecute offenders, including those found illegally dumping on vacant Crown Land within each Municipality.

Further detail of the key Northern Territory environmental protection legislation can be found at the DIPE website (<http://www.lpe.nt.gov.au/enviro/LEGISLAT/Legislat.htm>).

Commonwealth Environment and Heritage Legislation

The following Commonwealth Government legislation may have a bearing on the proposal.

- *Environment Protection and Biodiversity Conservation Act 1999*

Discussed in Section 1.3.2.

- *Australian Heritage Council Act 2003* retains the Register of the National Estate, which was originally established under the repealed *Australian Heritage Commission Act 1975*. Sites listed on the Register can be protected in conjunction with the *Environment Protection and Biodiversity Conservation Act*.

- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*

The Act aims to preserve and protect places, areas and objects of particular significance to Aboriginal and Torres Strait Islander people.

- *Aboriginal Land Rights (Northern Territory) Act 1976*

The Act provides for the granting of Traditional Aboriginal Land in the Northern Territory for the benefit of Aboriginal people.

- *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*

This Act provides for a system of controls on the manufacture, import and export of substances that deplete ozone in the atmosphere. It also provides for the institution of such controls for ozone depleting substances. The Act encourages Australian industry to replace ozone-depleting substances and achieve a faster and greater reduction in the levels of production and use of ozone depleting substances than are provided for in the Vienna Convention and the Montreal Protocol.

Territory Policy Considerations

There are a number of policy documents and draft legislative measures that may be relevant to the proposed development.

Darwin Harbour Regional Plan of Management

Although not finalised, the NT Government is evaluating the Darwin Harbour Regional Plan of Management, and will implement recommendations as appropriate, through incorporation into the NT Planning Scheme. The draft Plan aims to protect the environmental, recreational, cultural and heritage values of the Harbour while encouraging sustainable development.

Proposed Urban Stormwater Strategy

Under the National Water Quality Management Strategy the Northern Territory Government is obliged to implement an urban stormwater strategy and regulate urban stormwater systems in the Territory within a set timeframe. The NT Government is likely to develop a strategy in the near to mid term to regulate stormwater management.

Erosion and Sediment Control Guidelines

The soon to be released *Resource Management Guidelines for Soil Erosion and Sediment Control* will be a resource to assist the land owner/developer to satisfy their Duty of Care under the *Soil Conservation & Land Utilisation Act*.

Draft Environment Protection Objective for Management of Site Contamination

The NT Government has recently tabled a proposal to prepare a draft Environment Protection Objective (EPO) for the management of site contamination. The proposed EPO would be developed in accordance with Part 4 of the *Waste Management and Pollution Control Act* (WM&PC Act) and would set the rules for prevention, identification, assessment and clean-up or management of site contamination. The EPO is intended to provide greater certainty to landowners and developers, consistency of approach by regulators and transparency of process to the general community.

1.5 Investigations undertaken for the Draft EIS

An integrated schedule of environmental, geotechnical and site contamination studies has been undertaken to characterise the site and the environmental implications of the proposal. The following investigations and assessments have been undertaken to prepare the Draft EIS:

- contaminated Site Assessment (Phases 1, 2 and 3);
- geotechnical assessment;
- land use, geology and soils;
- hydrogeology;
- hydrology;
- terrestrial ecology (flora and fauna);

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- marine and intertidal ecology;
 - biting insects (mosquitoes and biting midges);
 - indigenous cultural heritage
 - historical (European) heritage;
 - visual impact;
 - air quality;
 - noise;
 - traffic and transport;
 - construction and waste management;
 - dredging, land reclamation and spoil disposal options;
 - oil spills and vessel discharges, including ballast water;
 - unexploded ordnance (UXO); and
 - social Impact Assessment (incorporating a socio-economic study).

1.6 Historical Overview of Land Uses at the Site

The Darwin port area was established around 1870 and has been utilised for varied port related and land based uses, and various industrial purposes, since that time. The original shoreline of the redevelopment site followed the base of Fort Hill, along the present Kitchener Drive and curved around the base of Stokes Hill. Kitchener Bay has been progressively reclaimed over the years (URS, 2003- Phase 1). An estimation of the original shoreline and major periods of land reclamation are shown on **Figure 1.6**. The land use history is most easily understood by considering seven major land use areas (URS, 2003) (**Figure 1.3**):

- Fort Hill area;
- bitumen plant area;
- warehouse area;
- Northern Cement Plant area;
- recent land reclamation areas;
- Stokes Hill area; and

-
- Kitchener Drive fuel pipelines and World War II storage tunnels area.

1.6.1 Fort Hill

The Fort Hill area has its origins from the earliest establishment of Port Darwin and Palmerston (later to be renamed Darwin). The foreshore below Fort Hill was the site of Goyder's landing for the initial surveys of the area in the 1870s. From these early days, Fort Hill became the site for unloading of shipping. Fort Hill Wharf handled stock in the early 1900s, expanding to broader trade in more recent decades, particularly the storage of iron ore (from the Frances Creek mine) and lead and zinc concentrate from Woodcutters Mine, which were loaded onto ships using a system of overhead conveyors. The site has also been used for the storage of barites, copper, copper sulphides, zinc sulphide and lead sulphide. In 1969 supply pipe lines were installed on the Iron Ore Wharf, which were reported to have been used for oil, LPG (1977) and sulphuric acid (1978). The fuel oil lines have been used to supply petroleum products to the Naval Fuel Installation (NFI), Shell Bitumen Plant and commercial oil companies. Cruise ships, and Australian and international Warships, frequently berth and refuel at the Fort Hill Wharf

1.6.2 Shell Bitumen Plant

The Shell Bitumen Plant was constructed in 1963, with the first bitumen shipment occurring in 1966. The Bitumen Plant was constructed on land that was reclaimed in the late 1950s. The former Tipping Shed to the west of the Bitumen Plant has been used for housing, workshops, a railway line and for iron ore export. The area to the south and south east of the Bitumen Plant was utilised for a Navy buoy shed and Sorting Shed/Bond Store in the 1940s. The Cockburn Cement silo was constructed in this area in the early 1980s and ceased operation in approximately 1993. The silo was demolished between April and June 2003.

1.6.3 Warehouse Area

Reclamation of the Warehouse Area appears to have occurred in the late 1960s. Uncontrolled fill was used and may have contained old aeroplane engines, ex-Army vehicles and natural material sourced from the excavation of Stokes Hill. Some of the reclamation in this area is also reported to have been undertaken using Cyclone Tracy debris. Since the area has been reclaimed, the major usage of this area has been for storage of shipping containers and goods for import and export. The south-western end of the Warehouse Area was used for a sandblasting operation and for fabrication works for the building of the New Fort Hill Wharf.

1.6.4 Northern Cement Area

This area was reclaimed in 1965 specifically for construction of the Northern Cement works. The fill material is assumed to comprise non-putrescible building and demolition waste. Throughout its operation, information suggests that the site was used for the storage of bulk dry materials with no mixing

of raw products undertaken. Information suggests that the site was used up until approximately 1999 with all infrastructure on the site demolished soon after closure.

1.6.5 Recent land Reclamation Area

The area to the south of the Warehouse Area between the Northern Cement Area and Stokes Hill remained part of Kitchener Bay until approximately 1975. From this time progressive landfilling was undertaken. Uncontrolled landfilling occurred until the early 1990s with deposited material including soils, demolition debris, construction materials, oil drums, vehicle bodies and machine parts. The eastern section of the area was completely filled to its current extent between 1991 and 1994 with relatively clean fill from demolition and excavation activity in the CBD.

1.6.6 Stokes Hill Area

The Stokes Hill area comprises the Fuel Tank Storage Area, the former Stokes Hill power station, Stokes Hill Wharf and the Steam Pump House area. The original Stokes Hill Wharf was constructed in the early 1880s. The Pine Creek-Darwin railway was completed soon after, with railway yards at the base of the wharf. The railway handled mainly stock for live export to the Philippines and some ore such as tin. The live export of stock was discontinued around 1920 when the United States closed the Philippines market. The railway suffered substantial damage from Cyclone Tracy and was abandoned in the late 1970s. The Steam Pump House was constructed in 1928 to pump fuel oil between the Town Wharf (Stokes Hill Wharf) and the NFI. Stage one of the current Stokes Hill Wharf was constructed in 1956 and was the prime general cargo wharf until the new Fort Hill Wharf became operational in 1984.

The NFI tanks were constructed in the late 1920s with pump houses and pipes along Stokes Hill Wharf. The area within Stokes Hill was first developed in 1939 with the installation of two above ground storage tanks within an excavated area of Stokes Hill. After the destruction of the original tanks during World War II, the area was left undeveloped until construction of replacement tanks in the 1970s. With the closure of the Stokes Hill power station, the non-naval tanks were no longer used. A concrete water tank was installed on the south-eastern edge of Stokes Hill in approximately 1968 and remains operational.

The Stokes Hill power station was constructed in the early 1960s and comprised steam-powered turbines. Cyclone Tracy removed the roof of the power station without causing other structural damage, however many of the components within the plant were severely water damaged. Generation of power for Darwin was relocated to Channel Island in the 1980s. The power station was demolished in the mid-1990's.

1.6.7 Kitchener Drive Fuel Pipelines and World War II Storage Tunnels

Construction of the WWII Storage Tunnel system, comprising six tunnels, commenced in 1943 with the aim of storing fuel without exposure to Japanese air raids. The system was not used for fuel storage during wartime, however tunnels 5 and 6 were used for approximately three years from 1955 for the storage of aviation fuel. Oil fuel lines have been present in this area since 1944. Further lines were

installed in the early 1960s for the bitumen plant and off-loading of fuel and refuelling at the Fort Hill and Iron Ore Wharves.

1.6.8 Wharves

The Darwin City Waterfront wharves include Fort Hill Wharf, Stokes Hill Wharf and the Iron Ore Wharf. These wharves are used by cruise ships, bulk cargo vessels, research ships, fishing and pearl industry vessels, and military vessels from the Royal Australian Navy and international navies. The wharves continue to be used for overflow shipping unable to berth at the East Arm Port. The wharves provide shipping with fuel and logistical support. There is a goods and cargo storage area for import and export activity and refuelling occurs through pipelines from nearby fuel storage tank facilities located near the redevelopment site.

1.7 Land Tenure and Planning Issues

1.7.1 Land Tenure

The site of the proposed development is owned by the NT Government, under the care of DIPE and the Darwin Port Corporation and no land acquisition is required. Darwin Port Corporation presently has tenure over lot 7249, which includes much of Kitchener Bay as well as Fort Hill and Stokes Hill wharves and the approach to Stokes Hill Wharf

The majority of the project site is covered by Lot 7248, though this Lot extends beyond the site. It includes the Fort Hill area, the area of reclaimed land south of the Stokes Hill Wharf access road and the fuel line easement along the north of Kitchener Drive. The area in the vicinity of Stokes Hill and the former power station is covered by Lots 5225, 6521, 6590 and 6604. The parcels of land within the site are described by the Certificates of Title information listed in **Table 1.2** and the land parcels are shown in **Figure 1.7**.

The following parcels are excluded from the development site:

- Lot 5251 [Vol 631, Folio 599, Plan S 97/011G], which is owned by the NT and will be used for heritage conservation of the Steam Pump House;
- a portion of Lot 6590 as shown on (**Figure 1.7**);
- Lot 6605 [Vol 653, Folio 668, Plan S 97/212B] which recently transferred to freehold title for the operation of a restaurant (*The Jetty*);
- a portion of Lot 6604 (as shown on **Figure 1.7**), which is leased to the Pumphouse Gang Pty Ltd under Crown Lease 1690 respectively;

- the major part of Lot 7249 (as shown on **Figure 1.7**) which is owned by the Darwin Port Corporation;

Table 1.2: Land title, Tenure and Ownership of Land within the Project Site

Lot	Whole or part of Lot	Volume	Folio	Town of Darwin Plan(s)	Tenure Type	Lot Area (Ha)	Owner
5225	Whole	0	0	S 78/019	Vacant Crown	7.56	Crown
6521	Whole	0	0	S 93/327B	Vacant Crown	0.03	Crown
6590	Part	631	600	S 96/219	Estate in Fee Simple	1.17	NT (DIPE)
6604	Part	643	373	S 97/212B	Crown Lease Term ¹	0.40	Crown
7248	Part	641	599	S 2000/157A	Estate in Fee Simple	143.9	NT (DPC)
7249	Part	664	576	S 2000/157A	Estate in Fee Simple	35.23	NT (DIPE)

- Notes:
1. The project site contains numerous easements for access and services. These easements will be rationalised as part of the redevelopment.
 2. Lot 6604 is to be surrendered to the Northern Territory in the near future.

- Lot 7398 which is leased to the Pumphouse Gang Pty Ltd; and
- a 7,500 m² secure staging area adjacent to Fort Hill Wharf.

Stokes Hill Wharf and Fort Hill Wharf are owned by the Darwin Port Corporation. Both wharves are excluded from the redevelopment site, although over time it is likely that they will continue to be developed to complement the facilities created by the DCWR.

It is likely that two Development Leases of the DCWR site will be granted to the eventual developer to provide title and access rights during the development phase of the DCWR Project.

1.7.2 Proof of Lease and other Authorisations

As noted in Section 1.6.1, the site of the proposed development is owned by the NT Government, under the care of DIPE and the Darwin Port Corporation.

1.7.3 Land Claims

Native Title claims

There are two Native Title claims under the Native Title Act 1993 centred on the Darwin Wharf area registered by the Larrakia People (National Native Title Tribunal Number DC96/7). The area under claim within the project areas is Lot 5225 (the Stokes Hill area) (**Figure 1.8**). Part of Lot 5706 (Lameroo Beach to the north-west of the project site) is also under claim. There are no outstanding land claims under the Aboriginal *Land Rights (Northern Territory) Act* 1976 affecting the project area.

The proponent's legal advice is that there are no Native Title impediments to the proposal.

Sacred Sites

The proponent obtained an Aboriginal Areas Protection Authority Certificate (C2004/04) on 13 January 2004, issued under the *Aboriginal Sacred Sites Act* (**Appendix B**). The Certificate identifies a Sacred Site (No. 5073-93) on Stokes Hill (**Figure 1.9**). It notes that the portion of this Sacred Site within the project area is a Restricted Work Area with no excavation allowed. In addition, no other works can be undertaken in this area without the formal approval of the senior Aboriginal custodians of the site.

1.7.4 Acquisition Requirements

No land acquisition is required. The Northern Territory owns all land within the project site.

1.7.5 Access Requirements

A number of businesses and other operations require continued access (including both pedestrian and vehicular access from the CBD) and uninterrupted services to facilities within and near the project site. These include:

- port activities at Fort Hill including berthing of naval and cruise ships and roll-on roll-off (RoRo) activities;
- the Secure Staging Areas at the base of Fort Hill Wharf;
- berthing and refueling activities at the Iron Ore Wharf;
- businesses and facilities on Stokes Hill Wharf;
- the Indo Pacific Marine, the Australian Pearling Exhibition and the Jetty Restaurant at the base of Stokes Hill Wharf;
- the tours of the WWII tunnels; and

-
- the Deckchair Cinema.

The eventual developer will be under contractual obligations to ensure uninterrupted access and service provision to these sites. These obligations include:

- maintenance of access and services to existing commercial activities on Stokes Hill and Fort Hill Wharves; and
- road access to Fort Hill Wharf, the RoRo facility and the Secure Staging Area with the capacity for buses and military vehicles, and with appropriately designed pavements and geometry.

The Commonwealth Department of Defence (Defence) has a 15 year licence (commenced 24 June 2003) from the Darwin Port Corporation for non-exclusive use of Fort Hill Wharf and the adjacent RoRo Facility. The deed of licence also requires the NT to make available to Defence an area of approximately 7500 m² in close proximity to Fort Hill Wharf for use as a military vehicle marshalling area from time to time. This area will be provided outside the DCWR site.

1.7.6 Zoning

The site is wholly within the Central Business Darwin zone of the NT Planning Scheme under the *Planning Act*. The objective of this zone is:

“to accommodate a diversity of activities including high density commercial, retail, residential and tourist facilities and to encourage the development of a mixed use area with a maritime theme near the foreshore consisting primarily of residential and tourist accommodation and commercial, entertainment and leisure facilities in conjunction with a limited expansion of the existing waterfront and maritime industrial activities.”

The policy under this zoning states that:

“Smith Street Mall is to remain a significant retail focus of the city centre. Mixed use developments, such as retail, office and residential will be encouraged to increase the residential component of the locality. Waterfront and maritime industrial purposes are described in the Darwin Town Plan 1990 as special purposes.”

A draft revised Planning Scheme has been developed, which labels the current Central Business Darwin zone as Zone CB (Central Business). The proposed purpose of this zoning is “to provide for a diversity of activities including administrative, judicial, professional, office, entertainment, cultural, residential, retail and other business activities while maintaining a commitment to the separation of incompatible uses. Building form and design is expected to be sensitive to the needs of pedestrian movement and should facilitate the creation of safe and active street frontages and public places and a vibrant commercial precinct.”

1.7.7 Timeframe and Project Schedule of the Proposed Project***Timeframe of the Proposed Project***

Aside from the Darwin Convention and Exhibition Centre (DCEC) and associated Stage 1 residential, commercial and public infrastructure works, which is expected to provide a catalyst for the entire redevelopment, the construction of residential, commercial and hospitality facilities will be reliant on market forces such as demand. The components and the timing of each stage of the redevelopment have not been confirmed and will be guided by the final Master Plan and demand for each facility proposed for the site.

At the time of preparing the Draft EIS, three short-listed proposals for the Master Plan were being prepared. The preferred proponent and their Master Plan will be finalised, and Public consultation and assessment of the Master Plan is planned to occur before December 2004.

Construction of the first stage of the development is expected to commence in early 2005. The timing of future stages of construction, particularly any residential developments, will be demand led.

Lifespan of the Project

Redevelopment of the site is anticipated to occur in stages over a 10 to 15 year period. Once all of the components of the final Master Plan have been completed, the Redevelopment Plan will be a permanent feature of the site.

Status of the Redevelopment

Extensive investigations to assess the location, level and type of contamination across the site have occurred during late 2003 and 2004. The results of site contamination assessments are being independently audited by a Victorian EPA (Vic EPA) Contaminated Land Auditor (CLA), which will lead to the finalisation of the remediation requirements. A draft Remediation Action Plan has been developed, and once this has been finalised and accepted by the independent Auditor the site will be remediated to the required level. A draft Site Management Plan has also been prepared which outlines the requirements for ongoing management of the site after remediation to ensure risks from any potential residual contamination are reduced to the extent practicable.

The removal of redundant industrial infrastructure and services has commenced, and this activity will continue as individual facilities are decommissioned and relocated. This initial work will also facilitate the project by clearing the site in preparation for the remediation of contaminated soil and groundwater. Pre-remediation site works also allow further investigation and characterisation of contamination in areas that are currently inaccessible.

Remediation actions to address the range of contamination issues across the site will be undertaken, starting as soon as practical, but likely from August or September 2004. This remediation work will be

based on the results of the contamination assessments and the conditions imposed by the Vic EPA CLA in his “Statement of Environmental Audit”.

Potential for Additional Development

The final Master Plan will be implemented over 10 to 15 years, and additional development in that timeframe is not expected.

Redevelopment of adjacent and nearby areas, such as Stokes Hill and Fort Hill Wharves, may occur in the future, and this may be encouraged by the redevelopment of the project site. However, any such redevelopment will be undertaken independently of the current project.

Objectives and Benefits of the Proposed Project SECTION 2

2.1 Objectives

The primary objective of the project is to invigorate the Darwin City Waterfront area, generate significant economic benefit to the Northern Territory and create an active precinct with new facilities and attractions that draws more Darwin residents and visitors to the area and the Darwin CBD.

The project aims to create a balanced and integrated world-class development that incorporates a broad range of land uses without any one dominating. These land uses will include:

- space for community activities;
- tourist attractions;
- the Darwin Convention and Exhibition Centre;
- commercial activities; and
- residential accommodation.

The redevelopment will connect the Darwin CBD, with the harbour by providing world-class facilities close to the waterfront without excluding the broader community from enjoying a waterfront lifestyle. It aims to attract greater numbers of tourists to Darwin, while maintaining the waterfront area for regular and accessible use by the people of Darwin. In particular, the project aims to reflect the tropical Top End environment, the history and culture of the region and the character of Darwin's lifestyle.

The project also aims to stimulate the further economic development of Darwin and the Northern Territory through the expansion of the region's infrastructure, a higher and more widespread profile for the city and increased tourism and business visitation.

These objectives will be coordinated with other initiatives affecting Darwin, the harbour and the region.

2.2 Benefits

The redevelopment will create a world class waterfront site with major financial/economic, social, urban design and environmental benefits for Darwin and the Northern Territory.

The DCWR will transform the area and create a community asset and provide a significant boost to the Darwin and Northern Territory economy and the business community. It will be a substantial investment which will expand the infrastructure base of Darwin and generate employment in the tourism, hospitality and services sectors during its construction and in operation.

The project will provide a major focus for highlighting and enhancing Darwin and the Northern Territory as a national and international tourism destination. It will attract a significant portion of the business tourism sector. Modelling has indicated that the redevelopment may generate 40,000 visitor nights per year, and this will have significant multiplier effect on the community. For comparison, the Adelaide

Objectives and Benefits of the Proposed Project SECTION 2

Convention Centre is estimated to provide a nine-fold multiplier effect with each dollar generated by the Centre bringing nine dollars to the city of Adelaide. This will bring commercial benefits for a range of sectors including retail business who will benefit from this extra spending.

Redevelopment of the site is proposed to be an integrated process rather than through multiple independent developments. The business arrangements for the redevelopment are to be established with a single consortium that will help to achieve consistent development design and ensure that the public assets that form part of the project will be of a high standard.

The project will open a neglected part of the Darwin foreshore for greater community use and enjoyment. Features that will facilitate this include:

- establishing a continuous promenade along the foreshore connecting adjacent areas at either end of the site;
- continuing the operation of Stokes Hill and Fort Hill wharves to maintain the economic benefits to the CBD from visiting cruise ships and navy vessels, as well as the maritime character of the area;
- continuation of food stalls on Stokes Hill Wharf; and
- providing a direct connection between the site and the Darwin CBD to encourage movement between both areas and expanding the recreational and commercial opportunities close to the city.

Environmental benefits include the remediation of the contamination from past industrial activities and the protection of the escarpment and its vine-forest vegetation as a green backdrop to the redevelopment.

2.3 Justification

Until recently, the Darwin Wharf Precinct was a focal point for trade, communications and defence. However with the removal of the major port facilities to East Arm, much of the area has become disused and semi-derelict. The project offers the opportunity to redevelop the industrial land on the fringe of the CBD into a place of importance to the people of Darwin. It will reclaim valuable and strategically situated land into the social and economic framework of Darwin, and utilise the site for the economic and social benefit of Darwin and the Northern Territory.

3.1 Introduction

The Guidelines for the EIS require analysis of reasonable alternatives to the various elements of the proposed project. The purpose of this analysis is to identify the most environmentally sound, cost-effective and practical means of accomplishing the broader project objectives. The primary objective of this project is to revitalise a disused and contaminated industrial area close to the Darwin CBD and create a more valuable, environmental economic and social resource.

3.2 Non-Development

The project site is a largely disused former industrial area that is now in a semi-derelict state. Parts of the site and adjacent areas are utilised by sections of the local community and visitors. However, a large portion of the area is inhospitable with redundant or semi-used industrial buildings and infrastructure with residual contamination from past land uses. Most of the foreshore within the site does not allow easy or enjoyable access.

Leaving the site in its current state will not generate the economic benefits listed previously, including:

- increased private and business tourism;
- employment during construction and ongoing operation; and
- a broader profile for Darwin and the Northern Territory within Australia and internationally.

Non-development will not realise the social and community benefits from opening up a neglected part of inner Darwin and establishing a balanced and inviting area for use by Darwin residents and visitors. It will not bring the expected increase in the range and number of attractions in the vicinity of the CBD.

Not proceeding with the project is also likely to leave the existing contamination from past land uses remaining on the site, with the risk of future spread of some contaminants to the harbour environment.

3.3 Alternative Locations and Layouts for Components of the Proposal

3.3.1 Darwin Convention and Exhibition Centre (DCEC)

The initial primary driver for the Redevelopment was the DCEC. Significant analysis has been done on the optimum location for the DCEC. Initially, nine possible sites were considered in detail for the DCEC (PricewaterhouseCoopers, 2003):

- the MGM Hotel Casino (Mindil Beach);
- the old hospital site on Lambell Terrace (between the CBD and Cullen Bay);

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- the Post Office car park in Cavenagh St (CBD);
 - the old primary school in Woods St (CBD);
 - the wharf precinct along Kitchener Drive;
 - the Holiday Inn on the Esplanade (formerly the Carlton Hotel) site (CBD);
 - adjacent to Parliament House in Herbert St (CBD);
 - the Chan Centre in Smith St (CBD); and
 - Admiralty House on the Esplanade (CBD).

The current wharf precinct area was given the highest ranking of these sites for the following key evaluation criteria:

- a minimum size of two hectares;
- sufficient parking capacity and space for semi-trailers to unload;
- potential to develop or enhance themes at the site;
- marketability (including attractiveness for events and capability for integration with the waterfront);
- pedestrian accessibility to and from Smith St Mall;
- proximity to the CBD;
- pedestrian accessibility to and from the hotel precinct;
- compatibility of land uses and aesthetics;
- the potential to act as a catalyst for redevelopment;
- minimal traffic impact;
- the capacity for complementary uses;
- ease of servicing the site; and
- visitor amenity (including safety and noise).

The PricewaterhouseCoopers report noted that:

The Wharf precinct has the capacity through its careful masterplanned redevelopment using the convention and exhibition centre as its flagship to elevate Darwin as a major destination for tourists and locals alike to celebrate this unique Australian city.

The wharf precinct was assessed by PricewaterhouseCoopers (2003) as being particularly suitable because of:

- its potential to integrate with and economically reinforce the CBD;
- the potential of the DCEC to stimulate broader redevelopment of the site;
- the availability of adequate land area under Northern Territory ownership;
- marketability of the waterfront landscape; and
- the potential to open up the foreshore areas to the public.

The potential of the DCEC to stimulate broader redevelopment has consolidated the potential of the Redevelopment Concept Plan. The integration of DCEC, within a Waterfront Redevelopment Concept, increases value and limits the potential for other sites to emerge with the same wide range of benefits.

3.3.2 Residential development

Residential development(s) is expected to be included in the redevelopment of the project site. Other areas close to the Darwin CBD have been, and are being progressively, redeveloped for medium to high density housing. However, few of these sites offer the residential amenities that the project site contains. The features of the site, including the waterfront location, the extended promenade, the ready availability of restaurants and cafes and the focal point for community gathering, will attract a range of prospective residents and not compete with nearby residential areas. Inclusion of residential areas will also contribute to the amenity of the redeveloped site by maintaining use of the area over a greater part of the day.

4.1 Introduction

The Concept Plan for the DCWR (refer to Section 1.2.2 and **Figure 1.4**) provides a framework for the redevelopment and indicates the range of land use activities it may include. In particular, the Concept Plan notes any industrial or other incompatible uses of the land will be excluded.

The preferred Master Plan for the redevelopment which builds on the current Concept Plan, will confirm components of the site, including their exact locations and the staging and timeframe for the Redevelopment. The Master Plan will aim to integrate the existing commercial, entertainment, tourism and wharf activities with an expanded recreational and business base within the area, while also establishing a visual and functional connection between the site and the Darwin CBD. It will include:

- the full design concept for the redevelopment;
- project models and site plans;
- design and documentation for the DCEC;
- feasibility studies and design analyses; and
- a financial analysis and assessment.

It will also define the necessary management structure and contractual arrangements to carry out the redevelopment and detail the local industry participation in the project.

Redevelopment of the site (with the exception of the DCEC) is expected to be funded on a private commercial basis in partnership with the Northern Territory Government. The Government will provide the following investments into the redevelopment:

- \$100M towards the development of the DCEC and associated infrastructure;
- the site for redevelopment; and
- headworks, timed to integrate with the stages of the development.

The Redevelopment is expected to occur in stages over a 10 to 15 year period based on the timing of demand for the different components.

Given the previous industrial uses of the land and the inclusion of residential and recreational activities, remediation of portions of the site will be required. This section provides further details about the project. Issues related to the post remediation site preparation phase of the redevelopment, including infrastructure, required temporary facilities, workforce etc, are addressed in the Construction Environment Management Plan (refer to Section 8.9.4).

4.2 Location Details

The proposed site for the redevelopment is the existing Darwin Wharf Precinct on southern end of the short peninsular on which the Darwin CBD is located (refer to Section 1.2.2 and **Figures 1.1** and **1.2**). The site is approximately 2 km from the entrance to Darwin Harbour at the head of Frances Bay on the north-east shore of the harbour. The project site is located approximately 8 km south-west from Darwin International Airport, and 6 km north-west of East Arm Port. Other natural features include the entrance to Middle Arm 7.5 km south, the entrance to West Arm 12 km south-west, Charles Darwin National Park 3 km to the north-east, Wickham Point 6 km to the south, and the Western Shore of Darwin Harbour 9 km to the west of the site.

The area of approximately 25 hectare includes the land to the south-west of the escarpment and Kitchener Drive from the Fort Hill area in the west to the site of the former Stokes Hill power station and the old Deckchair cinema site. The southern portion of Stokes Hill is included, however, the NFI on the northern side is not. The site also includes the intersection of McMinn Street and Kitchener Drive, and a narrow section of the escarpment along the Smith Street axis.

The Kitchener Bay wharves (Stokes Hill, Old Fort Hill, New Fort Hill and Iron Ore) are outside the project site, but their use and development may be affected indirectly by the project. The area at the base of Stokes Hill wharf (including *The Jetty* restaurant) and the Steam Pump House are not part of the project site.

4.3 Proposed Land uses

The Project Site

The following details of the proposed future land uses at the site have been obtained from the Concept Plan (**Figure 1.4**).

General features of the proposed redevelopment include the following.

- The foreshore will include a broad pedestrian promenade, likely to extend the full length of the site and connect to adjacent walkways.
- The DCEC will be constructed at the site (1,500 seats and 4,000 m² of exhibition space). The specific location has not been determined.
- Residential development is likely to be focused on the former Stokes Hill power station site and the Fort Hill Area, with some development across the whole of the site.
- The escarpment will be maintained as a buffer of vegetation and a backdrop to the site.
- In general, unless deemed appropriate, building heights on the central section of the site will be restricted to no greater than RL 25 m (the height of the escarpment) to maintain the panorama from the escarpment.

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- Significant areas of open space will be incorporated into the site. The proportion has not been determined.

The redevelopment may include further reclamation of Kitchener Bay. Current operations and commercial, retail and recreational activities on Stokes Hill and Fort Hill Wharves will continue.

Fort Hill Area (refer to **Figure 1.3**) covers approximately 5.1 ha located at the western end of the Wharf Precinct. The proposed land use for this area is medium to low density residential housing, commercial and retail. The Concept Plan suggests that building height may be encouraged to mimic the former landform of Fort Hill, with some taller tower structures envisaged. Sites along the wharf will be reserved for a diverse range of community, entertainment, exhibition, residential development and tourist oriented retail. The old (inner) Fort Hill Wharf will be demolished for safety reasons.

Bitumen Plant Area is approximately 1.7 ha and lies on the eastern side of the Fort Hill Area. The proposed land uses for this area are open space and light commercial business operations and residential. The existing plant will be demolished and the site remediated by November 2004.

Warehouse Area, covering approximately 4.2 ha at the centre of the Wharf Precinct, is bounded by the Bitumen Plant Area to the east, Kitchener Drive to the north and the Recently Reclaimed Area to the south. The proposed future land uses for this area are mixed and include public open space, residential housing and commercial business operations, such as the possible siting of the convention centre and hotels. This area will likely include some form of landmark structure to integrate the site with the existing CBD.

Old Northern Cement Plant Area is approximately 0.6 ha, located between the Bitumen Plant to the west and the Recently Reclaimed and Warehouse Areas to the north. The proposed land uses for this area are public open space and light commercial business operations, such as the possible siting of the convention centre, hotels and residential development.

Recently Reclaimed Area, an area of approximately 4.1 ha, lies to the south of the Warehouse Area in the centre of the Wharf Precinct. The proposed land uses for this area are open space and commercial businesses, such as the possible siting of the convention centre, hotels and residential development.

Stokes Hill Area covers approximately 5 ha in the eastern portion of the project site. The proposed future land use for the level area to the north-east of Stokes Hill (the former power station site) is a landmark residential tower development. Stokes Hill is registered with the Aboriginal Areas Protection Authority as a Sacred Site, and no works can be undertaken without the formal approval of senior Aboriginal custodians of the site. The fuel tanks currently in the depression of Stokes Hill will be demolished and the site rehabilitated to remove a source of hydrocarbon contamination. This will be negotiated with senior Aboriginal custodians of the Sacred Site. The eventual land use for Stokes Hill has not been determined.

Adjacent Areas

Much of the existing land uses in adjacent areas are not expected to be affected directly by the proposed project. The fate of the Iron Ore Wharf has not been determined and it may be demolished if no appropriate use can be identified for it. The existing conveyors and ship loader will be removed from the site. Refuelling activities are likely to remain, but commercial fuel off-loading is intended to cease when alternative means of providing fuel have been established.

The operation of the NFI adjacent to Stokes Hill will continue in the short to mid term. Long term operation of the facility is being negotiated with the Federal Government and the Department of Defence.

Easements across the site will be rationalised as redundant services are removed and new infrastructure is developed.

4.4 Proposed Tenure and Zoning

The Project Site

The project site will remain under the ownership of the Northern Territory Government and be handed to the developer as freehold as the project is developed. The site will be developed progressively through a Public Private Partnership between the Northern Territory Government and the selected private developer. Build, Own Operate and Transfer (BOOT) arrangements are expected for the construction and operation of the DCEC, with suitable key performance indicators to ensure the economic return to the Northern Territory is maximised. Under such arrangements the developer would hold a lease to operate the Centre, with the land and the building transferring to government ownership at the expiry of the concession period.

It is likely that the land will become part of the rateable area for Darwin City Council.

Adjacent Areas

The redevelopment is not expected to affect the tenure and zoning of adjacent areas. The redevelopment is likely to significantly increase the amenity and value of adjacent areas.

4.5 Major Components of the Proposal

The Concept Plan for the redevelopment depicts a notional range of land use and activities and specifically excludes any incompatible industrial or related land use and activities. The specific nature of the development will not be determined until the preferred Masterplan is announced.

Possible components of the development include:

- passive and active areas of open space to encourage a diversity of community- oriented recreation, activities and functions;
- community uses and tourist attractions such as a visitor centre, cultural / heritage centre, and public buildings;
- the Darwin Convention and Exhibition Centre;
- residential development;
- commercial and retail activities, such as cafes and kiosks;
- hotel(s);
- serviced apartments;
- leisure craft moorings and associated marina-oriented commercial and public transport facilities;
- a focal "landmark" feature;
- raising the level of low-lying land, on which buildings are to be constructed, to RL 6.5 m AHD above the storm surge level for a 1 in 1000 year average occurrence interval event [0.1 % Annual Exceedance Probability (AEP)], which includes a 0.3 m allowance for rise in sea level to take account of long term global warming
- construction of a revetment structure along the coast comprising armour rock, sheet piles, precast concrete retaining wall sections or similar. Alternatively a sea wall maybe constructed off shore;
- land reclamation in Kitchener Bay requiring dredging of marine mud;
- construction of a marina or jetties in Kitchener Bay including dredging of marine mud; and
- minor reclamation and/or marine structures such as a jetty adjoining the western side of Fort Hill.

The most significant single feature of the redevelopment will be the DCEC, which will comprise a 1,500-seat convention centre, 4,000 m² of exhibition space and provision for car parking and cover approximately 10,000 m².

Components of the development considered to be desirable planning features are:

- continuous public access along the length of the waterfront to maximise public accessibility, most likely as a promenade;
- significant public open space. An attractive waterfront with a diversity of activities and functions avoiding incompatible land and water-based activities;

-
- focal ‘landmark’ feature to achieve orientation and create a sense of place;
 - pedestrian connections to the CBD along the Smith Street axis;
 - a strong visual and functional access to the waterfront, and automated pedestrian facilities providing access to the civic and retail areas of the city;
 - road realignment of McMinn Street and Frances Bay Drive to improve direct vehicle and public transport access, and pedestrian accessibility;
 - potential development sites along the waterfront reserved for a diverse range of community, entertainment, exhibition, and residential development, and tourist-oriented retail activities; Varied building height where appropriate to encourage uniquely interesting cityscape and skyline views of the escarpment;
 - diversity in building mass and heights to avoid a monotonous harbour-front image;
 - numerous vistas to the waterfront and harbour between buildings;
 - passive/active areas of open space incorporating community and recreation-oriented facilities;
 - decommissioning and refurbishing the Iron Ore Wharf for a future use related to the redevelopment, and/or to maintain Naval operations excluding bulk fuel off-loading.

4.6 Layout of Major Components

The exact location and layout of the components of the redevelopment including access and circulation roadways have not been determined. The Concept Plan for the redevelopment gives an indication of the possible locations of general land uses across the site.

4.7 Associated Headworks

The Northern Territory Government will provide associated infrastructure to the site boundary in support of the redevelopment. Associated headworks that are proposed included:

- roads, including vehicular, pedestrian and bicycle access;
- water supply, sewage and drainage; and
- electricity.

4.8 Staging of Development

The redevelopment of the site is expected to be undertaken over a 10 to 15 year period because of economic and commercial requirements. The site is likely to be redeveloped in stages, which may comprise:

- construction of the DCEC, vehicle and other access networks to service the Centre, the foreshore promenade, and other complimentary facilities including residential and commercial accommodation;
- construction of other public infrastructure and private facilities such as cafes and restaurants; and
- construction of residential developments in one or more stages depending on demand.

5.1 Introduction

5.1.1 Overview

This section focuses on the physical, biological, built, cultural and socio-economic components of the environment. Issues related to land administration have been addressed in Section 1.6. These issues include:

- proposed tenure and zoning of the site;
- land claims under the *Native Title Act* and the *Aboriginal Sacred Sites Act*;
- acquisition requirements; and
- access requirements.

The current and proposed land uses within the site are discussed in Section 4.

5.1.2 Field Surveys

Elements of the existing environment were characterised by extensive ecological, geotechnical, hydrogeological and contaminated site investigations.

An initial site investigation was presented in the report “Phase 1 Site Contamination and Geotechnical Preliminary Site Investigation Report and Sampling Analysis Plan – Darwin Waterfront Project” (URS 2003). This initial site investigation involved site walkovers, review of historical documentation and interviews with relevant people in order to characterise the potential contamination and geological conditions present at the site. The Phase 1 investigation formed the initial basis for the contamination and geotechnical assessment, presented in the report “Phase 2 Detailed Site Contamination Investigation and Field Geotechnical Investigation Report – Darwin Waterfront Project” (URS, 2004). A further stage of site assessment (Phase 3) was undertaken in early 2004 to further investigate and, characterise site contamination.

A summary of all other investigations and surveys conducted as part of the Draft EIS are presented below:

- An investigation of marine sediment quality was conducted from 31 October to 4 November 2003 by URS. The objective of the survey was to characterise typical heavy metals, tributyltin (TBT) and hydrocarbon concentrations within the intertidal and subtidal sediments of the project area. The results of the marine sediment quality assessment are presented as **Appendix C**.
- An investigation of the surface hydrology was undertaken in February 2004 by URS. The scope of the investigation assessed the existing drainage at the site and the potential impacts of the DCWR project. Preliminary plans for erosion and sediment control, water management in ponds and

swimming pools, and stormwater runoff are presented in the study. The results of the surface water hydrology investigation are provided as **Appendix D**.

- An investigation of the site hydrogeology was undertaken in February 2004 by URS. The investigation assessed the existing hydrogeology and the potential impacts of the DCWR project on groundwater at the site as well as potential measures to minimise the effects. The result of the hydrogeology investigation is included as **Appendix E**.
- A survey of the terrestrial and intertidal flora within and adjacent to the project site was conducted by Kristin Metcalfe, Consultant Environmental Scientist, between 19 January and 22 March 2004. The survey was conducted from the mid to late Wet season, a suitable time to investigate a wide range of species. The terrestrial and intertidal flora report is presented as **Appendix F**.
- The terrestrial fauna of the DCWR area was documented through field surveys conducted by Indicus Biological Consultants from 26 to 30 November 2003. The field survey was conducted over three transects with the use of traps. The study also incorporated the results of relevant previous surveys in the area. The terrestrial fauna study report is presented as **Appendix G**.
- A survey of frog fauna in the DCWR area was conducted on four occasions during March 2004. The Graeme Sawyer (Northern Territory Frogwatch Coordinator) and Ian Morris conducted the survey. The investigation was conducted by distinguishing frog calls, visual sightings and tadpole identifications. The results of the frog fauna survey are presented as **Appendix H**.
- Samples of freshwater macroinvertebrates were taken from ephemeral watercourses at the project site by URS and identified by specialists with the Environmental Research Institute of the Supervising Scientist.
- A survey of biting insects, including biting midges and mosquitoes, was conducted by the Medical Entomology Branch (MEB) of the Northern Territory Department of Health and Community Services during the 2003/2004 Wet season. Knowledge of the potential breeding areas of mosquitoes and biting midges and mosquitoes will assist in developing management strategies to combat biting insects problems and reduce risk of insect-borne disease. A report on the biting insects of medical importance affecting the DCWR site is included as **Appendix I**.
- Indigenous cultural heritage was investigated by Austral Archaeology to identify use of the area by Aboriginal people and sites of significance to Aboriginal people. **Appendix J** presents the results of the anthropological study and **Appendix B** presents the relevant Sacred Site Certificate issued by the Aboriginal Areas Protection Authority (AAPA).
- Bob Alford, Heritage Consultant conducted an investigation of the European (historical) heritage of the DCWR site, to assess the significance of any historical archaeological materials that might occur in the DCWR area. The report from the historical review is included as **Appendix K**.
- SVT Engineering Consultants conducted an acoustic assessment of the DCWR precinct. An assessment of the existing environment, the impacts of the proposed development and potential

mitigation measures were conducted as part of the investigation. The result of the acoustic assessment is presented as **Appendix L**.

- A visual impact assessment was conducted by URS in January and February 2004. The investigation was designed to identify the range and type of view situations, the visual catchment and visual user groups. Recommendations were made for potential design techniques to reduce future visual impact. The result of the visual impact assessment is presented as **Appendix M**.
- A traffic impact assessment was conducted of the DCWR and surrounding area by Andrew Leedham, Traffic Engineer with Connell Wagner. Surveys of the current traffic volumes were conducted and forecasts of traffic volumes due to the development activity were presented. The results of the traffic impact assessment are included as **Appendix N**.
- Communications Consultants SOCOM conducted a series of community consultations. These consultations involved traditional owners, the general community, government agencies and major stakeholders to seek feedback on the proposed Redevelopment. The majority of discussions were held in workshops from the 19 to 21 January 2004 and followed up in April 2004. The results of the community consultation are presented as **Appendix O**.
- A UXO assessment was carried out by G-Tek Australian Pty Ltd. The results are included as **Appendix R**.

Desk-top assessments were conducted by URS experts of the following issues using existing available data:

- Land use, geology and soils;
- Hydrogeology;
- Hydrology;
- Air quality; and
- Construction and waste management.

5.1.3 Literature Review

A wide-ranging review of published literature and technical reports was carried out in the course of preparing the EIS. Details of the references cited in the text are provided in Section 12.

The major sources include several environmental and historical studies on Darwin Harbour and adjacent areas, as well as previous environmental impact reports and statements.

5.1.4 Consultations

Consultations were undertaken with experts in various specialities related to the project. The assistance provided by the persons consulted is acknowledged in Section 9.

5.1.5 Limits of Site Contamination Information

The information about site contamination is based on an ongoing investigation. Preliminary advice about the type and level of contamination has been included in this document, however advice may change as further assessment and interpretation are carried out. Further details about the limitations on the assessment of contaminated soil and groundwater are noted in Section 13.

5.2 Physical Environment

5.2.1 Climate and Meteorology

The closest meteorological station with comprehensive climatic data to the project site is at Darwin Airport, a distance of approximately 7 km to the north-east. The Darwin Wharf Precinct lies within the monsoonal (Wet/Dry) tropics of Northern Australia and experiences two distinct seasons: a hot, wet season from November to March and a warm, dry season from May to September. April and October are transitional months between the Wet and Dry seasons (Parkinson, 1996). The meteorological characteristics of the Darwin area are detailed in **Appendix P**.

The distinctive seasonality of rainfall is the most distinguishing feature of the regional climate. There is a pre-Wet season transitional period, commonly referred to as "the build up", during October and November. This period is characterised by thunderstorms occurring at irregular intervals prior to the onset of the more predictable rain systems associated with the monsoon trough during the Wet season (Dames and Moore 1994). Darwin has a mean annual rainfall of 1,711 mm (111 rain days), most of which falls within the Wet season (Bureau of Meteorology, 2004). Humidity over this period averages 70–80%. In the Dry season humidity is often below 35–55% and there is virtually no rainfall. Monthly mean evaporation ranges from 167 mm in February to 259 mm in October. The mean annual evaporation is 2,630 mm.

While the maximum temperatures are defined as hot all year round, November is the hottest month with a range of 25 to 33°C. June and July normally experience the lowest monthly minima with a range of 20 to 30°C (Bureau of Meteorology, 2001). Darwin has a yearly average of 8.5 sunshine hours per day, with August experiencing the highest monthly average of 10.3 hours per day.

Prevailing winds during the Wet season are light west to north-westerly, freshening in the afternoon due to sea breezes. In the Dry season, the prevailing winds are the south-easterly trade winds (Parkinson 1996). Seasonal wind direction and strengths are shown in **Figure 5.1**.

The monsoonal tropics also experience cyclonic activity. The strongest winds and heaviest rainfall are associated with the passage of tropical cyclones, which can occur in the region at any time during the period November to April, and occur on average once every two years. Tropical cyclones cause most damage within a distance of 50 km from the coast; once a cyclone has passed onto land it weakens rapidly, but resultant storm surge can be of concern to coastal developments and flood damage can result from associated squally rains. **Figure 5.2** indicates the average annual number of cyclones across northern Australia (Bureau of Meteorology, 2003). **Table 5.1** shows the occurrence and intensity of cyclones affecting the Western Arafura and Timor Seas (west of 135°E) between November 1963 and April 2000 (Evans, undated), and indicated peaks in cyclonic activity during December and March/April.

Table 5.1 Cyclones affecting the Western Arafura and Timor Seas

Category	Nov	Dec	Jan	Feb	Mar	Apr	Total
C1		6			4	2	12
C2		1	4	2	4	2	13
C3,4,5	1	4			1	3	9
Total	1	11	4	2	9	7	34

Figure 5.3 shows the median maximum wind gusts during each month of the year between 1959 and 2000. This figure also shows the range of maximum wind gusts for each month. The association with cyclonic activity is indicated by the peak wind speeds during December and March/April.

5.2.2 Topography

The Darwin region is characterised by low, generally flat plateaus with an average elevation of 15 m and occasional rises of up to 45 m. The DCWR area is generally flat at the base of the escarpment on which the Darwin CBD is situated (RL 25 m) (**Figure 1.3**). The flat areas of the site range in elevation from 4 to 7 m AHD, with Kitchener Drive at the base of the escarpment ranging in elevation from 6.5 to 7.0 m.

Apart from the escarpment adjacent to the site, Stokes Hill is the major topographic feature in or near the site, rising to about 25 m. The sides and top of Stokes Hill have been excavated to accommodate fuel storage facilities, however it remains a significant landscape feature. Until the 1960s, Stokes Hill was similar in profile to Fort Hill at the opposite end of Kitchener Bay. However, Fort Hill was levelled in the early 1960s to gain fill for reclamation of the surround foreshore areas and to provide additional level ground for port facilities.

The existing foreshore along the site consists of exposed fill material. A section of the foreshore in the central section of the site has a vertical 2 m sea wall supporting the reclaimed area.

The marine sediments in Kitchener Bay are relatively flat and are approximately 3-5 m lower than the adjacent reclaimed areas and approximately 7 m lower than the Fort Hill area.

5.2.3 Geology

The 1:100,000 scale ‘Darwin’ (1983) Geological Survey of Northern Territory Map (Sheet No. 5073), indicates that the geology underlying the proposed development generally comprises (**Figure 5.5**):

- Quaternary sediments along the foreshore consisting of mud, clays, silts, intertidal marine alluvium; underlain by;
- Bathurst Island Formation sediments of the Lower Cretaceous Period, comprising radiolarian claystone; sandy claystone; clayey sandstone; quartz-sandstone; ferruginous sandstone; glauconitic sandstone, underlain by;
- Burrell Creek Formation of the Finnis River Group, comprising siltstone; shale; sandstone (quartz arenite, sublitharenite); quartz pebbles conglomerate; metamorphosed to lower greenschist facies (referred to below as phyllite).

5.2.4 Soils

Soils in the Project Area

The project area comprises up to four main soil/rock units (URS 2004 Phase 2 CSA) (**Table 5.2**):

- Unit 1 – Fill (mixture of silt, gravel, cobble and debris);
- Unit 2 – Marine Sediment (mud);
- Unit 3 – Alluvium/Colluvium (gravely silty clay);
- Unit 4 – Bedrock (phyllite)

Typical subsurface cross-sections are shown on **Figures 5.6, 5.7 and 5.8**. The top layer (unit 1) is typically fill material ranging from soft/loose to firm/dense in consistency. At most locations the fill material is clean and ranges from Silt (Crushed Phyllite) to Gravel (Phyllite, Porcellanite and Siltstone) and with varying amount of Silt and Gravel in between. The phyllite gravel is very weak and in most cases can be broken by hand. The Porcellanite and siltstone gravels are generally of medium strength and require several hammer blows to break. In other places, the clean fill is mixed with variable amounts of concrete and building debris.

Underlying the fill is weathered Phyllite (Unit 4) bedrock at the Fort Hill and Stokes Hill areas and along Kitchener Drive. A layer (Unit 2) of firm marine/mud sediments (Clay/Silty Clay) of variable thickness underlies the fill material in all reclaimed areas seaward of Kitchener Drive, the Fort Hill area and Stokes Hill. This unit also occurs across Kitchener Bay. The third soil unit (unit 3), where present, is a colluvium/alluvium layer of hard/dense Gravely Clay/Clayey Gravel. The bottom stratum is moderate to completely weathered Phyllite bedrock (Unit 4).

The site has been heavily disturbed with extensive importation of fill material for reclamation of Kitchener Bay, the leveling of Fort Hill and widespread industrial development. Numerous areas of

exposed soil and fill material occur through the site with significant likelihood of erosion during the Wet seasons.

The conceptual land use is generally compatible with the existing soils and geology. The Fort Hill and Stokes Hill areas are more suited to heavier loaded structures due to the more competent subsurface conditions. Taller structures are more suited to areas that have been cut into the original hills as part of previous earthworks. The reclaimed Kitchener Bay areas are more suited to lightly loaded structures if shallow foundations are employed.

Table 5.2: Assessment of Soil and Rock Units

Soil/Rock Unit	Material Description	Excavation Characteristics	Drainage Status	Erosion Potential	Problem Soils	Comments
1	Fill – soil and rock, mixture of Silt, Gravel, Cobble.	Diggable	Poorly to imperfectly drained	High - in loose state	Moderate - some loose/soft soils	Extremely low CBR when soaked in water. Variable in thickness and density
1	Fill – soil and rock, mixture of Silt, Gravel, Cobble with debris (building, domestic and industrial waste)	Diggable with more effort	Poorly to imperfectly drained	High – in loose state	Low to Moderate - with debris	Debris variable in nature. Variable in thickness and density
2	Marine Sediment – onshore, Silty Clay/Clayey Silt.	Diggable	Poorly drained	Low	High - Acid sulfate soils/soft soils	Highly plasticity clay, acid sulfate/potential acid sulfate soil
2	Marine Sediment – offshore, Sandy Silty Clay/Clayey Silt with gravel.	Diggable	Poorly drained	Low	Low -no Acid Sulfate soils in top 1.0m	Interbedded layers of sand and gravel.
3	Alluvium/Colluvium - Gravely Silty Clay	Diggable	Poorly drained	Low	Low	-

Table 5.2: Assessment of Soil and Rock Units

Soil/Rock Unit	Material Description	Excavation Characteristics	Drainage Status	Erosion Potential	Problem Soils	Comments
4	Bedrock – weathered Phyllite, metamorphosed Siltstone.	Rippable	Poorly drained	Low to Moderate	Low	Soil-like, friable and breaks down to silt when mechanically disturbed.
4	Bedrock – less weathered Phyllite, metamorphosed Siltstone.	Rippable with more effort	Poorly drained	Low	Low	Weak, soft and friable rock.

5.2.5 Existing Soil Contamination

Overview

Soil contamination varies across the site and may be due to both natural sources (with respect to certain metals) and historical land uses. The types of contaminants found within the soil and/or marine sediments include:

- elevated concentrations of metals (arsenic, barium, cadmium, copper, lead, manganese, mercury, nickel and zinc) above human health and/or ecological guidelines;
- hydrocarbons, including total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs), typical of heavy fuel oil and chlorinated hydrocarbons, potentially from fuel storage tanks
- tri-butyl tin;
- significant areas of visually impacted material (e.g. by ore concentrates); and
- small quantities of miscellaneous contamination associated with waste fill materials.

Whilst there is potential for asbestos wastes to be located in areas of fill and the former Stokes Hill power station area, no significant evidence was noted during the Phase 2 and Phase 3 site investigations., Investigations have shown positive results for dioxins, however the results are not conclusive. Further assessment is proceeding to clarify the issue.

Metals

Metals have been found in areas associated with waste fill materials (demolition debris) and areas associated with ore handling activities. The primary areas of contamination by metals are locations of

historic stockpiling of ore prior to loading onto ships for transport. **Figure 5.9** shows the areas within the site where the levels of metals in the upper 1 m of soil exceed Health Investigation Levels (HILs).

Figure 5.10 shows areas where metal levels exceed Ecological Investigation Levels (EILs) in this surface layer (0 to 1 m). **Figure 5.11** shows areas with EIL exceedances for metals in soils deeper than 1 m. The metals impact is generally restricted to the surface 1.0 m within the fill materials.

Iron Ore Concentrate

Iron ore wastes are visibly apparent as red to purple fill and are generally limited to the top 1 m of ground surface in impacted areas (**Figure 5.12**). As stated, limited concentrations of lead are present within the iron ore above health-based assessment thresholds, and samples of the purple iron ore material have reported concentrations of arsenic exceeding HIL-E and lead exceeding both the HIL-D and HIL-E guideline levels.

Mixed Ore Concentrate

Spillage of mixed ore concentrate from the Woodcutters mine is located in the Fort Hill area (**Figure 5.13**). This ore concentrate is comprised of several materials, and the colours range from green, to cream or brown.

Encountered contamination appears to be restricted to the top 100 – 200 mm of present ground surfaces in impacted areas. Where material sits on the top of iron ore, this suggests that the spillage of the mixed ore concentrate occurred after the deposition of iron ore.

Samples of the overlying mixed ore have reported exceedances of health-based guidelines: concentrations of arsenic in exceedance of the HIL-D and HIL-E; cadmium in exceedance of the HIL-D and HIL-E; copper in exceedance of the HIL-D and HIL-E; lead in exceedance of the HIL-D and HIL-E, and zinc in exceedance of the HIL-E.

General Fill Materials

Individual samples reported concentrations of metals in fill across the site that exceeded various health-based concentration values. The locations of exceedances in health-based assessment thresholds appear to be random, indicating the heterogeneous nature of the fill materials. In undertaking additional sampling at proximal locations to initial samples reporting health-based assessment threshold exceedances, concentrations of metals in surrounding samples were variable. The presence of “hot spots” of fill contaminated with significant quantities of metal bearing waste was not indicated.

Many soil samples collected from fill materials reported concentrations of metals that exceeded EILs across the site. The exceedances of EILs were found both within the upper 1.0 metre, and at depth.

Petroleum Hydrocarbons

There are widespread impacts from petroleum hydrocarbons across the site. The hydrocarbons are primarily comprised of fuel oils with very limited concentrations of highly volatile fractions. Limited

areas of hydrocarbons were observed as surface spills resulting from commercial business operations. Benzene, a carcinogenic volatile hydrocarbon commonly associated with petrol, has not been found in either soil or groundwater samples. Volatile hydrocarbons found at the site have a far lesser degree of toxicity than benzene, however these fractions can still give rise to objectionable odours and potentially health considerations.

Hydrocarbon contaminated soil (**Figure 5.14**) was primarily observed as a vertical “smear zone” where apparent seasonal groundwater level fluctuations have given rise to soils contaminated with adsorbed concentrations of discoloured hydrocarbon staining. The “smear zone” is the interface between the groundwater and unsaturated soil zone influenced by either seasonal rainfall or tidal influences. The “smear zone” generally corresponds to the range of movement of the groundwater surface, and therefore is present at approximately 2 to 6 metres below the present surface ground level depending upon the site area.

Hydrocarbon Sources

Importation of contaminated fill may also have contributed to areas of hydrocarbon contamination in soil. Hydrocarbon impacted fill has not been identified during investigations undertaken at the site. Accordingly, no buried drums of oil or other waste materials were found to have been the source of general areas of hydrocarbon contamination in soil and groundwater. It should be noted, however, that the potential exists for isolated areas of fill to be impacted by waste debris and imported contaminated fill.

To date, specific areas of the site have not been accessible to fully characterise potential source areas of hydrocarbon contamination. This has been due to limitations in being able to access areas of multiple utility services (electricity, fuel oil, water, etc.). These areas may contain sources of hydrocarbon contamination. Additionally, hydrocarbon contamination may be migrating onto the site from offsite sources, e.g. from the Navy Fuel Installation (NFI).

An identified area of significant contamination exists in the area of the valve pit at the north-east of Kitchener Drive. This pit is not visible, and is covered with soil. Other potential sources of contamination that have been identified include pipelines along Kitchener Drive and the bedding sands associated with utilities buried along Kitchener Drive.

Future additional investigations are planned in conjunction with removal and relocation of existing subsurface utilities. Investigation of potential offsite contamination sources are also planned to be undertaken. Discussions between the Northern Territory Government and relevant offsite owners are required to confirm access for further investigations to proceed.

Stokes Hill Storage Tanks

Shallow soils underlying the two existing above-ground oil storage tanks within Stokes Hill have been assessed to be contaminated with petroleum hydrocarbons. Contamination may also be present in the underlying fractured rock.

Chlorinated hydrocarbons have been found in groundwater at depth to the east of the Stokes Hill tanks. While the source of this potentially volatile contaminant has not been fully assessed to date, these tanks may be the original source of this contamination.

Polycyclic Aromatic Hydrocarbon Contamination

In general only limited areas of low concentrations of PAH contamination have been identified at the site, and the PAHs generally do not exceed relevant assessment guidelines.

Exceptions identified to date are two potential hotspots in the Stokes Hill area where PAH concentrations reported exceed the relevant health-based assessment levels. This contamination appears to be associated with an oily material above a concrete base and potentially in concrete lined canals used for carrying cooling water between the bay and the former power station.

Further investigation is underway to delineate these hot spots. This further investigation will assess the need for remediation of this localised PAH material.

5.2.6 Hydrogeology

The assessment of hydrogeology at the site was based on the results of a number of studies from as early as 1970, but predominantly undertaken since the late 1990s (URS, 2004). In addition, extensive field investigations carried out as part of the geotechnical and contaminated site assessments in late 2003 and early 2004 contributed significant new data from 25 groundwater monitoring wells and 64 soil bores. The full hydrogeological assessment is presented in **Appendix E**.

Groundwater Geology and Hydrogeological Setting

Groundwater under the Darwin CBD is typically encountered in low permeability, fractured bedrock aquifers of the Burrell Creek Formation, with typical bore yields of 0.5 to 5.0 L/s. Groundwater levels vary seasonally by 10 to 15 m.

The proposed development is located below the bedrock scarp and is largely on reclaimed land overlying low permeability marine sediments (mainly mud) and bedrock ranging from fresh to weathered. Near the coast, the groundwater level under this low-lying area is more or less equal to mean sea level. Inland towards the bedrock scarp, groundwater elevations increase, resulting in a generally south-easterly groundwater flow under the proposed development. The site includes both confined and unconfined aquifer zones.

Groundwater Levels and Movement

A groundwater mound exists beneath Stokes Hill with the maximum groundwater elevation for the site of approximately 5.0 m AHD (**Figure 5.15**). Another groundwater mound (to approximately 3.0 m AHD) occurs beneath the Fort Hill area. Radial groundwater flow occurs away from these mounds towards the coast. A groundwater mound exists along the toe of the escarpment along the northern portion of the

Kitchener Drive. Along the southern portion of this road, the gradient reverses with flow towards the bedrock scarp, possibly due to drainage effects from the nearby World War II storage tunnels.

Groundwater through flow under the proposed redevelopment is estimated to be less than 10 m³/day, and generally flowing towards the marine environment.

Tidal Influence

Monitoring has indicated that tidal fluctuations have no affect on groundwater levels in bedrock, but have influenced aquifers in marine sediment. The tidal influence does not indicate significant movement of seawater into and out of the aquifers under the site. Along the steep beach line, some movement of seawater into and out of the marine sediments may be occurring, but these sediments have such a low permeability that very little movement of groundwater can take place.

Hydraulic Parameters

Vertical infiltration and hydraulic permeability of the underlying materials, including fill and the marine sediments, are low. Groundwater flow in the bedrock is restricted to secondary structures such as faults and joints.

Groundwater Chemistry

Groundwater in the area is typically fresh to saline (<1,000 to 40,000 mg/L Total Dissolved Solids), generally depending on distance from the coast and the aquifer substrate. Groundwater in the bedrock near the scarp and in groundwater mounds is generally less than 1,000 mg/L and is generally suitable for human consumption. Groundwater in the marine sediments near the coast has Total Dissolved Solids contents of 20,000 to 40,000 mg/L.

Groundwater Quality and Uses

Groundwater quality at the site is highly variable. At northern portions of the site where groundwater recharge is evident, concentrations of total dissolved solids (TDS) meet drinking water standards. At monitoring well locations more proximal to the coast, TDS values were reported to be hyper-saline. There is an obvious saline divide identified in groundwater likely to be the result of a saline wedge (salt water intrusion).

The use of groundwater is therefore considered unlikely as extraction of groundwater may facilitate the movement of the saltwater wedge as well as the migration of contaminants. For comparison purposes, however, reference has been made in assessment documents to guideline threshold contaminant values for drinking water and irrigation water.

5.2.7 Existing Groundwater Contamination

Overview

Groundwater contamination varies across the site and may be due to natural sources as well as past and current land uses. Contaminants include dissolved-phase petroleum hydrocarbons (aliphatic and polycyclic aromatic hydrocarbons [PAHs] and phenols), metals (arsenic, cadmium, copper, lead, manganese, zinc) and ammonia.

Investigations to date have not observed phase separate hydrocarbons (PSH) found in groundwater, however dissolved phase fractions exist in the groundwater at many locations (**Figure 5.16**). Groundwater monitoring wells across the site have not detected PSH using field measurements with sensitivity capable of detecting thicknesses of PSH greater than 1.0mm thick. PSH is often defined as thicker than 10 mm, although this definition can vary. To assist in delineating areas where petroleum hydrocarbons were present at visible concentrations in groundwater, a series of test pits were excavated to below the saturated zone. In many test pits, sheens of no apparent thickness were noted to comprise either merely “rainbow” colours on the surface of groundwater to obvious discontinuous oil globules of approximately 1mm thickness on the water surface which were reported as “heavy sheens”.

Movement of Groundwater Contamination

Based on groundwater elevations, the general movement of groundwater under the proposed redevelopment is towards the harbour. However, based on aquifer parameters and simplistic calculations, the movement of groundwater (and therefore groundwater contaminants) towards the ocean is very slow.

5.2.8 Hydrology and Surface Water Quality

The assessment of hydrology of the site was based on reviews of the topography of the site and adjacent areas, past land use changes and current and past drainage plans. The hydrology report is included in **Appendix D**.

Drainage

The catchment for the development area extends above the escarpment into the southern CBD area (**Figure 5.17**). Surface water drainage in the development area and the upslope contributing catchment has been heavily modified during development for urban and industrial uses. There are no natural surface water drainage lines in the project area. A network of roadside drains and underground stormwater pipes currently drain the area and discharge to Darwin Harbour.

Kitchener Bay receives most of the runoff water, draining the catchment from Fort Hill to Stokes Hill. Frances Bay receives runoff from the catchment to the east of Stokes Hill. Runoff from the catchment to the west of Fort Hill flows west to the harbour.

Water Quality and Contaminant Loadings in the Development Area Catchment

There are no formal water quality data for runoff in the development area, but a number of studies have characterised runoff water quality from urban and industrial land uses around the city. **Table 5.3** summarises predicted quality and loadings on Darwin Harbour for the development area and contributing catchment.

**Table 5.3: Predicted Water Quality and Loadings from the Project Site Catchment|
(including the southern CBD) under existing conditions**

Catchment	Area	Average annual runoff fraction (%)	Average annual runoff	Indicative Water Quality				Predicted Loadings to Darwin Harbour						
				Sediment	Metals	Oil & grease/ hydrocarbons	Nutrients/ pesticides	TSS	Total P	Total N	Arsenic	Cadmium	Lead	Zinc
								(T/year)	(T/year)	(T/year)	(Kg/year)	(Kg/year)	(Kg/year)	(Kg/year)
Urban	0.05	0.50	40.8	L	L	L	M	372	0.6	5.5	7	2	166	431
Escarpment	0.04	0.25	18.7	L	L	L	L	72	0.1	1.7	2	0	3	9
Industrial	0.18	0.70	214.5	M	M	M	L	2,714	15.4	64.4	205	29	1,074	10,562
Disturbed	0.09	0.40	59.2	H	H	H	L	1,568	13.0	62.6	220	19	784	8,114
Foreshore	0.01	0.75	7.9	M	L	L	L	10	0.0	0.2	0	0	0	1
Total loading to Darwin Harbour	0.37		341.1					4,736	29.2	134.4	434	49	2,027	19,118

Notes: Loadings calculated from rates given in Padovan (2001); L = low levels, M = medium levels, H = high levels.
These estimations are used to predict the changes in water quality in Section 6. 3.5 (Table 6.1)

The development area itself is made up mainly of industrial and disturbed areas with residual contamination from past activities. Elevated levels of soil contaminants combined with poorly implemented drainage systems in parts of the existing site indicate that runoff from the site could contain elevated levels of metals, hydrocarbons and sediment. Runoff from the catchment above the escarpment may have elevated levels of metals, hydrocarbons and pesticides (Padovan, 2001). Runoff from the escarpment and vegetated areas is likely to be of relatively good quality, though flow concentrations may lead to erosion and increased turbidity of runoff water.

Estimated Flood Levels

A map of estimated flood levels at the existing site during a 100-year average recurrence interval (ARI) storm surge is shown in **Figure 5.4**. This map is based on an estimated extreme high water level of 5.1 m at Wickham Point that incorporates effects of cyclone storm surge, cyclone wave setup and astronomical tide (GHD-MacKnight, 1997). Surface water flows from the upslope catchment are not likely to contribute significantly to flooding in the developed area compared with the impact of the storm surge.

5.2.9 Marine Environment

Harbour Setting

Darwin Harbour, with an area of about 500 km², is a large ria system, or drowned river valley, formed by postglacial marine flooding of a dissected plateau. In its southern and south-eastern portions, the harbour has three main components: East, West and Middle Arms which merge into a single unit, along with the smaller Woods Inlet, before joining the open sea.

Bathymetry

The bathymetry of Darwin Harbour is shown in **Figure 5.18**. A channel of greater than 20 m water depth (below Lowest Astronomical Tide [LAT]) extends in a south-easterly direction from Darwin Port Limits to the confluence of Middle and East Arms. The channel favours the eastern side of the harbour, with broader shallower areas occurring on the western side. The intertidal flats and shoals are generally more extensive on the western side of the harbour than on the eastern side. The channel continues into East Arm at water depths of greater than 15 m LAT. The bathymetry in this area has been modified by dredging at the East Arm Port development (Dames & Moore, 1998).

Water depth for the majority of the length of the viaduct (the span between Stokes Hill and the main wharf section of Stokes Hill Wharf) is 6 m, deepening to approximately 11 m in the outer quarter. The depth on the Kitchener Bay side of the wharf is around 3 m, which shallows to the north to 0 m depth within a distance of 100 m. A broad intertidal mudflat then extends for 150-250 m to the edge of the existing revetment.

To the north east of Stokes Hill Wharf, the water shallows to approximately 2 m at the mouth of Frances Bay, east of Stokes Hill, and is generally around 0.5 m at the mouth of Sadgroves Creek. The mud banks on either side of the channel are emergent at low tide.

Oceanography and Hydrodynamics

Darwin Harbour is characterised by a macrotidal regime with a maximum range of 7.8 m. The mean neap tidal range is 1.9 m, while spring tides average 5.5 m. Tides are predominantly semidiurnal (two highs and two lows per day), with a slight inequality between the successive tides during a single day. Nearly diurnal tides occur for a two-day period during the neaps. The lowest spring tides of the year occur during October, November and December. Tidal excursions range from 8 to 15 km during springs and 2 to 8 km during neaps (Steedman & Associates, 1982; Semeniuk, 1985; Hanley & Caswell, 1995a).

Tidal currents of up to 1.2 kn can occur within Kitchener Bay at approximately mid-ebb spring tides. Tidal currents can be stronger (up to 3.0 kn) along the faces of the wharves (Australian Hydrographic Service, 2004).

Byrne (1988) summarised data on the hydrodynamics and coastal processes of Darwin Harbour. The harbour is considered well protected, with wind-generated waves typically less than 0.5 m with periods of two to five seconds. The majority of waves are generated within the harbour or in Beagle Gulf. The available data did not include cyclonic conditions, but predicted waves during cyclones would be of the order of 3 to 3.5 m. Extreme wave conditions were modelled by GHDM (1997) using wind data from Cyclone Tracy. Waves with significant wave height of 4.5 m, and average periods of approximately 7.5 seconds, were found to occur at the entrance to Darwin Harbour.

Marine Sediments

Sedimentology

Over the 6-8,000 years since Darwin Harbour was formed by rising sea levels, erosion from the adjoining terrestrial environment has carried substantial quantities of sediment into the harbour. This sediment now forms much of the intertidal flats that veneer the pre-flooding bedrock.

Michie (1988) reported three sources of sediments available to Darwin Harbour:

- breakdown of rocks in the catchment area by weathering and erosion;
- remobilisation of existing sediments, including partially consolidated sediments; and
- sediments of biogenic origin, including those derived from corals.

Most harbour sediments are a mixture of all three types. There is a general annual cycle of sediment deposition during the Wet season and erosion during the Dry.

Michie (1988) divided harbour sediments into four types:

- terrigenous gravels, which occur primarily in the main harbour channel;
- calcareous sands with >50% biogenic carbonate, which are among or close to the small coral communities at East Point, Lee Point, and Channel Island. Carbonate sediments, largely derived from molluscan shell fragments, occur in spits and shoals close to the harbour mouth;
- terrigenous sands on beaches and spits, with 10-50% carbonate, largely derived from molluscs. This type of sediment is predominantly quartz and clay; and
- mud and fine sand on broad, gently inclined intertidal mudflats that occur in areas characterised by low current and tidal velocities, such as in Kitchener Bay.

Contaminant Status of Marine Sediments

As a result of the previous land and water use history, the key potential contaminants of concern in the project area are considered to be metals, hydrocarbons and tri-butyltin (TBT) (URS 2003).

Sources of potential metal contamination of the sediments include:

- seasonal stormwater inflow from the southern Darwin CBD drainage system;
- stormwater runoff and dust deposition from former mineral stockpiles at the base of the Fort Hill and Iron Ore wharves;
- dust deposition and spillage from conveyor transfers and loading of minerals at the wharves;
- vessels using the wharf facilities, including Stokes Hill Wharf; and
- degradation products and waste from maintenance of the wharf structures.

Most of the hydrocarbons entering the world's oceans are a result of chronic low levels of contamination from runoff, rather than from major oil spill events. Potential sources of hydrocarbon contamination in the project area are from:

- seasonal stormwater inflow from the southern Darwin CBD drainage system;
- underground pressurised fuel lines to the Fort Hill and Iron Ore wharves;
- the Naval Fuel Installation; and
- former fuel storage at the power station.

In the late 1960s, TBT came into widespread use as an antifoulant additive to marine paints applied to the hulls of vessels. The leaching of TBT from the paint was effective in preventing the growth of fouling organisms on hulls, but also led to other detrimental environmental effects. TBT in port sediments is

typically associated with paint flakes, which may be dislodged from vessel hulls during berthing or whilst alongside wharves, when their hulls rub against wharf structures during the rise and fall of tides.

A recent survey of marine sediment quality in the project area (URS 2004) has shown:

- elevated concentrations of metals (especially cadmium, lead and zinc) in the vicinity of Fort Hill wharf; and
- the presence of petroleum hydrocarbons, PAHs and TBT across the project area.

Marine Water Quality

Salinity

Salinities in Darwin Harbour vary considerably during the year, particularly in East, Middle and West Arms where freshwater influence is greatest during the Wet season. Salinities throughout the Harbour are about 37 parts per thousand (ppt) during the Dry season, with surface and bottom depths having similar salinities (AIMS 2004).

At the height of monsoonal inflow during February/March, areas in the middle of the harbour such as Weed Reef can decrease to 27 ppt. Salinities in the arms, which are largely influenced by freshwater inflow, can reach as low as 17 ppt. The water at this time is highly stratified, with freshwater input from the surrounding catchments flooding the harbour and overlying the intrusion of more dense, higher salinity water from outside of the harbour, forming a classical "salt wedge" characteristic of estuarine systems (AIMS 2004). Salinities on the bottom of the harbour can be as much as 12 ppt higher than on the surface. As the rains cease, runoff decreases and salinities return to their higher dry season levels (Parry & Munksgaard 1995).

Temperature

With its tropical location, water temperatures in Darwin Harbour are very high, but some seasonal variations do occur. Temperatures range between 31 and 32 °C for most of the year, but they decrease to about 29 °C during the height of the Wet season. In contrast to salinities, there is little temperature stratification in Darwin Harbour during the Wet season (Hanley & Caswell 1995a).

Turbidity

Light levels reaching the sea surface in Darwin Harbour are very high. However, because of water turbidity the light is rapidly dissipated, and even within the space of a few metres levels can become very low, particularly during the Wet season when turbidity levels are very high. Even at a depth of only 3 m below the surface light levels during the Wet season can be as low as 7.7% of surface levels. Light levels near the bottom can be as low as 1% of surface levels during the Wet season (Hanley & Caswell 1995a).

Natural variations in turbidity typically occur with:

- season - higher in the Wet than the Dry due to the influx of terrigenous sediments to harbour waters through the rivers and surface water sheetflow; and
- tidal cycle - higher during Spring than Neap tides due to the stronger tidal currents suspending fine seafloor sediments.

Water Quality

Water quality in Darwin Harbour is generally high, even though naturally turbid for most of the time. Harbour waters can generally be considered pristine, with anthropogenic influences confined to the port development at East Arm, Darwin waterfront (historical industrial activities), Sadgroves Creek and wastewater outfalls.

Studies of heavy metal concentrations in Darwin Harbour waters were undertaken by Peerzada & Ryan (1987), Peerzada (1988), Currey (1988), and Hanley & Caswell (1995a); all showed results below the ANZECC & ARMCANZ (2000) guidelines for maximum dissolved levels to protect aquatic ecosystems. In many cases, the readings were an order of magnitude, and sometimes two orders of magnitude, lower than the recommended upper limits. Contaminant inputs to the harbour, including those from the Darwin CBD catchment, have more recently been characterised by Padovan (2001) (refer to **Table 5.2**).

5.2.10 Acid Sulfate Soils

Formation of Acid Sulfate Soil

Acid Sulfate Soil (ASS) materials are naturally occurring materials containing a build-up of iron sulfides (pyrite) under waterlogged or highly reducing conditions. These conditions are often characteristic of low-lying coastal areas, which are ideal for acid sulfate soil formation. In the natural setting these layers are covered by soil or sediment and are below the local water table. In this state, the potential acid generation is held within the soil (as sulfide minerals). When the ASS are exposed to the atmosphere, either directly by removal of the covering soil layers or by the lowering of the local water table, oxidation of the iron pyrite occurs resulting in the formation of sulphuric acid. Problems arise when the rate of acid production from oxidation of sulfides exceeds the buffering capacity of the soil. The excess production of acid reduces pH and can result in leaching of iron, aluminium and other trace metals from the local soils into waterways and groundwater, sometimes at levels toxic to aquatic organisms. The acidity of the discharge can be sufficient to cause serious environmental problems even without leaching of metals.

Potential acid sulfate soils (PASS) contain acid producing material but have not yet been exposed to air. Acid sulfate soils (ASS) are PASS that have been exposed to air and have produced acid leachate.

Location and Extent of Acid Sulfate Soils

Sampling and analysis for ASS was undertaken as part of the Contaminated Site Assessment and field geotechnical investigation, and the findings of these investigations are summarised below. The results of the Acid Sulfate Soil investigations are also presented on **Figure 5.19**. This figure also shows the elevation of the upper limit of acid sulfate soils under the existing fill material.

Fort Hill

ASS materials were identified at locations near the marine environment on the western and eastern boundaries of this area. ASS were associated with marine sediments underlying fill materials. The current acidity in the soil in this area presents a low threat to human health or the environment.

Bitumen Plant Area

ASS materials were identified at locations in the western portion of this area, adjacent to the Fort Hill Area, and the ASS were associated with marine sediments underlying fill materials. The current acidity in the soil in this area presents a low threat to human health or the environment.

Warehouse Area

ASS materials were identified at numerous locations including some locations in the western portion of the area adjacent to the Shell Bitumen Plant and isolated locations along the southern portion of the site adjacent to the Northern Cement Plant Area and the Recently Reclaimed Area. They were associated with marine sediments underlying fill materials. The current acidity in the soil in this area presents a low threat to human health or the environment.

Old Northern Cement Plant Area

ASS materials were identified in this area adjacent to the marine environment and were associated with marine sediments underlying fill materials, including adjacent to the eastern boundary with the Recently Reclaimed Area. The current acidity in the soil in this area presents a low threat to human health or the environment.

Recent Land Reclamation Area

ASS materials were identified throughout this area, including locations in its western portion, adjacent to the Northern Cement Plant area, in the northern portion of the area adjacent to the Warehouse Area and some locations in the southern portion of the area adjacent to the marine environment. The current acidity in the soil in this area presents a low threat to human health or the environment.

Stokes Hill Area

ASS materials were identified in this area associated with marine sediments underlying fill materials at isolated locations adjacent to Frances Bay. The current acidity in the soil in this area presents a low threat to human health or the environment.

Kitchener Bay Marine Sediments

No AASS or PASS materials were identified within the top 1 m of these marine sediments.

5.2.11 Air Quality

Regional Ambient Air Quality

DIPE has undertaken a number of benchmark studies to quantify ambient air pollution in the Darwin area. The objective of these studies was to support jurisdictional commitments to the implementation of the National Environment Protection Measure for Ambient Air Quality (Air Quality NEPM) and the National Pollutant Inventory (NPI).

A pilot study of ambient air quality in Darwin was undertaken in March to December 2000, a period including both Wet and Dry season conditions (DIPE 2001a; CSIRO 2001). Particulate matter was identified as the primary pollutant of concern for the Darwin population at that time, with occasional exceedances of the Air Quality NEPM standard of 50 µg/m³ (24-hr average) being recorded. These peaks were generally caused by bushfire smoke. Concentrations of other pollutants were generally found to be low in comparison to NEPM standards.

Of the key source categories identified for the Darwin Air Emissions Inventory for NPI reporting purposes, fires in the Dry season were shown to be the most significant source of pollution, with other minor point sources of pollution also identified (DIPE, 2001b). Mobile (transport) sources remain a significant contributor to air pollution, characteristic of most urban airsheds in Australia. **Table 5.4** and **Figure 5.20** summarises the annual pollutant loads estimated for the Darwin region, and the relative contribution of key source categories.

Table 5.4 Relative Contribution of Key Sources to Air Pollution in the Darwin Region (DIPE 2001b)

Pollutant	Annual emission (kg/year)	Percentage contribution of key sources (%)						
		Bushfires	Commerce	Households	Industry	Large Industry	Transport	Other
NO _x	1.1 x 10 ⁷	18	0	0	0.5	24	58	0
PM ₁₀	6.2 x 10 ⁶	94	0	0	0	4	2	0
CO	6.2 x 10 ⁷	78	0	0.7	0	1	20	0
SO ₂	5.5 x 10 ⁵	31	0	0	0.8	4.7	63	0
Lead	8.2 x 10 ³	7	0	0	1	0	92	0
Benzene	1.8 x 10 ⁵	83	1	3	0	3	10	0
Total VOCs	6.1 x 10 ⁶	46	3	2	3.5	8	22	15

Hazardous Air Pollutants (Air Toxics)

The sources, patterns and implications of emissions of hazardous air pollutants (air toxics) are poorly defined in the Northern Territory. Monitoring of ambient air toxics is not conducted at present. Some emission estimation studies of air pollutants (including eight air toxics), carried out in 2000 as part of the NPI, showed that bushfires are the most significant regional source of benzene (83%) and volatile organic compounds (46%). The transport sector produced the greatest proportion of arsenic (85%), chromium IV (67%) and lead (92%), although this sector is small and the amounts low in comparison to other jurisdictions (*Reference: Impact Statement for the Air Toxic National Environment Protection Measure, May 2003*). Small proportions are generated by industrial, commercial and household activity (NEPC, 2003).

Local Air Quality

At a local level, the DCWR area contains a mixture of existing industries that generate atmospheric discharges.

- The Shell bitumen plant and above ground bulk fuel oil storage tanks are a localised source of particulate matter, combustion products (carbon dioxide [CO₂], nitrogen oxides [NO_x], sulfur oxides [SO_x]) and carbon monoxide [CO]) and small amounts of organic compounds (including volatile organic compounds [VOC], and methane [CH₄]). The Bitumen plant is due to be demolished and remediated November 2004.
- The quarantine incinerator located at Fort Hill is expected to emit combustion products (CO_x, NO_x, and SO_x). The incinerator is due to be removed as part of demolition works.
- The bulk sulfuric acid storage tank in the Fort Hill area is a localised source of SO_x. The tanks are due to be relocated as part of demolition works.
- The NFI storage tanks and associated transfer pipelines are localised sources of fugitive releases of VOCs, hydrocarbon odours, and possibly air toxics such as PAHs.
- Combustion products from marine diesel engines (CO₂, NO_x, particulate matter and SO_x) and evaporative loading losses of VOCs are produced from Stokes Hill and Fort Hill Wharves.

5.2.12 Noise

Until recently, the project site served as the primary wharf for Darwin with associated industrial development and activity. Loading conveyors, marine vessel noise, transportation vehicles and processing plants would have dominated the noise climate of the site at that time. With the transfer of a large proportion of significant port operations to East Arm, numerous industrial facilities across the site have been decommissioned with a corresponding reduction in noise levels generated within the wharf precinct. An increasing commercial focus of the wharf precinct is expected to have resulted in lower

ambient noise levels from within the site. However, these reductions may be offset by expansion of the Darwin CBD and increasing daytime noise levels associated with increased business activity.

Background Noise Levels

Recent monitoring indicated that background noise levels at the northern boundary of the site (near The Esplanade at the top of escarpment) fluctuate between approximately L_{A90} 45 to 55 dB throughout the daytime hours, reducing to a typical minimum of L_{A90} 35 to 40 dB in the early morning (over 15-minute sampling periods). With the current level of wharf usage, daytime noise levels within the actual wharf area are estimated to be greater than this level by between 5 and 10dB due to noise associated with localised wharf activities. A 24-hour noise monitoring survey in April 2004 found typical daytime background levels along the foreshore of the project area of between L_{A90} 45 to 51 dB, reducing to an overnight minimum of L_{A90} 42 dB.

Event Noise Levels

Area specific events contribute to the area's existing noise climate. Activities at the Iron Ore Wharf, Fort Hill operations and Stokes Hill Wharf generate varying levels of noise associated with their operations. The contribution of such events to the noise levels received on the site will vary according to the separation distance and the level of noise generated at the facility. Monitoring found that idling vessels on the wharves produced a noise level of L_{eq} 55 dB(A) at the foreshore. Operation of the crane on Fort Hill Wharf produced levels of L_{eq} 55 dB(A) approximately 100 m inland from the foreshore. The crane has recently been relocated to East Arm Port.

5.3 Biological Environment

5.3.1 Intertidal and Terrestrial Flora

The intertidal and terrestrial flora of the project site was assessed by analysis of aerial photographs and field ground-truthing. Field surveys were undertaken between January and March 2004 during the mid Wet season. Vegetation communities both within and adjacent to the project area were assessed. All plant species observed within the project area were listed, noting habitat, dominance, lifeform and presence in the upper, mid or lower strata. Given that much of the existing waterfront area has been cleared or heavily disturbed over several decades, detailed quantitative assessment of remnant vegetation was not undertaken. Assessment was made of:

- the conservation status of plant species and communities;
- the location of trees listed on the Register of Significant Trees;
- the native/introduced status of all species;

-
- the diversity and distribution of weeds; and
 - botanical, historical, ecological and aesthetic value of remnant native vegetation.

The full report of the vegetation assessment, including species list, is provided in **Appendix H**.

Overview of Vegetation Characteristics

The project area has an extended history of disturbance from industrial development and clearing associated with progressive reclamation of the shoreline. The vegetation of the project area is characterised by large expanses of cleared land with pockets of cultivated native and introduced plant species and abundant weeds. Nevertheless, a number of small areas of remnant vegetation remain including coastal vine-forest and mangrove habitats. In addition, significant areas of existing vegetation occur immediately adjacent to, but outside the project area. The site is bordered by the linear band of coastal monsoon vine-forest along the coastal escarpment that forms an almost complete western border around the city and extends as a continuous feature for several kilometres around to the north and east. Extensive mangroves occur to the east of the site along of the shores of Frances Bay and Sadgroves Creek.

A total of 187 plant species from 68 families were recorded from the project site. Seventy-one introduced species were recorded, comprising 38% of the flora, and 57% of species in the three most abundant families were weeds. The high number and proportion of introduced flora reflects the high level of disturbance, the proximity of the site to a major urban centre and the overall relatively poor biological condition of the site.

Vegetation Communities

The current landform of the site largely determines the three major habitat types: intertidal mudflats, coastal flats and escarpment. The project site contains seven main vegetation communities within these habitat types (**Figure 5.21**). Only two remnant vegetation types occur: vine-forest and minor mangrove areas. The remainder of the site is cleared or modified landscapes, native regeneration on disturbed sites, private gardens and public open space. The characteristics and conservation significance of these plant communities are summarised in **Table 5.5**.

Coastal vine-forest

Remnant native vegetation is largely restricted to the heavily vegetated escarpment areas fringing the CBD. Although only a small area of this community lies within the site (0.7 ha, 2.8% of the site), considerably larger areas are adjacent. These areas comprise intact, well-established coastal vine-forest vegetation. A total of 75 species from 40 families were recorded from this habitat - the most floristically diverse across the site. Although 23 introduced species (31% of the total) occurred in this vegetation type, a large proportion of these exotics were cultivated species. The vine forest in and adjacent to the project area shows structural complexity with the canopy of most trees at around 15 to 20m with emergent trees reaching 25 m.

Public open space

A small area of public open space (1.00 ha, 4% of the site) occurs within the site on recently reclaimed land with a scattered mixture of native and exotic species. Adjacent areas of the CBD contain larger areas of public open space.

Table 5.5: Summary of Major Vegetation Types

Map Unit	Vegetation type (area within DCWR site)	Dominant upper stratum tree species	No. plant species (No. of families)	No of weed species (%)	Conservation significance
1	Coastal vine-forest (0.75 ha)	<i>Acacia auriculiformis</i> , <i>Ficus virens</i> , <i>Terminalia microcarpa</i> , <i>Albizia lebbbeck</i>	75 (40)	23 (30.7%)	No species of declared rare status (Commonwealth listing). One species <i>near threatened</i> (Northern Territory IUCN listing). Rainforest vegetation of high ecological and aesthetic significance. Of potential recreational, aesthetic and educational value in future landscape.
2	Public open space (1.00 ha)	<i>Hibiscus tiliaceus</i> , <i>Petoporum pterocarpum</i> , <i>Eucalyptus camaldulensis</i> , <i>Pongamia pinnata</i>	29 (17)	13 (44.8%)	No conservation significance – mainly cultivated species on recently reclaimed land.
3	Private gardens (0.60 ha)	<i>Samanea saman</i> , <i>Citharexylum subserratum</i> , <i>Chrysalidocarpus latescens</i> , <i>Plumeria spp.</i> ,	28 (17)	10 (35.7%)	No conservation significance – high proportion of exotic species in cultivated landscape.
4	Regenerating native landscape (1.11 ha)	<i>Acacia auriculiformis</i> , <i>Lophostemon lactifluus</i> , <i>Melaleuca leucadendra</i> , <i>Alstonia actinophylla</i> ,	49 (27)	14 (28.6%)	No species of declared conservation status. Healthy native regeneration assisting in soil stabilisation and weed control. Of moderate aesthetic value for future landscape. Minor ecological significance.

Table 5.5: Summary of Major Vegetation Types

Map Unit	Vegetation type (area within DCWR site)	Dominant upper stratum tree species	No. plant species (No. of families)	No of weed species (%)	Conservation significance
5	Dense weed infestations in native regeneration (1.60 ha)	<i>Leucaena leucocephala</i> , <i>Acacia auriculiformis</i> , <i>Spathodea campanulata</i> , <i>Melaleuca leucadendra</i>	73 (33)	35 (47.9%)	No conservation significance. No botanical, aesthetic or ecological value for retention in future landscape.
6	Disturbed ground with scattered plantings (17.52 ha)	<i>Gmelina arborea.</i> , <i>Eucalyptus camaldulensis</i> , <i>Acacia auriculiformis</i> , <i>Casuarina equisetifolius</i> , <i>Delonix regia</i>	64 (26)	36 (56.2%)	Aside from two trees of historical significance (Tamarind trees No.'s 121 and 197) and several established shade trees (<i>Peltophorum pterocarpum</i>) of some aesthetic and current recreational value, no species or communities of declared conservation significance. No botanical or ecological value for retention in future landscape.
7	Mangrove (0.53 ha)	<i>Avicennia marina</i> , <i>Sonneratia alba</i> , <i>Rhizophora stylosa</i>	10 (8)	nil	Darwin Harbour mangroves are to be generically zoned for conservation (DIPE, 2004), but not all areas will be protected or retained. Of ecological value with potential to be of recreational, educational and aesthetic value if retained and expanded within future landscape.

Private Gardens

Private gardens are present bordering the site, with exotic ornamental species as well as remnant and planted native trees located on the escarpment and within the NFI.

Regenerating native landscape

The site contains several areas regenerating vigorously after previous clearing (1.1 ha, 4.4% of the site), typically located along the steep slopes surrounding the fuel tanks and bordering the southern face of Stokes Hill. These areas are dominated by native colonising species with introduced species understorey. They support 49 flora species with a comparatively low proportion of introduced species. This area may have significant ecological and aesthetic benefits as the native vegetation matures, but occur in substantial quantities elsewhere in the Darwin region.

Dense weed infestations amongst native regeneration

These areas (1.6 ha, 6.4% of the site) have almost monospecific stands of Coffee Bush (*Leucaena leucocephala*) on disturbed ground and in un-maintained sections of the site, resulting in greatly reduced native botanical diversity. These areas have low ecological value in their current condition.

Disturbed ground with scattered plantings

The extensive reclaimed coastal flats along Kitchener Bay comprise grassland, bare areas and informal plantings interspersed with sporadic landscaping. This vegetation type is by far the most extensive within the project site (17.5ha, 70% by area), but provides minimal environmental value.

Mangrove

Although extensive intertidal mudflats occur along the seaward margin of the site, relatively little mangrove vegetation exists along the shore (0.52 ha, 2.1% of the site). The mixed species mangrove community, which formerly extended almost to the base of the escarpment, has been displaced by reclamation. Mangrove vegetation in Darwin Harbour is established between –1 and 4 m AHD, with approximately 50% of this vegetation type occurring between 2 and 3 m AHD. The elevation of much of the current intertidal zone bordering the reclaimed area is too low to be colonised by mangroves. The small areas of mangroves along the shoreline of the site do not have sufficient elevation range to develop typical zonation. These areas contain the ten most common species of a possible 26 species characteristic of Darwin Harbour.

Vegetation of Conservation Significance

One plant species (*Pittosporum moluccanum*) recorded within the site is denoted *near threatened* on the Northern Territory listing of plants with significant conservation values. However, the plants appear to be cultivated during bush regeneration along the escarpment and natural populations of the species are known to occur in the Darwin region. There are no species with significant declared IUCN threat codes (endangered or vulnerable) and no species present occur on national lists of endangered species.

The coastal vine-forest habitat bordering the site is of some ecological importance and potential educational, recreational and aesthetic value.

Register of Significant Trees

The significant tree register (compiled and administered by Greening Australia NT) lists 33 trees in the southern CBD for their historical and/or aesthetic significance (**Figure 5.22**). Seven of these are within the project site with an additional six close to the site boundary. These comprise:

- Four *Pterocarpus indicus* along the foreshore near the inner Fort Hill Wharf;
- Two Yellow Flame Trees (*Peltophorum pterocarpum*) to the south of the bitumen plant;
- Two very old Tamarind trees (*Tamarindus indica*) adjacent to the Port Darwin offices on Kitchener Drive (121 and 197); and
- Five *Pittosporum moluccanum* near Hughes Avenue.

Weeds

Historical disturbance across the project site has allowed establishment and proliferation of numerous weeds, with introduced species dominating the vegetation in all areas outside public open space and the coastal vine-forest. Weeds and introduced species comprise 38% (71 species) of the 187 flora species recorded. None of these species are declared Class A Noxious Weeds requiring eradication under the *Weeds Management Act 2001*. However, five Class B noxious weeds were recorded at the site (*Hyptis suaveolens*, *Lantana camara*, *Pennisetum polystachion*, *Senna obtusifolia* and *Sida acuta*). The Act requires the spread and growth of Class B weeds to be controlled.

Although not a declared weed, Coffee Bush (*Leucaena leucocephala*) is a significant environmental weed of tropical Australia and occurs in numerous dense stands throughout the site. Other weeds occurring in high densities include grasses (*Melinis repens*, *Pennisetum polystachion*), vines (*Centrosema molle*, *Passiflora foetida*, *Merremia aegyptia*) and herbs (*Senna obtusifolia*, *Alysicarpus ovalifolius* and *Tridax procumbens*). The distribution of weeds and areas that are currently relatively weed free are shown in **Figure 5.23**.

Weed infestations are most abundant within Map Units 5 and 6 where removal of existing vegetation and associated disturbance has encouraged weeds to proliferate.

5.3.2 Terrestrial Fauna

The terrestrial fauna of the project site and surrounding areas were assessed by field surveys and reference was made to existing reports and databases. The following information summarises the Terrestrial Fauna Assessment report, which is provided in **Appendix G**.

Survey Methods

Surveying was undertaken during November 2003. Standard field methods were used and included small mammal “Elliot” trapping, cage trapping, bat call detection, direct and indirect observations and scat identification. Trapping was undertaken over three nights at four transects; two on the escarpment and one each on the Stokes Hill and the former site of the Deckchair Cinema at the eastern end of the site. Active searches were also carried out throughout the remainder of the site during the survey period. Observations were made both during the day and at night using spotlights. Following advice from the bat specialist with the Conservation and Natural Resources Group within DIPE, surveys for bats were initially made using call recording and analysis. Mist netting was to be undertaken if any threatened species calls were found, however no threatened species were identified or suspected. The methods used were consistent with the Northern Territory Parks and Wildlife fauna survey standard methodology. The distributions of the highly disturbed vegetation on the site rendered the standard quadrat shape impractical, therefore three transect lines were constructed. Additional surveys for amphibians were carried out on four occasions in early March 2004 at a range of times during the day and night following rain. These surveys included call identification, sightings and call-backs from playing an audio recording. **Figure 5.24** shows the location of each fauna survey site within the study area.

Amphibians

Although the site provided relatively low habitat diversity, six species were recorded during the current surveys. The most common species recorded were Rocket Frog (*Litoria nasuta*), Marbled Frog (*Limnodynastes convexiusculus*), Green Tree Frog (*Litoria caerulea*) and Red Tree Frog (*Litoria rubella*). Low numbers of Northern Dwarf Tree Frog (*Litoria bicolor*) and Roth’s Tree Frog (*Litoria rothii*) were recorded. Several refuge sites for frog species were identified including the vegetation strip along the escarpment edge, the area surrounding the remaining fuel tanks near the former Deckchair Cinema, and in drains and old pipe infrastructure in the Stokes Hill Fuel Tanks area. After rain the frogs, particularly *Litoria rubella* and *Litoria nasuta*, moved into pools of water below the tank locations. The overall populations appeared to be healthy although much of the breeding activity was noted from construction areas and temporary pools left by earth moving equipment.

Reptiles

Seven species of reptile were recorded during the survey, comprising five lizard species and two snake species: Bynoes Gecko (*Heteronotia bynoei*), Tropical Dragon (*Amphibolurus temporalis*), Arboreal Snake-eyed Skink (*Cryptoblepharus plagiocephalus*), Floodplain Monitor (*Varanus panoptes*) and Slaty-grey Snake (*Stegonotus cucullatus*). The one introduced species (Asian House Gecko, *Hemidactylus frenatus*) occurred at all transect sites. The Brown Tree Snake (*Boiga irregularis*) has been previously recorded in the Darwin CBD but was not found during the current survey.

The only monitor lizard recorded during the survey was found at the former Deckchair Cinema site and the adjacent Stokes Hill site (presumably the same individual).

Birds

From the survey, 34 bird species were recorded across the site from both recordings along transects and incidental recordings. The bird species that occurred at all transect sites were: Rufous-banded Honeyeater (*Conopophila albogularis*), Masked Lapwing (*Vanellus miles*), Bar-shouldered Dove (*Geopelia humeralis*), Rainbow Lorikeet (*Trichoglossus haematodus*) and Little Friarbird (*Philemon citreogularis*). An additional 38 species have been recorded in the Darwin CBD.

Few shorebirds were noted during fauna surveys. These comprised Intermediate Egret (*Ardea intermedia*), Eastern Curlew (*Numenius madagascariensis*) and Common Sandpiper (*Actitis hypoleucos*). There are many birds (mostly migratory waders) that have been recorded in the general area. Many of these species are covered by international migratory bird agreements (China Australia Migratory Bird Agreement [CAMBA], Japan Australia Migratory Bird Agreement [JAMBA] or the Bonn Convention) and the migratory provisions of the EPBC Act. These species could occur sporadically along the coastline edges of the site at different times of the year. However, the habitats that support these species are well represented in both the local and the regional area.

Mammals

Few mammals were found across the site, reflecting the level of physical disturbance of the habitat and disruption by human activity. Two native mammal species were recorded; Common Brushtail Possum (*Trichosurus vulpecular*) from the escarpment transect and Black Flying-fox (*Pteropus alecto*) as an incidental recording. Two introduced species were found: the Black Rat (*Rattus rattus*) and the Feral Cat (*Felis catus*).

Ghost Bats (*Macroderma gigas*) and Northern Blossom-bats (*Macroglossus minimus*) have been previously recorded in the Darwin CBD but were not found during the current survey. Ghost Bats, which are considered threatened, have been recorded only once within the Darwin region. They require large caves, mines or deep rock fissures in which to roost in (Strahan 1998). Although there are some World War II oil storage tunnels present on the site, no Ghost Bats were recorded in this survey and due to their habitat requirements it is unlikely that they occur in the area.

Five micro bat species were distinguished from analysing call recordings from four sites: Little Northern Freetail Bat (*Mormopterus loriae*), Large-footed Myotis (*Myotis macropus*), Little Broad-nosed Bat/ Northern Broad-nosed Bat/ Hoary Wattled Bat (*Scotorepens greyii* / *S. sanborni* / *Chalinolobus nigrogriseus*), Large-footed Myotis (*Myotis macropus*) and Northern Pipistrelle/ Common Bent-wing Bat (*Pipistrellus westralis* / *Miniopterus schreibersii*). The latter three recordings could not be identified to species level but represented a separate species. It is possible that more than one species was present for these recordings. Surveys at Stokes Hill and Stokes Hill Wharf identified only ones species at each location. More species were found at the entrance to the Oil Storage Tunnel (three species) and at the Escarpment transect (four species).

5.3.3 Freshwater Biota

As noted in the description of hydrology, there are no natural drainage lines remaining in the study area and most of the site is drained by a system of underground pipes which discharge into the Harbour. Several short ephemeral surface drains occur in the site with highly disturbed subcatchments. The aquatic biota present in these areas was dominated by mosquito (Culicidae) and chironomid (non-biting midge) (Chironomidae) larvae reflecting the highly disturbed nature of the catchment.

5.3.4 Biting Insects

The Medical Entomology Branch within the Northern Territory Government carried out the assessment of biting insects at and near the site by:

- monitoring of biting insects with traps at nine locations across the site and timed to coincide with peak abundance of both biting midges and mosquitoes;
- Wet season field inspections of the site to identify areas with potential to provide breeding habitat;
- sampling of identified mosquito breeding habitats and identification of species;
- interpreting aerial photographs to identify potential problem biting midge breeding sites within and near the redevelopment area; and
- review of the results of previous monitoring and inspection activities.

These methods aimed to identify the type and density of biting insects, as well as actual and potential breeding sites, in the area. Biting insect traps were set on the nights of 8, 9 and 10 November 2003, 12 days after the October monthly high tide. The full moon occurred on 9 November.

Occurrence of Biting Midges

Four species of biting midge were found at the site with 92 % of these being *Culicoides ornatus*. The highest densities of this species was on Stokes Hill, with moderate densities on the foreshore areas east of Stokes Hill. Very low numbers were found elsewhere on the site.

Culicoides ornatus breeds in mangrove areas and is a widespread species causing major pest problems throughout coastal northern Australia. Following emergence, females can migrate 1 to 2 km inland of the mangrove margin, and up to 3.5 km inland in much lower densities. Highest numbers tend to occur on escarpment areas facing mangroves. This species is a significant human pest for the Darwin area because of its dispersal patterns. The species and all other midge species in Australia are not vectors for human disease.

Biting Midge Breeding

Little or no productive biting midge breeding sites occur within the project site. Biting midges present on site originate from off site breeding locations within flying range of the site. The closest major breeding habitat to the site is the extensive foreshore and dendritic mangrove areas to the east, north-east and north associated with Charles Darwin National Park and Sadgroves Creek. The small area of mangroves within the site is not a productive breeding site.

Occurrence of Mosquitoes

Routine weekly monitoring undertaken near the Darwin Port Offices at the lower end of Hughes Avenue indicates that the site has low numbers of mosquitoes for most months of the year, except for a sharp rise in the abundance of salt marsh mosquito (*Ochlerotatus vigilax*) during December.

Eleven mosquito species were found across the site, with *Ochlerotatus vigilax* accounting for 79% of the individuals trapped. The highest abundance of mosquitoes was found at the former Deckchair Cinema site near Mavie St.

Ochlerotatus vigilax is a vector of Ross River virus and Barmah Forest virus diseases, and can be a severe pest due to its persistent biting behaviour. The species can travel significant distances inland and breed in high numbers in small bodies of water. The species was found in minor pest numbers, but has the potential to breed to significant numbers at the site. Another species, *Culex annulirostris*, was trapped in low numbers, but also has the potential to breed in pest numbers at the site. It is also a vector of a number of human diseases.

At present, the mosquito problem in the project area is minor compared to other areas of Darwin, and the public health issue is also minor.

Mosquito Breeding

Poorly Drained Areas

The project site contains several poorly draining areas resulting from disturbance by industrial activity and poor landscaping. Mosquito breeding has been identified in the past two Wet seasons at two locations within the Recently Reclaimed Area:

- the grassy area and drainage line south and south-west of the “trams” eatery; and
- the bare area west of grassed section near the “trams” eatery.

The other poorly draining area with the potential for mosquito breeding is located on vacant land east of the Shell Bitumen Plant. These mosquito breeding sites are within close proximity of the harbour, and sea spray is likely to provide ideal breeding conditions for the salt marsh mosquito *Ochlerotatus vigilax*. Freshwater breeding mosquitoes also breed in these depressions during the Wet season.

Potential mosquito breeding sites are also located within the bamboo forest along Hughes Ave just outside of the site. The bamboo forest provides habitat for container breeding mosquitoes when hollow stumps are created after individual stem cutting. Any other depressions across the site would provide suitable conditions for mosquito breeding.

Stormwater drainage

Stormwater drainage in the area consists of open unlined drains, open concrete drains and underground pipes. The drains are subject to the dry season low flows and moderate silt loading in their lower sections. Ponding behind this silt, and any other factor preventing free drainage, can create conditions for mosquito breeding. The stormwater drains most likely for mosquito breeding are at the base of Stokes Hill, along McMinn St and Kitchener Drive and at the Deckchair Cinema.

Potential Exotic Mosquito Species

The location and nature of the project site makes it susceptible to the introduction of exotic species of mosquito, most notably *Aedes aegypti* and *Aedes albopictus*. Both of these species are vectors for the Dengue virus. Both species could be introduced from shipping and quarantined foreign fishing vessels, and *Aedes aegypti* could be transported from Queensland and from a recently detected population in Tennant Creek.

5.3.5 Marine Biota

The assessment of marine ecology was undertaken by review of data on the marine communities of Darwin Harbour and field surveys including:

- dive surveys within Kitchener Bay to assess the range of habitats present; and
- identification of benthic fauna from samples of the marine sediments in Kitchener Bay.

Regional Context

The marine fauna of northern Australia is part of the vast Indo-West Pacific biogeographical province. The great majority of species are widely distributed in this region, with the northern part of the Australian continent being simply a small part of the wider ranges of most species. Most recent studies consider there to be one Tropical Australian Province extending from Shark Bay or North West Cape in Western Australia across the top of the continent and to the southern end of the Great Barrier Reef in Queensland; a small proportion of the species west of Cape York occur only in Australian waters, but are generally widespread within the region (Wilson & Allen 1987; Wells 1986, 1990; Ponder & Wells 1998).

This knowledge of the broad geographical patterns of the north coast has a direct relevance to the understanding of the marine biota of Darwin Harbour. Larson (1988) and Hanley (1988) emphasised the lack of knowledge of fish and invertebrates respectively living in the harbour, and there are certainly many species which have not yet been collected or identified. However, the broad distribution of the

great majority of marine species suggests there will be few, if any, species restricted to the harbour itself. Instead Darwin Harbour is one of many areas inhabited in the broader range of the species.

Darwin Harbour Habitats

Darwin Harbour has a complex assemblage of habitat types, but there are large differences in the extent of each. The distribution of various habitat types in Darwin Harbour has been mapped by DIPE (**Figure 5.25**). Rocky intertidal areas are found where hillsides meet the sea. Seaward of these, extensive mangroves typically dominate in the upper intertidal zone, particularly in bays and other protected areas. Seaward of the mangroves, extensive flats occur in the lower intertidal. Many of these flats are mud, but some areas are basement rock which may or may not be covered with a veneer of sand or mud. The sides of the channels are generally rocky, but the bottoms are similar to the intertidal in that they vary from exposed pavement, through sand veneered pavement to beds of sediment.

The biotic assemblages discussed below provide a convenient structure for examining the biological features of the marine environment. However, it should be emphasised that the environment is complex, and many of the habitats are present as small units on a single shoreline, with complex patterns of habitats such as rocky shores, mangroves and mudflats all occurring in a small area. Kitchener Bay is dominated by intertidal flats, with smaller habitats of mangroves and the artificial habitat of the wharves and associated structures.

Wharf Structures

The existing wharf structures in the project area would be expected to support biota communities typical of those found on intertidal rocky shores and subtidal pavements within the harbour.

Rocky shores occur in many areas of Darwin Harbour, particularly on headlands. Zonation patterns can be readily seen, with relatively few species occurring in the upper intertidal where organisms are exposed to variable conditions of temperature, sunlight, salinity, and other factors which can change suddenly as storms pass through the area during the Wet. Diversity increases further down the shore where conditions are not as extreme. Species in the middle of the intertidal region are adapted to life in that region and do not occur subtidally. Characteristic species such as gastropods (limpets, nerites, the pulmonate slug *Onchidium*, and thalids such as *Morula*), chitons (*Acanthopleura* spp.), bivalves (oysters of the genus *Saccostrea*), barnacles (*Chthamalus* and *Tetraclita*), and others live in the midtide region. In some areas the calcareous tubes of *Galeolaria* worms (Polychaeta) are common. Similar communities would be expected to inhabit the intertidal portions of jetty piles and the rocky revetments along the margins of the reclaimed land areas.

The subtidal portions of the jetty piles would be expected to support biota communities similar to those occurring on hard substrate areas of the harbour floor. These are typically comprised of a highly diverse fauna comprising sponges, ascidians, bryozoans, soft corals and gorgonian whips and fans, often with attendant crinoids (feather stars). These fauna rely on water currents to provide their food source and favour high-current areas.

Intertidal Flats

While limited previous studies have been undertaken on the flora and fauna of mudflats, in some areas of Darwin Harbour the invertebrate fauna is known to be diverse, abundant and of a high biomass (Wells 1983, 1984). These areas are invaded by fish, mobile invertebrates, and some vertebrates during high tide for feeding, and similarly at low tide by birds.

Hanley (1993) recorded a total of 131 species of invertebrates representing eight phyla within Darwin Harbour. Dominant molluscs are typically potamidids (*Terebralia*, *Telescopium* and *Cerithidea*), the slug *Onchidium*, the nerite *Nerita balteata*, and several species of ellobiids. Dominant crustaceans are fiddler crabs (*Uca*), alpheid shrimp (Alpheidae), the mud lobster *Thalassina anomala*, sesarmid crabs (*Perisesarma semperi*), and mudcrabs (*Scylla serrata*). Mudskippers (*Periophthalmus* sp.) are often associated with many of the burrows on the mudflats.

Grab samples collected recently (October 2003) from the Kitchener Bay mudflat showed the benthic fauna were dominated by polychaete worms, crustaceans (crabs and shrimp-like amphipods) and bivalve and gastropod molluscs. There was no clear pattern in abundances, either from west to east or with depth.

Corals and Rocky Reefs

Corals in Darwin Harbour are scattered as individual coral heads or colonies, and do not form true coral reefs. They are restricted to a very small vertical region extending from just above the low tide zone to a depth of 2-3 m below it (Hooper 1988; Hanley & Caswell 1995a). Species living in Darwin Harbour are those which are tolerant of conditions which exclude most corals: variable salinities, which can be very low during the Wet season; high turbidity which adversely affects symbiotic zooxanthellae living within the coral tissue; sedimentation; and other factors. Although the environmental tolerances of species living in Darwin Harbour are not known, it is likely that at least those individuals living well within the harbour are in suboptimal habitats and are naturally stressed.

Within the harbour, coral-dominated rocky reefs are located in the lower intertidal to high subtidal areas where strong currents keep the sediment load in suspension. The predominant reefs are at East Point, Weed Reef, Stephens Rock and Gunn Point (DHAC 2003). A rocky reef at Channel Island is listed on the Register of the National Estate and has been declared a Heritage Place under the Northern Territory *Heritage Conservation Act*. The declaration is based upon the presence of a relatively diverse coral community, which demonstrates that a coral based community can survive in an area where most physical conditions are adverse.

Seagrass Beds

Seagrasses in Darwin Harbour are known to occur off Mandorah, Casuarina Beach, Weed Reef, Wickham Point and between Channel Island and the mainland (Dames & Moore 1993a, LeProvost Dames & Moore [LDM] 1997, DHAC 2003). Rather than forming dense beds, the seagrasses are typically very sparse, primarily comprising *Halodule uninervis* and *Halophila decipiens* with some *Halophila ovata* and

Cymodocea serrulata. No seagrasses were recorded in the project area during the October 2003 survey by URS.

Mangroves

Mangroves occupy most of the margins of Darwin Harbour but are poorly represented within the project area, with only a few trees around the main drainage line across the Kitchener Bay mudflat (refer to Section 5.4.1).

The mangroves of Darwin Harbour are recognised as being among the key primary producers of the marine ecosystem and major nursery habitat for vertebrate and invertebrate species. The animals may be benthic species (largely marine invertebrates) which inhabit the mangroves throughout their juvenile and adult phases, or they move into the mangroves during high tide (fish, prawns, sea snakes, etc.) or alternatively low tide (birds, small mammals, etc.) to feed. Primary production may be used by animals either in the mangroves or it can be exported by tides and currents and used elsewhere.

Fish

Harbour waters support a high abundance of both resident benthic and transient pelagic fish species. The fish fauna of Darwin Harbour has been poorly studied (Larson 1988), however it is expected that most species typical of estuarine habitats in the Tropical Australian Province will be present. Of the fish species recorded in the Darwin Harbour region, 15 species are classified as threatened under IUCN classifications (DHAC 2003). However, only three species are listed as protected or partially protected under the *Territory Parks and Wildlife Conservation Act*:

- dwarf sawfish (*Pristis clavata*);
- Queensland grouper (*Epinephelus lanceolatus*); and
- estuary rock cod (*Epinephelus coiodes*).

Reptiles

Turtles tend to occur throughout the harbour, with Flatback Turtles (*Natator depressus*) and Olive Ridley Turtles (*Lepidochelys olivacea*) known to nest at Channel Island, Casuarina Beach and Mica Beach (DHAC 2003). Green Turtles (*Chelonia mydas*) and Hawksbill Turtles (*Eretmochelys imbricata*) also occur in the harbour (M. Guinea, cited in Dames & Moore 1993a), but there are no nesting or significant feeding sites known in the project area

Saltwater (also known as Estuarine) Crocodiles (*Crocodylus porosus*) occur but are regularly removed by the Northern Territory Government. Sea snakes are infrequently seen in Darwin Harbour (K. Martin, URS, pers. comm.).

Turtles, crocodiles and sea snakes are protected under both the Commonwealth EPBC Act and the *Territory Parks and Wildlife Conservation Act*.

Marine Mammals

Dugongs (*Dugong dugon*) and cetaceans (whales and dolphins) are protected under both the EPBC Act and the *Territory Parks and Wildlife Conservation Act*. Indo-Pacific hump-backed dolphins (*Sousa chinensis*) and Irrawaddy River dolphins (*Orcaella brevirostris*) are commonly observed within the Harbour.

Bayliss (1986) made an aerial census of populations of dugongs over large areas of the coastline of the Northern Territory. Darwin Harbour was shown as being a small part of a general area where dugongs occur in densities of 0.01 to 0.10 animals per square kilometre. They are known to occur in East and Middle Arms and in the vicinity of Channel Island (Bayliss 1986, Whiting 2001).

The project area does not contain habitats which could be considered critical for dugongs or other marine mammals. In addition, the activities associated with the wharves generate noise which would discourage the presence of any noise-sensitive marine mammals.

Marine Heritage, Conservation and Sensitive Areas

The nearest areas of sensitivity to potential impacts from the wharf development are:

- Doctors Gully Aquatic Life Reserve (fish feeding area), 2 km to the north-west of the project area; and
- the mangroves of Charles Darwin National Park and Sadgroves Creek, 3 km to the north-east of the project area.

The nearest coral areas, all which are considered to be well beyond the potential influence from works at the project area, are:

- South Shell Island, 5 km to the south-east;
- Weed Reef, 6 km to the south-west; and
- East Point Aquatic Life Reserve, 7 km to the north-west.

5.3.6 Ecological Function and Conservation Status of Major Biotic Groups

Coastal Vine-Forest

Although only a small area of coastal vine-forest lies within the site, considerably larger areas are adjacent. These areas comprise intact, well-established coastal vine-forest vegetation, and are the major

remnant native vegetation near the CBD. Vine-forests typically support a diverse range native species, many of which are relatively fire-sensitive (Panton, 1993) and are only found within this habitat (Wightmann and Andrews, 1989). The linear nature of this community leaves it vulnerable to disturbance, particularly from weed invasion.

Significance of Fauna Habitat across the Site

The former Deckchair Cinema and Stokes Hill power station site are largely comprised of cleared land with introduced flora species among old building foundations and rubble. This site provides breeding and roosting habitat to a few locally and regionally common species, but overall is of very little significance to native fauna. Two ground-dwelling bird species were recorded breeding on the former Deckchair Cinema site; Bush Stone Curlew (*Burhinus grallarius*) and Masked Lapwing (*Vanellus miles*).

The introduced Coffee Bush (*Leucaena huecocephala*) dominates parts of Stokes Hill and there is very little habitat for native fauna species. This was evident during the survey by the conspicuous lack of skink species, a usually abundant component of local woodland habitats that contain substantial leaf litter. One widespread and common bird species (Masked Lapwing (*Vanellus miles*)) was noted to be breeding at this location.

The escarpment contains remnant vegetation and the most species were recorded from this site. However, the vast majority of these were locally common birds. The site provides little habitat for ground dwelling species such as skinks. Only one arboreal species was recorded (Brushtail Possum, *Trichosurus vulpecula*). The site probably provides roosting/breeding and foraging sites for many bird species throughout different times of the year.

Significant Terrestrial Fauna Species

The majority of species recorded within the study area are widespread in tropical Australia. Two migratory species recorded at the site are listed as threatened under the CAMBA, JAMBA and the Bonn Convention. The Eastern Curlew (*Numenius madagascariensis*) is considered abundant around the Northern Territory coast, and the Common Sandpiper (*Actitis hypoleucos*) is considered to be widespread in the northern half of the Top End (Chatto, 2003).

The Bush Stone-Curlew (*Burhinus grallarius*) is listed as Near Threatened by the New Threatened Species List of the Northern Territory (DIPE, 2002). A pair of this species was recorded breeding on the Old Deckchair Site during the survey. The Northern Territory Bird Atlas database has numerous records of Bush Stone Curlew around the Top End and the site is unlikely to support more than a few pairs of this species. Therefore any impacts on this species from this development could not be considered significant at a regional level.

A number of threatened bird species occur in Charles Darwin National Park (about 3 km to the north-east of the site), however they are highly unlikely to inhabit the study area due to their habitat requirements and life history traits.

5.4 Built Environment

5.4.1 Existing Land Uses

Current Land Uses within the Site

The site is used for a range of tourism, commercial, industrial and port related activities.

Current land uses on the DCWR site are limited as most industrial activity has ceased or has been relocated. In addition, the following current land uses and activities at the site will cease in the near future:

- The Shell Bitumen Plant is expected to be decommissioned following the expiration of the lease;
- The quarantine incinerator (Fort Hill area) will become redundant in the near future when all quarantine and customs waste will be replaced by a new facility at East Arm Port;
- The Sulphuric Acid storage tank will be relocated to East Arm Port prior to the redevelopment proceeding;
- The remaining warehouse in the central section of the site will be dismantled and relocated to Fred's Pass; and
- The disused fuel tanks on Stokes Hill (Tanks 13 and 14) will be decommissioned.

Detailed descriptions of the existing structures, buildings and infrastructure within the DCWR site are provided in **Appendix Q**. This includes details of the potential intended purposes for the buildings and structures. (Refer also to Section 4).

Current Land Uses in Adjacent Areas

Stokes Hill and Fort Hill Wharves provide berths for naval ships, cruise liners and commercial and other vessels, and Stokes Hill Wharf supports a range of tourism and commercial activities. Fort Hill Wharf and the Iron Ore Wharf support fuel transfer facilities with pipelines from these wharves to fuel storage tanks at the NFI on Stokes Hill and other commercial tanks located at Stuart Park.

Immediately to the north of the site are the World War II storage tunnels. Five tunnels remain excavated into the escarpment with two tunnels, numbers 5 and 6 open to the public for inspection.

The Steam Pump House and the Jetty restaurant are not included in the project site and will remain separate from the redevelopment. The Steam Pump House is likely to be a heritage feature of the area.

The Darwin civic precinct is situated immediately to the north-west of the site on the plateau above the escarpment and includes Government House, the Supreme Court, Parliament House and Darwin City

Council (DCC). The Darwin CDB lies beyond this area. The recently relocated Deckchair Cinema operates seasonally (April to October) on the foreshore area to the west of the site. The outdoor screenings occur in the evenings only.

The northern half of Stokes Hill is occupied by the NFI. The north of the former Stokes Hill power station site includes a number of marine industrial enterprises including ship repair facilities, barge operations and fishing fleet berths.

5.4.2 Visual Characteristics and Values

A visual impact assessment (VIA) was carried out to describe the overall landscape and visual characteristics of the redevelopment site in conjunction with the surrounding landscapes, land use and developments.

Site Landscape Elements and Land Use

The project site is a landscape in transition. It contains elements from the original biophysical setting and from the past and present human use of the site. Some of the buildings and infrastructure from past port activities have been or are to be decommissioned and demolished.

The principal landscape elements of the site (**Figure 5.26**) are:

- 1) The outer wharves (Stokes Hill, Fort Hill, Old Iron and Old Fort Hill) provide the dominant ‘port’ landscape elements. The alignment of the dominant Fort Hill Wharf and Stokes Hill Wharf extending out from the shoreline at either end of the existing shoreline of the overall site provides a sense of symmetrical enclosure. However, the western wharves create a visually confused layout due to their historic and sequential development. Old Fort Hill Wharf is especially incongruous. Except for the conveyor on the Iron Ore Wharf, which will be demolished, most wharf fixtures are not intrusive. Visual aspect of the wharves from land and sea varied markedly between high and low tides, with the sub-structure/support structures significantly more prominent when exposed.
- 2) The tidal zone and mudflats are an important and dominant landscape element, exposed for significant periods during low tides. These areas can extend to within 30 m of the wharves at the lowest tides. Although often perceived as unsightly, tidal mudflats are a dominant element of the Darwin Harbour coastal landscape
- 3) The industrial area occupies the majority of the site south of Stokes Hill and dominates the existing landscape elements within the site. It comprises the following sub-elements:
 - Sub-element 1 includes the Fort Hill Wharf staging area and mostly lies outside the project area.

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- Sub-element 2 covers most of the remainder of the Fort Hill area, and the industrial structures in this area similar in height and mass. These buildings are being progressively decommissioned and hence part of their appearance is of vacancy and dereliction.
 - Sub-element 3 is the former warehouse area that is currently in an advanced stage of demolition and site clearance.
 - Sub-element 4 is an area of both completed and progressive reclamation on the seaward side of sub-element 3.
- 4) This existing recreational and commercial tourism site includes Indo Pacific Marine, the Australian Pearling Exhibition, the Jetty Restaurant, the Tram Eatery and the Steam Pump House. These features are mainly occupied, in use, well maintained and relatively ordered and tidy.
 - 5) The partly landscaped open foreshore area on the western edge of the site allows a degree of visual integration with the adjacent section of foreshore extending to the north and including the Deck Chair Cinema.
 - 6) The former Stokes Hill power station site forms a large cleared and partly rehabilitated landscape. Former structures have been demolished and removed, and the site has been left largely cleared and vacant. There are some concrete structures located underground, such as cooling water discharges for the former power station, which will be demolished.
 - 7) The Stokes Hill Fuel Tank site ‘depression’ is a distinct man made landscape element.
 - 8) The steep vegetated Stokes Hill scarp and ridge form a visual enclosure on the eastern side of the site. Prominent structures in this area include the water tank on the south-east ridge and the half-circle remains of a tank at the foot of the scarp.
 - 9) The main escarpment is the predominant topographic feature of the site, and forms the physical northern boundary of the site. Visually, the dense cover and canopy of the vine forest on the 25 metre high escarpment presents a strong vegetated enclosure and setting to the site. This boundary definition is likely to be greater in the future if the vegetation is allowed to continue to mature. Although visually uniform, this element contains several land uses:
 - private land ownership extending down from the Esplanade at the eastern end of the scarp;
 - public road access (Hughes Avenue) to the wharf precinct running diagonally down the scarp from north east to south west;
 - Survivors Lookout on the Esplanade and the associated steps down to Kitchener Drive; and
 - Government House property that extends over the entire south west ‘spur’ of the scarp.

Visual User Groups

The current visual user groups of the area include a widespread section of the community:

- port area employers and employees;
- visiting crews of the various ships and vessels using Darwin Port;
- all passing marine and boating traffic in Darwin Harbour;
- tourists visiting the site for a range of activities;
- the local Darwin community visiting the site for a range of activities;
- public servants and government representatives from the civic precinct above the escarpment;
- nearby city workers in the Darwin CBD;
- occupiers of various key buildings with direct visual access; and
- residents and occupiers of houses on Larrakeyah Terrace and Larrakeyah naval base.

Visual Accessibility

The site is generally contained within a closed visual catchment, largely unseen from the adjacent land areas of the CBD and nearby suburbs. It is obviously visually accessible from the open waters of the Harbour. Views to and from the city are extremely limited by the escarpment and the canopy of vine-forest it supports. The site offers the following visual accessibility (**Figure 5.27**).

- Visual accessibility to and from the CBD is limited to glimpses and views to and from floors of the tallest buildings at various distances back from the Esplanade frontage above the scarp.
- Visibility from the Esplanade is limited to Survivors Lookout and to glimpses from the eastern end of the road, and full visual access from several buildings along the top of the escarpment.
- The gap between the escarpment and Stokes Hill provides the only significant visual corridor between the site and nearby areas of the city and inner suburbs. This corridor will be significant if the redevelopment of the nearby former railway yards (between Tiger Brennan and Frances Bay Drives) includes high rise buildings
- Restricted visibility into the western edge of the site exists from the coastal portions of Larrakeyah. This locality is at sufficient distance for landscape detail to merge to the naked eye. Only major structural landscape elements and man-made structures can be seen with clarity.

Visual Catchments and View lines

The principal visual catchments and view lines were identified from various key points of visibility within the site or from key locations outside or peripheral to the site.

The internal visual catchments and view lines (**Figure 5.28**) include.

- a wide panorama from the Stokes Hill Wharf looking generally northward back to the redevelopment site (visual catchment 1);
- a wide panorama from the edge of the site over Darwin Harbour (visual catchment 2);
- view lines covering the main portion of the port, tidal mudflats and jetty wharves looking southward from near the base of Stokes Hill Wharf (visual catchment 3);
- similar view lines covering the open water, mudflats and wharves from the western end of Kitchener Bay (visual catchment 4);
- a more restricted but nevertheless open view of the port from the Tram Eatery (visual catchment 5); and
- the view from near the Steam Pump House (visual catchment 6).

The site also has a series of realised or potential key vantage points shown in **Figure 5.28**.

The external visual catchments and view lines (**Figure 5.29**) include:

- the western shoreline with visual connection along the western foreshore of Darwin city centre and visible to (and from) Larrakeyah (visual catchment 1);
- wide panoramas over the overall site from the elevated positions at the eastern end of Esplanade (visual catchment 2);
- a visible zone through the gap between the main escarpment and Stokes Hill (visual catchment 3a and 3b);
- a wide panorama from the existing Survivors' Lookout (visual catchment 4); and
- a potential wide and strategic visual catchment and sight lines from Government House gardens (visual catchment 5).

Topography and Key Visual Features

The main topographic features of significance to the visual qualities of the site include:

- the main escarpment;

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- the spur at the western end of the main scarp (Government House site);
 - Stokes Hill scarp;
 - the spur at the south-easterly point of Stokes Hill scarp;
 - the foreshore edge;
 - the intertidal zone (tidal mudflats and existing foreshore edge); and
 - the open water zone contained within the main wharves;

The key visual features of the site include:

- the lookout on Stokes Hill spur and existing storage tanks;
- the wharf structures and the structures and activities on the public accessible Stokes Hill Wharf, including visually interesting vessels tied up at the jetty;
- the dense green cover of the vegetated escarpment;
- existing in-use and disused/derelict industrial structures; and
- untidy vacant land use areas (decommissioned, derelict, demolished sites) that currently support prolific colonising vegetation, mainly weed species.

These various landscape features include both positive (high attribute, scenically attractive) and negative elements (visually intrusive, unsightly and incongruous). Of these the most problematic and in need of visual amelioration/enhancement include:

- the storage tank on Stokes Hill;
- all industrial structures;
- vacant, decommissioned and disused derelict sites;
- the untidy wharf structures (Old Fort Hill Wharf, Iron Ore Wharf);
- the central foreshore edge; and
- the mudflats.

5.4.3 Road Network and Traffic

Land Use and Traffic Generation

The site comprises a small number of disparate land uses. The majority of these, including operation of the wharves, are expected to be retained at least in the short to medium term and will continue therefore to generate vehicle and pedestrian activity. The following developments, which are located near, but outside of, the project site, are known to generate traffic movements into and out of the precinct and along main access roads.

- The Deck Chair Cinema has recently been relocated to just outside of the south-western end of the site with its own car park. It operates in the evenings during the Dry season with vehicle access to the site via Kitchener Drive and pedestrian access from Bicentennial Park along the Esplanade.
- There are three developments abutting Leydin Court located immediately north of the precinct and east of McMinn Street:
 - a six storey commercial office building (Harbour View Plaza): and
 - two townhouse complexes comprising 15-16 apartments each.
- At the time of assessment, multi-storey residential developments were being constructed within the immediate proximity of the precinct and its main access roads, and other land nearby which is either vacant or suitable for redevelopment has the potential to be similarly developed in the foreseeable future.

Road Network and Traffic Access

Road Access

The site contains a moderate but low standard road network servicing two distinct and physically separated components:

- the majority of the site south of Stokes Hill with access via McMinn Street and Hughes Avenue); and
- the former Stokes Hill power station site with access via Mavie Street (connecting to Frances Bay and Tiger Brennan Drives).

McMinn Street links the precinct with Tiger Brennan Drive and the Stuart Highway and is expected to be progressively upgraded as warranted by traffic demands. Hughes Avenue provides a very low standard access into the southern end of the precinct. It connects with The Esplanade and Kitchener Drive and is steep and narrow.

The network of sealed and undivided roads within the site are generally on level grade but in poor condition. These have also been designed and constructed to a low geometric standard with little or no

provision for drainage. Kitchener Drive extends south-westwards from its junction with McMinn Street along the base of the escarpment and into Fort Hill. It serves as a collector road for the few remaining developments and together with other connecting local roads provides access to the abutting land.

Pedestrian Access

Pedestrian access to the precinct is also limited and is not generally conducive for use by mobility-impaired persons. Access is possible via any of the approach roads mentioned above or two walkways (one stepped and one paved) linking The Esplanade with Kitchener Drive. A footpath is provided along part of McMinn Street south of the intersection with Bennett Street. There are no footpaths along Frances Bay Drive, and pedestrians have to walk on the road pavement or unsealed road verges. The stepped walkway is the most direct link between the CBD and the precinct. There are no clearly delineated pedestrian crossings at either end of the walkway where pedestrians are required to cross roads.

Cyclist Access

There are no dedicated facilities for cyclists to access or circulate within the precinct. There are no marked bicycle lanes on the access or internal circulation roads. Hughes Avenue is the most direct route between the CBD and the precinct but the road is steep and narrow and visibility at the junctions at each end is restricted.

Public Transport

There are no public passenger bus services operating within the site, and the bus terminus near Browns Mart (immediately off Smith St) is the closest facility. Passengers wishing to access the precinct must either walk or take a taxi. Buses access the CBD via either the Stuart Highway or Tiger Brennan Drive and travel to and terminate at the Browns Mart facility via Mitchell Street, Cavenagh Street or Bennett Street.

Intersections

McMinn Street – Tiger Brennan Drive – Bennett Street

This major intersection is one of the two major entry points to the CBD. It is controlled by traffic signals. The majority of traffic through the intersection travels between Tiger Brennan Drive and Bennett Street and there are only moderate volumes of conflicting traffic movements travelling along McMinn Street during peak periods. The intersection has capacity to cater for additional traffic volumes. However, the opposed filter turn movements from the single lane McMinn Street approaches could potentially reduce capacity significantly with only moderate increases in traffic volumes, or could introduce safety concerns.

Frances Bay Drive – Tiger Brennan Drive – Dinah Beach Road

This intersection is signalised and provides convenient access to the Stuart Highway at Stuart Park via Dinah Beach Road and Duke Street. The unusual approach of Frances Bay Drive to the intersection with Tiger Brennan Drive restricts the capacity to some extent although this is not presently evident with its current level of traffic usage.

Frances Bay Drive – McMinn Street

Frances Bay Drive forms a priority controlled T-junction with, and on, the northern side of McMinn Street about 300 m south east of Tiger Brennan Drive. There is no separation of through and turning traffic on the McMinn Street approaches to the junction.

Kitchener Drive – McMinn Street

Kitchener Drive also forms a priority controlled T-junction with McMinn Street about 200 m south of, and on, the opposite side of the junction with Frances Bay Drive.

McMinn Street – Leydin Court

Leydin Court forms a priority-controlled T-junction with, and on, the northern side of McMinn Street about 130 m south of the intersection of McMinn Street with Tiger Brennan Drive.

Hughes Avenue

The T-junctions at each end of Hughes Avenue with Kitchener Drive and The Esplanade are both problematic. The Hughes Street approaches are on moderately steep grades and form acute angle junctions. Visibility to and from the junction is restricted.

Traffic Volumes

Traffic volume surveys indicate seasonal variations with higher volumes being recorded during the Dry season. The estimated annual average daily traffic (AADT) for 2003 for McMinn Street (west of Bennett Street) was 5,900 vehicles per day (vpd) but the daily volumes varied between 6,500 in July/August and 5,000 in January. Similarly the estimated AADT (2003) for Tiger Brennan Drive was 16,100 vpd varying between 17,000 in August to 13,300 in January. The volume of traffic using McMinn Street (and Stuart Highway) has reduced in recent years while the traffic volume using Tiger Brennan Drive has increased.

Two-way demands for the access into the precinct are not high and reflect the present levels of traffic-generating activities occurring in the precinct:

- McMinn Street (west) - 570 vehicles in the morning peak hour and 290 in the evening peak hour (excluding the left turn into Tiger Brennan Drive);
- McMinn Street (east) - 358 vehicles in the morning peak hour and 411 in the evening peak hour; and
- Frances Bay Drive - 363 vehicles in the morning peak hour and 374 in the evening peak hour.

Car Parking

The site contains provision for free formalised car parking such as on Stokes Hill Wharf and off-street facilities at each of the developments abutting McMinn Street. Parking is occasionally restricted at the wharf during times when ships are loading and unloading. On-street parking within the precinct is generally permitted but is not prominent. Public car parking outside of the precinct is provided predominantly within the CBD. Many of these facilities are considered to be too far from the precinct unless some form of improved public transport link is provided. All-day parking is permitted on the northern side of McMinn Street, between Bennett Street and Stuart Highway, however this parking area is expected to be removed with the eventual widening of McMinn Street.

5.5 Unexploded Ordnance

An assessment was undertaken of the risk from Unexploded Ordnance (UXO) and Explosive Ordnance (EO) occurring at the site. EO comprises all munitions containing explosives. UXO are explosive ordnance prepared and deployed for detonation but which did not explode. The assessment was undertaken in two stages. An initial assessment was made of the likelihood of UXO / EO occurring at different sections of the site by review of historical information about the 28 World War II bombing raids between 19 February 1942 and 2 May 1943 on what is now the Darwin CBD and the wharf precinct. This historical material included recorded accounts from witnesses of the bombings and aerial photographs of the site at low tide following the bombings. The type, number and capacity of Japanese bombers used during the bombings was also analysed. On-site electro-magnetic detection of UXO was attempted on several occasions and areas, but the large amount of metallic debris in the fill material masked possible signals and hindered detection. This assessment categorised the site by determining the level and types of risk and was used to minimise risks during the intrusive sampling of the site (drilling and excavation).

UXO specialists were also on-site during intrusive sampling and this was used to provide additional characterisation of the site and the capability to detect possible UXO. The full reports from UXO assessment are shown in **Appendix R**.

5.5.1 Overview of UXO Risks across the Project Site

The project site may contain EO and/or UXO. The aircraft involved in the 28 bombing raids had the capacity to carry in excess of 100 tonnes bombs and possibly in excess of 1,600 individual bombs (G-tek, 2003). The acceptance rate (the proportion of shells which explode on impact) may have been significantly below 95% in the 1940s, and lower again on soft impact surfaces such as marine muds. With a conservative estimate of failure of 5 to 10% between 80 and 160 UXO are estimated to have been left across the bombing zone (which includes “Darwin Town” and the wharf precinct). In addition, allied EO and UXO may have been scattered across the precinct and sections of the CBD by the explosion of the munitions ship *Neptuna*, loss of munitions during loading and unloading, and from anti-aircraft firing during the bombing raids. There are only minimal records of the location and recovery or disposal of UXO during the years that followed the raid (and therefore what may remain).

The most likely explosive contained within EO and UXO that may be present at the site is trinitrotoluene (TNT). Potential EO and UXO are expected to be stable and intact under environmental conditions that any UXO would occur in across the site. It is however, unlikely that firing mechanisms will still be operational after such long periods of environmental exposure. Nonetheless, the risk of UXO is an additional factor to incorporate into site management procedures.

5.5.2 Likelihood of Occurrence of UXO

An assessment of the risk from UXO was undertaken to support the field investigations and intrusive sampling. The risk of UXO occurring in an area is based on several factors.

- The bombing raids were often carried along several axes with bombings clustered around key targets. Thus the location across the site at least partly determines the likelihood of receiving ordnance.
- The nature of the surface at each location in 1942 affected the likelihood of an ordnance detonating or surviving the impact without exploding. The rocky surface of Stokes Hill and the escarpment would have a higher detonation rate than the soft marine muds of Kitchener Bay, and higher numbers of UXO would be expected in the marine muds.
- Areas that have been heavily disturbed since 1942 are more likely to have had any remnant UXO discovered and removed. Conversely, undisturbed areas may still contain UXO.

Figure 5.30 shows the areas of the site with different levels of risk of the presence of UXO.

UXO/EO potential in old landforms

Existing landforms that remain unchanged from 1942 may contain embedded UXO, and these UXO may be exposed by any construction activity and site development. These areas include:

- Stokes Hill;
- a large portion of the former Stokes Hill power station site;
- the escarpment adjacent to Kitchener Drive; and
- the very early fill areas to the north-east of the former Fort Hill.

UXO/EO potential in and under fill

The areas within Kitchener Bay and to the west of Fort Hill were subject to uncontrolled filling. UXO may have been introduced inadvertently to these areas in fill material if that material was sourced from other sections of the wharf precinct or the CBD. In addition, marine sediments under this fill may contain undisturbed UXO.

UXO/EO potential under fill

The source and quality of the fill material in these areas is better characterised and less likely to contain UXO. However, the underlying marine sediments may contain undisturbed UXO.

UXO/EO potential in harbour muds

As noted for the above reclamation areas, UXO are likely in the marine muds of Kitchener Bay out to the wharves and along the eastern and western marine areas of the site.

UXO/EO potential under fill (ex salvage)

Areas around Fort Hill were used during marine salvage operations some years after the war. It is possible that UXO and EO collected during these activities were disposed on-site and may remain under the later fill material. Undisturbed UXO may also be present in the underlying marine muds.

5.6 Cultural Environment

5.6.1 Archaeology and Aboriginal Cultural Heritage

The assessment of Indigenous heritage of the site was based on review of relevant information about the site and the region, searches of the national, Northern Territory and local heritage databases and registers, consultation with relevant stakeholders and a field survey. Heritage significance and values were determined with reference to relevant Commonwealth and Northern Territory legislation, and the Burra Charter provides guidance for the conservation and management of places of cultural significance. The full report of the assessment is included as **Appendix J**. Native Title issues are addressed in Section 1.

Aboriginal Use of the Area

The Darwin region is part of the traditional lands of the Larrakia Aboriginal people living in close association with the foreshore and the sea, and using the freshwater springs of foreshore areas and the resources of the harbour environment. The large number of shell middens documented in the Darwin region indicates the resource rich nature of the coastline and its importance to the Larrakia (Gregory, 1996). Middens have been found in nearby areas including Bayview 3 in Frances Bay (Hiscock, 1996). Analysis of material from the location indicated that formation of the midden began between 1,250 and 1,550 years ago, and that the midden was in use until 700 to 1,000 years ago.

Burns (1996) noted several conclusions about archaeological sites in the region:

- the region contains numerous unrecorded prehistoric sites;
- the most common site type are middens associated with mangrove communities; and
- these sites tend to occur on the boundaries of biogeographic land units.

Kitchener Bay would have provided significant food and raw material resources. The original landform would have provided vantage points on the two knolls at either end of the bay (Stokes Hill and Fort Hill) and from the escarpment to view the coastline and harbour. These areas and the escarpment also provided an elevated camping area close to the resources of the foreshore. Stokes Hill in particular has been recognised as an important place for ceremony, and the area between the escarpment and Stokes Hill has been reported as being an Aboriginal camp in the past. However, evidence of this occupation is difficult to find. Extensive land disturbance within the site has changed the natural landforms and has greatly reduced the likelihood of intact archaeological material remaining. Although the tidal mudflats would have been a major resource for the Larrakia, reclamation of much of the area has concealed any remnant archaeological material. The reclaimed areas of Kitchener Bay are least likely to contain remnants of cultural heritage and further reclamation will conceal any potential remnant archaeological material.

The first recorded contact with Europeans occurred in 1839 with the arrival of John Lort Stokes aboard *The Beagle*. At the time of the arrival at Fort Hill of South Australian Surveyor General Goyder in 1869, about 700 Larrakia Aboriginal people were living on the harbour foreshore and hinterland. The site of Goyder's Camp may provide evidence of the interaction between the surveyors and local Aboriginal people at that time.

Archaeological Values and Sacred Sites

No archaeological sites or areas or archaeological sensitivity were identified within the site. However, two areas of Aboriginal cultural value were identified either within or near the project area. Both of which have been recorded as Sacred Sites:

- Sacred Site 5073-83, located at Lameroo Beach about 800m to the north-west of the project site, is not expected to be directly affected by the redevelopment.
- Part of Sacred Site 5073-93, covering Stokes Hill, extends into the project area (**Figure 1.9**). This is a Restricted Works Area under the Aboriginal Areas Protection Authority Certificate (No. 5073-93) (**Appendix B**). No excavation is allowed on this area and any other works require formal approval of the senior Aboriginal custodians for the site.

5.6.2 European Cultural Heritage

An assessment of European (historical) heritage in and near the project site was undertaken by review of published and unpublished historical records including several reports by local historians and consultants. Field investigations were not undertaken, but several sites near the project area were identified for future investigation (Refer table 5.6). The full report of the assessment is included as **Appendix K**.

Historical Overview

The Darwin wharf precinct has been fundamentally linked to the establishment and development of Palmerston Town (to be renamed Darwin in the early 1900s) and its port. Port Darwin was named by John Lort Stokes in 1839 when *The Beagle* sailed from Port Essington. The first permanent European settlement was established at Port Darwin with the arrival of Goyder and the establishment of his camp at the base of Fort Hill on 5 February 1869. Features of the site from 1869 to 1904 are shown in **Figure 5.31**.

The landing of the cable from Britain for the Overland Telegraph occurred on 7 November 1871. The Overland Telegraph inadvertently led to the discovery of gold in the region when the metal was found in a hole dug for one of the telegraph poles.

The first stable jetty at the wharf area was established in 1874 with the hull of the unseaworthy *Gulnare* and fill material at the eastern side of Fort Hill. The construction of the first jetty at Stokes Hill occurred in 1886, linked with the development of the railway linking Pine Creek to Port Darwin which was completed in 1888. Traffic at the wharf included construction material for the new railway, live cattle export and passengers. A cyclone in 1897 and damage from torpedo worms led to the replacement of the jetty (with the Town Jetty) in 1904.

Darwin's strategic location was recognised with the establishment of the NFI constructed between 1926 and 1929. The facility was expanded from four to nine tanks in 1933. The other developments in the area during the defensive build-up in the late 1930s included:

- a submarine boom net (which stretched from across the harbour from East Point to West Point);
- a shed to maintain the netting and buoys ("The Boom Shed");
- an extension of the railway line to the boom shed; and
- a flying boat terminal at the base of Stokes Hill.

The engagement of Japan in World War II saw a major increase in shipping and other activity in Darwin Harbour. The first Japanese air raid occurred on 19 February 1942. Eight of the 47 ships in the Harbour were sunk, including the MV *Neptuna*, a munitions cargo ship berthed at Stokes Hill Wharf. A total of 46 raids were made on Darwin with twenty eight (28) of these directed at the wharf area. These attacks causing widespread damage to the wharves, the NFI and other infrastructure, and significant loss of life, estimated to be between 400-500 people. The bombings killed many waterside workers, with 22 killed in the first raid alone. These and later deaths are commemorated by plaques at the base of Stokes Hill Wharf.

Oil fuel storage tunnels were constructed from 1943 as more secure facilities but were not used before the war ended. Stokes Hill Wharf was rebuilt in the mid 1950s and opened in 1956, with an extension completed in 1966.

The wharf area has also been a major focal point for migration to Darwin and regional areas, with all people arriving by sea prior to regular air services commencing in the 1930s.

Sites of Historic Interest

The wharf area as a whole has significant historic values and has been recognised as the most historic part of central Darwin. The following specific historical heritage features occur in or near the site:

- Stokes Hill both for indigenous cultural values and its historical values;
- Goyder's Camp site in the vicinity of the Darwin Port Offices near the lower end of Hughes Avenue;
- Goyder Memorial at the lower end of Hughes Avenue;
- Plaques near the base of Stokes Hill Wharf commemorating the deaths of waterside workers during the bombings in 1942;
- Tamarind trees near the Darwin Port Offices near the lower end of Hughes Avenue which may date back from early development of the area;
- Submarine Cable landing point to the west of the project site;
- Hughes Avenue which runs approximately along the line of the original path from Goyder's Camp to the escarpment and the developing town. It also runs close to the site of an historic long-term rubbish dump;
- Knight's Residence (also known as "Knight's Folly" and "the Mud Hut") which was constructed in the late 1800s on the southern edge of Hughes Ave;
- Kitchener Drive which runs along the line of the original foreshore of Kitchener Bay, the alignment of which may have been used as a walking path from at least the late 1800s;
- Oil Storage Tunnels which are prominent evidence of Darwin's wartime role and the involvement of Australia's Defence Forces;
- Boom Maintenance Shed, significant for its use during World War II for the storage and maintenance of the world's longest anti-submarine boom;
- Number 6 Oil Tank, with its remnant concrete revetment which has historical connections to the OFI, the Steam Pump House and the broader wharf area;
- Steam Pump House which was constructed in the mid 1920s and was an integral part of the development and operations of the Stokes Hill NFI;
- The wrecks of the *Warrego* and MV *Neptuna*;

-
- Traveller's (Chinaman's) Walk which was the main access way from Stokes Hill Wharf to the township from as early as the late 1880s;
 - The Burnett design "G" Type Residence at the southern side of the junction of Kitchener Drive and McMinn Street which was relocated from the CBD in about 1991. This relocation limits its heritage significance;

There are also a number of heritage sites on the periphery of the development site which will contribute to the historical heritage context of the area and link the historical elements of the project site with those in the CBD. These include:

- Government House, the Former Court House and Police Station and the Christ Church (portico) along The Esplanade above the escarpment;
- the stone kerbing along Smith Street, the Town Hall Ruins and Browns Mart close to the Smith Street Mall; and
- Damoe Ra Park and spring for its cultural significance to the Larrakia people and historical importance

The heritage status of these sites is shown in **Table 5.6**. Although many of the sites are not included in any heritage register, there is recent interest in nomination several of these. None of the heritage sites within the project area are subject to Conservation Management Plans.

Marine Archaeological Places and Objects

Significant marine archaeological places and objects within or adjacent to the site include the following.

- Gulnare Wharf site is the first stable jetty constructed in the area in 1874 on the eastern side of Fort Hill using the hull of the unseaworthy *Gulnare*.
- The hull of the *Warrego*, driven aground by strong winds onto the shoreline east of Stokes Hill, was a landmark of the Darwin foreshore and remains a significant maritime artifact. It remains on the site covered by fill during reclamation.
- MV *Neptuna* was a munitions cargo ship was bombed in 1942 and exploded at its berth alongside Stokes Hill Wharf. The superstructure was salvaged for scrap metal in the late 1940s, but the remainder of the buried hull is still on site.

Marine heritage sites between 1 and 1.5 km from the project site are the *Peary* (to the west) and the *British Motorist* and the *Zealandia* (both to the south). These sites are wrecks of ships sunk during the bombings of Darwin during World War II.

Table 5.6: Status of Heritage Sites in and near the Project Site

Site	Within Development Site	Heritage Status
Stokes Hill	Yes	Sacred Site (5073-93); NFI (outside project site) included National Trust <i>Register of Significant Places</i>
Kitchener Drive	Yes	Not included on any register
Boom Maintenance Shed	Yes	Not included on any register
Steam Pump House	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and National Trust <i>Register of Significant Places</i>
Warrego wreck	Yes	Not included on any register
Burnett design "G" Type Residence	Yes	Included on National Trust <i>Register of Significant Places</i> and <i>will be relocated</i>
Goyder's Camp	No – adjacent	Nominated for <i>NT Heritage Register</i> (2 April 2004)
Goyder Memorial	No – adjacent	Not included on any register
Tamarind trees	No – adjacent	On <i>Register of Significant Trees</i> (Greening Australia); Not included on any heritage register
Submarine Cable landing point	No – adjacent	Not included on any register
Hughes Avenue	No – adjacent	Not included on any register
Knight's Folly	No – adjacent	National Trust <i>Register of Significant Places</i>
Oil Storage Tunnels	No – adjacent	Tunnels 5 and 6 included on <i>NT Heritage Register, Register of the National Estate</i> and National Trust <i>Register of Significant Places</i> Tunnels 1, 10 and 11 also on <i>Register of the National Estate</i>
Traveller's (Chinaman's) Walk	No – adjacent	Included on <i>Register of the National Estate</i> (to be delisted as demolished site) and National Trust <i>Register of Significant Places</i>
MV <i>Neptuna</i>	No – adjacent	Included on <i>NT Heritage Register</i>
Government House	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and National Trust <i>Register of Significant Places</i>

Table 5.6: Status of Heritage Sites in and near the Project Site

Site	Within Development Site	Heritage Status
Former Court House and Police Station	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and <i>National Trust Register of Significant Places</i>
Christ Church portico	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and <i>National Trust Register of Significant Places</i>
Smith Street stone kerbing	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and <i>National Trust Register of Significant Places</i>
Town Hall Ruins	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and <i>National Trust Register of Significant Places</i>
Browns Mart	No	Included on <i>NT Heritage Register, Register of the National Estate</i> and <i>National Trust Register of Significant Places</i>
Damoe Ra Park	No	Contains a registered Sacred Site

Legislative Protection of Heritage Sites

Under the *Heritage Conservation Act* 1991, declared heritage places and heritage objects (i.e. places or objects listed on the Northern Territory Heritage Register) are protected from damage, demolition, destruction, desecration or alteration, unless the activity complies with a Heritage Management Plan. The following heritage sites, within the project area, are on the Northern Territory Heritage Register: the Oil Storage Tunnels, the Steam Pump House and the MV *Neptuna*. In addition, Goyder’s Camp was nominated for inclusion on the Heritage Register on 2 April 2004.

Register of the National Estate was established under the *Australian Heritage Commission Act* 1975 and now retained under the *Australian Heritage Council Act* 2003. Sites listed on the Register can be protected under the *Environment Protection and Biodiversity Conservation Act*. Sites within or in the vicinity of the project area on the Register are: Oil Storage Tunnels (1, 5, 6,10 and 11), the Steam Pump House and Traveller’s/Chinaman’s Walk (to be delisted).

The Stokes Hill Sacred Site (5073-93) is protected under the *Aboriginal Sacred Sites Act*.

The following sites in or near the vicinity of the project area are listed on the National Trust Register of Significant Places: Knight’s Folly, the Oil Storage Tunnels (5 and 6), Traveller’s (Chinaman’s) Walk and the Burnett design “G” Type Residence.

5.7 Socio-economic Environment

5.7.1 Economic Structure

Overview

The Northern Territory's Gross State Product at around \$9.1 billion (2003 figures) accounts for around 1.3% of Australia's Gross Domestic Product. The economic structure of the Northern Territory economy is significantly different to that of Australia generally. Key points include:

- a higher proportion of public and defence spending;
- the significant contribution of the mining sector;
- the significance of tourism for the Darwin and Northern Territory economies, and to employment;
- the traditional role of construction as an important economic driver;
- the very small manufacturing sector compared with the rest of Australia;
- the higher proportion of public housing and private rented accommodation than the rest of Australia; and
- lower Consumer Price Index increases in Darwin over recent years than in other capital cities.

Tourism contributes an estimated 6.8% of the Northern Territory's Gross State Product, and more than 11% of wage and salary earners (compared with 7.1% nationally).

In the longer-term, the Territory's economic development is likely to be influenced by the Timor Sea gas development and on-shore processing, by the development of Darwin's East Arm port and the operation of the recently-opened Adelaide to Darwin railway. These developments offer potential for significant economic stimulus through the establishment of new industries and improved communications with Asia and the rest of Australia.

Labour Force

The Northern Territory's workforce profile is significantly different to that of the national as a whole, being typically younger, more mobile and transient – and highly responsive to changes in economic conditions and employment opportunities. The dynamic nature of the Territory's labour force is reportedly reflected in high staff turnover, and consequent significant costs to business in recruitment, training and the retention of valuable skills and expertise.

Table 5.7 shows the employment in Darwin's major industry sectors.

Table 5.7: Northern Territory employment by industry

Industry	2001 (No.)	2001 (%)	1996 (%)	1991 (%)
Tourism	8,400	15.9		
Manufacturing	2,762	5.3	5.1	4.6
Construction	3,377	6.4	8.9	6.1
Retail	7,089	13.5	12.4	12.6
Property and business	5,515	10.5	9.0	7.0
Education	4,052	7.7	7.4	7.5
Health and community services	4,392	8.4	9.1	7.7

5.7.2 Community attitudes

Seven consultation workshops were conducted by Communications Consultants Socom in January 2004 with identified community priorities for the Darwin Wharf Redevelopment project. The workshops sought to enable stakeholders to articulate what they thought would make the waterfront:

- an exciting place for national and international visitors who will use the convention centre;
- a place that Territorians would want to visit regularly; and
- a place that would enable the local community to mix with visitors so that the latter could understand what made Darwin a wonderful place.

The workshops suggested that the Darwin community would welcome the redevelopment if it created or highlighted:

- a sense of place with connection between the land and the water;
- history and culture of the site;
- tropical environment and lifestyle
- local sense of ownership as a place for Darwin people;
- varied dining options;
- masking of the tidal mudflats;
- residential at the ends of the site to maximise the public open space;
- a positive visual impact of the DCEC from all vantage points;

-
- a showcase local and international artists and performers;
 - boats access;
 - a strong connection to the CBD; and
 - appropriate access and transport.

5.7.3 Outcomes from Stakeholder Interviews

Interviews with key local government, business, environmental and community stakeholders identified the following broad range of views.

- More medium-term strategic and comprehensive planning is needed to integrate the redevelopment within a broader, community-backed vision for the future development of Darwin and its surroundings.
- The redevelopment would deliver significant benefits to businesses throughout Darwin, despite possible negative impacts in the short-term.
- More effective consultation about the redevelopment was needed.
- Darwin's economic sustainability requires population growth.
- Some scepticism was raised about the viability of the project and, in particular, about the proposed exhibition and conference centre's capacity to attract large numbers of visitors to Darwin.
- Impacts of the redevelopment on the viability of the CBD were a concern.
- The redevelopment could establish an international showcase for tropical architecture and design, in contrast to much of Darwin.
- The redevelopment provides both the risk of loss of the site's significant historical and heritage values and an opportunity to fully incorporate and protect that heritage.
- Protection of the scenic and ecological values of the escarpment is important.
- Construction may cause impacts from increased noise, traffic and disturbance.
- The redevelopment may limit itinerants and their use of parts of the foreshore.

5.8 Systems and Habitats

5.8.1 Site Contamination

The site contamination affects several components of the environment including terrestrial soils, groundwater and surface water quality and movement, marine sediments, Acid Sulfate Soils, terrestrial and marine biota and land uses. In summary, the distribution, movement and potential mobilisation of contaminants can be influenced by:

- the distribution, types and levels of contaminants in soils and marine sediments;
- the physical and chemical characteristics of the soils and marine sediments;
- the location and condition of existing sources of contaminants within and adjacent to the site;
- the potential for surface run-off from the site to move contaminated sediment or soluble contaminants downstream and to the near shore marine environment of Kitchener Bay;
- groundwater movement over the year (seasonal fluctuations with the Wet and Dry seasons) and over daily tidal influence in the areas closer to Kitchener Bay;
- the types of marine habitats and associated marine flora and fauna;
- tidal movement of marine sediments; and
- earthworks and other human activity (including lowering the water table by extracting groundwater) that may either bring contaminated material to the surface or expose Acid Sulfate Soils to air and cause the generation of acidic run-off or groundwater which can mobilise some contaminants.

The interaction between these components of the environment has been dealt with in Section 5.2 and in later sections of the Draft EIS.

5.8.2 Acid Sulfate Soils

The effects of Potential Acid Sulfate Soils on the environment depend on a number of factors. In most cases and without intervention, these soils usually remain unexposed and stable *in situ*. They may be disturbed under unusual natural conditions such as extraordinary fluctuations in groundwater levels or physical disturbance of sediments. These soils are discussed in more detail in Section 5.3.8. The effects of intervention, such as excavation or dredging, are discussed in Section 6.

5.8.3 Terrestrial Ecology

Terrestrial flora and fauna are intimately linked and the loss of vegetation and the habitat it forms can lead to losses in fauna species or abundance. The prolonged history of disturbance and industrial activity

over the site has left the area with minimal natural habitat values, although several individual trees and the small mangrove community provide some aesthetic and amenity value. In addition, aesthetics and habitat values of the regenerating native species on the scarps of Stokes Hill may increase with time and management. The clearing of vegetation on the site will not have a significant impact on flora or fauna values.

5.8.4 Intertidal and Marine Systems

The intertidal and marine environment is linked to foreshore and near shore areas through tidal, groundwater and surface flow processes, and terrestrial soils can be blown into Kitchener Bay. The condition of the terrestrial environment, particularly the extent of vegetative surface cover and the level of surface disturbance, influences the degree of erosion and movement of soils by run-off and wind.

A small mangrove community has established at the western end of Kitchener Bay and provides some amenity value by softening the existing harsh foreshore. This community is partly dependent on the freshwater inflows from the stormwater drain at the part of the foreshore.

5.8.5 Use of Current Site Facilities

In its current form, the project site supports a range of tourism, commercial and tourism activity. Much of this activity is dependent on the waterfront setting, and Stokes Hill Wharf in particular, and historic features of the area. The site also includes existing commercial and tourism attractions:

- the Indo Pacific Marine;
- the Australian Pearling Exhibition;
- *The Jetty* restaurant;
- the Trams eatery;
- the tours of the World War II tunnels; and
- small businesses on Stokes Hill Wharf.

Remaining industrial activity (at the time of writing) includes:

- the Shell Bitumen Plant (due to be decommissioned);
- the cargo facilities at Fort Hill Wharf (including roll-on roll-off operations and live cattle export);
and
- a Darwin Port Corporation workshop.

The area is a focus of several tour operators, and passengers on visiting cruise ships and sailors from visiting Navy vessels pass through the area to reach the CBD and other parts of Darwin. Road access to the Deckchair Cinema is through the site.

All of these businesses and activities depend on road access through the site and the general amenity of the area. Other businesses in the vicinity (largely in the CBD) are not directly dependent on the area.

6.1 Introduction

The purpose of this section is to identify and, where appropriate, quantify all of the principal potential impacts on the existing environment that may arise during the construction and operation of the proposed project. This includes impacts on the biophysical and socio-economic environments. The assessment has been undertaken on the basis of information available at the time of writing (May 2004) and is based on the Darwin Waterfront Revitalisation Concept Plan (Northern Territory Government Department of Infrastructure, Planning and Environment July 2003).

This section identifies the potential for both adverse and beneficial impacts that may arise and highlights issues that may need to be addressed.

The phases of the project are:

- site preparation and remediation;
- construction; and
- operation.

Remediation of contamination at the site is being undertaken prior to the development proceeding. The level of remediation and any subsequent site management conditions will comply with the requirements of the Victorian EPA Contaminated Land Auditor (CLA) in the “Statement of Environmental Audit”. Pre-remediation site works, including demolition of above and underground infrastructure and services will be undertaken on the central 9.2 ha portion of the site to allow for further testing and site preparation which will enable remediation activities to proceed effectively. Removal of oil from the fuel tanks 13 and 14 located in the depression at Stokes Hill, and the importation and stockpiling of clean fill material will also be part of pre-remediation site works.

The assessment considers impacts from both the construction and operational phases of the project. It also considers impacts from potential incidents and accidents throughout the life of the project from abnormal operating procedures. This section deals with these phases of the project as part of the various components of the environment (physical, biological, built, cultural and socio-economic).

Construction will be staged over a 10 to 15 year period, with different components of the Redevelopment being built as residential and commercial real estate demand dictates. Operation of the Redevelopment site will change over this 10 to 15 year period as additional components and facilities are constructed. Major construction stages are expected to include:

- the Darwin Convention and Exhibition Centre;
- vehicular access to, from and within the site;
- service infrastructure;
- public space and infrastructure including the foreshore promenade

-
- residential development across the site, likely to be constructed in phases; and
 - commercial facilities such as restaurants and cafes.

Impacts considered in this section include:

- direct and indirect impacts;
- short, medium and long term impacts;
- cumulative impacts; and
- both adverse and beneficial impacts.

The potential impacts from the existing contamination of the site traverse several components of the environment such as soil, groundwater, surface water, terrestrial and marine biota and risks to human health. To avoid repetition and loss of clarity of the interactions affecting these potential impacts, all aspects of site contamination relating to the biophysical environment are discussed in one section (Section 6.2).

6.2 Site Contamination

6.2.1 Overview

The primary potential environmental impact from the existing contamination at the project site is from mobilisation of contaminants in soil, marine sediments and groundwater. If mobilised, these contaminants may have impacts on terrestrial and marine organisms and pose a risk to human health. Mobilisation may occur through:

- Disturbance of buried contaminated soil or sediments;
- Distribution of contaminated soil as dust or in surface runoff; and/or
- Exposure of Acid Sulfate Soils (ASS) to the atmosphere and generation of acidic surface runoff or groundwater discharge, which may dissolve and transport contaminants.

The following discussion provides further details of these processes.

It should be noted that the assessment of site contamination and the necessary remediation of the site is subject to separate and rigorous review and approval procedures through the Northern Territory Government and an independent Auditor accredited under the Victorian EPA Contaminated Land Auditor (CLA) scheme administered by the Victorian Environment Protection Authority. Extensive investigations have been undertaken and further assessment is underway to characterise the sources, type and extent of contamination across the site. These investigations and the auditing and approval procedures will define the remediation required for safe future use of the site.

6.2.2 Soil Contamination

Residual Hydrocarbon Impacted Soils

Soils heavily impacted with hydrocarbons associated with disused infrastructure will be removed and remediated. Residual hydrocarbon contamination within the vertical smear zone will remain in place subject to the requirements of the Auditor.

The Auditor appointed to review the contaminated site investigations for the project expressed concern for excavations below 3.5 m, which could intersect this hydrocarbon smear zone. The proponent has advised that excavation below 3.5 m is not expected, other than for major excavations such as the basement for the proposed convention centre and the drilling of piers. While no remediation may be required, site management controls, such as tanked basements, will be necessary in these situations to provide sufficient protection to human health and the environment. These controls will be provided through the implementation of a Site Management Plan (SMP), to be agreed with the Vic EPA CLA auditor.

Management of Volatile Petroleum Hydrocarbons

Assessments undertaken to date generally indicate that hydrocarbon contamination primarily comprises fuel oil and does not have high volatile fractions. Assessment data reviewed at the time of preparing this document does NOT indicate the presence of carcinogenic volatile hydrocarbon contaminants (such as Benzene). The CLA Auditor has advised that a risk-based management approach to remediation may be feasible in the absence of toxic concentrations of volatile contaminants.. However, fuel oil contamination can still give rise to objectionable odours that may require mitigating actions.

Excavation of Disused Infrastructure, Building Foundations and Piping

Subsurface piping and sands surrounding piping may contain hydrocarbon contamination and will be required to be dealt with appropriately. Hydrocarbons were identified in association with disused piping and sand surrounding the piping within several site areas, and additionally associated with cooling water structures from the former power station. Additionally, concrete building foundations are known to be present in the area of the former Stokes Hill power station. Demolition of some disused infrastructure is presently scheduled. However, the power plant foundations and some utilities may remain at the time of construction.

Surface Water Transport

During the remediation and construction phases of the Redevelopment, when contaminated soil may be exposed to the atmosphere, there will be increased risk of both contaminants and sediments being carried into Kitchener Bay in surface waters. This will be addressed in the Site Management Plan (SMP).

6.2.3 Marine Sediments

The results of the sampling programs undertaken indicated that the surface 50 cm of sediments within Kitchener Bay may be unsuitable for unconfined sea disposal. Elevated concentrations of metals and organic compounds (cadmium, lead, zinc and PAHs) were found in the western end of the Kitchener Bay. The capability of some of these metals (lead and zinc) to enter the water column exceeded water quality trigger values for samples collected in the western and central parts of the bay. Ecotoxicological testing of the sediments will most likely be required if sea disposal of these sediments is to be considered.

Some of the metals and organic compounds with elevated concentrations in the western end of Kitchener Bay (arsenic, cadmium and PAHs) were found to not be bioavailable and hence these contaminants are not expected to influence spoil disposal options. Elevated concentrations of organic compounds (PAHs) were found at the eastern end of Kitchener Bay. These were found not to be bioavailable, hence these contaminants are also not expected to influence spoil disposal options.

The investigations indicate that outside Kitchener Bay, some limitations in spoil disposal options could occur from metals and organic contamination, including sediments from:

- the western end of the Wharf Precinct (cadmium);
- behind the Iron Ore Wharf and Navy refuelling facility or adjacent the old power station cooling water outfall (PAHs);
- behind Fort Hill Wharf (cadmium and lead); and
- off the face of Fort Hill Wharf (TBT).

If dredging works were to be proposed at these locations, then tests of the sediments to determine the capacity for the contaminants to be released to the water column would be undertaken to ascertain their suitability for unconfined sea disposal. Any disposal would be undertaken under the requirements of the Darwin Harbour Dredging Technical Advisory Committee.

6.2.4 Groundwater Contamination

Dewatering Excavations

If excavations are required that go deeper than the standing groundwater level, dewatering is likely to be necessary. Contaminated groundwater is present at the site and will likely be encountered during excavation. Contaminated groundwater has the potential to re-contaminate surface soils on the site if allowed to collect on the surface and also contaminate surface waterways and the marine environment of Kitchener Bay if uncontrolled discharge is allowed. Contaminated groundwater may present a health concern if contact or ingestion occurs.

The lowered groundwater level associated with dewatering may cause groundwater contamination plumes to change flow direction. This may have the effect of changing the distribution of contaminated groundwater.

Potential Contaminant Impacts on the Marine Environment

Concentrations of hydrocarbons and metals were detected in groundwater monitoring wells located in close proximity to the shoreline. The potential steady state nature of the hydrocarbon plume suggests that the current extent of the identified plume area and the concentration of hydrocarbons in groundwater near the shoreline would not be expected to increase significantly. However, the current data highlights a potential for contaminants to be flushed into the marine environment.

Seawalls, a marina and lock systems could have an impact on the groundwater regime at the site including:

- causing the groundwater level to rise at the site particularly during recharge from the escarpment during the Wet Season. This could result in significant amounts of groundwater discharging through the ground surface at the site; and
- reducing the head difference across the site and thus affecting the rate of groundwater discharge; and
- a significant reduction in water level variation limiting the existing tidal flushing effect on groundwater contamination.

Site management based on current data is highly dependent on the nature of the development to be constructed in the near shore marine area and the potential impacts of that development on the areas of contaminant impacted groundwater.

6.2.5 Stages of the Redevelopment

Pre-Remediation Site Works

Pre-Remediation site works are likely to occur at an early stage in the development and will include the demolition and removal of selected buildings and disused surface and subsurface infrastructure, asphalt pavements, concrete structures including slabs, foundations and sumps. These works have been included here for completeness but are not to be assessed as part of the Draft EIS. Due to the potential for pre-remediation site works to occur at an early stage in the project, an environmental management plan (EMP) for the works was submitted to the Office of Environment and Heritage on the 14 May 2004, prior to the commencement of works.

These works have the potential to mobilise contaminants such as metals and hydrocarbons in dust and surface water run-off. Material will likely be stored on site in a roofed and lined building or removed from site. Current plans indicate that contaminated infrastructure and debris will be stored in the boom shed located on Fort Hill prior to being removed from site as part of the site remediation works. If

material is to be removed from site, either via McMinn St or Tiger Brennan Drive, there is the potential for contaminants to mobilise as dust and carry to residential and commercial areas. Site management measures have been included in the tender documentation to ensure there are no adverse impacts from the works.

Remediation of Site Contamination

The results of Phase I and Phase II site investigation works indicate elevated concentrations of a range of metal and metalloid contaminants, including arsenic, zinc, cadmium, lead and manganese within the top 1 m of the soil profile (URS 2003). In particular, the former Fort Hill Iron Ore and Zinc Concentrate Storage area has historically been used for the storage of copper lead and zinc concentrates. Additional areas are known to contain elevated concentrations of petroleum hydrocarbon compounds.

During the removal of site infrastructure, remediation works for the removal of contaminated soil and fill material, there is the potential for the release of contaminants adsorbed to soils during disturbance. Transport of this material through commercial and residential areas may also result in the generation of contaminated dust or stormwater run-off. An appropriate location and type of disposal facility for contaminated material will be determined.

Areas of the precinct may have been used for the disposal of Asbestos Containing Material (ACM) during uncontrolled land filling. Disturbance of the site during remediation (or during earlier site works) has the potential to release airborne asbestos fibres. The Remediation Action Plan for the site will address this issue.

Construction

In light of the past industrial land uses of the area, there is a significant potential for dust emissions from these construction activities to contain metalloid contaminants. Hydrocarbon contamination may be objectionable in appearance and malodorous.

6.3 Impacts on the Physical Environment

6.3.1 Overview

This section describes the anticipated environmental impacts on the quality of land, groundwater, surface water, the marine environment and air during the construction and operational phases of the project. The potential impacts from ASS have implications for several elements of the physical environment and are discussed in one section (Section 6.3.3). The discussion of the impacts on the physical marine environment (Section 6.3.6) includes dredging, reclamation and the construction of seawalls. Impacts on marine biota are discussed in Section 6.4.4. Demolition and remediation are addressed in Section 6.5 (Impacts on the Built Environment).

6.3.2 Geology, Topography and Soils

A detailed description of the regional and local geology, topography and soils in the vicinity of the project site is provided in Section 5.

Erosion and Sedimentation

The project site is generally level with the one prominent topographic feature of Stokes Hill. The site has a steep escarpment backdrop. Both Stokes Hill and the escarpment have an elevation of about 25 m and consist largely of rock with shallow soils. Erosion from these two features is unlikely. The erosion potential across the remainder of the site is moderate due to the conflicting factors of very low slope and exposed soils and fill material. Most of the run-off generated from the upper catchment (above the escarpment) is directed to receiving waters by underground drains and does not contribute to the erosion potential. Nonetheless, run-off from direct rainfall on the site may mobilise sediment and lead to erosion, particularly following the loss of vegetation ground cover and terrain disturbance.

The following potential effects may result from site preparation, excavation and construction activities and must be appropriately managed.

- soil erosion can be a major problem in a high rainfall environment such as Darwin. Erosion and sedimentation will be of particular concern during the Wet season;
- dust may be generated during the Dry season. Once disturbed and exposed, the silt fraction of the fill material has a high potential for dust generation when dry;
- ASS exist at several locations in the onshore marine sediments underlying the fill material in the reclaimed area of Kitchener Bay. Disturbance and exposure of these materials should be managed to prevent the release of acid leachate;
- remediation of the existing fill material and buried structures will generate unsuitable debris and buried structures will need to be removed and disposed off site at the relevant disposal facilities. General construction wastes will also be generated; and
- problematic subsurface conditions exist across the site. Buildings constructed across interfaces between areas of different lithology (for example between the original Fort Hill and the reclaimed areas) may be subjected to differential soil settlement. This may affect the long term integrity of those buildings. Similarly, buildings founded on areas with a greater marine sediments thickness and/or loose fill materials are expected to experience larger settlements.

An Erosion and Sedimentation Control Plan for the site is described in Section 7. Section 6.3.6 discusses the downstream implications of erosion and sedimentation on the inshore marine environment of Kitchener Bay.

Sources of Fill and Bulk Building Material

Fill material will be required for raising significant areas of the existing reclaimed areas to a sufficient level to protect against storm surge. In addition, fill material may be required for further reclamation of Kitchener Bay and/or the construction of a sea wall or other engineered foreshore structure. Sand may also be imported to the site for landscaping and more specifically for water features. Only clean fill will be used at the site.

6.3.3 Acid Sulfate Soils

Excavation and/or dewatering activities of marine sediments in areas with ASS has the potential to result in the oxidation of sulfides contained in this material, and the resulting release of acidic leachate into the surrounding environment. Excavation may bring ASS to the surface, while dewatering may lower the water table and lead to generation of acidic groundwater and this may present a health concern if contact or ingestion occurs. There may also be ecological effects on flora and fauna. Acidification of nearby groundwater or surface water may also mobilise metal contaminants.

Stockpiling of excavated marine sediments with ASS also has the potential to result in the oxidation of sulfides contained in this material, without treatment this could result in the release of acidic leachate into the surrounding environment. Stockpiling is most likely to impact by release during rainfall that will result in contamination of stormwater, contamination of surface soils that stormwater flows over and release to the marine environment and this may present a health concern if contact or ingestion occurs.

6.3.4 Hydrogeology

The Redevelopment may have impacts on groundwater underlying the site in two ways:

- by causing a change in recharge patterns; and
- through the extraction of groundwater during dewatering or other activities.

Though resulting from different causes, the processes leading to these impacts are similar.

Changes to Groundwater Recharge

Changes to the drainage and stormwater systems across the site may lead to increased or decreased recharge from surface runoff and subsequently either a rise or lowering of the groundwater levels. These potential changes will be most evident at different times of the year. A lowering of the groundwater will have its greatest impact during the Dry season, with stress on mature vegetation and possible tidal saltwater intrusion. Increase recharge and a higher water table may result in water-logging of low-lying areas of the development during the Wet season with the associated environmental problems.

Groundwater Extraction

Groundwater pumping and drainage is likely to be required for local dewatering associated with construction activities such as foundation placement and infrastructure installation. Groundwater pumping will lead to a lowering of the water table (although the degree and direction of the fall in groundwater levels has not been determined). This may result in:

- a localised change in groundwater flow with the potential of spreading groundwater contamination plumes to uncontaminated areas of the site;
- seawater intrusion into the strata under the site (from lowering the groundwater near the foreshore); and
- exposure of PASS to air and activation of their acid generating capacity.

Treatment of extracted groundwater may also be required prior to disposal or on site discharge.

Investigations have demonstrated that movement of groundwater towards the ocean is slow, indicating that the soils and sediments have a low permeability. This low permeability is also likely to minimise saltwater intrusions, that is the movement of seawater to areas where groundwater has been extracted.

6.3.5 Hydrology and Surface Water Quality

Overview

It is expected that drainage in the project area will be redeveloped based on drainage best practice and will not restrict flows from the catchment above the escarpment or within the project area. This will require the drainage system to prevent flooding up to a 100 year ARI event.

Modifications to Existing Hydrological Regimes and Water Quality

The Redevelopment is expected to substantially change the land use composition of the catchment from the existing industrial and disturbed landscape to a predominately urban area with convention centre, parks and gardens, and retail developments. The extent of the wharf and industrial area is expected to retract significantly. The Redevelopment will require upgrading of the existing drainage system in the area. Additional parts of Kitchener Bay may be reclaimed, increasing the surface water catchment. These changes will have the net effects of improving stormwater flow management and significantly improving the quality of stormwater discharged to the harbour.

Redeveloped areas are expected to be constructed using best-practice techniques to manage stormwater flows and quality, including:

- capping or removing contaminated soils and fill materials to prevent contamination of stormwater;

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- upgrading the drainage network to reduce the risk of flooding, erosion or contamination; and
 - upgrading systems for treating flows from within the remaining industrial area as required, using best practice urban water management techniques, to improve stormwater quality prior to discharge to the harbour.

An analysis of the implications of the land use changes was undertaken using data from studies conducted by Padovan (2001). This estimate of changes in loadings to Darwin Harbour provides an assessment of the water quality outcomes from the proposed Redevelopment. It indicates that, once the site has been remediated and developed, stormwater quality should be high and contain only low levels of sediments and rubbish. This should result in an overall improvement in water quality. Reductions in loadings for various water quality parameters should vary from 40-80% (Table 6.1, refer to Table 5.2 for estimations of existing loadings), and bring the estimated discharge quality into line with what would be considered best practice for the Darwin CBD. The increase in runoff resulting from the increase in catchment area was estimated to be small (2%), in part due to the addition of future recreation areas such as parks and gardens, which will generate less run-off than the current industrial site. Run-off from roofed and paved areas in an urban setting is expected to be of a similar order to the current situation. Surface water interactions with tidal water are not significant across the site, and are restricted to the outflow drains from the underground stormwater system. This freshwater discharge may be locally important for the maintenance and development of the small mangrove community on the western end of Kitchener Bay. Loss of outflow to this area may diminish the long-term viability of this vegetation.

Flooding

The main flood risk to the site is from storm surge and the development will not increase the flood risk. The upstream contributing catchment is small and not likely to generate sufficient stormwater to impact the project area.

Buildings within the development will be constructed with floors above 6.5m AHD (1000 year ARI storm surge, including a 0.3 m allowance for rise in sea level to take account of long term global warming) to reduce their susceptibility to storm-surge flooding. Other areas will be designed as appropriate to either not flood during a 100-year ARI storm surge event (5.1 m AHD), or be safely inundated and recover after the event.

Drainage infrastructure will be upgraded throughout the Redevelopment area as required to safely accommodate runoff from heavy rainfall events, including cyclones, up to a 100-year ARI event.

Impacts on Receiving Waters

Potential impacts on the receiving waters of Darwin Harbour are likely to stem from:

- erosion during construction causing elevated sediment levels in stormwater and/or sediment deposition in near-shore areas;

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- contamination with stormwater containing metals, hydrocarbons or acid leachate entrained from contaminated areas within the site; and
 - increased runoff as a result of reclamation and the subsequent increased catchment area (greater percentage of sealed areas).

Potential Impacts

SECTION 6

Table 6.1: Predicted Water Quality and Loadings from the Proposed Redeveloped Catchment

Catchment	Area	Average annual runoff fraction	Average annual runoff	Predicted Water Quality				Predicted Loadings to Darwin Harbour						
				Sediment	Metals	Oil & grease, hydrocarbons	Nutrients, pesticides	TSS	Total P	Total N	Arsenic	Cadmium	Lead	Zinc
	(km ²)	(%)	(ML/year)					(T/year)	(T/year)	(T/year)	(Kg/year)	(Kg/year)	(Kg/year)	(Kg/year)
Urban	0.26	0.50	221.2	L	L	L	M	2,015	3.5	29.6	36	9	899	2,336
Escarpment	0.04	0.25	19.0	L	L	L	L	73	0.1	1.7	2	0	3	10
Industrial	0.08	0.70	97.0	M	M	M	L	752	4.2	13.4	34	6	275	3,053
Disturbed	0.004	0.40	2.6	H	H	H	L	69	0.6	2.7	10	1	34	356
Foreshore	0.01	0.75	7.8	M	L	L	L	37	0.0	0.3	1	0	20	20
Total loading to Darwin Harbour	0.40		347.6					2,946	8.3	47.8	82	16	1,231	5,776
Change compared with existing loadings (%)			2					-38	-71	-64	-81	-67	-39	-70

Notes: Loadings calculated from rates given in Padovan (2001); L = low levels, M = medium levels, H = high levels; See Table SW1 for existing loading. These predictions are based on the estimations of existing water quality loading in Section 5.2.8 (Table 5.2)

Impacts on the receiving environment are likely to be minor. The erosion risk, stemming mainly from bare areas and stockpiles during the Wet season, will need to be managed using standard soil conservation works (Refer to Chapter 8, Section 8.3.3). The likelihood of gross erosion occurring is small, and minor to moderate erosion and sediment loads can be controlled on site. Sediment loads in near-shore and shallow areas are already high as a result of tidal actions and local runoff.

The estimated slight (2%) increase in run-off from the site is not expected to adversely impact the water quality of Darwin Harbour nor have a discernable impact on harbour salinity or tidal flows.

6.3.6 Marine Environment

Overview of Potential Impacts

Possible components of the Concept Plan for the Redevelopment that, have the potential to impact upon the marine environment include:

- leisure craft moorings and associated marina-oriented commercial and public transport facilities;
- construction of a revetment structure along the coast or a sea wall off shore;
- possible land reclamation in Kitchener Bay which may require dredging of marine mud;
- construction of a marina or jetties in Kitchener Bay including dredging of marine mud; and
- minor reclamation and/or marine structures such as a jetty adjoining the western side of Fort Hill.

Once facilities have been constructed, the site may support more recreational and tourism related boating activity than at present and may include provision of services for recreational boats such as boat launching, washing and ablution facilities for visiting yachts.

Most of these activities will not have significant impacts, and some of the disturbance may be beneficial. Construction of jetties is a localised and temporary impact but results in long-term creation of localised artificial reef ecosystems that can be beneficial for recreational fishing. Operational recreational marinas tend to result in only localised minor impacts and are unlikely to adversely affect the wider harbour environment. Dredging and reclamation have the potential to produce either irreversible or temporary disturbances of the marine environment.

None of the potential activities proposed for the project area are likely to have significant adverse impact on the broader marine environment of Darwin Harbour and few, other than dredging, are likely to have affects outside the project area itself.

Issues related to site contamination are addressed in Section 6.2.

Dredging

Overview of Sediments

The sediments of Kitchener Bay are unlikely to be suitable for use as fill for reclamation purposes due to:

- their geotechnical properties, which render them unsuitable for use as an engineering fill (URS 2003c); and
- elevated metal concentrations in the surface (0.5 m) sediments of some parts of Kitchener Bay, particularly adjacent Fort Hill Wharf;
- elevated levels of PAHs at the eastern end of the bay.

Sediments from the western and central parts of Kitchener Bay held lead and zinc in forms that could be released to water, while contaminants in sediments from the eastern end of Kitchener Bay are not bioavailable.

The sediments in Kitchener Bay are typically soft but cohesive silty sands and muds. They contain a high percentage of fines, but also contain surficial sands presumably washed into the area from the mainland and previous reclamation in the project area. As such they are not typical mangrove muds near the surface and only have a low PASS rating. However, there is some potential for sediments deeper in the profile to have a higher PASS rating.

Spoil Disposal Issues

Any dredging proposals will need to address the issue of spoil disposal. Disposal options for moderately to highly contaminated sediments could include:

- removal to a secure impermeable cell onshore; or
- confined ocean disposal (e.g. lateral confinement or capping).

The selection and approval of the sites to meet these needs would be a key step in planning dredging operations.

The options for the sediments from the western and central section of Kitchener Bay would depend on an assessment of their ecotoxicity. Some of the surface sediments in Kitchener Bay may need to be disposed onshore in a secure location, whilst the remainder can be disposed at sea in a location acceptable to the Darwin Harbour Dredging Technical Advisory Committee. Sediments from the eastern end of Kitchener Bay appear suitable for unconfined sea disposal. Outside of Kitchener Bay, some limitations in spoil disposal options could occur for sediments from:

- the western end of the Wharf Precinct (due to elevated cadmium concentrations);
- behind the Iron Ore Wharf and Navy refuelling facility or adjacent the old power station cooling water outfall (elevated PAHs);

-
- behind Fort Hill Wharf (elevated cadmium and lead); and
 - off the face of Fort Hill Wharf (elevated TBT).

Dredging operations, including the type(s) of dredge, will need to consider the location of proposed operations, the contaminant status of the sediments and the proposed disposal location. This will ensure that impacts from dredge operations either at the project site or the disposal grounds will be minimised.

The removal and containment of existing contaminated sediments would be of benefit to the local marine environment.

Water Quality Issues

Water quality issues associated with dredging relate to both increased water turbidity locally in the vicinity, and downstream of, the dredge and disposal area, and the release of contaminated waters from the reclamation during dewatering of contaminated sediments. Most contaminants are bonded to fine silts and the control of the release of contaminants will be closely related to the control of silt movement and the spread of turbidity.

Increases in turbidity associated with dredging are unlikely to cause significant adverse impacts to the marine environment as:

- the project area is remote from habitats that are sensitive to high levels of water turbidity (see Section 5.3.7);
- water turbidity is naturally high in Darwin Harbour, particularly at spring tides and during the Wet season; and
- the dredging is likely to be accomplished within a limited time period.

Reclamation and Seawalls

The main issues associated with reclamation are permanent loss of marine habitat and water quality issuing from the reclamation activity, either via tail water overflow or via groundwater seepage.

Land reclamation can cause localised and temporary water turbidity as material is placed into the marine environment. The usual procedure is to build the retaining wall first, then to fill in behind to minimise loss of fill material and the extent of water turbidity.

Reclamation activity is unlikely to cause significant adverse impacts to the marine environment of Darwin Harbour and may well create benefits if used to contain contaminated sediments. However this preliminary assessment should be confirmed at the time a specific proposal is put forward and may require hydrodynamic modelling using existing models to confirm the extent of the zone of turbid water influence anticipated as a result of the proposed dredging methodology and volume(s).

Commercial and Recreational Vessel Facilities

Overview

Boat marinas, wharves and jetties provide substrates in the marine environment that rapidly become colonised by a wide range of fouling organisms and benthic biota. These tend to act as artificial reefs and attract a wide range of fish life to their vicinity to seek food and shelter.

However some of the activities associated with these facilities have the potential to cause adverse impacts locally if not adequately managed. Such activities include:

- fuel offloading and vessel refuelling;
- accidental spillages of hydrocarbons and other hazardous substances;
- wastewater discharges; and
- disposal of rubbish and other wastes.

Adverse impacts can include:

- toxic or physical effects on biota from spillages;
- nutrient enrichment or introduction of bacteria to receiving waters through wastewater discharges;
- introduction of marine pests, including in ballast water from visiting vessels; and
- accumulation of corrosion products in marine sediments.

Whilst recreational and commercial vessel facilities are potential sources of contaminant inputs to the marine environment, most adverse impacts of inappropriate waste disposal can be minimised by sensitive design and rigorous management. Fuel spills will occur, as will gradual accumulation of corrosion products locally. However, given the area's history of use and high level of disturbance and existing contamination levels, such impacts are considered of minimal significance on a regional or ecosystem scale.

Spillages

It is assumed that fuel transfers at the Navy refuelling facility (at the Iron Ore Wharf) are conducted in accordance with strict procedures to minimise the potential for accidental spillages into the marine environment.

Accidental spillages of small volumes of petroleum or diesel are unlikely to significantly affect the harbour environment and traces of hydrocarbons are only likely to be found in the immediate vicinity of the fuelling jetty. Releases of lubricating oils are generally forbidden within marinas and waste oil storage tanks are provided for responsible disposal of such oils. The Darwin Harbour oil spill contingency plans will be activated to respond to any spillages from these type of operations.

Corrosion Products

These include zinc from sacrificial anodes and copper leached from anti-fouling paints. Most marinas accumulate moderate to high concentrations of both products in surface sediments over time. Whilst such contamination results in elevated levels of corrosion products in sediments locally, concentrations rarely accumulate to levels where they pose a threat to marine organisms living in the vicinity, especially in areas of high tidal flushing such as Kitchener Bay.

Wastewater Discharges

These can occur at times from live-aboard vessels although it is banned in most marinas, which typically provide cooking, washing, ablution and toilet facilities on land for use by visitors. These facilities are usually either connected to wastewater and sewerage systems and treated as domestic greywater and blackwater, or disposed to onsite septic tank systems.

Wastes

Most modern marinas cater for disposal of wastes and rubbish from recreational and commercial vessels by the provision of rubbish skips and oily waste tanks at appropriate locations onshore. These facilities are regularly removed by waste disposal contractors, for disposal in approved manner at appropriate locations.

Significance of Potential Impacts on Marine Ecology

The marine habitats of Kitchener Bay are presently highly modified and disturbed, and in places moderately to highly contaminated. They are also well represented in better condition elsewhere in the harbour, and do not support habitat that is important to listed protected marine species. The project is relatively remote from sensitive conservation areas. The nearest areas of sensitivity to potential impacts from the Redevelopment are:

- Doctors Gully Aquatic Life Reserve (fish feeding area), 2 km to the north-west of the project area; and
- mangroves of Charles Darwin National Park and Sadgroves Creek, 3 km to the north-east of the project area.

The nearest coral areas, both of which are considered to be well beyond the potential influence from Redevelopment, are:

- South Shell Island, 5 km to the south-east;
- Weed Reef, 6 km to the south-west; and
- East Point Aquatic Life Reserve, 7 km to the north-west.

Most activities proposed for the site will affect local waters only. The main activity with potential for adverse impacts beyond a local scale is dredging.

6.3.7 Noise

Noise Sensitive Premises

Noise generated as a result of the Redevelopment, may impact upon both surrounding premises, and premises within the project area. The noise sensitive premises outside the boundary that may be impacted by noise are:

- Government House; and
- nearby residential premises, particularly along The Esplanade.

The noise sensitive premises proposed as a part of the development and within its boundary include:

- serviced apartments and residential developments proposed; and
- hotel and other possible short-term accommodation.

The main aspects of noise generation within the development, supporting a potential impact on the above premises, have been identified in the following sections.

Wharves

A large proportion of the wharves current commercial activities (servicing of small vessels, cruise liners and Navy ships, and restaurants) are expected to continue throughout both the construction phase(s) and upon its completion. Noise from these activities forms a potential impact upon the amenity of the site. Services for marine vessels conducted throughout the night-time periods (19:00 – 07:00 hours) stands out as the primary concern for noise impacting upon proposed residential accommodation facilities within the site.

Convention and Exhibition Centre

The entertainment complex is proposed to cater for both indoor and outdoor events, with a maximum anticipated internal (convention) capacity of approximately 1,500 people. Noise generated by this facility is expected to comprise the following:

- entertainment noise, including the break out from the internal space and external noise from outdoor events; and
- mechanical and electrical noise from air conditioning plant noise (likely to be roof mounted unit/s); refrigeration systems and ventilation systems (for any underground car parks).

Entertainment events, as opposed to conferences, are most likely to occur in the evening, and any noise generated from such events would be required to comply with more stringent night-time noise requirements relating to the expected reduced background noise levels. Noise from mechanical and electrical equipment is discussed later in this section.

Traffic

Remediation and construction activities, although likely to be staged over ten years or more, are likely to result in significant increase in truck movements to and from that site. These activities are yet to be quantified. Following construction, the development will generate an increase in traffic movement in the local area due to an increase in private and commercial road vehicles accessing the development, and this may result in an increase in noise levels on site and in the surrounding area.

Convention and Exhibition Centre

Events held within the Convention and Exhibition Centre are expected to dramatically increase road traffic volumes before and after each event. With the expected inclusion of adequate car park bays within the complex, a noise impact may be generated if the traffic paths for these traffic volumes are located near noise sensitive premises. It may also be possible to use car parks located closer to the city centre to reduce traffic volumes, particularly during major events.

Residential Accommodation

Road traffic to and from the proposed residential facilities, typically throughout morning and evening periods, will introduce increased traffic volumes both within the development and its surrounding area. The placement of the traffic paths will determine the potential noise impact.

Mechanical and Electrical Systems

The Redevelopment is likely to incorporate the following fixed equipment and mechanical plant:

- air-conditioning plants;
- ventilation systems (for restaurant kitchens and below ground car park); and
- refrigeration units.

Due to Darwin's warm climate, many of these items are likely to operate throughout 24-hour periods, creating a potential noise impact on neighbouring noise sensitive premises. Reduced night-time noise criteria again exacerbate the potential impact of such noise sources. These impacts can be reduced by the use of acoustic enclosures.

6.3.8 Air Quality

Demolition and Removal of Existing Infrastructure and Remediation

Demolition of the following site components and remediation of the site may generate dust:

- the Old Fort Hill Wharf;
- the Iron Ore Wharf (if it is to be removed) and the conveyer system;
- existing warehouses in the central area, the site of the future proposed Convention Centre; and
- additional infrastructure within the precinct required to be removed for future development of compatible land uses.

Relatively minor emissions of NO_x, CO_x and SO_x would be expected as a result of the operation of machinery and support vehicles during demolition works. Contamination issues relating to dust generation are dealt with in Section 6.2.

Construction

Dust may be generated during the construction phase due to site clearing activities, loss of vegetation cover, the excavation and handling of soils, blasting (if required), wind erosion from disturbed areas and stockpiles, site grading activities and vehicle movements. These impacts may result from works on the site or for the establishment of engineering headworks, such as connecting road infrastructure, to service the redeveloped site.

Construction of the following key project components has the potential to give rise to significant air emissions:

- the Darwin Convention and Exhibition Centre;
- other major building works;
- marina and jetties in Kitchener Bay, and
- roadworks required for the proposed realignment of McMinn Street and Frances Bay Drive and construction of additional road infrastructure.

It is anticipated that the resultant dust impacts during construction would be localised in nature and predominantly affect on-site land users. Through adoption of best practicable dust suppression measures, it is likely that ambient particulate levels would be able to be maintained so as to have a negligible impact on human health or amenity in the CBD.

Ongoing Precinct Development

Air quality impacts arising from the continued operation of the Redevelopment (including greenhouse emissions) are anticipated to be minimal compared with the potential impacts during construction works. It is anticipated that the proposed Redevelopment will contribute only marginally to existing levels of key pollutants at a local and regional scale.

The eventual replacement of current industrial facilities within the site, particularly the bitumen plant and bulk handling of ores and chemicals, with non-industrial land uses will result in some key local pollution sources being removed, and improvements in the local air quality. There is potential for the Redevelopment to increase vehicle emissions (NO_x, CO_x, and minor levels of SO_x) from increasing numbers of residents and visitors to the area, which may be partially offset by encouraging public transport use and pedestrian access.

The current Concept Plan allows for the continued operation of the NFI in the Stokes Hill area. The NFI is likely to continue to be a localised source of hydrocarbon odours and some hazardous air pollutants (air toxics). The preliminary assessment suggests that areas around the NFI may be classed as a Stage 1 site under the Air Toxics National Environment Protection Measure (NEPM) (that is, an area with elevated levels of one or more of the five priority air toxics; benzene, toluene, xylenes, benzo- α -pyrene and formaldehyde). The Air Toxics NEPM has been established primarily to gather standardised information about the levels of the listed hazardous air pollutants across Australia to facilitate the development of appropriate standards in the future. These standards are unlikely to be developed until after 2010. The NEPM does not place any restrictions on identified Stage 1 sites, and in its current form is not expected to impact on the redevelopment.

There are currently no standards against which to measure what constitutes a Stage 1 site, and the Northern Territory Government has not undertaken a determination of Stage 1 sites in the Darwin region. An assessment of impacts from emissions is of limited value until the future operational lifespan of the NFI has been confirmed and suitable guidelines are established. Residential development is not predicted in the near future, and baseline air quality monitoring may be recommended should there be significant overlap between the operational life of the NFI and active residential use of nearby areas.

6.4 Impacts on the Biological Environment

6.4.1 Vegetation and Weeds

Potential Negative Impacts on Flora

Given the relatively degraded current state of the project site, most negative impacts of the development on flora are expected to be of minor significance. The only priority issues are the protection of vine-forest and weed management. Though immediately outside the site, the vine-forest is the only area of conservation significance in or near the area, and the intrinsic environmental value of healthy remnant

rainforest vegetation in such close proximity to the CBD has been recognised by the NT Government (1996). The Redevelopment will include a constructed pedestrian connection between the CBD and the site aligned along the Smith St axis. This connection will cross the escarpment and the coastal vine-forest the escarpment supports. As noted in Section 5.4.1, this habitat is the most significant habitat in and near the project site. Every attempt should be made to minimise any impacts from construction activity, particularly clearing, and maintain the integrity of this vegetation community. The margins of this vegetation community are particularly vulnerable to weed invasion, and the construction of the Smith St connection and other facilities bordering the vine-forest should be managed to prevent the introduction of weed species. Construction activities may also introduce and spread weeds into other relatively weed-free areas.

Other potential (though minor) negative impacts include:

- further reclamation of the western end of Kitchener Bay will result in the loss of the small mangrove community which has established at the western drainage outflow;
- regrading or changes to the drainage system may affect vegetation, particularly the small mangrove community mentioned previously which is dependent on seasonal freshwater inflows; and
- clearing of vegetation may result in habitat loss and displacement of the existing fauna.

Potential Positive Impacts on Flora

Again given the degraded state of the site, the Redevelopment offers opportunities for improvements in the condition of vegetation across the site. Clearing of vegetation in disturbed areas should reduce weed populations in the project area. This will also decrease seed production and assist with ongoing weed management and control across the site and in surrounding areas. The pedestrian connection could utilise the escarpment canopy and provide a scenic feature while minimising disturbance to the surrounding vegetation.

The vine-forest community along the escarpment will become a significant feature of the site and will offer notable aesthetic, amenity, recreational and educational benefits. These benefits may be maximised by sympathetic design and construction of the pedestrian connection along the Smith Street axis.

6.4.2 Terrestrial Fauna

Habitat Protection

The habitat on the site is of poor quality in comparison to nearby areas such as Charles Darwin National Park (2 km to the north-east), but it provides some patches of habitat for locally common species. Therefore the loss of habitat from on-site vegetation clearance is not significant. Although the site is heavily degraded, some areas such as the escarpment are expected to provide habitat for many bird

species at different times of the year, and the vine-forest habitat should be protected to maintain its habitat values.

Night Lighting

There is not expected to be any significant impact from night lighting at the redeveloped site on susceptible species. Impacts have been shown to be hazardous to migratory birds (Evans Ogden 1996), but it is not considered a major issue in northern Australia at present.

Feral Animals

Several feral animals occur across the site in its current state including the Asian House Gecko (*Hemidactylus frenatus*), the Black Rat (*Rattus rattus*) and Feral Cat (*Felis catus*). The Redevelopment is unlikely to introduce additional feral animal species to the site, and is not expected to result in a significant increase in the numbers of feral animals given the presence of the heavily developed CBD nearby.

6.4.3 Marine Ecology

The assessment of impacts on the physical elements of the marine environment (Section 6.3.6) provides the basis for consideration of impacts on marine ecology. The primary habitats within and near the project area are:

- intertidal flats which constitute a large portion of Kitchener Bay;
- the artificial wharves and associated artificial reefs;
- the open water area at the mouth of Frances Bay and adjacent to the wharves; and
- the small area of mangroves at the western end of Kitchener Bay.

There are no corals, seagrass beds or rocky reefs within the vicinity.

Habitat and Community Structure

The components of the Redevelopment that may have an impact of the marine habitat and community structure are dredging, reclamation and construction of foreshore engineering works.

As noted previously, dredging will remove benthic habitat. In the project area, dredging will remove intertidal sandy mud flats and associated intertidal marine organisms such as crabs, polychaete worms and bivalve molluscs, leaving a subtidal muddy seafloor habitat. This seafloor habitat will be rapidly colonised by burrowing in fauna from adjacent subtidal habitats, providing resources for marine and tidal vertebrates. Reclamation results in permanent loss of marine habitat and may localised and temporary water turbidity, depending on the engineering technique used. The habitat to be removed is well

represented throughout the harbour, and its loss in part or whole is most unlikely to be ecologically significant.

Turbidity that may be created by dredging or reclamation activity is likely to be localised and short term. The impacts on marine communities, particularly the epibenthos and pelagic species around the wharves, are expected to be minimal due to the strong tidal flushing of the area.

Contamination and Acid Generation

As noted in Sections 6.2 and 6.3.6, sections of Kitchener Bay and some areas to the east and west of the site contain contaminants in the surface layers (0.5 m). The appropriate removal of the existing contaminated sediments and containment, either on the site or elsewhere, would reduce the potential biological contaminant load and be of benefit to the local marine environment.

Much of the surface sediments of Kitchener Bay have originated from the terrestrial soils and therefore have only low acid generating capacity. Sediments at greater depth however have some potential to have a higher PASS rating. These sediments could be exposed to air by dredging, and if that exposure is of sufficient time they could generate acid leachate to the marine environment.

Marine Pests and Aquatic Pathogens

Marine pests can be introduced to local waters by visiting international yachts and coastal vessels. Darwin has already experienced an outbreak of the Black-striped Mussel (*Mytilopsis sallei*) in Cullen Bay marina (Russell & Hewitt 2000), which was fortunately brought under control. Customs and AQIS officers inspect all visiting vessels to Darwin Harbour on arrival to reduce the potential for the introduction of marine pest species. Given the existing marina facilities adjacent the harbour, and the wide range of commercial and fishing boats which use the harbour, the construction of marina facilities at the project area is unlikely to significantly increase the risk of marine pest introductions to Darwin Harbour.

6.4.4 Biting Insects

Mosquito Breeding

The present mosquito problem at the site is significantly less than other suburbs of Darwin within the vicinity of coastal areas, due to the lack of any extensive nearby breeding sites. The proposed development should reduce the number of mosquito breeding sites, therefore further reducing mosquito numbers in the area.

Nonetheless, any proposed development has the potential to create mosquito breeding sites by land disturbance and creation of water ponding, especially near tidal areas. This can lead to on-site pest and potential health impacts. Due to the long flight range of the salt marsh mosquito (*Ochlerotatus vigilax*), any breeding sites for this species created in the proposed development area also have the potential to

impact on the Darwin CBD. Other mosquito species that may breed in poorly draining areas at the proposed development site may also have potential health and pest impacts on-site and off-site.

Key actions that lead to mosquito breeding and the associated negative impacts on public health and amenity include:

- creation of ponding areas during earthworks during construction or maintenance activities
- inappropriate design of stormwater drains;
- poor drainage of landscaped areas can lead to mosquito breeding and provide breeding sites; and
- creation or use of artificial receptacles, such as empty drums, in and nearby to the Redevelopment area, which are exposed to rain or other water inflows.

There is a risk of exotic mosquito importation into the project site, because of its proximity to active international wharves and quarantined Indonesian fishing boats.

Biting Midge Breeding

As there are little or no biting midge habitats in the project area, development activities are not likely to create or impact on any existing significant biting midge breeding sites affecting the area.

6.4.5 Impacts on Species of Conservation Significance

There are no flora species of conservation significance occurring naturally in the area. The coastal vine-forest community offers some conservation values. This community occupies the escarpment along the north-west border of the project site and is continuous with similar habitat along most of the foreshore of the Darwin CBD. The project is not expected to diminish the conservation values of this community nor the linkages with other areas. However, construction of the Smith St pedestrian connection between the CBD and the project site should be undertaken with the aim of minimising clearing of escarpment vegetation and preventing the introduction of weeds into vine-forest areas.

Many of the native fauna species of conservation significance found at the site have been recorded in Charles Darwin National Park (2km to the north-east). The majority of species that are likely to inhabit the study area are migratory or widely foraging birds. Most would only utilise the coastline sections of the study area, predominantly foraging along the small mudflats of Kitchener Bay during low tides. At present this habitat is abundant in Darwin Harbour and its surrounds. Other species, including Rainbow Bee-eaters and Leaden Flycatchers, and their habitats are still abundant in the Top End.

Surveys found five species of insectivorous bat in the project area at Stokes Hill, Stokes Hill Wharf, the entrance to the Oil Storage Tunnel and at the Escarpment. The threatened species *Macroderma gigas* (Ghost Bat) was not detected at any site, and due to their habitat requirements it is unlikely that they occur in the area.

6.5 Impacts on the Built Environment

6.5.1 Changes to the Existing Built Environment

As noted in Section 5.5.1, the project site includes several buildings and some infrastructure that is disused or redundant or will be so in the near future. Much of this will be demolished and/or removed from the site. **Table 6.2** shows the structures that will be removed or retained. The fate of several structures is yet to be determined and these are also shown in **Table 6.2**.

Existing services that may require upgrading, removal or replacement or will remain include:

- Fort Hill Area: Electricity, water, telecommunications and stormwater;
- Bitumen Plant Area: Water, telecommunications, water and fuel lines are to remain;
- Warehouse Area: Redundant services are to be removed. Active services including electricity, water, telecommunications, stormwater and oil lines to remain;
- Northern Cement Plant Area: Water and telecommunications to remain;
- Recently Reclaimed Area: Stormwater to remain; and
- Stokes Hill Area: Removal of water and fuel lines from the fuel tank storage area. Removal of redundant services including cooling water infrastructure. The existing water, telecommunications and sewerage to the Jetty and Pump Station area are to remain. The sewer connection to Stokes Hill Wharf will remain.

Any new site buildings with toilet facilities including the Convention and Exhibition Centre and residential land use on the Stokes Hill and Fort Hill Areas will be connected to sewer.

The locations of proposed changes to the site including new infrastructure, structures and buildings will be addressed in the Master Plan for the project.

The overall impact of the rationalisation and removal of disused and redundant structures, buildings and infrastructure will be to remove either potential or actual sources of soil, groundwater and atmospheric contaminants and/or remove detrimental impacts on the visual landscape of the site. The removal will be conducted in a manner that recognises the heritage value of specific sites and structures noted in Section 5.6.

Demolition and soil remediation activities will include potential sources for contamination of surface water, including hydrocarbons from equipment and trucks, exposed sediments and exposed contaminated soil and stockpiled sediments and clean and contaminated soil. Specific activities that may impact water include site clearance, excavation, earthworks, stockpiling and transport of sediments and soils.

Groundwater remediation activities will include potential for impacting surface waters, if contaminated groundwater mixes with surface water or contaminated groundwater discharges off site to the marine

environment. Specific groundwater remediation activities that may impact water include open excavations that intersect the groundwater table and off site discharge of contaminated groundwater.

Table 6.2: Changes to the existing structures

Location	Structures to be removed	Structure with fate undecided	Structure to remain or be relocated
Fort Hill Area	Workshop	Buildings on New Fort Hill Wharf	New Fort Hill Wharf and RO RO facility
	Boom Shed	Iron Ore Wharf	Shipping Container Storage and Handling Area
	Woodcutters shed		
	Old Fort Hill Wharf		
	No. 2 Conveyor		
	Shipping container storage and handling area compressor shed, machinery house and above-ground storage tanks		
	Sulphuric acid tanks		
	Quarantine incinerator		
Bitumen Plant Area	Shell Bitumen Plant		
	Former Tipping Shed		
	Former Cockburn Cement area weighbridge and office		
Stokes Hill Area	Two above-ground fuel tanks (Tanks 9 and 10)	Former Stokes Hill power station cooling water underground infrastructure	Stokes Hill Wharf
	One above-ground water tank and associated structure		Jetty and Steam Pump Station Area
Kitchener Drive		Pipelines that do not supply the NFI	World War II Storage Tunnels Area
		NFI pipelines	
			Burnett Design "G" Type structure

Potential Impacts on Air Quality

Demolition activities will have the potential to impact on air quality from emissions of dust during these activities. Specific activities that may impact air quality will include demolition of buildings, transport of materials, excavation of subsurface infrastructure as well as sediments and soils, earthworks or sediments and soils, and stockpiling of sediments and soils.

Soil and groundwater remediation will have the potential to impact on air quality from emissions of dust and odour during these activities. Specific activities that may impact air quality will include transport of clean and contaminated soil materials, excavation of subsurface infrastructure as well as clean and contaminated sediments and soil, earthworks or clean and contaminated sediments and soils and stockpiling of clean and contaminated sediments and soils.

6.5.2 Unexploded Ordnance

As noted in Section 5.5.6, the project site and surrounding areas may contain explosive ordnance (EO) and /or unexploded Ordnance (UXO), and the risk of UXO occurrence is an additional factor to incorporate into site management procedures during all construction and maintenance activities. The risk to people from UXO on the site is a factor of:

- the type of UXO;
- its functionality (that is, its ability to detonate); and
- its location and the surrounding material.

Low risk activities include all above ground work. Excavations into fill material carry a medium risk. High risk activities are those requiring any penetration into the existing pre-1942 landform including terrestrial soils and rocks, and marine sediment. High risk areas include:

- the escarpment, Stokes Hill and the saddle between this areas;
- the base of the escarpment along Kitchener Drive;
- the former marine salvage area near Fort Hill Wharf (with the potential for discarded munitions from the salvage operations); and
- marine muds.

It is highly unlikely that the detonation devices of remaining UXO would be intact and the likelihood of detonation of UXO is low. Nonetheless, appropriate procedures should be followed to further minimise this risk, particularly during dredging and excavation works. Ordnance landing in soft marine mud are more likely to have survived the impact without firing. These items can become entrained in equipment during dredging of marine sediments.

The consequences of contamination from the contents of UXO being disturbed are minor.

6.5.3 Visual Impacts

The project site is a semi-derelict former industrial port zone, now largely in a transition stage of vacancy, decommissioning and demolition. As a result, the proposed Redevelopment concept will almost entirely result in a visually positive outcome. Some short-term adverse impacts will result during site preparation and the construction of different components of the Redevelopment due to earthworks and loss of screening vegetation. However, the overall visual impact will be significant, but it will be almost entirely positive.

The Concept Plan for the Redevelopment outlines a well integrated development with visually attractive and scenically integrated key features. The Redevelopment should produce very positive visual impact outcomes, if it is undertaken with good site planning, design excellence of all structures and outdoor spaces, and seamless functional integration. The following key issues need to be addressed to ensure this outcome.

- The development that occurs in the vicinity of the McMinn Street and Frances Bay Drive intersection (the former railway yards) will affect the visual site lines and the view corridor through the gap between Stokes Hill and the escarpment. This development should be of sufficient aesthetic quality to enhance the viewpoints from a number of locations within the project site, and vice versa.
- Appropriate height controls on new structures in the project site are required to prevent visual incongruity and intrusion in the landscape of the adjacent civic, parliamentary and associated heritage precinct on the northern side of the Esplanade.
- The visual impact of marina developments or navigable channels in the shallow tidal mudflats zone within the harbour could be high. Dredging activities should aim to minimise the unsightly contrast of open channels and mudflats at low tides.
- Design treatment of the foreshore edge to the development will need to avoid detracting from visual quality and the experience of the development.
- Appropriate visual and functional integration between the project site and the CBD should be achieved by the Redevelopment to avoid weaken the connection between the two locations, diminishing important existing historical and heritage values and limiting commercial synergies. The Redevelopment must also integrate with the natural landscape of the escarpment and other areas.
- Internal design/aesthetic and functional integration, particularly of existing heritage and key landscape elements, is required to protect these values. These features could provide a major visual focus for the Redevelopment.
- Tidal mudflats comprise a large proportion of Kitchener Bay and are exposed for extended periods during low tides. Despite the extensive and natural occurrence of mudflats throughout the harbour and their ecological importance, this landform is widely perceived to be unsightly.

- Car parking should be designed to avoid detracting from both the functionality and aesthetics of the site.

6.5.4 Traffic, Roads and Public Transport Network

The basis for the estimation of traffic volumes and potential impacts from traffic and transport changes is provided in **Appendix N**.

Traffic Generation

Each of the individual land use activities associated with the Redevelopment of the precinct will generate demands for traffic movements into and out of the site as well as within the site. The volume and rate of vehicle trips will depend on the nature of the activity. These trips will be additional to the trips generated by existing developments.

The daily and peak hour volumes of traffic likely to be generated by the key components of the development scenario are shown in **Table 6.3**. The impacts of this generated traffic on the existing adjacent road network are most likely to be evident during the peak commuter period and not necessarily during the peak time for the entire development. Possible development within the site with peak activity at other times will have significantly less impact.

Table 6.3: Estimated traffic generation

Traffic Source	Morning Peak (vpd)	Evening Peak (vpd)	Total Number of Daily Trips
DCEC - Convention activities (private)	500	500	1,450
DCEC - Convention activities (taxi)	80	80	
DCEC - Exhibition activities (arrivals)	160	50	2,900
DCEC - Exhibition activities (departures)	25	320	
DCEC – Coincident events (arrivals)	660	130	4,350
DCEC – Coincident events (departures)	105	820	
Residential development (arrivals) ¹	65	210	3,000
Residential development (departures) ¹	260	105	

Note 1: The estimates for residential traffic generation are for each residential development (assumed to be one each in the Stokes Hill and Fort Hill areas).

Over the duration of the staged development, the volume of traffic generated will be significant but most of this will occur during weekday business hours.

Traffic Distribution

The estimated traffic volumes associated with the individual and combined developments have been determined for the assumed stages of development (**Table 6.4**):

- Stage 1 – Darwin Convention Centre and Exhibition Centre (separate and combined events);
- Stage 2 – Stage 1 plus 500 dwellings at Stokes Hill Wharf; and
- Stage 3 – Stage 1 and 2 plus 500 dwellings at Fort Hill Wharf.

The volumes indicated below are additional to the existing traffic volumes and do not include additional traffic volumes from growth over time external to the site.

Table 6.4: Estimated Traffic Volumes for the Stages of the Redevelopment

Stage	Road	Morning Peak (vpd)	Evening Peak (vpd)	Total (vpd)
Stage 1 DCEC	McMinn Street (east of Tiger Brennan Drive)	185-765	370-950	1450-4350
	McMinn Street (west)	75-306	148-380	580-1740
	Tiger Brennan Drive	110-459	222-390	870-2,610
Stage 2 Stokes Hill residential	Frances Bay Drive	325	325	3,000
	Tiger Brennan Drive (without DCEC event)	228	228	2,100
	Tiger Brennan Drive (from DCEC event)	338-687	450-618	2,970-4,710
	Dinah Beach Road	97	97	900
Stage 3 Fort Hill residential (without DCEC event)	McMinn Street (east of Tiger Brennan Drive)	325	325	3,000
	McMinn Street (west)	130	130	1,200
	Tiger Brennan Drive	195	195	1,800
Stage 3 Fort Hill residential (from DCEC event)	McMinn Street (east of Tiger Brennan Drive)	510-1,090	695-1,275	4,450-7,350
	McMinn Street (west)	205-436	278-510	1,780-2,940
	Tiger Brennan Drive	533-882	645-813	2,670-4,410

Traffic Impacts

The impacts of the estimated traffic volumes will be most evident at locations closest to the precinct and diminish further away from the site. Traffic volumes will be concentrated at the major road access points at McMinn Street and to a lesser extent Frances Bay Drive and at the intersections of these roads with Tiger Brennan Drive.

Internal Road Network

In the first stage of development, the internal road network will be required to cater for traffic volumes generated by the convention and exhibition centres (estimated maximum of 4350 vpd). This volume can be accommodated by a two lane road however, if Kitchener Drive is to be retained to provide this function then it would need to be widened and upgraded to also make provision for buses, cyclists and pedestrians. The junction with McMinn Street would need to be upgrade to cater for the additional traffic.

In its present layout, Kitchener Drive also provides access to the Fort Hill Wharf area. However, traffic to this area is likely to have different timing to events at the DCEC and not impact on maximum traffic loads.

When stage 3 of the development is complete, residential traffic (3000 vehicles) will use Kitchener Drive to access the site. This will only impact on maximum traffic loads on days when the DCEC is operating at capacity, when the volume of traffic using Kitchener Drive may increase to as much as 8,400 vehicles per day and this volume will require significant management.

McMinn Street

The additional traffic volumes using McMinn Street (east of Tiger Brennan Drive) as a consequence of the development will vary from between 1,450 and 4,350 vehicles per day (Stage 1 only) to between 4,450 and 7,350 when the site is fully developed in 10 to 15 years time (Stage 3). On days when there are no events at the DCEC, there will be little additional traffic using McMinn Street during Stage 1 of the development. The traffic attributed to the DCEC is significant but any adverse impacts on the operation of McMinn Street are likely to be infrequent and short lived.

When Stage 3 is completed and there are no events at the DCEC, the additional traffic volume using McMinn Street would be about 3,000 vehicles per day. This volume by itself would likely be accommodated by the existing intersection layout, but the increase in traffic volumes on the other roads over the 10-15 year period may warrant improvements to the intersection. It is possible that the intersection improvements as part of the duplication of McMinn Street (west) may well have been completed at this stage.

As the site is redeveloped, traffic volumes on McMinn Street and through the intersection at Tiger Brennan Drive will increase progressively. At some stage, duplication of McMinn Street between Tiger Brennan Drive and Kitchener Drive and capacity improvements at the major intersection will be required. Similarly, the traffic using McMinn Street to access the Stuart Highway or the CBD will increase by

about 1,200 vehicles per day on a normal day (Stage 3) but could reach as high as 1,780 to 2,940 with events at the DCEC. This will require duplication of this section of McMinn Street.

Frances Bay Drive

The additional traffic volumes using Frances Bay Drive (between Mavie Street and Tiger Brennan Drive) as a consequence of the development will be about 300 vehicles in the peak hours and 3,000 vehicles per day, requiring upgrading of the road and intersection.

The intersection at Tiger Brennan Drive will be subjected to significant and progressively increasing traffic volumes as development of the precinct proceeds. When the precinct is fully developed, as many as 7400 vehicles per day will pass through the intersection over and above the existing traffic volumes and in addition to any traffic growth generally.

Construction Traffic

The development of the precinct will take place in a staged manner over a number of years and involve remediation, site preparation, infrastructure provision and construction activities. This may involve in some cases removal of soil and the importation of replacement fill and construction materials.

Large commercial vehicles deployed in the site remediation and construction activities will access the two areas of the precinct via McMinn Street or Frances Bay Drive. The route adopted by vehicles external to the precinct will depend on the locations of the sources of construction materials and equipment and the disposal sites for the contaminated soil deposits. It is most likely that these vehicles would use Tiger Brennan Drive (where appropriate) rather than McMinn Street/Stuart Highway.

The increased heavy traffic will lead to increased rates of deterioration of road pavements. The roads that will be subjected to the most frequent use by heavy vehicles include McMinn Street and Frances Bay Drive. These and other potentially affected roads may need to be strengthened and maintained regularly to ensure that the roads do not become safety concerns for other road users. Localised widening of key intersections may also assist in reducing the damaging impacts of heavy vehicles.

Provision for Parking

It is assumed that each of the components of the Redevelopment of the precinct will comply with the Development Consent Authority (DCA), including adequate off-street parking. There is some scope for shared use of parking between complementary land-use activities that generate peak parking demands at different times, particularly between the DCEC and recreational activity. There may also be opportunities to reduce the level of parking provided within the site by providing parking facilities, other than for residential dwellings, elsewhere through the DCC parking contribution fund. This would require adequate public transport links between the CBD and the Redevelopment site, but would reduce traffic demands at key intersections.

Pedestrian and Bicycle Movement Patterns

Redevelopment of the precinct will generate increased demands for the movement of pedestrians and cyclist into, out of and around the area. These will most likely be concentrated on the routes between the CBD and the site. However, such access is poor and potential unsafe at present and will need to be upgraded including disabled access. Within the Redevelopment site, pedestrian and cycle paths will need to be integral features of the layout of the road system.

Public Transport

The use of taxis and buses to provide public passenger transport to the precinct offers an opportunity to reduce the demands for passenger car traffic to enter the site and to generate additional visitation. To be effective, the upgraded internal road network will need to incorporate appropriate provisions for buses include appropriate width lanes and junctions, indented bus stops and areas for buses to lay-over and turn around.

6.5.5 Construction and Waste Impact

The following section provides information on the types of waste expected to be generated at the site during building demolition, surface and sub-surface demolition, soil and groundwater remediation, construction and site operations and maintenance activities.

Building Demolition

Demolition of buildings will include non-hazardous building materials for existing above ground infrastructure including:

- Fort Hill Area: Workshop, Boom Shed, Woodcutters Shed, Old Fort Hill Wharf and conveyors No. 2, Shipping Container Storage and Handling Area compressor shed, machinery house and above ground storage tanks; Quarantine Incinerator, Sulphuric Acid Tank, Diesel above-ground storage tanks and Waste Oil above-ground storage tanks.
- Bitumen Plant Area: Shell Bitumen Plant, Former Tipping Shed, Former Cockburn Cement Area weighbridge and office;
- Warehouse area: Two substations; and
- Stokes Hill Area: Two above ground fuel tanks.

Existing structures and buildings that may be removed or may remain on site include:

- Fort Hill Area: New Fort Hill Wharf building and Iron Ore Wharf;

-
- Stokes Hill Area: One above-ground water tank and the Former Stokes Hill power station cooling water infrastructure; and
 - Kitchener Drive: Pipelines that do not supply the NFI.

Building demolition waste generated while this activity is conducted will include structural steelwork, steel sheeting and other metal material, reinforced concrete, concrete, electrical and mechanical services and other miscellaneous building materials. The demolition material will be removed off site for salvage or be disposed to a licensed disposal facility.

Potentially hazardous liquid wastes from the fuel tanks may be generated during demolition and are likely to include oil, diesel and oily water. Similarly, potentially hazardous solid wastes from asbestos containing building materials may be generated. These materials will be removed and transported off site for appropriate disposal.

Surface and Sub-surface Infrastructure Demolition

Non-hazardous materials will be generated from demolition of roadways, hardstand areas, foundations and below ground infrastructure including footings, stormwater infrastructure, fuel storage underground storage tanks, sewerage pipes and septic tanks, wash-bay, valve pit, triple interceptor pit, cooling water intakes at Stokes Hill and other bunded areas.

Waste generated while this activity is conducted will include bitumen, concrete, reinforced concrete, steel tanks, structural steelwork, concrete and plastic pipework, rock and gravel materials, soil and contaminated soil. Soil contaminants have been identified during the detailed Contaminated Site Assessment.

Potentially hazardous liquids wastes from the underground fuel storage tanks are likely to include hydrocarbons and hydrocarbon-water mixtures. Sewage may be present in the septic tanks. These materials will be removed and transported off site for appropriate disposal.

Soil and Groundwater Remediation

Hazardous waste generated during remediation activities may include contaminants such as hydrocarbons and heavy metals removed during soil and groundwater remediation. Non-hazardous waste generated during the remediation activities may include treated groundwater, clean soil and treated soil.

Construction

Non-hazardous waste generated during construction activities may include clean topsoils and fill material, vegetation and residual building materials. Construction personnel will generate putrescible wastes, including solid waste, liquid waste and sewage. Hazardous waste generated during the construction activities may include hydrocarbons and other chemicals such as solvents, paints, fertilisers, pesticides and insecticide and cleaning products.

Site Operation and Maintenance

Hazardous wastes including paints, fertilisers, sewage, pesticides, insecticides and cleaning products will be generated during site operation and maintenance.

6.6 Impacts on the Cultural Environment

6.6.1 Aboriginal Cultural Heritage, Archaeology and Native Title

Cultural Heritage and Archaeological Values

The likelihood of any intact items of Aboriginal cultural heritage remaining on site is low because of the extensive disturbance from landform changes and industrial activity. As a result, the potential impacts for further disturbance to cultural heritage significance and subsequent loss of heritage items is also low.

The Redevelopment is unlikely to impact significantly on any remaining Aboriginal archaeological values of the area. The construction of additional buildings and infrastructure, land reshaping and modification, deep excavation and ground leveling have the capacity to damage the context of any surface site or subsurface archaeological deposit and/or destroy an archaeological site due to soil removal. However given the extensive disturbance of the site over the last 130 years, this is not expected to be a major impact.

Sacred Site and Native Title

A Sacred Site and a Native Title claim cover sections of the project area, both centered on Stokes Hill. The registered Sacred Site has the potential to limit future land use, including commercial and residential development, of Stokes Hill. The Sacred Site also incorporates part of the NFI and tanks 13 and 14 in the depression of Stokes Hill. Any decommissioning of tanks 13 and 14 and subsequent remediation will require formal approval under the Aboriginal Areas Protection Authority Certificate (AAPA). The AAPA certificate for this area stipulates that no excavation works may be carried out and that no works may be undertaken within the restricted works area without formal approval of the senior Aboriginal site custodians. This will obviously influence the scope of works for the area but more importantly, this issue will require extensive consultation with the relevant custodians to determine what land uses, if any, are appropriate for the site.

The Redevelopment is likely to create a visual impact from Lameroo Beach, a listed Sacred Site, and other sites in the vicinity. It may also pose a potential impact on the contemporary use of the escarpment base by Aboriginal people. These impacts are not considered to be significant but sympathetic design may help to alleviate any concerns.

6.6.2 European Cultural Heritage

The primary potential impact on the historical heritage of the project site and nearby areas is the damage to or loss of significant sites and structures during the Redevelopment. Fifteen sites have been identified within the project site with particular significance for the history of Darwin and the wharf area.

As noted in Section 5.6.2, the project area contains 15 identified sites with heritage significance including:

- Three (3) sites listed on the NT Heritage Register (the Oil Storage Tunnels, the Steam Pump House and the MV *Neptuna*). In addition, Goyder's Camp was nominated for inclusion on the Heritage Register on 2 April 2004;
- Three (3) sites listed on the Register of the National Estate (the Oil Storage Tunnels 1, 5, 6, 10 and 11, the Steam Pump House and Traveller's/Chinaman's Walk [to be delisted]);
- One (1) site registered under the *Aboriginal Sacred Sites Act* (Stokes Hill); and
- Four (4) sites listed on the National Trust Register of Significant Places (Knight's Folly, the Oil Storage Tunnels 5 and 6, Traveller's/Chinaman's Walk and the Burnett design "G" Type Residence.

6.7 Impacts on the Socio-economic Environment

This section provides an assessment of the potential socio-economic impacts from the project. If the final Master Plan is sensitive to socio-economic conditions, the biophysical landscape and the heritage values of the site, it should not produce significant adverse socio-economic impacts. Short-term adverse impacts may arise if construction activities do not cater to provide adequate access for existing users of the area, particularly existing businesses.

The socio-economic impacts of the Darwin City Waterfront development have been assessed according to:

- *Qualitative data* drawn from community consultation and in-depth stakeholder interviews designed to determine community values, attitudes and concerns in relation to the project; and
- *Quantitative data* drawn from Census studies, published research, government and industry strategy documents and reports.

The site is currently used for industrial purposes, associated with bulk cargo operations, and for some tourism and recreational activities. This prime waterfront site has significant socio-economic potential and important heritage and environmental values. However, the site is under utilised, provides low visual amenity values and requires environmental remediation. The proposed redevelopment is expected to generate significant and sustainable benefits to the region. These socio-economic impacts are summarised in the **Table 6.5**.

Table 6.5: Socio-economic impacts and measures of impact

Socio-Economic Impact Categories	Measures of Impact	Expected Impact
Demographic characteristics	Changes in property values as result of Waterfront development New residential development as result of the Waterfront development Number of people/households affected by the Waterfront Redevelopment Changes in the demographic structure of the area during construction and operation of the Waterfront development Changes in in-migration patterns as a result of Waterfront development Changing home ownership patterns during Waterfront Redevelopment and operation Number of properties subject to compulsory acquisition and compensation	Increase, positive Increase, positive Undefined at this stage Increase, positive Increase, positive Undefined at this stage None
Social patterns and linkages	Changes in community linkages and cohesion as a result of Waterfront development Change in access to community services and facilities as a result of Waterfront development Change in access to cultural, social, recreational and sporting facilities as a result of Waterfront development Change in number/activity of voluntary community-based organisations as a result of Waterfront development	Undefined at this stage Increase, positive Increase, positive Undefined at this stage
Economic factors	Contribution of Waterfront Redevelopment to Gross Territory Product New businesses established as a result of Waterfront Redevelopment Change in Territory's balance of trade during construction and operation of the Waterfront Business closures as result of Waterfront development Changing household expenditure patterns during Waterfront Redevelopment and operation Changing median income levels during Waterfront Redevelopment and operation Distribution of economic costs and benefits as a result of Waterfront development Growth in convention and exhibition business	Increase, positive Increase, positive Increase, positive Undefined Undefined at this stage Undefined at this stage Undefined at this stage Increase, positive

Table 6.5: Socio-economic impacts and measures of impact

Socio-Economic Impact Categories	Measures of Impact	Expected Impact
Employment	Employment generated by the construction and operation of the Waterfront development	Increase, positive
	Employment in service industries associated with Waterfront development	Increase, positive
Education and training	Education and training provided by project developers	Increase, positive
	New education and training opportunities generated to support construction and operation of the Waterfront development	Increase, positive
Access	Usage of the Waterfront site: locals, interstate visitors, international visitors	Increase, positive
General amenity	Change in recreational development and opportunities	Increase, positive
	Change in landscape conditions affecting amenity: eg the escarpment, mudflats	Increase, positive
	Community satisfaction with development	Increase, positive
	Consistency of Waterfront Redevelopment with tropical location	Increase, positive
	Change in site’s attractiveness to community	Increase, positive
	Change in overall value of site to future generations	Increase, positive

6.7.1 General Economic Impacts

The general economic outcomes from the project include:

- significant economic benefits at local and Territory levels;
- a positive contribution to the Territory’s Gross State Product; and
- a positive contribution to the Territory’s balance of trade through increased interstate and international investment and visitor numbers.

6.7.2 Employment

The Redevelopment will have positive impacts in generating local direct and indirect employment. The existing strength of the Territory’s construction industry, and the relatively long timeframe for construction activities, suggests that construction demands are likely to be absorbed by existing local businesses and that employment is likely to be sourced from local area. Similarly, given the Territory’s

well-established hospitality, entertainment and tourism industries, it is likely that most employment in the operational phase of the development (both on-site and in associated services) will be locally sourced.

6.7.3 Demand for Services

The Redevelopment will increase demands on current service infrastructure, e.g on transportation, power and utilities. There is no evidence that these will generate significant negative impacts for Darwin, its population or the viability of the Redevelopment.

6.7.4 Existing Businesses

Potential impacts on existing businesses within, around, or using the facilities in, the redevelopment area is the most significant potential negative impact, particularly related to possible short term and transitional costs for businesses in the Darwin CBD. Construction activities may have some short term negative impact on Stokes Hill Wharf cafes and restaurants.

6.7.5 Sites of Recreational or Other Socio-economic Importance

Overall, the development will generate significant positive impacts by increasing the range of recreational opportunities for the local community and visitors. In the short term, the Redevelopment is likely to increase local competition in cultural, social and recreational sectors. However, in the medium to longer term, it should increase visitor numbers and demand for those facilities, and raise Darwin's profile as a centre for the arts, entertainment, and conventions and exhibitions.

6.7.6 Visual Amenity, Noise Levels and Recreational Water Quality

The redevelopment is likely to have significant positive impacts on existing visual amenity, noise levels, and recreational water quality. If the Master Plan is sensitive to the concerns expressed by local people, the community is likely to benefit from remediation of the site and the generation of important economic, social, cultural and environmental values.

6.8 Systems and Habitats

6.8.1 Terrestrial Systems

The coastal vine-forest along the escarpment is the most significant vegetation in or near the project site, and is close enough to be effected by dust, physical disturbance along its base or the spread of weed species.

6.8.2 Intertidal and Marine Systems

Dredging and reclamation will lead to some habitat disturbance for intertidal and marine communities. Reclamation will cause the permanent loss of local marine habitat and poor water quality. However, this activity is unlikely to cause significant adverse impacts to the marine environment of Darwin Harbour. As discussed in Section 7.3.6, any dredging operations may cause increased turbidity.

The small mangrove community at the western end of Kitchener Bay provides some amenity value by softening the existing harsh foreshore. The Redevelopment and the likely replacement of foreshore edge will require the removal of this community. This is not considered a significant impact in the context of the extensive mangrove habitats throughout Darwin Harbour and requires no mitigation measures.

6.8.3 Use of Current Site Facilities

As noted in Section 5.8.5, the project site supports a range of tourism, commercial and tourism activity with the Deckchair Cinema dependent on road access through the site, although external to it. All of these businesses and activities depend on road access through the site and the general amenity of the area. Any disruptions to that access, during site remediation, construction or ongoing operation, could have significant local impacts on the businesses in the area and the enjoyment of the area by visitors.

Existing users of the area may also be affected following completion of the different stages of Redevelopment. In many cases, these impacts will be positive with increased visitation and business opportunities. However, some adverse impacts on existing users may occur through:

- restrictions on either vehicular or pedestrian access;
- increased competition with larger operators drawn to the area;
- loss of significant features of the area that form the resource base for businesses (e.g., heritage elements); and
- increased activity across the site detracting from the existing amenity values of the area.

Generally, these potential adverse impacts are expected to be minor in comparison to the socio-economic benefits of the project and can be addressed by incorporation of appropriate measures in the Redevelopment Master Plan.

7.1 Introduction

7.1.1 Aims and Scope

The general aim of this preliminary hazard analysis is to identify hazards associated with the proposed DCWR and assesses the level of risk to the public, the environment and nearby facilities from the proposed operations. This hazard analysis covers activities likely to occur during construction, commissioning and operation of the development.

Key principles, objectives and essential components of the Redevelopment have been specified. This preliminary risk assessment has been compiled using the known features of the development and information gained during preparation of the Draft EIS. The preliminary risk review should be revisited following publication of the final Master Plan, to confirm assessment criteria and assumptions, and conduct further quantified risk assessment where appropriate.

7.1.2 Scope and Methodology

Assessment Methodology

The assessment methodology for the Preliminary Hazard Analysis (PHA) follows the general outlines on risk assessment methodologies used in Australia and overseas, including the relevant Australian Standards, such as AS4360:1999 Risk Management, AS3931-1998 Risk Analysis of Technological Systems Application Guide, and associated handbooks (HB):

- HB203:2000 Environmental Risk Management Principles and Process; and
- HB143:1999 Guidelines for managing Risk In the Australian and New Zealand Public Sector.

All of these documents make use of a generic risk management approach as shown in **Figure 7.1** below.

The key components of the risk approach are:

1. hazard identification;
2. analysis of risk, which includes consequence and frequency analyses;
3. assessment of risk against criteria; and
4. risk treatment (elimination, mitigation, retention).

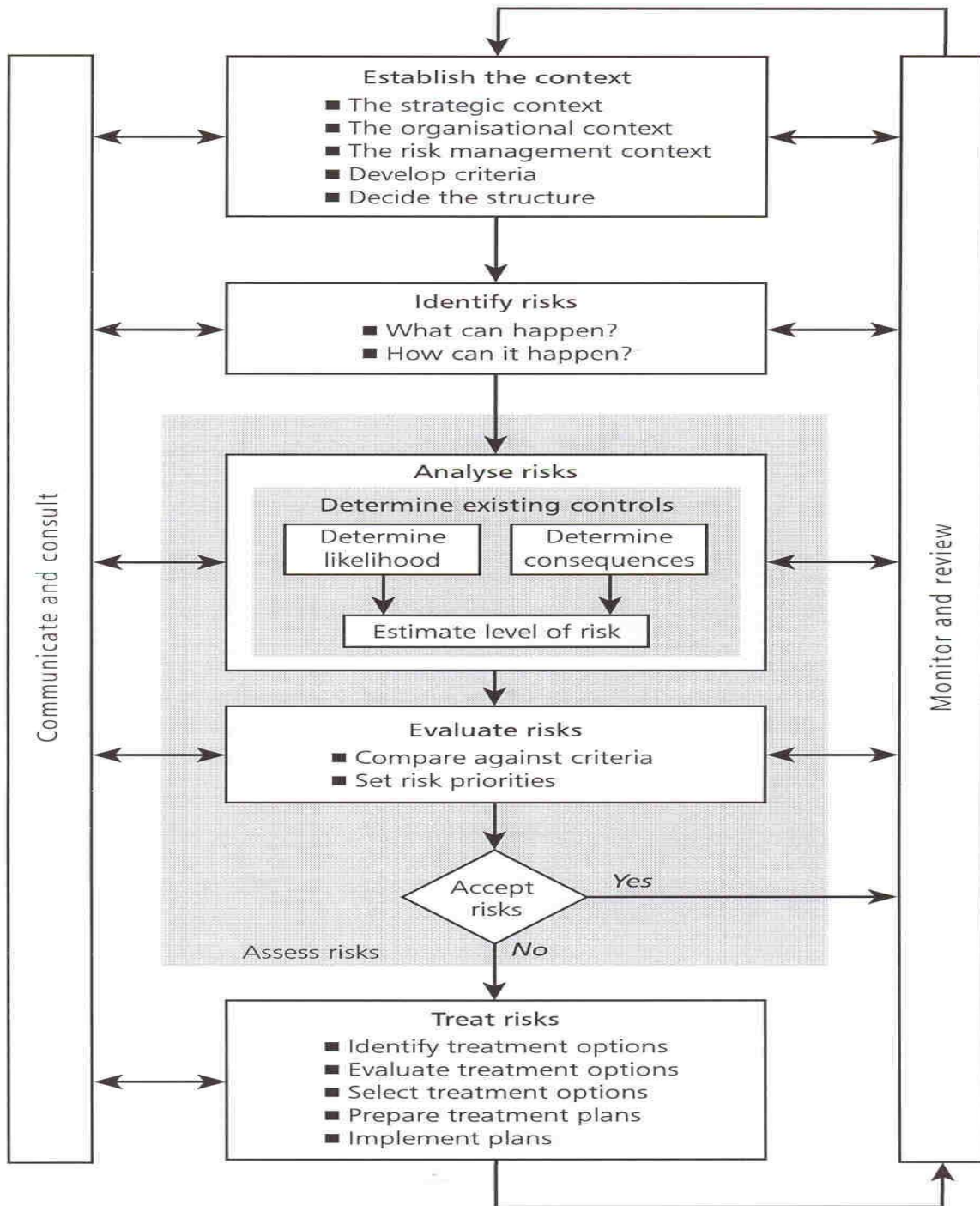


Figure7.1: Risk Management Process (AS4360:1999)

Drawing on the generic risk approach (Figure 7.1), a tailored risk approach was specifically developed for this study. The flow diagram shown in Figure 7.2 demonstrates the risk assessment approach adopted for this study. The approach comprises a systematic review of inputs, actions and outputs, to define

potential hazardous events and then evaluates risks. The preliminary review concludes at this level of risk assessment.

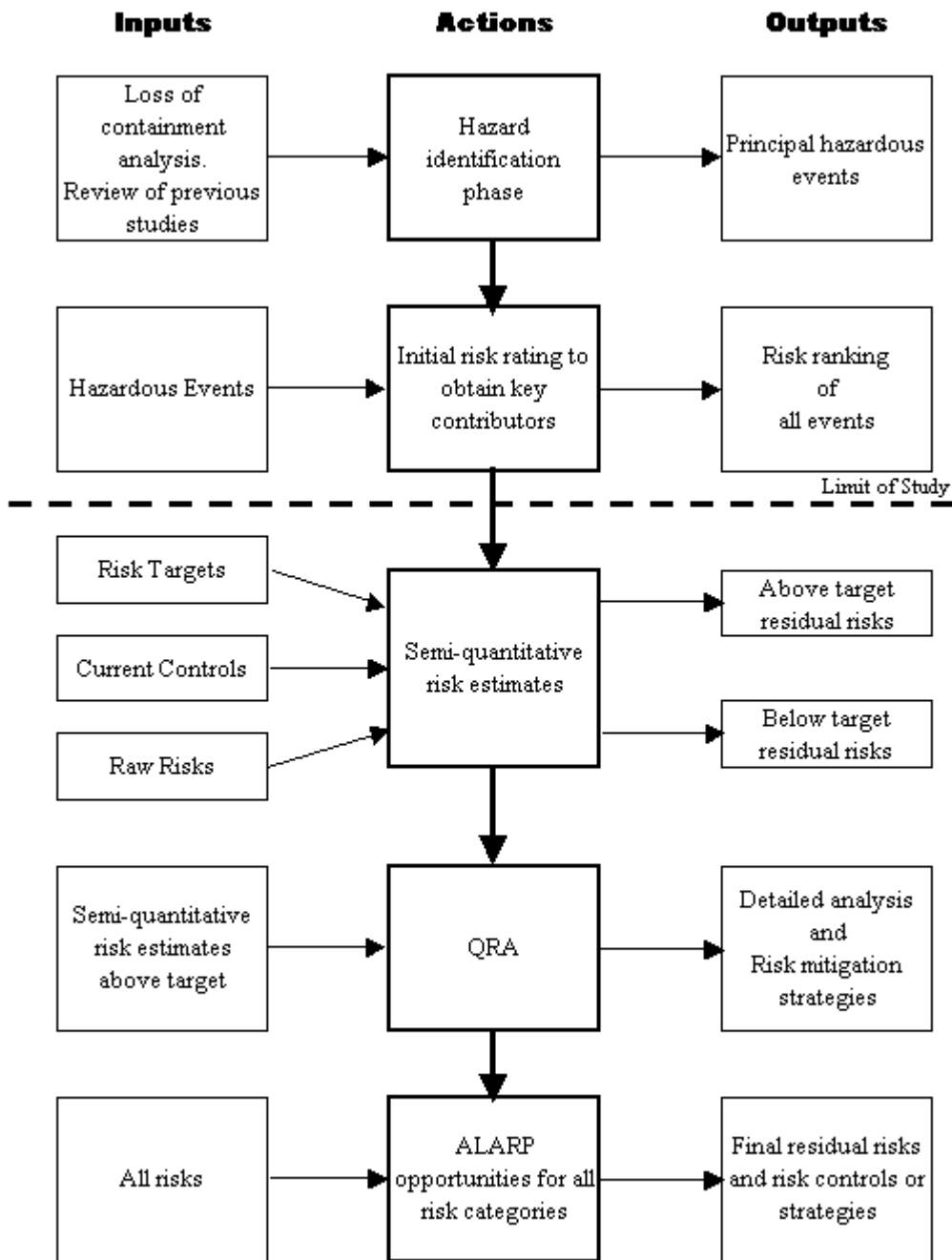


Figure 7.2: Adopted Risk Assessment Approach

Hazard Identification

The generally used methods for hazard identification range from comparative studies using check-lists and standards through to fundamental studies relying on a more formal systematic and structured approach. A qualitative approach to hazard identification was based on Redevelopment in the Concept Plan.

The qualitative approach adopted, was to use of a team of experts to conduct an analysis of what can go wrong in complex development environments, with many activities, land-uses and structures. The normal conditions of construction and operation were defined and then the following questions posed:

- What abnormal events can occur?
- How likely are these events to occur?
- What are the consequences of the event?
- What are the overall Risks (likelihood x consequence)?

Risk Rating

Initial risk rating and ranking of the events developed from the hazard identification phase were undertaken using qualitative methods which allowed the key risk contributors to be analysed in further detail. The objective of a risk management program is to ensure that all risks are as low as reasonably practicable (ALARP). In line with this concept it is necessary to still consider further risk mitigation by means of elimination, substitution, intensification, engineering and administrative controls, or personal protection. However, the principal, high and priority level risks must be identified and addressed first.

It is important to note that raw risks were assessed where the current controls are not initially taken into account.

The adopted risk rating and ranking process involves the assignment of a consequence rating from 1 to 5 and a corresponding likelihood weighting from A to E to each risk, based on the weightings descriptions. Likelihood and consequence ratings applied in the risk assessment process, tailored for the proposal and the type of risks, are described in following tables. There may be one or more different consequence types for each scenario, a fuel spill and fire would have environmental, safety, financial, community outrage and other consequences. For a particular scenario, the consequence type with the highest (i.e. worst) rating is adopted and a letter descriptor is included to indicate the consequence type.

Criteria for Consequence

Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)
Injury and Disease (includes workers and community) (S)				
Minor injury. No medical treatment Eg, cuts, bruises, no measurable physical effects.	Significant injury. Medically Treated Injuries from which recovery is likely. Eg, burns, broken bones, severe bruises, cuts.	Serious Injury. Moderate permanent effects from injury or exposure. Eg, serious burns, serious internal and/or head injuries, gassings that require hospitalisation.	Single fatality and/or, Severe permanent injury, paralysis, brain damage, life threatening exposure to a health risk	A Multiple fatality and/or, Significant irreversible exposure to a health risk that effects greater than 10 people
Environmental Impacts (E)				
Low Pollution. No observable effect to plants or animals. No requirement to inform authorities. No visible discharges observed offsite	Minor Pollution. Minor effects on plants & Animals. Required to inform authorities. May involve a cleanup. Visible discharge observed offsite.	Moderate Pollution. Moderate effects on plants & animals. Physical impact on the public. Required to report to authorities. Extensive cleanup may be required.	Major Release. Major effects on Plants & Animals. Substantial cleanup costs. Personal & business prosecution possible	Extreme Event. Permanent effects on the environment. Potential loss of licence to operate. Prosecution of company and directors possible.
Total Cost Impact (F)				
< \$50k	\$50k - \$500k	\$500k - \$5m	\$5m - \$25m	> \$25m
Community / Government / Media / Reputation/Outrage (O)				
Public concern restricted to local complaints. Ongoing scrutiny / attention from regulator. Individual concern. No discernable impact on reputation.	Minor, adverse local public or media attention and complaints. Significant hardship from regulator. Reputation is impacted with a small number of people.	Attention from media. Heightened concern by local community. Criticism by local NGOs. Significant difficulties in gaining approvals. Reputation impacted with some key stakeholders.	Significant adverse national media / public / NGO attention. Licence to operate suspended or not gain approval. Reputation impacted with significant number of key stakeholders.	Serious public or media outcry (international coverage). Damaging NGO campaign. Licence to operate threatened. Reputation impacted with majority of key stakeholders.

Criteria for Likelihood of Events

A – Almost Certain	Event is <u>expected</u> to occur in most circumstances	Definite history of occurrence. Frequency between once and ten times per year.
B – Likely	Event will <u>probably</u> occur in most circumstances	Probably occur once per decade and history of near misses. Frequency between once per every ten years and once per year.
C – Moderate	Event <u>should</u> occur at some time	May happen once per lifetime of the facility. Frequency between once per every 100 years and once per every 10 years.
D – Unlikely	Event <u>could</u> occur at some time	Low likelihood of occurrence. Frequency between once per every 1,000 years and once per every 100 years.
E – Rare	Event <u>may</u> only occur in exceptional circumstances	Very low likelihood of occurrence. Frequency between once per every 10,000 and once per every 1,000 years.

The combination of the likelihood and consequence ratings is then compared to a qualitative risk analysis matrix, providing an indication of the magnitude of consequence (ranging from low to priority). The adopted risk level matrix is as follows:

Risk Matrix

LIKELIHOOD	CONSEQUENCE				
	1 – Insignificant	2 – Minor	3 – Moderate	4 – Major	5 – Critical
A – Almost Certain	M	M	P	P	P
B – Likely	M	M	H	P	P
C – Moderate	L	M	M	H	P
D – Unlikely	L	L	M	H	P
E – Rare	L	L	M	H	H

(P) Priority (H) High (M) Moderate (L) Low

Legend

P = Priority risk: detailed research and management planning required at senior levels

H = High risk: senior management attention needed

M = Moderate risk: management attention and integration into management plans required

L = Low risk: managed by routine procedures

Further Assessment

Following the qualitative risk assessment, recommendations have been made for those hazards likely to require semi and/or fully quantitative risk assessment (QRA). This further analysis will only be possible following detailed review of facilities and technological systems to be implemented as part of the Redevelopment Masterplan.

7.2 Hazard Scenarios

Hazard identification has been undertaken based on a review of the activities at and around the proposed development location.

7.2.1 Biting Insects

There is likely to be only one biting midge species with the potential to cause a pest problem, the mangrove biting midge *Culicoides Ornatus*. Biting midges do not currently transmit human disease in Australia, but can impact on humans due to painful and irritable bites, secondary infection and scarring from scratching. The numbers of biting midges trapped during surveys indicate that low to insignificant numbers of the mangrove biting midge will be present in the study area.

Hazard:	Impacts from Biting Midges			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Minor	Minor	NA	NA	Low
Event Likelihood	Likely			
Overall Risk Rating	Moderate risk; management attention and integration into management plans required			
Potential Management Controls	Routine personal protection and use of repellents Publicity and procedures concerning the presence of minor pest levels of biting midges Use of insecticide treatments			
Further Recommendations	Biting insects management plan to be developed			

The main mosquito species likely to cause health impact is the salt marsh mosquito *Ochlerotatus Vigilax* which breed in coastal areas in tidal and brackish water such as those encountered in the development area. This mosquito species is a vector of the Ross River virus (RRV) and Barmah Forest virus (BFV) diseases and can be a severe pest due to its persistent biting habits and its willingness to bite during the daytime. The number of salt marsh mosquitos trapped during surveys indicated very low numbers in the development area.

Hazard:	Impacts from Biting Mosquito			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	Moderate	NA	NA	Minor
Event Likelihood	Moderate			
Overall Risk Rating	High Risk: senior management attention needed			
Potential Management Controls	Routine personal protection and use of repellents Removal of artificial receptacles that can fill with water and breed mosquitoes Landscaping, to allow use of insecticide barrier treatments and to limit plant species capable of holding water and breeding mosquitoes Use of yellow lighting around any human activity areas to reduce mosquito attraction Publicity and procedures concerning the presence of disease carrying and minor pest levels of mosquitoes Use of insecticide treatments			
Further Recommendations	Biting insects management plan to be developed			

Currently the mosquito problem at the Redevelopment area is minor. However, the development area is susceptible to the introduction of exotic species of mosquitos, which carry the Dengue virus. These species may be brought into the area on visiting ships or cargo from overseas where these species are endemic. These Dengue vector species may also be introduced from road transports from Queensland and Tennant Creek where the species has been detected.

Hazard:	Impacts from Introduced Dengue Vector Mosquito			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Major	NA	Moderate	Moderate
Event Likelihood	Unlikely			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	Publicity and procedures concerning the presence of minor pest levels of biting midges Use of insecticide treatments for incoming shipping, cargo and storage areas Routine personal protection and use of repellents Removal of artificial receptacles that can fill with water and breed mosquitos			

<p>Potential Management Controls (cont'd)</p>	<p>Landscaping, to allow use of insecticide barrier treatments and to limit plant species capable of holding water and breeding mosquitos</p> <p>Use of yellow lighting around any human activity areas to reduce mosquito attraction</p> <p>Publicity and procedures concerning the presence of disease carrying and minor pest levels of mosquitos</p> <p>Use of insecticide treatments in landscaping</p>
<p>Further Recommendations</p>	<p>Biting insects management plan to be developed</p>

7.2.2 Transport and Traffic

The current volumes of traffic on the approach roads and intersections in the vicinity of the development are not considered to be high. Traffic conditions on the approach roads and intersections in the vicinity of the development area will change as a consequence of numerous factors, including the onset of construction activities; further residential and commercial traffic generated by developments on the outskirts of the city; and traffic generated from the development itself. Traffic volumes on the main approach and circulating roads, including into and out of the waterfront development area, are expected to grow generally as a consequence of increased population, new commercial and retail development, employment opportunities and growth in tourism. Added to this general increase, each of the individual land use activities associated with the Redevelopment will generate demands for traffic movements. These increases will come from Convention and Exhibition centre traffic, residential and construction traffic.

Increased traffic movements may result in an increased likelihood of personal accidents.

<p>Hazard:</p>	<p>Traffic Accidents</p>			
<p>Highest Consequence</p>	<p>Injury and Disease</p>	<p>Environmental Effects</p>	<p>Total Cost Impact</p>	<p>Community</p>
<p>Major</p>	<p>Major</p>	<p>Insignificant</p>	<p>NA</p>	<p>Insignificant</p>
<p>Event Likelihood</p>	<p>Likely</p>			
<p>Overall Risk Rating</p>	<p>Priority risk: detailed research and management planning required at senior levels</p>			
<p>Potential Management Controls</p>	<p>Upgrades to road network</p> <p>Application of speed limiting techniques and signage</p> <p>Definition of traffic movement areas during construction</p> <p>Use of personal protective equipment and signage during construction</p>			
<p>Further Recommendations</p>	<p>Traffic controls to applied in construction management plan</p>			

The development of the waterfront area will take place in a staged manner over a number of years and will involve site preparation and construction activities. In view of the previous industrial uses and the resultant contamination of the land, this will involve demolition and selective remediation of the site as well as excavation and construction activities. These activities will be significant with an increased heavy vehicle movement of waste soil and infrastructure from the site. There will also be the importation of construction materials and clean fill. The construction of buildings associated with the individual developments and the provision of new infrastructure including upgraded internal roads and services will also represent significant activities that will generate traffic movements.

The increased heavy truck movements may damage roads within and adjacent to the development area. The volume and type of vehicle trips likely to be generated cannot be estimated at this time but are likely to be significant. It is likely that a use pays system will be established, to make funds available for upgrading roadways damaged during construction.

Hazard:	Damage to Roadways			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	NA	Minor	Moderate	Minor
Event Likelihood	Likely			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	Upgrade roads experiencing degradation from excessive traffic movement Vary routes of travel Implement upgrade of all internal development roadways following major demolition and construction activity			
Further Recommendations	None			

There are a number of vulnerable areas of above ground infrastructure that may be at risk from accidental damage from vehicles. These include the above ground pipelines used for transporting fuel products that run along a section of McMinn Street and along the majority of Kitchener Drive. The section on McMinn Street has some protection in the form of steel barriers, however the section on Kitchener Drive remains unprotected. There is also an above ground valve point for all the fuel lines off Iron Ore and Fort Hill wharves. Increased traffic, including significant heavy construction vehicle movements, will increase the risk of damage to these facilities during the development.

Damage to these pipelines is likely to present a hazard from release of petroleum products to the environment, potentially contaminating soil, stormwater systems and groundwater. An accident of this type may also cause production of hydrocarbon vapours with resulting health impacts. Vapours may cause secondary fires if they come in contact with ignition sources. The hazards of fuel release and petroleum products are discussed further in Section 2.1.4 Fuel Storage, Transfer and Offloading. The pipelines are fitted with pumps, which are operational only when products are being transferred. At other

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times valves will be closed and no flow is possible. The lines are full of products when not being used for fuel transfer. Risks will be increased if an accident was to occur during the pumping of volatile products such as petrol.

Hazard:	Heavy Vehicle Accidents Causing Damage to Infrastructure			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	NA	NA	Moderate	Minor
Event Likelihood	Unlikely			
Overall Risk Rating	Moderate: management attention and integration into management plans required			
Potential Management Controls	Install vehicle crash barriers between the roadways and the lines Enforce safe speed limits Install adequate roadways for truck manoeuvrability Use traffic management during trucking activities Relocation or removal of fuel pipelines			
Further Recommendations	None			

Hazard:	Small Traffic Accidents Causing Damage to Infrastructure			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Insignificant	NA	NA	Insignificant	Insignificant
Event Likelihood	Moderate			
Overall Risk Rating	Low risk: managed by routine procedures			
Potential Management Controls	Install vehicle crash barriers between the roadways and the lines Enforce safe speed limits Install adequate roadways for truck manoeuvrability Use traffic management during trucking activities Relocation or removal of fuel pipelines			
Further Recommendations	None			

7.2.3 Storage, Transfer and Offloading of Fuels and Other Hazardous Materials

The Redevelopment area and adjacent land is used extensively for the storage and transfer of fuels. The fuel lines are used by the Navy for the transfer of F76 Naval Fuel Oil and by the major oil companies that transfer diesel, Jet A1 (Aircraft Fuel) and petrol. These products are offloaded from fuel tankers that dock at Iron Ore Wharf and are transferred across the development site using both underground and aboveground pipelines. The above ground lines run down Kitchener Drive from north of the Shell Bitumen Plant to the intersection of McMinn Street.

Navy and commercial marine tankers offload fuel at Iron Ore Wharf and this fuel is piped to six above ground bulk storage tanks located at the NFI. The NFI is located on the northern boundary of the development site. F76 is then used for the refuelling of Navy warships and cruise ships. The oil company products are piped to facilities located at Stuart Park, some two km from the site. All oil company bulk storage facilities are being transferred to East Arm Port as part of the Redevelopment program. It is therefore likely that the transfer of Diesel, Jet A1 and petrol by private fuel companies will cease in 2005 when the commercial pipelines will be decommissioned. It should be noted that the removal of the oil company operations from Stuart Park to East Arm Port will remove the presence of volatile products such as Jet A1 and petrol. This will greatly reduce the risk of the operation of the fuel lines. The NFI is to remain and as such the above ground fuel lines will remain.

The release of hydrocarbon products from offloading/refuelling activities may occur at some time if a failure of coupling system or connection hoses was to occur. If a release were to occur at maximum pumping rate during refuelling this would maximise the potential for fuel spills. Other significant releases include overfilling of fuel tanks on ships. The tanks may fill and excess fuel may overflow into the environment through overflow vents. Other scenarios may include valve failure both onshore and offshore. Minor spills may include leaks from couplings and small pressure leaks in the transfer pipes. The Naval facilities including the pipelines were pressure tested by an independent engineering consultant and at the time of the investigation were reported to be in good condition. Other spills and releases may include spills and releases from valve points and couplings at the near by tank farms.

Releases and spills have the potential to impact the environment. At the refuelling point the impacts are likely to be seen in the near shore marine environment, with pipeline and bulk storage tank failures the impacts will be to soils, surface water and groundwater.

It should be considered a marine pollutant and an environmentally hazardous substance. It is a variously coloured liquid, producing potentially hazardous vapours.

The heavy fuel oils are considered a low fire hazard due to its relatively low susceptibility to ignite, however it is combustible and will burn producing smoke, fumes and oxides of carbon.

Jet A1 and petrol are considered highly flammable and a high fire hazard.

All hydrocarbon products handled through the fuel transfer network have the ability to produce volatile gases and emit invisible vapours, either the liquid or vapour may accumulate in service pits or travel some

distance along the ground or surface to ignition sources where they may ignite or explode. The vapour may form explosive mixtures in air, and dangerous atmospheres (low levels of oxygen) in enclosed environments. This is not readily reactive with water and considered relatively stable.

Fuel carrying road trains are used to supply fuel to vessels on a needs basis. The frequency of road trains is not known. These road trains are not used for offloading operations. The supply to ships would be predominantly marine diesels however the tankers may carry other more volatile products for supply to different customers in the Darwin area.

Hazard:	Product Spills & Releases to the Marine Environment from Refuelling and Bunkering at Port ¹			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Minor ²	Major	Moderate	Major
Event Likelihood	Unlikely			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	<p>Management and engineering controls need to be further investigated and will be assessed as part of semi-quantitative risk assessment and hazard and operability study (HAZOP).</p> <p>Larger scale spills to the marine environment need to be carried out as required by the Darwin Harbour Oil Spill Contingency Plan, which provides for a coordinated response to a significant spill.</p> <p>In the event of a spill, scientific and environmental advice would be provided by the Department of Infrastructure, Planning and Environment using knowledge of local environmental conditions, the NT Oil Spill Response Atlas and a network of environmental specialists. Many of the most sensitive areas within the harbour have already been assigned priority levels for protection and clean-up to allow more rapid and effective decision making during and after a spill</p> <p>Responsibility for the rescue and rehabilitation of oil-affected wildlife rests with the Parks and Wildlife Commission of the NT, and an "Oiled Wildlife Kit" has been supplied by the Australian Maritime Safety Authority through the National Plan to Combat Pollution of the Sea by Oil</p> <p>If leak or spill has not ignited, use water spray to disperse vapours and provide protection to these attempting to stop the leak</p>			
Further Recommendations	<p>Semi-quantitative risk assessment and hazard and operability study (HAZOP). This will require the assistance of Defence and commercial tanker operators.</p> <p>Mitigation and engineering controls will need to be further researched.</p>			

¹ Based on major release

² Inhalation of hydrocarbon vapours requiring medical treatment

Hazard:	Product Spills and Releases to Land from Pipeline Rupture ³			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Minor	Major	Moderate	Moderate
Event Likelihood	Rare			
Overall Risk Rating	High: senior management attention needed			
Potential Management Controls	<p>Management and engineering controls need to be further investigated and will be assessed as part of semi-quantitative risk assessment and hazard and operability study (HAZOP).</p> <p>Contingency plans should be developed and may include some of the following:</p> <ul style="list-style-type: none"> Recover free product Add sand earth or other suitable absorbent 			
Potential Management Controls (cont'd)	<p>Minimise breathing vapours and skin contact through the use of personal protective equipment</p> <p>Clean up and disposal of contaminated material to licenced waste facility</p> <p>Keep product away from ignition sources in the vicinity such as heat, sparks static electricity and open flame</p> <p>Keep out of sewers, watercourses, services conduits and other sumps and trenches by dyking and impounding</p> <p>If leak or spill has not ignited, use water spray to disperse vapours and provide protection to these attempting to stop the leak</p>			
Further Recommendations	<p>Semi-quantitative risk assessment and hazard and operability study (HAZOP). This will require the assistance of Defence.</p> <p>Mitigation and engineering controls will need to be further researched.</p>			

Hazard:	Product Spills and Releases to Land from Pipeline Leak ⁴			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	Minor	Moderate	Minor	Insignificant
Event Likelihood	Moderate			
Overall Risk Rating	High: senior management attention needed			

³ As a result of pipeline failure not accident and without resultant fire or explosion

⁴ Flange or fitting leak or hole in pipeline

Hazard:	Product Spills and Releases to Land from Pipeline Leak ⁴
Potential Management Controls	<p>Contingency plans should be developed and may include some of the following:</p> <ul style="list-style-type: none"> Recover free product Add sand earth or other suitable absorbent Minimise breathing vapours and skin contact through the use of personal protective equipment Clean up and disposal of contaminated material to licenced waste facility Keep product away from ignition sources in the vicinity such as heat, sparks static electricity and open flame If leak or spill has not ignited, use water spray to disperse vapours and provide protection to these attempting to stop the leak Keep out of sewers and watercourses services conduits and other sumps and trenches by dyking and impounding
Further Recommendations	Spill contingency plans should be developed which minimise impacts to land, groundwater and the marine environment.

Hazard:	Fire and Explosion from Refuelling and Bunkering (including NFI) ⁵			
Consequence Criteria	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Critical	Critical	Critical	Major	Major
Event Likelihood	Rare			
Overall Risk Rating	High: senior management attention needed			
Potential Management Controls	<p>Contingency plans for fire and explosion scenario should be developed and or reviewed and exercises conducted.</p> <p>Larger scale spills to the marine environment need to be carried out as required by the Darwin Harbour Oil Spill Contingency Plan, which provides for a coordinated response to a significant spill.</p> <p>In the event of a spill, scientific and environmental advice would be provided by the Department of Infrastructure, Planning and Environment using knowledge of local environmental conditions, the NT Oil Spill Response Atlas and a network of environmental specialists. Many of the most sensitive areas within the harbour have already been assigned priority levels for protection and clean-up to allow more rapid and effective decision making during and after a spill</p> <p>Responsibility for the rescue and rehabilitation of oil-affected wildlife rests with the Parks and Wildlife Commission of the NT, and an "Oiled Wildlife Kit" has been supplied by the Australian Maritime Safety Authority through the National Plan to Combat Pollution of the Sea by Oil</p>			

⁵ Assumes uncontrolled ship fire

<p>Potential Management Controls (cont'd)</p>	<p>Contingency plans should be developed for land based spillage and fire protection and may include some of the following:</p> <ul style="list-style-type: none"> Recover free product Add sand earth or other suitable absorbent Minimise breathing vapours and skin contact through the use of personal protective equipment Clean up and disposal of contaminated material to licenced waste facility Keep product away from ignition sources in the vicinity such as heat, sparks static electricity and open flame Keep out of sewers and watercourses services conduits and other sumps and trenches by dyking and impounding Foam, water spray (fog), dry chemical, carbon dioxide and vapourising type liquid extinguishing agents are suitable. Use water to keep containers cool. If leak or spill has not ignited, use water spray to disperse vapours and provide protection to these attempting to stop the leak.
<p>Further Recommendations</p>	<p>Quantitative risk assessment (QRA) focussing on potential risk to development facilities should be carried out in conjunction with Navy and commercial tanker operators.</p> <p>Mitigation and engineering Controls will need to be further researched.</p>

<p>Hazard:</p>	<p>Fire, Explosion and Release of Product from Traffic Accident Damage to Fuel Pipelines</p>			
<p>Highest Consequence</p>	<p>Injury and Disease</p>	<p>Environmental Effects</p>	<p>Total Cost Impact</p>	<p>Community</p>
<p>Major</p>	<p>Major</p>	<p>Major</p>	<p>Moderate</p>	<p>Moderate</p>
<p>Event Likelihood</p>	<p>Unlikely</p>			
<p>Overall Risk Rating</p>	<p>High: senior management attention needed</p>			
<p>Management Controls</p>	<p>Contingency plans should be developed and may include some of the following:</p> <ul style="list-style-type: none"> Recover free product Add sand earth or other suitable absorbent Minimise breathing vapours and skin contact through the use of personal protective equipment Clean up and disposal of contaminated material to licenced waste facility Keep product away from ignition sources in the vicinity such as heat, sparks static electricity and open flame Keep out of sewers, watercourses, services conduits and other sumps and trenches by dyking and impounding If leak or spill has not ignited, use water spray to disperse vapours and provide protection to these attempting to stop the leak 			

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Further Recommendations	<p>Quantitative risk assessment (QRA) focussing on potential risk to development facilities. This will require the assistance of Defence and commercial tanker operators.</p> <p>Mitigation and engineering controls will need to be further researched.</p> <p>Spill contingency plans should be developed which minimise impacts to land, groundwater and the marine environment.</p>
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Hazard:	Fuel Transport Vehicle Accidents			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Critical	Critical	Major	Moderate	Moderate
Event Likelihood	Rare			
Overall Risk Rating	High: senior management attention needed			
Potential Management Controls	<p>Contingency plans should be developed and may include some of the following:</p> <p>Traffic management routes measures</p> <p>Recover free product</p> <p>Add sand earth or other suitable absorbent</p> <p>Minimise breathing vapours and skin contact through the use of personal protective equipment</p> <p>Clean up and disposal of contaminated material to licenced waste facility</p> <p>Keep product away from ignition sources in the vicinity such as heat, sparks static electricity and open flame</p> <p>Keep out of sewers, watercourses, services conduits and other sumps and trenches by dyking and impounding</p>			
Further Recommendations	Contingency plans to develop traffic management measures.			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Critical	Major	Moderate	Major	Major
Event Likelihood	Rare			
Overall Risk Rating	High: senior management attention needed			
Potential Management Controls	<p>Recover free product</p> <p>Add sand earth or other suitable absorbent</p> <p>Minimise breathing vapours and skin contact through he use of personal protective equipment</p>			

<p>Potential Management Controls (cont'd)</p>	<p>Clean up and disposal of contaminated material to licenced waste facility</p> <p>Larger scale spills to the marine environment need to be carried out as required by the Darwin Harbour Oil Spill Contingency Plan.</p> <p>Keep product away from ignition sources in the vicinity such as heat, sparks static electricity and open flame</p> <p>Keep out of sewers, watercourses, services conduits and other sumps and trenches by dyking and impounding</p>
<p>Further Recommendations</p>	<p>Pool fire modelling to determine radiating heat contours and fault or event tree analysis to determine probability.</p>

7.2.4 Vessel Collision/Grounding

The Redevelopment area includes a section of Kitchener Bay, which extends from mid way along the Fort Hill wharf across to the southern edge of the jetty of the steam pumphouse area. This portion of Kitchener Bay is subject to the macrotidal nature of Darwin Harbour, revealing mudflats at low tide and experiencing potentially strong tidal currents during flood and ebb tidal movements. It is anticipated that the impending Master Plan for the Redevelopment area will include details on the provision of a marina complex within Kitchener Bay (referred to here as the ‘harbour’). Based on information within the Darwin Harbour Concept Plan, a series of jetties will be constructed and installed to form the marina complex within the harbour.

The addition of a marina within the harbour will provide opportunity for vessel owners and operators to berth within Kitchener Bay and use the DCWR as a gateway to Darwin CBD. The marina facility will also introduce increased public transport and tour operator visits to Kitchener Bay.

In light of the potential increase in vessel traffic within the harbour, the potential for vessel collision and grounding increases also. It must also be noted that much of the increase in This section presents a qualitative risk assessment of the potential for vessels to collide within Kitchener Bay and also for the event of vessels running aground within the Bay.

Bathymetry

Water depth for the majority of the length of the viaduct (the span between Stokes Hill and the main wharf section of Stokes Hill Wharf) is 6 m, deepening to approximately 11 m in the outer quarter. The depth on the Kitchener Bay side of the wharf is around 3 m, which shallows to the north to 0 m depth within a distance of 100 m. A broad intertidal mudflat then extends for 150-250 m to the edge of the existing revetment.

To the north east of Stokes Hill Wharf, the water shallows to approximately 2 m at the mouth of Frances Bay, east of Stokes Hill, and is generally around 0.5 m at the mouth of Sadgroves Creek. The mud banks on either side of the channel are emergent at low tide.

Darwin Harbour Oceanography

Darwin Harbour is characterised by a macrotidal regime with a maximum range of 7.8 m. The mean neap tidal range is 1.9 m, while springs average 5.5 m. Tides are predominantly semidiurnal (two highs and two lows per day), with a slight inequality between the successive tides during a single day, but nearly diurnal tides occur for a two-day period during the neaps. The lowest spring tides of the year occur during October, November and December. Tidal excursions range from 8 to 15 km during springs and 2 to 8 km during neaps (Steedman & Associates 1982; Semeniuk 1985; Hanley & Caswell 1995a).

Tidal currents of up to 1.2 kn can occur within Kitchener Bay at approximately mid-ebb spring tides. Tidal currents can be stronger (up to 3.0 kn) along the faces of the wharves (Australian Hydrographic Service 2004).

Byrne (1988) summarised data on the hydrodynamics and coastal processes of Darwin Harbour. The harbour is considered well protected, with wind-generated waves typically less than 0.5 m with periods of two to five seconds. The majority of waves are generated within the harbour or in Beagle Gulf. The available data did not include cyclonic conditions, but predicted waves during cyclones would be of the order of 3 to 3.5 m. Extreme wave conditions were modelled by GHDM (1997) using wind data from Cyclone Tracy. Waves with significant wave height of 4.5 m, and average periods of ~7.5 seconds, were found to occur at the entrance to Darwin Harbour.

The type of natural and man-made habitats found in the harbour area includes intertidal flats; wharf structures and a small section of mangroves. These areas are less likely to cause significant damage to grounded vessels.

Wind Movements

The Darwin Wharf Precinct lies within the monsoonal (wet/dry) tropics of Northern Australia and experiences two distinct seasons: a hot, wet season from November to March and a warm, dry season from May to September. April and October are transitional months between the Wet and Dry Seasons.

The strongest winds and heaviest rainfall are associated with the passage of tropical cyclones, which can occur in the region at any time during the period November to April, and occur on average once every two years. Prevailing winds during the wet season are light west to north-westerly, freshening in the afternoon due to sea breezes. In the dry season, the prevailing winds are the south-easterly trade winds (Parkinson, 1996).

Collision

Collision of vessels involves two or more vessels coming into physical contact. The same applies to collision (or physical contact) between vessels and fixed or floating structures such as wharves, jetties and pontoons. The frequency of vessels using the marina (or harbour) area will increase from pre-development levels to a level determined by the size of marina expansion and the demand for such facilities. At this point in time it is unknown how many additional vessels will use the harbour, however,

depending on the number of permanent recreational vessels, transient vessels, commercial vessels and public transport vessel movements, it is anticipated that daily movements in and out of the harbour could exceed 50 per day.

It is anticipated that the types of vessel using the harbour will not change significantly from the types of vessel currently using the harbour. At present, the harbour is used by commercial, private and Government (e.g. Defence and Customs) vessels. Generally the type of vessels using the harbour are not likely to change, the proportion of vessel types may change relative to current levels.

It should be noted that this assessment includes vessel movements inside the harbour and on the outside of the harbour. This includes the berthing and departure of vessels of displacement greater than 1,000 tons, such as bulk carriers (solid and liquid cargo), cruise liners and Naval ships of all types. These vessels generally berth with the assistance of tugs.

The primary factor influencing vessel collision is the frequency of vessel movements. However, apart from human error, a range of other factors may influence the probability of vessel collision. These include:

- Tidal movements - Tidal currents (or streams) may alter or affect a vessel's course;
- Harbour speed limits - Generally, the speed limit for vessels moving within harbours and marina complexes is 4 knots or less;
- Wind movements - Sudden or prolonged wind movements can affect a vessel's movement and contribute to collision with other vessels and with fixed or floating structures;
- Tidal surge - Unexpected sea level rise associated with storms and cyclonic conditions may contribute to stronger tidal currents, inundate physical structures and affect navigational features; and
- Loss of vessel power - Generally, vessels movements within protected harbours and marina facilities are done so under power. Vessels of greater displacement that berth inside Kitchener Bay are often assisted by tug vessels. Loss of a vessel's power could contribute to collision inside the harbour.

The **types** of potential environmental impacts resulting from vessel collision depend on the types of hazardous materials usually carried on board vessels using the harbour. The **extent** of environmental impact presented by commercial vessels, private vessels such as yachts and public transport vessels is determined largely by the volumes of hazardous materials carried on board. The **severity** of damage sustained by vessels in a collision event then influences the potential for release of hazardous materials to the marine environment. Certain vessels may carry a greater volume of hazardous material than others, particularly bulk fuel lighters/tankers.

Hazard:	Collision of Vessels ⁶			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Major	Minor	Moderate	Minor
Event Likelihood	Moderate			
Overall Risk Rating	Priority risk: detailed research and management planning required at senior levels			
Potential Management Controls	Maintain all navigational aids, including lights, signs, special markers, etc Enforce speed limits within and adjacent to harbour area. Restrict vessel movements during periods of tidal surge or strong winds/cyclonic conditions. Use tugs for berthing and departure of large vessels. Conduct berthing and departure activities during slack tidal movements. Salvage of sunken vessels will be undertaken as soon as practicable. Fire fighting facilities will have coverage to extend across the harbour. State of readiness of Oil Spill Contingency Plan will be maintained. Clean up of large-scale spills to the marine environment need to be carried out as required by the Darwin Harbour Oil Spill Contingency Plan.			
Further Recommendations	Consideration of this risk will need to be made as part of the normal Port Management and Planning Process. This will be important as part of any new marina development			

Grounding

Vessels run aground when the keel (or hull) comes into contact with the seabed. Damage to vessels sustained during grounding may range from surface scratches to a large hole(s) in the hull. The resultant effect could be a loss of hazardous material from a holed hull. The potential environmental impact would be pollution of the marine environment by hazardous material such as oil, diesel fuel or other liquid or solid substance. Vessels entering Kitchener Bay will in the main be small vessels, but navy warships, cruise ships are all likely to frequent Fort Hill. Fishing and survey vessels will also likely use Stokes Hill.

Factors affecting the grounding of vessels might include:

- Dredging activity. Dredging may have been inaccurate, resulting in incorrect position being dredged. Dredging may not have been deep enough;
- Navigational aids. May not have been adequate at time of vessel movement (however, changes to depths are usually noted in Notices to Mariners as Chart Corrections);
- Tidal movements. Tides may not be taken into account by vessel Masters, (for large vessels this is mitigated by the use of pilots within the harbour) resulting in miscalculations in depth-below-keel. Unforeseen storm surges may also mask the true tide height, affecting tide calculations; and

⁶ Considered to be collision of small craft with large vessel due to increase in ferry boat and yacht activity

- Changes in bathymetry (seabed depth) may occur as a result of tidal stream movements such as scouring and deposition.

Upon grounding, a vessel may either become stuck fast, or dislodge itself on a rising tide. In the event that a vessel runs aground and becomes stuck fast, either due to an ebb tide or the nature of the grounding, a greater potential exists for hazardous material to escape and pollute the marine environment. If a vessel that has run aground is dislodged from its grounding ‘point of contact’, then there is also risk of further (or initial) loss of hazardous material (cargo) to the marine environment.

The loss of hazardous materials during either ebb or flood tide may have impacts on the marine ecology of Darwin Harbour. Depending on the type and volume of hazardous material lost to the environment and the prevailing tidal movement at the time of a grounding incident, upstream and downstream marine environments are at risk of pollution by contaminants. This hazard is significantly reduced as traffic is likely to be dominated by small pleasure craft. Darwin Harbour’s diurnal macrotidal environment has the potential to spread contamination upstream and downstream of any discharge point.

Hazard:	Grounding of vessels ⁷			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	Minor	Moderate	Moderate	Moderate
Event Likelihood	Moderate			
Overall Risk Rating	Moderate risk; management attention and integration into management plans required			
Potential Management Controls	Dredging activity to be undertaken to correct depth and location. Maintain all navigational aids, including lights, signs, special markers, etc. Enforce speed limits within and adjacent to harbour area. Pilotage of large vessels within Darwin Harbour. Restrict vessel movements during periods of tidal surge or strong winds/cyclonic conditions. Avoid berthing and departure during night or times of poor visibility. Use tugs for berthing and departure of large vessels. Conduct berthing and departure activities during slack tidal movements. Salvage of sunken or damaged vessels will be undertaken as soon as practicable. Fire fighting facilities will have coverage to extend across the harbour. State of readiness of Oil Spill Contingency Plan will be maintained. Clean up of large-scale spills to the marine environment need to be carried out as required by the Darwin Harbour Oil Spill Contingency Plan.			
Further Recommendations	Consideration of this risk will need to be made as part of the normal Port Management and Planning Process.			

⁷ Due to presence of muds impact is considered to be damage to muds (disturbance etc) not to vessel

7.2.5 Hydrocarbon Soil and Groundwater Contamination

Hydrocarbon impacted soil and groundwater is noted to be widespread across the site. No significant amounts of Phase Separated Hydrocarbon (PSH) or free product were noted at the site. The soil impact was contained in a “smear zone” which is associated with the groundwater fluctuations in specific areas of the site mobilising soil impact. The depth of the impact is generally greater than 3.0 m below ground level.

The major fuel type transported through the network of above and underground pipes at the site has been heavy oils which have minimal volatile components and therefore pose a low health risk from vapour release and/or accumulation. There were reported concentrations of aromatic hydrocarbon fractions (health toxic) in sampled soils exceeding guideline values at the site which indicates that uncontrolled contact with the contamination should not be allowed and excavated soils should not be allowed to impact clean surface materials.

Due to the depth of the majority of the impact and the likely depth of proposed excavations it is unlikely that the impact will be intersected in the majority of areas across the site. There is potential for vapour accumulation beneath slabs, buildings and within underground structures such as basement car parks. Measures such as vapour barriers and/or diffusion layers will be required to ensure the accumulation of vapours does not occur.

There is potential that dewatering of excavations will be required during construction activities. Control will have to be maintained on the handling and disposal of potentially hydrocarbon impacted groundwater. This will require separation ponds or similar to ensure any hydrocarbon impact is removed or treated prior to disposal.

Hazard:	Exposure to Hydrocarbon Impacted Soil and Groundwater			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	Minor	Moderate ⁸	Minor	Minor
Event Likelihood	Moderate			
Overall Risk Rating	Moderate risk: management attention and integration into management plans required			

⁸ Looking at change in impact due to development not current situation

Hazard:	Exposure to Hydrocarbon Impacted Soil and Groundwater
Potential Management Controls	<p>All visually impacted or odorous material must be returned to the point at which it was originally intersected. These soils should not be allowed to contaminate surface soils. If unable to return to excavations, off site disposal will need to be arranged.</p> <p>All structures and slab surface coverings will require vapour barriers to ensure hydrocarbon vapours don't build up and infiltrate through surfaces.</p> <p>Installation of diffusion barriers (such as gravel layers) may be deemed necessary to allow the vapours to escape from the enclosed areas.</p> <p>Groundwater requiring pumping from the excavation areas will require testing and potentially treatment prior to disposal to the marine environment.</p> <p>Dermal contact with hydrocarbon impact in both soil and groundwater should be minimised with the appropriate personal protection equipment (PPE).</p>
Further Recommendations	In part this risk will be addressed through the site RAP and SMP. In addition the developers will be required to manage these potential risks.

Hazard:	Exposure to Hydrocarbon Impacted Vapours ⁹			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Major	NA	NA	NA
Event Likelihood	Rare			
Overall Risk Rating	High: senior management attention needed			
Potential Management Controls	<p>All visually impacted or odorous material must be returned to the point at which it was originally intersected. These soils should not be allowed to contaminate surface soils. If unable to return to excavations, off site disposal will need to be arranged.</p> <p>All structures and slab surface coverings will require vapour barriers to ensure hydrocarbon vapours don't build up and infiltrate through surfaces.</p> <p>Installation of diffusion barriers (such as gravel layers) may be deemed necessary to allow the vapours to escape from the enclosed areas.</p> <p>Groundwater requiring pumping from the excavation areas will require testing and potentially treatment prior to disposal to the marine environment.</p> <p>Dermal contact with hydrocarbon impact in both soil and groundwater should be minimised with the appropriate PPE.</p>			
Further Recommendations	In part this risk will be addressed through the Remediation Action Plan (RAP) and Site Management Plan SMP			

⁹ Vapours in low lying areas and underground structures likely to be considered as confined spaces

7.2.6 Unexploded Ordnance (UXO)

G-tek Australia Pty Ltd (G-tek) was commissioned by URS to conduct a historical review of the development area and a site investigation. The results of their investigations were presented in the report title “G-tek Australia Waterfront Redevelopment Darwin, Northern Territory – Initial Report” (**Appendix R**). The following is a summary of the G-tek report.

The development area was heavily bombed during World War II bombing raids. 64 bombing raids were recorded between 19 February 1942 and 12 November 1943, of which 28 are known to have been centred on the Darwin area.

Based on the estimated failure rates of the EO of the era (5-10%) there is the potential for 80 to 160 UXO to remain in the development area. There is also the potential for Allied UXO in the area due to damaged ships and losses during loading and unloading of ordnance. Salvage works conducted after the War were also thought to have brought UXO onto land and disposal practices were not controlled, with reports of find, by members of the public at low tide to the south of the Fort Hill Area.

From the results of the initial assessment works G-tek made the following conclusions:

- There is a potential for remnant Japanese UXO within the Waterfront Redevelopment Site.
- There is potential for remnant Allied EO and UXO within the site.
- A high potential for remnant UXO exists in areas of land that remain basically unchanged from their 1942-1943 form.
- A high potential for remnant UXO exists in the harbour mud areas, including within those areas that remain unchanged since 1942-1943 and under the areas of subsequent fill
- A potential exists for remnant UXO within the fill material from soil excavations subsequent to 1942-1943, including material from Fort Hill and ‘Darwin Town’.
- A high potential for remnant Allied EO exists in the harbour mud areas, including within those areas that remain unchanged since 1942-1943 and under areas of subsequent fill.

There is a greater potential for UXO to be present in the soft marine mud sediments that existed at the time of the bombing raids. The majority of these areas have now been reclaimed with thick layers of miscellaneous fill materials which were deposited on top of the natural marine sediments. The probability of UXO remaining on the land surfaces that existed at the time would be reduced due to the solid nature of the earthen material (largely bedrock materials) and the removal of large amounts of these areas (Fort and Stokes Hills).

Due to the depth of fill at the site the probability that UXO will be intersected during excavation works is considered low. There is a greater chance of intersection during piling works which will require piles to be driven through the fill and marine materials to the bedrock. The potential for widespread dredging in Kitchener Bay will also have a high potential for UXO intersection.

Due to the marine environment at the development area there is a high potential that the firing pins in the UXO will have corroded away making them very unlikely to explode upon intersection. However, all UXO should be treated as live until proven otherwise. Qualified UXO disposal technicians should be contacted immediately and all works in the area ceased on the discovery of UXO.

Hazard:	Explosions from Unexploded Ordnance			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Critical	Critical	NA	NA	Major
Event Likelihood	Rare			
Overall Risk Rating	High: senior management attention needed			
Potential Management Controls	<p>Qualified UXO Technicians to investigate work areas to minimise chance of intersection.</p> <p>All persons working on site shall be trained and educated of the dangers of UXO, their potential locations and identification features.</p> <p>Consideration to be given to the need for blast resistant excavation materials and an appropriate exclusion zone developed.</p> <p>Care taken in sub surface works to allow for visual inspection of work area and spoil material for UXO</p> <p>Have procedures in place and contact people alerted in case of intersection.</p> <p>In the advent that UXO is discovered work shall be stopped and impact area sealed off.</p>			
Further Recommendations	UXO management plan to be developed and incorporated into the relevant site works management plans.			

7.2.7 Asbestos

Historical information suggests that there has been disposal of asbestos material within the fill material disposed at the site. This would mainly comprise building materials such as asbestos sheeting, however, there is also potential for fibrous asbestos lagging to have been disposed of in the area. Widespread soil excavation conducted during site investigations has not intersected significant asbestos impact at the site. Asbestos is still deemed to be a contaminant of concern and there needs to be awareness of the potential for exposure to buried asbestos materials.

In the advent potential asbestos containing material is intersected, appropriate containment and disposal procedures should be in place. All handling should be by appropriately qualified contractors and all works should comply with the relevant standards.

Hazard:	Exposure to Airborne Asbestos Fibres			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Major	NA	NA	Minor
Event Likelihood	Unlikely			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	<p>Areas where specific knowledge exists of asbestos disposal will be made known to all relevant site workers.</p> <p>Procedures will be required to be set out prior to commencement of excavation works to deal with the handling and disposal of asbestos materials if intersected.</p>			
Further Recommendations	An asbestos management plan needs prepared in case asbestos fibres are encountered during excavation works.			

7.2.8 Cyclones and Storm Surge

Tropical cyclones are low pressure systems in the tropics that, in the Southern Hemisphere, have well defined clockwise wind circulations with a region surrounding the centre with gale force winds, defined as sustained winds of 63 km/h or greater with gusts in excess of 90 km/h.

Tropical Cyclones produce destructive winds, heavy rainfall with flooding and damaging storm surges that can cause inundation of low-lying coastal areas. Cyclone wind gusts can be very destructive and can cause extensive property damage and turn airborne debris dangerous missiles. Heavy rainfall associated with the passage of a tropical cyclone can produce extensive flooding, which can cause property damage and death by drowning.

The destructive winds accompanying tropical cyclones also produce phenomenal seas, would be dangerous to vessels moored in the Redevelopment harbour areas. These seas can also cause erosion of foreshores.

The Redevelopment area is to be built up in required areas to account for the potential for storm surge. The site will be developed so the floor level of buildings which would be susceptible to storm surge flooding will be above 6.5 m Australian Height Datum (AHD). This is the level required to account for a 1000 year Average Recurrence Interval (ARI) storm surge, including a 0.3 m allowance for rise in sea level associated with long term global warming. Areas where buildings are not to be situated will either be designed to not flood during a 100 year ARI storm surge event, requiring a level of 5.1 m AHD; or to be safely inundated and recover after the event.

The development is not expected to be adversely affected by flooding from storm water runoff as the upper catchment are of Darwin is considered small. It is envisaged that the drainage infrastructure in the

Redevelopment area will sufficiently cope with runoff from heavy rainfall events up to a 100 year ARI event.

Storm conditions will also result in impacts to the development from wave motion. These wave impacts will need to be modelled prior to the design to avoid damage to sea wall and coastal protection structures and buildings. Design should be carried out to appropriate standards for tropical cyclone conditions. Typical standards include those provided by the *Coastal Engineering Manual*, produced by the U.S. Army Corps of Engineers

Hazard:	Flooding/Storm Surge/Wave Impacts ¹⁰			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Major	NA	Moderate	NA
Event Likelihood	Unlikely			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	<p>Buildings to be built to specified height datum (minimum 6.5 m AHD) to account for a 1000 year ARI storm surge event.</p> <p>Open areas to be built to a level of 5.1 m AHD to ensure no flooding from a 100 year ARI storm surge event.</p> <p>Development to have sufficient drainage infrastructure to account for heavy rains from a 100 year ARI event.</p> <p>Buildings and foreshore areas will be built to cyclone code standards to protect against winds and storm surge</p> <p>NT Government cyclone emergency procedures will be implemented</p> <p>Design sea wall structures to withstand tropical cyclone wave impacts – reference <i>Coastal Engineering Manual</i>, produced by the U.S. Army Corps of Engineers</p>			
Further Recommendations	None			

7.2.9 Tsunami/Earthquake

Northern Coast of Australia is proximal to an area of significant earthquake and volcano risk in Indonesia. Significant earthquakes or volcanos have the potential to generate tsunamis, which have the potential to impact of the north coast of Australia.

¹⁰ Scenario assumes 100 year ARI and loss of life through drowning

Hazard:	Tsunami/Earthquake			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Critical	Critical	NA	Critical	NA
Event Likelihood	Rare			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	<p>Buildings to be built to specified height datum (minimum 6.5 m AHD) to account for a 1000 year ARI storm surge event.</p> <p>Open areas to be built to a level of 5.1 m AHD to ensure no flooding from a 100 year ARI storm surge event.</p> <p>Development to have sufficient drainage infrastructure to account for heavy rains from a 100 year ARI event.</p> <p>Buildings and foreshore areas will be built to code standards to protect against storm surge</p>			
Further Recommendations	Further assessment of the likelihood and potential consequence of Tsunami.			

7.2.10 Terrorist Attacks

Terrorist attack could have significant consequences for human life, the economy and the marine environment if a terrorist threat to the Darwin Waterfront Redevelopment was to be realised.

The Darwin Waterfront Redevelopment when fully operational will offer a number of potential terrorist targets, including:

- Royal Australian Navy (RAN) and foreign warships;
- RAN fuel storage facilities and bunkering and refuelling infrastructure;
- Cruise ships;
- RAN and commercial fuel tankers;
- Commercial shipping; and
- The conference and exhibition centre, commercial and residential land use in the waterfront area.

Each of these targets will have individual security risks. There is also the combined risks associated with a number of these targets being in the Waterfront area simultaneously.

The Australian Government has developed legislation that will tighten port and maritime security to protect Australia from the threat of terrorism. This legislation was introduced into Parliament on 18 September 2003 as the Maritime Transport Security Bill 2003.

The new legislation will give effect to the Australian implementation and interpretation of the International Ship and Port Facility Security (ISPS) Code, which was developed by the International Maritime Organization (IMO) to address maritime security around the world.

The ISPS Code will bring about important changes in the global maritime industry, creating an industry-wide focus on preventive security measures and procedures. Compliance with the ISPS Code will help to protect Australians from the threat of terrorism and ensure continued access to international markets for Australian goods and services.

The Department of Transport and Regional Services (DOTARS) will be the maritime security regulator responsible for implementation of the ISPS Code.

Port authorities will fulfil a coordinating role, and they will be responsible for the establishment of local port security committees. Port authorities will be required to conduct security risk assessments and produce port security plans (PSP) which DOTARS will approve if they meet the requirements of the proposed legislation. The PSP will cover such matters as exclusion zones, access control arrangements, communication procedures and port-wide responses to specific security levels.

Hazard:	Explosion and Facility Damage from Terrorist threats from Port Operations			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Critical	Critical	Major	Major	Major
Event Likelihood	Rare ¹¹			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	<p>Under the requirements of the ISPS Code developed by the IMO, port operators will be required to be responsible for the establishment of local port security committees. Port operators will also be required to conduct security risk assessments and produce PSP which will need to be approved by the DOTARS.</p> <p>A PSP developed for the Darwin Waterfront will cover such matters as exclusion zones, access control arrangements, communication procedures and port-wide responses to specific security levels</p>			
Further Recommendations	This is a matter for State and Federal governments and security agencies to manage future risk.			

7.2.11 Snakes and Spiders

Whilst faunal surveys have not identified any species of venomous snakes or spiders in the Redevelopment Area, they could reasonably be expected to be present in the area at certain times of the year.

¹¹ For a successful major attack at the Darwin Waterfront

Hazard:	Snake or Spider Bite			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Moderate	Moderate	NA	NA	NA
Event Likelihood	Unlikely			
Overall Risk Rating	Moderate risk: management attention and integration into management plans required			
Potential Management Controls	<p>Public awareness of potential for venomous snakes and spiders in the area.</p> <p>Avoid handling of snakes or Spiders and limit interaction of any kind.</p> <p>Emergency procedures for snakes and spiders to include notification and removal by Conservation and Natural Resources Management Branch of Department of Infrastructure and Environment.</p> <p>Site health and safety procedures to include response to venomous bites.</p>			
Further Recommendations	None			

7.2.12 Crocodiles

Saltwater Crocodiles have been known to traverse the area on an infrequent basis. There have been no reports of resident crocodiles inhabiting the area. Crocodile attacks may cause serious injury or even death.

Hazard:	Crocodile Attacks			
Highest Consequence	Injury and Disease	Environmental Effects	Total Cost Impact	Community
Major	Major	NA	NA	NA
Event Likelihood	Rare			
Overall Risk Rating	High risk: senior management attention needed			
Potential Management Controls	<p>Public awareness of potential for crocodiles in the area.</p> <p>Integration with the reporting trapping and removal program administered by Conservation and Natural Resources Management Branch of Department of Infrastructure and Environment.</p>			
Further Recommendations	None			

8.1 Introduction

This section describes the general measures needed to prevent, minimise and mitigate environmental impacts from the Redevelopment, and the likely requirements of the various management and contingency plans.

All issues related to site contamination are dealt with in Section 8.2. This includes site contamination mitigation measures to address soil, groundwater, surface water, terrestrial and marine biota impacts and risks to human health.

8.2 Site Contamination

8.2.1 Introduction

As noted in Section 6.2.1, the assessment of site contamination, the necessary remediation of the site and the ongoing management of any residual contamination deemed acceptable by the government regulators and the Victorian EPA Contaminated Land Auditor are subject to separate and rigorous review and approval procedures. The outcomes of the audited Contaminated Site Assessment and subsequent remediation will define the management and mitigation measures required for the site. The inter-relationship between the environmental assessment process and the contamination assessment process are shown in Figure 8.1

This section provides preliminary information about the remediation activities for soil and groundwater that are proposed. The details of remediation will be clarified as:

- further information about contamination at the site is obtained, particularly from the preliminary demolition activities to be undertaken to clear the central 9.2 ha section in preparation for remediation; and
- the requirements of the Auditor and necessary remediation actions are finalised and confirmed.

This section also outlines the assessment, planning and documentation undertaken to ensure on-site contamination is managed appropriately during any on-site activities. The following documents have been prepared, or are in draft form, to provide adequate guidelines to ensure this is achieved. These documents are independent of, but linked to, the Draft EIS.

- The Pre-remediation Site Works Environmental Management Plan (EMP) will define requirements and operational standards to be adhered to during the initial demolition works. This plan is supported by an Occupational Health and Safety Plan for the pre-remediation site works which aims to protect site workers from possible exposure to contamination.
- The Remediation Action Plan (RAP) is currently in draft form. When finalised, it will define the actions that will be necessary to remediate the site to the necessary extent. The RAP will be finalised

once the Auditor is satisfied that remediation objectives have been clearly defined and that the proposed remediation methodologies will meet the objectives for cleanup of the site.

- The Site Management Plan (SMP) will define the on-going requirements for managing residual contamination at the site following remediation. Some contaminated material may be left on-site if it is shown to be stable and ecological and health and safety risks are at acceptable levels.

The areas noted in the following discussion have been defined in Section 5.2.

8.2.2 Staging of Remediation

The NT Government has agreed to remediate an area of 9.2 ha in the centre of the project site as one of the first site activities likely in the 2004 Dry season. This will have immediate short-term environmental benefits. Remediation of the remainder of the site will be the responsibility of the future developer(s), and must be carried out to the standards defined in the RAP.

8.2.3 Soil Remediation

Metal Ore Materials

The high levels of metals in the mixed ore are considered likely to require remediation. Preliminary meetings with DIPE and the Auditor indicate that the likely remediation for areas affected by metal ore materials will be to remove all identified ore contamination. Present remediation planning calls for validation that remediation has removed metal contaminants in these areas to below any assessment threshold levels in the health-based national standards (the National Environment Protection Measure for Contaminated Sites). Removal of all iron ore concentrate prior to redevelopment of the site is a likely remediation requirement.

General Fill

The site includes several randomly distributed sample locations where exceedances of health-based assessment thresholds for specific metals were found to be present in reclaimed areas. This appears to be due to the heterogenous nature of the fill material used during reclamation. These sample results indicate that contamination is not present in masses of bulk concentrations and therefore do not warrant remediation. Instead, management controls will be required for future developments to ensure that potentially contaminated soils do not impact the environment as either fugitive dust emissions or stormwater sediment. Further, areas to be landscaped or grassed are to be appropriately covered with clean imported topsoil to ensure protection from exposure and ensure desired plant growth.

Petroleum Hydrocarbons**Hydrocarbon Source Remediation**

Regulatory authorities generally require the removal of ongoing sources of pollution. Site investigations have not conclusively identified point sources of hydrocarbon contamination though diffuse widespread contamination is evident. Hydrocarbon contamination sources may be present in or adjacent to the site with potential impacts on soils and groundwater and investigations are continuing. Common point sources of contamination resulting in “hot spots” of soil impact and potential plumes of groundwater contamination include above ground storage tanks (ASTs), underground storage tanks (USTs), major surface spills, and leaks from subsurface infrastructure such as pits and pipelines.

Upon concurrence of the Auditor, approval from the proponent and Northern Territory Government regulators, it may be possible to allow contamination within the smear zone to remain in place. However, monitoring of contamination levels will be required to ensure that contamination concentrations are at a steady-state or declining. A contingency plan will also be necessary, should hydrocarbon contamination levels increase above presently assessed concentrations. This planned contingency is likely to involve the construction of an enclosed interception drain that will collect contaminated groundwater. This collection drain will be placed down-gradient from areas where increased concentrations of contaminants are found at monitoring locations. The design, size and depth of the intercept drainage trench will be dependent upon site conditions but is likely to require to be approximately 4 m wide and the length of up-gradient areas where hydrocarbon is deemed to be present. Areas adjacent to hydrocarbon sources will require to remain undeveloped to allow future trench construction, should the contingency action be required.

Management of Volatile Petroleum Hydrocarbons

Noting that hydrocarbons are likely to remain on-site, there is a requirement to ensure that accumulation of vapours and odours does not pose an unacceptable risk. Developers will be required to implement suitable odour and vapour protection measures.

Areas of potential odour/vapour accumulation may include:

- under buildings with basements;
- under slabs and foundations; and
- within service utility trenches and pits.

Minimum vapour protection requirements will include sealing potentially impacted structures with suitable vapour barriers (e.g. sealed HDPE or similar impermeable material systems) and tanked basements. Utility trenches shall be required to be designed to minimise the potential for the accumulation of vapours by the elimination of void spaces where possible.

There is potential for vapours to accumulate beneath buildings and migrate through the buildings and/or to discharge at the ground surface around the perimeters of constructed buildings (even with synthetic

vapour barriers). To prevent this occurring an external ventilation system may need to be included in building design. This system could be passive or active and include forced ventilation.

The developer will be required to confirm vapour exhaust design requirements. A vapour/odour ventilation system is likely to include a layer of highly permeable material such as 300 mm of gravel underlying the vapour barrier (synthetic impermeable liner) and a collection system such as perforated pipes to collect and discharge accumulating vapours. It may be preferable to include a curtain barrier around the perimeter of buildings to prevent the discharge of vapours at the surface around the perimeter of the building. This could consist of a paved surface underlain by the liner. The vapour collection system could discharge to ventilation pipes incorporated into the building design.

Note that the finalised SMP will contain minimum construction standards for the design of vapour barriers.

Excavation of Disused Infrastructure, Building Foundations and Piping

Any future excavations that encounter infrastructure, building foundations, and debris may intersect contamination associated with these features. If during the Redevelopment these features are unearthed and obvious contamination (e.g. liquid hydrocarbon wastes) are encountered, appropriate environmental management and site management controls will be required. Significant concentrations of contamination, if present, would require appropriate reporting in accordance with relevant NT contamination guidelines.

Stokes Hill Storage Tanks

DIPE has advised that they are in the process of scheduling the removal of residual product containing waste oil materials from tanks 13 and 14 located on Stokes Hill. Once hydrocarbon products are removed, the tanks can be demolished. Shallow soils underlying the tanks have been assessed to be contaminated with petroleum hydrocarbons. The final RAP is likely to require these soils to be excavated down to the level of the underlying rock. Hydrocarbon impact may remain within fractured rock at the completion of remediation.

Current data do not indicate that remediation of the chlorinated hydrocarbon contamination, detected in the Stokes Hill Power Station area, will be required. Further assessment is necessary to confirm that it does not impact on the use of the land or the marine environment. Should further investigation reveal significant risks associated with this contamination, then additional remedial actions and/or site management controls will be recommended.

Remediation of the Shell Bitumen Plant

Investigations indicate on and off site hydrocarbon impacts associated with the bitumen plant. DIPE has advised that Shell will be responsible for addressing contamination. It is understood that Shell commitments include remediation of contamination immediately following demolition of the plant. It is expected that Shell will remove all source material by excavation and removal of contamination from the site. DIPE has advised that they will require site remediation to be appropriately validated by an environmental auditor to meet clean up standards consistent with the redeveloped site.

DIPE anticipates requiring a statement of environmental audit from a Victorian EPA accredited auditor to confirm the site has been remediated to the appropriate standards for either high-density residential or public open space uses, and that no special conditions or limitations to use of the site will be imposed which are inconsistent with other areas of the site.

8.2.4 Groundwater Remediation

Hydrocarbon Impacted Groundwater

High tidal flushing of the groundwater discharge zone along the shoreline is considered to have a mixing capacity such that the level of dilution limits risks associated with hydrocarbon impacted groundwater discharge to the marine environment. A review of the assessment information, and potentially an ecological risk assessment, are required to finalise remediation requirements (if any) that would address unacceptable risks associated with groundwater entering the marine environment. It is currently anticipated that no remediation will be required, however monitoring and contingency management will be required. Treatment of dewatered groundwater will be required during construction before discharge to the marine environment.

Petroleum Hydrocarbons Impact on Marine Environment

If there is a marina proposed for the site, then the developer must provide an engineered program that satisfies the provisions of the *Waste Management and Pollution Control Act* and the *Water Act* and ensures that there is no hydrocarbon sheen in waters exiting marine structures. An assessment of the need for a barrier to prevent hydrocarbons in the groundwater migrating into the marina (e.g. underflow liner) will be required. If it is confirmed that there is no sheen in discharge, then there will be no requirement for a hydrocarbon barrier along the shoreline, but this would need to be coupled with ongoing program of inspection and a contingency planning.

Where development plans may significantly change the groundwater flow regime at the site, advice from specialists with hydrogeology and aquatic toxicology expertise should be obtained to confirm that modification to groundwater flow from specific development features and activities will not have an adverse impact on the marine environment. Compliance with the *Waste Management Control Act* and *Water Act* may be required, with the ultimate aim of ensuring changes to the flow regime do not increase the discharge of contaminants into the marine environment.

8.2.5 Contaminated Marine Sediment

A detailed Dredging Management Plan (DMP) for minimising the impacts from dredging works will be required if dredging is expected. The proposed contents of the DMP are described in Section 8.3.4.

With respect to contamination issues associated with dredging the marine sediments, the DMP will include:

-
- a detailed dredging strategy for the works that will prevent if possible, or minimise the amount of dredging around locations that are known to have metal and organic contamination and may include:
 - the west of Kitchener Bay;
 - the western end of the Wharf Precinct;
 - behind the Iron Ore Wharf and Navy refuelling facility;
 - adjacent the old power station cooling water outfall;
 - behind Fort Hill Wharf and off the face of Fort Hill Wharf;
 - methodologies that will minimise disturbance of the contaminated sediments identified including undertaking dredging operations in a manner that minimises the suspension and creation of turbid plumes of marine sediments around the locations above; and
 - suitable strategies, methodologies and sites for disposal of contaminated sediments that are required to be dredged for the development, including:
 - performance targets, monitoring and sampling programs;
 - actions if these performance targets are not met; and
 - contingency plans for unexpected events or procedure failures at both the dredging and disposal sites.

The DMP should be reviewed, audited and updated throughout the duration of the dredging to reflect knowledge gained during the dredging works. Any changes should be developed and implemented in consultation with relevant authorities. Dredging is dealt with in detail in Section 8.3.4

8.2.6 Acid Sulphate Soils and Contamination

The presence of ASS materials, and their potential to mobilise some contaminants if exposed to air, will be addressed in the RAP and SMP. Development works that may require excavation or dewatering of ASS or PASS will require a management strategy that shall include appropriate:

- storage and/or treatment of excavated ASS or PASS materials on site;
- disposal of PASS materials if not treated on site; and
- dewatering operations to minimise the exposure of in situ PASS materials.

Acid Sulfate Soil Management Plan

A detailed acid sulfate soil management plan (ASSMP) for minimising the impacts from the site works may need to be developed. The ASSMP is expected to include:

-
- methods of preventing the oxidation of iron sulfides, and in some cases avoidance of ASS;
 - treatment requirements for the ASS, which may include soil neutralisation with lime, use of barriers (lime or limestone) or reburial.
 - detailed earthworks, dewatering and stockpile strategy for the works. This should include estimates of volume and risk assessment for these activities during the works;
 - strategies may need to be developed for water table management both onsite and off site, during construction of the development and during operation of the development, including performance targets, monitoring and sampling programs, actions if these performance targets are not met and contingency plans for unexpected events or procedure failures.

The ASSMP should be able to be reviewed, audited and updated throughout the duration of the development to reflect knowledge gained during the development works. Any changes should be developed and implemented in consultation with relevant authorities.

Dewatering

If large-scale dewatering or excavation operations are proposed, a field trial could be conducted to test proposed management procedures, particularly the treatment of extracted groundwater during dewatering and the blending of lime, if this is anticipated to be required.

Excavation and Stockpiling

Stockpiling of excavated and untreated ASS should be minimised. The risks of stockpiling large volumes of ASS may be very high even over the short-term. Examples of short-term activities that may result in stockpiles include:

- part of day excavations being stockpiled over weekend before strategic reburial;
- weather slowing treatment;
- delays in obtaining laboratory test results; and
- insufficient space in treatment areas.

Details of recommended stockpile management (WADoE, 2003) are presented in **Tables 8.1** and **8.2**.

Short-term Stockpiles

Hot environments such as Darwin may result in soils and sediments being oxidised within a matter of hours and delay times should be determined prior to the stockpiling of this material.

Medium-term Stockpiles

Situations that require the stockpiling of untreated ASS soils for moderate periods of time should be avoided, where possible. Such activities are more likely to be conducted as a contingency and not standard practice. Guard layers of limestone, minimising exposed surface area, bunding, wetting, leachate collection and sediment control systems are typically required. If the risks associated with stockpiling cannot be demonstrated to be minimal then neutralisation treatment may be required.

Long-term Stockpiles

Long-term stockpiling, is not considered an appropriate management strategy for ASS soils.

Table 8.1: Indicative Maximum Period for Short-term Stockpiling of ASS.

Type of Material		Duration of Stockpiling	
Texture Range (McDonald et al (1990))	Approximate clay content (%)	Days	Hours
Coarse Texture Sands to loamy sand	≤5	Overnight	18
Medium Texture Sandy loams and light clays	5-40	2 ½	70
Fine Texture Medium to heavy clays and silty clays	≥ 40	2 ½	70

Table 8.2: Maximum Periods for Medium Term Stockpiling of untreated ASS soils

Type of Material		Duration of Stockpiling	
Texture Range (McDonald et. al. (1990))	Approximate clay content (%)	Days	Weeks
Coarse Texture Sands to loamy sand	≤5	14	2
Medium Texture Sandy loams and light clays	5-40	21	3
Fine Texture Medium to heavy clays and silty clays	≥ 40	228	4

8.2.7 Disposal of Contaminated Material

Disposal of contaminated material may take three forms:

- on-site disposal if this can be shown to adequately contain the material;
- disposal to a secure landfill; or
- disposal of dredged material at sea if the material is suitable and the disposal site and technique can contain it.

The selection of these options will depend on:

- the nature of the material (including its acid generating capacity);
- the type and level of contamination; and
- the suitability of the disposal method to contain the contaminated material and prevent any dispersion.

Selection of disposal facilities for contaminated terrestrial soils and contaminated marine sediments that are to be removed from the site will be undertaken through standard Northern Territory Government approvals processes and under the requirements of the *Waste Management and Pollution Control Act* and the Darwin Harbour Dredging Technical Advisory Committee.

8.2.8 Management Controls Addressing Contamination Handling Practices

Upon completion of contamination assessment investigations, a remedial program will be finalised which will include an initial cleanup of contaminants, and modifications to otherwise standard construction operations to account for planned residual contamination. Initial cleanup measures will be detailed in the RAP, while management controls required for future construction and intrusive maintenance operations will be addressed in the SMP. While some of the measures for remediation and site management will rely on isolation of contaminants, excavation and dewatering will generate contaminated wastes that will require special handling procedures.

8.2.9 Overview of the Contamination Management Plans

Contamination at the project site will be managed through a series of documents targeting the various stages of the Redevelopment.

- The Pre-remediation Site Works Environmental Management Plan has been prepared to ensure that initial site works undertaken prior to remediation are carried out in a manner that does not expose workers or the public to contaminants, or allow contamination to be mobilised. These works will provide additional information to assist in clarification of the contamination at specific areas of the

site. Contaminated material discovered pre-remediation site works will be either left in situ or stored in the “Boo Shed” to be taken care of during the remediation process.

- The Remedial Action Plan (RAP) will outline the remediation activities to be undertaken to ensure the site is safe for redevelopment and the ongoing future land uses. The RAP will meet the requirements of the Victorian EPA Contaminated Land Auditor.
- The Construction Environmental Management Plan (CEMP) will cover a range of issues and measures to prevent or minimise environmental impacts from construction activities. These will include measures to ensure workers and the public are not exposed to contaminants and to prevent mobilisation of contaminants. A framework for the CEMP has been prepared and is presented in **Appendix T**. Finalisation of the CEMP by the eventual developer of the site will be subject to the Northern Territory Government approvals process.
- The Site Management Plan (SMP) will define the management required to deal with any residual contamination at the site following remediation. Remediation of the site is likely to leave some contaminants on site if they are compatible with future land uses and do not pose a public health or environmental threat. This will necessitate appropriate measures to ensure they are not disturbed or mobilised by any future activities.

8.2.10 Remediation Action Plan

The RAP is required to form the basis of remediation that will allow future development of the site. RAPs are designed to reduce site contamination in order to minimise health risks and negative impacts to the ecological environment. The RAP may include cleanup, removal, containment, isolation or treatment of hazardous substances released or threatened to be released into the environment from a site.

The RAP for the site will be developed concurrently with the progression of final stages of the Contaminated Site Assessment. The RAP will summarise contamination issues found within the specific areas of the site, which are detailed in the Phase 1, 2 and 3 soil and groundwater investigations. The finalised RAP will identify the extent of contamination requiring remediation or mitigating management controls.

The final RAP will comprise the following sections.

- summary of the objectives of the RAP;
- site characterisation;
- assessment of remediation requirements and proposed land uses;
- evaluation of potential risks;
- identification of proposed remedial strategies;

-
- Construction Environmental Management Plan; and
 - preferred remedial strategies.

Remediation options will address appropriate methodologies to protect human health and the environment for agreed land uses such as:

- residential (medium to high density) – generally hardstand area with limited access to soil (and potential underground car parking);
- public open space – generally grassed area;
- commercial – comprising small businesses such as cafés and restaurants; and
- convention centre – large-scale development with underground car parking.

For each of these land use scenarios, different remediation objectives are required to address the potential developments that may be otherwise impacted by contaminants. An important objective of the RAP will be to determine the pathways for contaminants to impact human health or the environment. This will be highly dependent upon the final development of the land, the types of contaminants found within the area of the designated land use, and the toxicity, concentration, and fate and transport mechanisms associated with the contaminant(s).

8.2.11 Construction Environmental Management Plan

Waste handling and monitoring requirements for remedial activities will also be addressed in a CEMP, which will comprise details of how to control potential issues that may be encountered during construction works. It is expected that the CEMP will be developed in a format suitable for the nominated remediation contractors to cross reference in the preparation of their own EMP or work method statements.

The following list gives examples of potential issues to be included in the CEMP:

- site stormwater;
- soil;
- noise;
- air quality;
- vibration;
- dust;

-
- traffic; and
 - odour.

8.2.12 Site Management Plan

The SMP will govern the requirements for incorporating design requirements into construction development and landscaping plans to ensure that residual contaminants do not pose an unacceptable risk to human health or the environment. Additionally, the SMP will address environmental management and waste handling requirements for any ongoing and future intrusive maintenance or construction works that could compromise any implemented remediation or mitigation measures.

Waste handling and environmental control procedures will be addressed in the SMP, which will impose requirements for developers, contractors, maintenance workers and homeowners to abide by after initial site remediation. The SMP will address issues such as:

- excavation below protective encapsulating materials into contaminated soils;
- handling, treatment, and disposal of contaminated soil;
- handling, treatment, and disposal of contaminated groundwaters (e.g. from dewatering operations associated with construction); and
- containment, treatment and disposal of contaminated stormwater resulting from construction operations within contaminated zones.

8.3 Physical Environment

8.3.1 Soils

Site Preparation and Excavation

The potential effects resulting from site preparation and excavation activities will be minimised and managed with the following measures.

Soil Erosion and Sedimentation

- Activities will be restricted to the Dry season. Drains will be designed and constructed to produce non-scour velocities and to avoid erosion at inlet and outlet points. An Erosion and Sedimentation Control Plan (ESCP) will be produced to minimise soil erosion and sedimentation as part of the EMP.

Dust

- Water trucks will be used to suppress excessive dust generation.

Acid Sulfate Soils

- The disturbance of ASS and PASS will be minimised wherever possible. An Acid Sulfate Soil Management Plan and monitoring programme will be developed should ASS and PASS materials need to be disturbed. This will be determined once the Master Plan for the Redevelopment has been finalised.

Debris from Existing Fill Material

- Debris from existing fill material and buried structures that may be generated by or exposed during site preparation will be disposed at appropriate waste disposal facilities.

Problematic Subsurface Conditions

- Wherever possible, buildings will be located on areas with subsurface conditions that suit the load of the structures. Appropriate geotechnical assessment and engineering design will be undertaken for any buildings that are located on areas of poor geotechnical capability or that span areas of different subsurface characteristics.

Construction

The main potential effects resulting from construction activities can be managed as follows.

Construction Waste Generation and Management

- Waste management and disposal will be carried out in accordance with the *Waste Management and Pollution Control Act*.

Release of Contaminants from Dewatering

- A detailed dewatering plan will be prepared to ensure that the impact of dewatering activities is minimised. The plan and subsequent operations will pay particular attention to the disposal of the return water and monitoring of the return water quality.

Land Reclamation

Land reclamation will include the transport and placement of clean imported rock and fill material and the potential placement of dredge spoil material from Kitchener Bay. During dewatering, water could be released to groundwater or the marine environment. Management of this waste will require the use of impermeable barriers to prevent the release of contaminants.

There is potential for the generation of acid if ASS materials are incorporated with materials used for reclamation. These will therefore require neutralisation, including possible buffering with seawater.

There is potential for contamination of groundwater and stormwater of adjacent land, which could result in discharges of contaminants to the marine environment. Measures to minimise this are part of the RAP and include erosion control and stormwater diversion.

Excess clean imported rock and fill material could be a potential waste, however as this material will be obtained or purchased off site and has direct cost implications it is not anticipated that this activity will generate significant waste.

Mud waving, as a method of reclamation, is not expected to be used.

Erosion and Sedimentation Control Plan

Objectives

The objective of the Erosion and Sedimentation Control Plan is to manage on-site erosion and drainage and release of stormwater from the development area during construction so that there is no adverse impact on the quality of water in Darwin Harbour.

Implementation

Erosion will be managed on-site, during all stages of construction throughout the development area, using the following principles:

- protection of bare soil, slopes, topsoil stockpiles and stream lines from erosion by employing soil conservation techniques;
- management of stormwater flows to prevent erosion;
- use of temporary sediment traps and settling areas to trap sediment; and
- use of a monitoring and management plan to ensure water released to Darwin Harbour is of acceptable quality.

The following soil conservation techniques will be used.

- Activities that may cause erosion or increased turbidity will be undertaken during dry periods, and particularly during the Dry season. As far as possible, most disturbance will be undertaken during the Dry season and works put in place to manage erosion from the disturbed areas before the onset of the Wet season.
- The area of cleared and/or disturbed land that is susceptible to erosion will be minimised at any one time.

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- All efforts will be made to minimise constructed land slopes and/or retain or add surface cover on disturbed land and excavations susceptible to erosion. Cover will take the form of temporary or permanent annual or perennial grasses, shrubs or trees as appropriate or the use of hydro-mulch or other artificial surface covers.
 - Temporary silt traps and filters will be used. These may include graded channels, hay bales or shade cloth barriers and sediment traps.
 - Where possible works will be carried out in series (i.e. a treatment-train approach).
 - Temporary soil stockpiles will be stabilised with vegetation or artificial cover, and by:
 - reducing batter slopes;
 - reducing slope length using across-slope drains; or
 - reducing the stockpile size.

Stockpiles will not be located close to surface drains. Silt traps and filters will be installed as required at the base of stockpiles.

- Temporary roadways and traffic areas will be constructed to shed water to a constructed drainage system with appropriate treatment of water to maintain sediment loads at suitable levels for discharge to the harbour.

Silt traps will be sized to have sufficient capacity to retain runoff from a 30-minute, 10-year ARI event for 1 hour. Bunds and channels associated with the traps will be stabilised with grass or artificial cover. The traps will drain completely between rainfall events. Silt traps will be monitored and maintained as required to ensure they remain in operational condition.

The layout, design and specification of sediment control measures (including drains, silt traps, cross-flow banks, batter slopes, surface protective measures and topsoil stockpiling) will be determined following the finalisation of the Master Plan and construction timing and arrangements for specific elements of the Redevelopment. Similarly, estimation of the peak discharge flows and frequencies will be made once construction planning has defined the construction drainage system layout.

Monitoring

Monitoring will involve characterising erosion and surface water turbidity throughout the site during construction or at times when an erosion risk is present (Section 6.3.2). Should the monitoring indicate sediment levels greater than a threshold value, action will be taken to locate the source of the contamination, determine if the level is high enough or could become high enough to impact on the receiving environment, and determine what, if any, rectification action is required. If rectification actions are needed, these measures will be implemented to stabilise the current source and prevent recurrence.

Indicative thresholds for rectification action are given in **Table 8.3**. Local conditions will be taken into account when considering potential impacts on the receiving environment. Sediment levels in near-shore environments can vary due to tidal activity, and threshold levels may need to be varied to reflect seasonal and diurnal variation.

Table 8.3: Indicative Thresholds for Rectification Action
(Refer to Figure 5.17 for monitoring site locations)

Sample location	Threshold	Action Required	Comments
Sites SW1, SW2, SW3. MW1	Total Suspended Solids > 20 mg/L.	Determine if impact on the receiving environment could occur, and if so take rectification actions.	Local conditions to be taken into account when considering potential impacts.
Throughout the site.	Evidence of erosion/deposition uncontrolled by soil conservation works.	Identify and rectify cause of erosion.	Immediate action required if uncontrolled erosion is occurring.

Contingency Plans

Bund Wall Failures

Contingency Plans in the event of bund wall failure at the site during remediation should be addressed under the remediation contractor’s Environmental Management Plan (EMP), during construction under the construction contractor’s EMP and during operation under the SMP.

Measures to be included in the Remediation EMP and Construction EMP are:

- procedures for contacting emergency services including fire services, the Site Supervisor, the Superintendent and the Office of Environment and Heritage;
- construction of temporary bunding repairs such as temporary earth bunding. The Contractor would be required to include suitable stockpile(s) or material at the site for this purpose;
- appropriate repair to permanent bunding and the associated holding vessel to the satisfaction of the Contract Superintendent; and
- appropriate clean up and validation of any contamination that may result from the bund wall failure to the satisfaction of the Contract Superintendent.

Measures to be included in the Site Management Plan are:

- procedures for contacting emergency services including fire services, and the Office of Environment and Heritage; and
- procedures for the appropriate clean up and validation of any contamination the result of the bund wall failure.

Significant Acid Generation

Contingency plans in the event of significant volumes of acid being generated at the site would be addressed under the Acid Sulfate Soil Management Plan (ASSMP) and included the following measures:

- containment of the acidic leachate generated by constructing emergency earth bunding or excavating cut off drains;
- neutralisation of acidic leachate by adding a neutralising agent, such as lime, to the leachate, or buffering with seawater;
- constructing reactive barriers, such as limestone caps, to neutralise acid that comes into contact with the barrier;
- prevention of ASS coming into contact with rainfall, surface water or groundwater by constructing physical barriers, such as covering stockpiles or excavations with ASS with liners or inert earth material; and
- prevention of ASS in excavations being exposed to air by burial of exposed ASS or pumping seawater into excavations to prevent exposure of ASS to air and buffer the material.

8.3.2 Hydrogeology

Acid Sulfate Soils and Infrastructure Protection

The disturbance of acid sulfate soils needs to be carefully managed and this management should address the following issues.

- If such soils are stockpiled during construction, they must be treated with lime and encapsulated as much as practical to stop the generation of acid runoff and potential leaching of metal contaminants.
- Lowering of the water table could expose acid sulfate soils to atmospheric oxygen, acidify groundwater and potentially mobilise metal contaminants. Any dewatering required for foundation placement should be done as quickly as possible, and the dewatering discharge sampled and analysed on a regular basis to determine the initial baseline groundwater chemistry and any changes in groundwater chemistry during dewatering. If groundwater pH starts to decrease significantly, then a

suite of metals will also need to be analysed. If metals are detected, the dewatering discharge would need to be treated and/or removed for off-site disposal.

- All foundations, including piles, need to be designed with materials that are resistant to acid soils and the associated corrosion. Sulfate-resistant cement may be required in some or all of the development areas. Piles may require treatment with chemicals that are resistant to the potential acidification of soils and groundwater.
- Revegetation of the development area may need to take account of soil types and the potential for acid sulfate soils to generate acid in the subsurface.

Rising Water Table Due to Increased Recharge

A rising water table and groundwater levels may have negative impacts on the development and may need to be controlled by drains and or groundwater pumping. The design of the site drainage system will address this issue and ensure that local and off-site run-off is directed efficiently to the harbour without causing impacts from flow or water quality.

8.3.3 Hydrology

Most impacts on surface water as a result of the Redevelopment are likely to be benign or beneficial. The largest potential risks arise from erosion during construction and contamination of stormwater with metals and hydrocarbons entrained from existing contaminated areas. The erosion risk will be managed using an ESCP (Section 8.3.1), and contamination will be managed with appropriate site remediation and stabilisation (Section 8.2).

Water Management in Ponds and Swimming Features

The Redevelopment may include ponds and a swimming feature. This section lists general issues and measures for such elements of the Redevelopment.

Objectives

The objectives for water management in ponds and swimming features are to:

- maintain the aesthetic and functional characteristics of the features;
- maximise efficiency of water use and integration with systems for managing stormwater quality; and
- minimise adverse impacts on the environment or stormwater drainage system.

Implementation

Ponds and swimming features shall be constructed and managed according to the following guidelines.

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- Any ponds, pools, artificial beaches and swimming features not open to the sea will be designed to accommodate rainfall or stormwater inflows up to a 100-year ARI without flooding, scouring or discharging water of poor quality to Darwin Harbour.
 - Where possible, water supply for each feature will access water recycled from within the development area, accounting for the level of treatment necessary to maintain adequate quality for the purpose of the feature and considering evaporative concentration of salts.
 - Where possible, ponds will be incorporated into and supplement the stormwater quality treatment system.

Ponds and swimming features will be monitored as required by local and national guidelines and in accordance with their intended use.

The specifications for these features will need to be determined following the finalisation of the Master Plan, and include:

- their water requirements and sources;
- mechanisms for diversion of surface waters and recycling water;
- maintenance of salinity level;
- management of potential impacts from high/extreme rainfall events;
- measures to ensure potentially contaminated water is isolated from the feature; and
- details of the necessary water quality monitoring program (for protection of both the environment and human health).

Stormwater Management

Objectives

The objectives of stormwater management structures and management systems are to:

- minimise erosion on site, particularly during construction;
- ensure underground pipe and surface channel structures are adequate to convey runoff from the Redevelopment site and contributing catchments during all events up to a specified size without causing flooding nor entraining sediment or contaminants in transit, also ensure storm overflow considerations have been designed for; and
- use best practice urban stormwater techniques to maintain water quality at an acceptable level.

Implementation

The surface water management plan will address these objectives by detailing construction specifications and water management and maintenance procedures.

Erosion risk will be minimised by ensuring:

- potential erodible areas are managed according to the Erosion and Sediment Control Plan;
- channels and outfalls are erosionally stable by accounting for likely flow rates and the condition of the channel bed and banks and outfall area;
- temporary channels and flow management structures for use during construction are designed to accommodate flows up to a 10-year ARI without flooding or scouring; and
- permanent channels, pipes and flow management structures are designed to accommodate flows up to a 100-year ARI without flooding or scouring.

Best practice stormwater management techniques will be used to maintain water sourced from within the Redevelopment site at a suitable quality to be discharged to Darwin Harbour. This will be done by:

- matching treatment measures to the nature and severity of contaminants in the stormwater;
- installing a series of treatments in-line and treating water as close to the source as possible; and
- maintaining structures in good operating condition.

Treatment measures that will be employed, as necessary, will include:

- bunding and oil, grit, litter and gross pollutant traps to remove trash, oils, sediment and other contaminants from industrial, hardstand, roadway and traffic areas;
- grass swales and buffer strips to remove coarse sediment and nutrients;
- street sweeping to remove dust, organic matter and pollutants; and
- management systems to control the rate and timing of application of pesticides and nutrients to parks and gardens.

8.3.4 Marine Environment

Marine Water Quality

As noted in Section 6.3.6, water quality in Kitchener Bay and the surrounding harbour may be affected by:

- dredging of marine mud;

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- foreshore or near shore construction (e.g., for a revetment wall, sea wall, marina or jetty);
 - land reclamation;
 - maritime activity; and
 - inadequate management of run-off from the catchment.

Management of run-off from the catchment is addressed in the previous hydrology section (Section 7.3.3).

Dredging

If dredging of Kitchener Bay is required as part of the Redevelopment, a Dredging Management Plan will be developed to minimise any adverse environmental impacts. Dredging of marine sediments will include dredging activities in Kitchener Bay and potential re-use for land reclamation at the site and or disposal to sea or a licensed waste facility. Contaminated and un-contaminated spoil will be generated while this activity is conducted. Dredging will be managed so to minimise:

- the potential generation of turbid water plumes;
- the potential of suspension of contaminated sediments; and
- impacts due to sediments or contaminants in the tail water from any offshore disposal sites.

Options for Dredging Operations

Dredging operations, including the type(s) of dredge, will consider the location of proposed operations, the contaminant status of the sediments and the proposed disposal location.

- Where minimal dispersion of sediments during dredging is desirable, a backhoe dredge should be employed. Moderately to highly contaminated surface sediments (e.g. at the western end of Kitchener Bay) could be loaded onto trucks and transferred to a suitable waste disposal facility. Uncontaminated sediments could be loaded into bottom dump barges for ocean disposal. Approval will be required from the Northern Territory Government prior to selection of disposal options.
- A commonly used alternative is to construct a rock wall around an area for reclamation, with an impermeable membrane installed on the inside of the wall and held in place by clean sand fill. The contaminated sediments are pumped into the reclamation via a small cutter suction dredge to form a thin layer of sediments at the base of the reclamation. Once the contaminated sediments have been relocated into the reclamation, they are buried by clean sand and rubble fill.
- Where sediments are suitable for ocean disposal and a relatively large volume needs to be removed (greater than 50,000 m³), a trailer suction hopper dredge (TSHD) is the most cost efficient means of picking up the soft material and transporting it offshore for subsequent dumping at an approved

disposal location. However, the use of a TSHD within Kitchener Bay may be constrained by manoeuvrability and tidal limitations.

Since most contaminants are bonded onto fine silts, the release of contaminated waters from inside a reclamation area can be prevented by the installation of sediment settling devices such as stilling walls within the reclamation pond and a sediment curtain around the water overflow or discharge outlet. Where sediments are very fine and settlement is slow, the use of flocculants may be required.

Marine excavators tend to create low levels of turbidity in a localised area and downstream due to the intermittent and low volume nature of their operations. Similarly, cutter suction dredges in soft sediments do not create large plumes of turbid water whilst dredging as most of the material disturbed is sucked into the dredge and pumped via pipeline to the reclamation area. However, unless managed as described above, excess tail water from the reclamation can be a local source of water turbidity.

TSHDs can create substantial water turbidity whilst dredging as a result of both propeller wash and draghead action in shallow waters, and as a result of overflow of fines from the hoppers as they load with coarser materials. TSHDs and hopper barges also create localised turbidity at the spoil disposal location when dredged material is dumped to the ocean floor.

On-shore disposal of spoil with ASS or PASS could result in acid generation and these materials will require neutralisation. Any ASS or PASS disposed sub-tidally will not require neutralisation as there is minimal risk of oxidisation and acid generation.

UXOs present a safety risk and may be located during dredging. Mitigation measures are noted in Section 8.5.7.

Sea Wall Construction

Sea wall construction may be along the seaward side of the newly reclaimed area and foreshore of the development.

There is potential for excavation of residual contaminated soils during these activities that could be released as dust, to groundwater, to the stormwater system and the marine environment or have human health impacts. These issues are addressed in the RAP and the SMP for construction and landscaping.

Land Reclamation

As noted in Section 6.3.6, land reclamation results in localised loss of marine habitat and may cause localised and temporary water turbidity. If reclamation is undertaken, environmental specifications for the activity will be defined to ensure the fill material is contained and turbidity is minimised. The loss of habitat is not considered significant in the context of the broader harbour environment.

Maritime Activity

Any major spillages will be managed by the Darwin Port Corporation through its Oil Spill Contingency Plan (OSCP; Port of Darwin 2002). Depending upon the size and nature of a spill, mitigation measures can include:

- application of dispersants;
- containment and recovery (e.g. using booms and skimmers);
- physical breakup of slicks;
- shoreline protection; and
- monitoring only (relying on natural dispersion processes).

Sufficient materials to combat oil spills will be maintained within the site. Procedures will be put in place to manage any spills, including deploying materials for large spills through existing procedures established under the National Plan and the Australian Marine Oil Spill Centre.

Appropriate refuelling, cooking, washing, ablution and toilet facilities will be incorporated into the design of any marinas or jetties at the site to minimise the risks of small spillages of hydrocarbons, greywater and blackwater, and rubbish.

8.4 Biological Environment

8.4.1 Vegetation

Any clearing of vegetation within the coastal vine-forest habitat (for the proposed pedestrian access route to the CBD of other purposes) will be undertaken with a commitment to minimising any impact on the surrounding forest and maintaining the integrity of this significant vegetation community. Clearing of large trees will be avoided to maintain the character of this landscape and to maintain shade and continuity of habitat.

Given the high weed densities that already exist on the site, the spread and proliferation of weeds by construction activity is not of primary concern. However, a number of priority weeds can be identified and priority control areas can be selected. A weed management plan will be developed for the site to assist in the prevention of further introductions and for the long term control of weeds. The spread of Class B noxious weeds will be controlled, particularly to exclude them from adjacent relatively weed-free habitats. Wash-down facilities will be provided for earthmoving equipment to limit the spread of Class B noxious weeds on and off-site.

Where possible, trees listed on the Register of Significant trees in and near the project site (**Appendix G**) will be retained for their aesthetic or historical value, specifically:

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- the five *Pittosporum moluccanum* trees (listed as near threatened) in the vine-forest along rainforest along Hughes Avenue; and
 - the established Golden Flame Trees (*Peltophorum pterocarpum*) on the foreshore in the Fort Hill Area.

8.4.2 Terrestrial Fauna

Impacts on fauna are not expected to be significant. The major mitigation measure is to protect existing habitat adjacent to the site, particularly the escarpment vine-forest and to control the spread and introduction of weed species. This will be facilitated by the installation of temporary fencing of vegetation at the base of the escarpment prior to any road works.

8.4.3 Marine Ecology

Most activities proposed for the site will affect local waters only. However, dredging has the potential to have adverse impacts beyond the local scale. As noted in Section 8.3.4, the key issue associated with dredging is the selection of an appropriate location for disposal of spoil that may be contaminated. Section 8.3.4 also contains mitigation measures for dredging operations.

8.4.4 Biting Insects

Mitigation measures to minimise disturbance caused by mosquitoes and biting midges are based on reducing still water environments, the introduction of insect repellent vegetation and increasing public awareness of the problem and personal protective measures. Biting midges may seasonally affect the site but reach the site from other areas. Mosquitos breed on the site and this can be mitigated. The risk of introduction of exotic mosquito species underlines the importance of adequate mosquito breeding control, particularly in the underground stormwater drainage system that could pond water, such as in letterbox pits and side entry pits.

Topographical Depressions

Identified potential mosquito breeding depressions in the Redevelopment area will be either filled, drained or re-contoured. Development activity will not create new depressions or poorly draining areas capable of holding water for more than three days. Government authorities (the Medical Entomology Branch of the NT Government and Darwin City Council) will continue addressing depressions outside the proposed development area for rectification.

Stormwater Drains

The various stormwater drains identified as potential breeding habitats for mosquitoes will be treated to reduce the future potential for ongoing breeding. Measures will include:

- annual de-silting at the end of each Wet season;

-
- installation of erosion prevention structures to minimise siltation of drains;
 - replacement or redesign of drain sections disturbed by tree root growth to restore the adequate drainage.
 - redesign of drainage features such as letterbox pits to ensure they do not cause internal ponding;
 - installation of concrete low flow inverts to prevent water ponding; and
 - decommissioning or upgrading of the underground drainage system at the site of the former Stokes Hill power station (and possibly in other areas of the site) to prevent water from pooling.

Artificial Receptacles

Site preparation and construction will be undertaken to prevent an increase in artificial receptacles capable of mosquito breeding. The site will be maintained free of artificial breeding mosquito habitat, as far as is practicable.

Landscaping

Shrub type vegetation will be considered around any proposed public areas, to allow the use of bifenthrin insecticide barrier treatment to control adult biting mosquitoes.

Personal Protection from Mosquitoes

Where possible and practicable, the attraction of mosquitoes can be minimised by the use of:

- yellow lighting around areas of human activity; and
- white fluorescent or ultra-violet lights in areas away from human activity to divert mosquitoes from human activity areas.

Information about the timing of biting insects and personal protection measures will be provided to developers, potential residents, landholders and businesses in the project site.

8.5 Built Environment

8.5.1 Preliminary Site Activities

Site Clearance

Site clearance will include excavation of uncontaminated topsoil, removal of trees and scrub and residual surface level infrastructure.

Wastes generated while this activity is carried out will include non-hazardous green waste, uncontaminated topsoil, potential discharges to the stormwater system and dust. Non-hazardous wastes from the demolition of the remaining buildings will include bitumen and concrete from hardstand areas or underground services, as well as metal, wood, plastic, rubbish, rock and gravel or soil fill material.

Topsoil will be removed and separated from other materials and stockpiled for re-use on site during landscaping following construction. Cleared vegetation will be transported to a licensed green waste facility and the remaining material will be transported to salvage or to a licensed landfill. Stormwater runoff controls will be implemented to divert stormwater from stockpiled soils and minimise erosion. Dust generation will be minimised through dust suppression measures (e.g. application of water)

Construction

Excavation and Earthworks

Excavation and earthworks activities will include the preparation of the site for construction of buildings and will include:

- excavations for basements, foundations, footings and new underground services; and
- earthworks for engineering compaction of road sub-base and load bearing areas for footings and structures.

There is potential for dust generation and discharge of sediments to the stormwater system from this activity. Measures to minimise this will be addressed as part of the SMP and include stormwater diversion, stormwater treatment, erosion control and dust suppression.

Wastes may be generated during excavation works. This material will be either re-used appropriately elsewhere on site as fill material or transported off site to a licensed landfill.

Wastewater could be generated while this activity is conducted from excess wetting during compaction of road sub-base and load bearing areas. Measures to minimise this will be addressed as part of the SMP.

Underground Services

Construction of new underground services will include excavation and placement of new services and placement of engineered fill.

There is potential for excavation of residual contaminated soils during these activities that could be released as dust, to groundwater, to the stormwater system and the marine environment or have human health impacts. These issues will be addressed as part of the SMP which will detail the ongoing management of residual contaminated soils at the site.

Uncontaminated soils from excavations will either be re-used appropriately elsewhere on site as fill material or transported off site to a licensed waste facility.

Wastewater could be generated while this activity is conducted from excess wetting during compaction of engineered fill material. Measures to minimise this will be addressed as part of the SMP.

Roadways

Construction of new roadways will include placement of engineered imported fill material as road basecourse, construction of stormwater drainage and placement of pavement materials.

Waste chemicals associated with placement of pavement material will be generated during this activity and could pose a risk to human health or be discharged to the stormwater system. These issues will be addressed through measures in the SMP.

Dust generation will occur during this activity and could pose a risk to human health or nuisance. Dust suppression measures will be addressed part of the SMP.

Waste material could be generated while this activity is conducted from excess imported basecourse material, however as this material will be obtained or purchased off site and has direct cost implications it is not anticipated that this activity will generate significant waste.

Wastewater could be generated from excess wetting during compaction of engineered basecourse material. Measures to minimise this will be addressed as part of the SMP.

Buildings

Construction of buildings will include various commercial, community and residential buildings.

Non-hazardous waste generated while this activity is conducted will include a large range of building wastes including excess building materials such as structural steelwork and reinforcement, timber framework, glass, insulation material, paving, plumbing pipework and fittings, tiling, electrical wiring, pipework and fit out, internal fit out materials and fixtures. These materials should be re-used where possible.

Hazardous wastes generated during this activity will include chemicals, solvents, paints, oils and their associated containers. These pose a potential human health impact and could contaminate the soil, stormwater system, groundwater and marine environment. Measures will be implemented as part of the SMP for chemical storage, spill control and prevention as well as soil, groundwater and stormwater protection.

Discharge of sediment to the stormwater system is possible during this activity. The SMP will include stormwater diversion and erosion control measures to minimise the discharge of sediments to the stormwater system.

Dust generation will occur during this activity and could pose a risk to human health or nuisance. Dust suppression measures will be addressed part of the SMP.

Landscaping

Landscaping will include the establishment of trees, gardens and lawn areas and will include activities such as placement of irrigation systems, placement of topsoil, scarifying, seeding, fertilising, planting, watering and weeding. Clean topsoil may be required to be imported to facilitate the establishment of the landscape as intended.

Hazardous wastes generated during this activity will include chemicals, fertilisers, pesticides, insecticides, herbicides and empty containers. These pose a potential human health impact and could contaminate the soil, stormwater system, groundwater and marine environment. Measures will be implemented as part of the SMP for chemical storage, spill control and prevention as well as soil, groundwater and stormwater protection.

Discharge of sediment to the stormwater system is possible during this activity. The SMP will include stormwater diversion and erosion control measures to minimise the discharge of sediments to the stormwater system.

Dust generation will occur during this activity and could pose a risk to human health or nuisance. Dust suppression measures will be addressed part of the SMP.

Non-hazardous solid, liquid and putrescible waste will be generated during this activity. There may be some opportunities for re-use and recycling. The remaining waste needs to be transported and disposed of at licensed liquid and solid waste facility.

Site Personnel

Site personnel conducting the construction activities at the site will generate waste during the works at the site. This is anticipated to include hazardous and non hazardous waste throughout the construction works.

Non-hazardous solid, liquid and putrescible waste will be generated during this activity. There may be some opportunities for re-use and recycling. The remaining waste will be transported and disposed of at licensed liquid and solid waste facility.

Hazardous wastes generated during this activity will include sewage, pesticides, herbicides, chemicals, solvents, paints, oils and their associated containers. These pose a potential human health impact and could contaminate the soil, stormwater system, groundwater and marine environment. Measures will be implemented as part of the SMP for chemical storage, spill control and prevention as well as soil, groundwater and stormwater protection.

Site Operation and Maintenance

The persons occupying the site will generate non-hazardous solid waste and recyclable and non-recyclable domestic and commercial waste during normal operation of the site. Non-hazardous solid waste is likely to include domestic and commercial non-putrescible and putrescible wastes. Provision should be included for appropriate designated areas to place solid non-hazardous waste such as collection

containers by DCC. Collection of this waste will be conducted by DCC in accordance with the existing DCC hard rubbish collection program.

Provision will be included for appropriate and defined recyclable and non-recyclable waste systems at the site. Collection of recyclable waste will be conducted by DCC in accordance with the existing DCC recycling program.

Collection of domestic non-recyclable waste will be conducted by DCC in accordance with the existing DCC domestic rubbish collection program.

Hazardous wastes generated during this activity will include sewage, pesticides, herbicides, chemicals, solvents, paints, oils and their associated containers. These pose a potential human health impact and could contaminate the soil, stormwater system, groundwater and marine environment. Measures will be implemented for chemical storage, spill control and prevention as well as soil, groundwater and stormwater protection as part of the development.

8.5.2 Waste Management Register

The waste management register is shown in **Table 8.4**.

Mitigation, Management and Monitoring

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Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Building Demolition			
Non-Hazardous Building Materials	Materials such as steel, concrete and general building materials.	No potential adverse impacts.	Recycle, reuse and salvage where possible
Potentially Hazardous Liquid Waste	Waste oils, tank residues, including sulphuric acid and oily water.	Potential for spills and leaks during demolition and transport.	Remove liquids prior to demolition and remove by licensed contractor. Also potential for recycling and reuse of waste oils.
Potentially Hazardous Solid Wastes	Asbestos containing building materials.	Human health risk from asbestos dust.	Demolition in asbestos area to be carried out and controlled by licensed specialist contractor using techniques to minimise the creation of dust.
Sub-Surface Demolition			
Non-Hazardous Building Materials	Materials such as pipe work, footings, road base, hardstand, foundations, underground storage tanks, pits and bunded areas.	No potential adverse impacts.	Recycle and salvage where possible.
Residual Potentially Hazardous Liquid Wastes	Fuels and septic waste.	Potential for spills and leaks during demolition and transport.	Remove liquids prior to demolition and remove by licensed contractor.
UXO	WW II explosives.	Safety risk.	Clearance of areas of known UXO high risk areas and disposal of Ordnance by registered Defence personnel.

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Soil Remediation			
Contaminated soils	Elevated concentrations of metals (arsenic, barium, cadmium, copper, lead, manganese, mercury, nickel). Hydrocarbons (typical of diesel fuel and oil); Potential for asbestos in fill material. Potential for TBT. Potential for dioxin. Small quantities of miscellaneous contaminated associated with waste fill materials. PASS.	Release of contaminants to stormwater, air (as dust and odour), groundwater, and/or the marine environment. Potential soil, ground water and atmospheric impacts during transport, storage and treatment. Potential human health impacts.	Development of a RAP, which will form the basis of remediation which will allow future development of the site. Including clean-up, removal, containment, isolation or treatment of contaminated soils. The RAP will summarise contamination issues, including the extent of contamination requiring remediation or mitigating management controls; methodologies to protect human health and the environment; and waste handling and monitoring requirements. Development of a SMP, which will govern the design requirements for construction development and landscaping plans.
Groundwater Remediation			

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Contaminated Groundwater	Petroleum hydrocarbons including phase separate hydrocarbons (PSH). Elevated concentrations of metals (copper, lead, nickel, manganese, zinc). Localised concentrations of dissolved halogenated solvents (1,1-Dichloroethane, cis-1,2-Diochloroethene, Tetrachloroethene). Polycyclic Aromatic Hydrocarbons (PAHs). Chloroform.	Release of contaminants to the marine environment Potential soil, ground water and atmospheric impacts during transport, storage and treatment Potential human health impacts	Development of a RAP, which will form the basis of remediation which will allow future development of the site. Including clean-up, removal, containment, isolation or treatment of contaminated soils. The RAP will summarise contamination issues, including the extent of contamination requiring remediation or mitigating management controls; methodologies to protect human health and the environment; and waste handling and monitoring requirements. Development of a SMP, which will govern the design requirements for construction development and landscaping plans.
Site Clearance	Uncontaminated topsoil.	Entry to stormwater system through erosion. Dust generation.	Stormwater runoff controls. Implementation of dust suppression methods.
	Vegetation.	Recycling/reuse opportunities. Transport of weeds.	Chipping on site and/or disposal to Shoal Bay green waste facility. Weed export prevention measures.

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Site Clearance (cont'd)	Residual building materials.	<p>Recycling/reuse opportunities.</p> <p>Potential soil, stormwater, groundwater and atmospheric impacts from residual contaminants during transport and removal.</p>	<p>Recycling and reuse where possible.</p> <p>Supervise demolition to identify residual contaminants and implementation of remedial measures to prevent mobilisation of contaminants off-site (stormwater & dust). Residual material will be treated as part of the soil remediation programme.</p>
Dredging and Spoil Disposal	Contaminated spoil.	Release of contaminants to water and incorporation into food chain.	<p>Application of dredging methodologies which minimise potential for suspension of contaminated sediments.</p> <p>Management of tail water from any onshore disposal sites.</p>
	Uncontaminated spoil.	<p>Light attenuation by turbid water plumes.</p> <p>Smothering of seabed biota at offshore disposal site.</p>	<p>Application of dredging methodologies which minimise potential for generation of turbid water plumes.</p> <p>Selection of offshore disposal site(s), which do not contain seabed biota of regional significance and are not in the sensitive biological communities of regional significance.</p>

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Dredging and Spoil Disposal (cont'd)	ASS	Generation and release of acid residue if exposed to air at onshore disposal site. No acid generated if disposed subtidally.	Neutralisation and burial if disposed onshore. No management required if disposed subtidally.
	UXO	Safety risk.	Magnetometer survey of area pre-dredging and disposal of ordnance by appropriate Defence personnel.
Land Reclamation	Settlement Tail Water	Release of contaminants to the groundwater and/or marine environment.	Use of impermeable barriers to prevent release of contaminants.
	Acid Sulfate Muds	Generation and release of acid residue if exposed to air at onshore disposal site. No acid generated if disposed subtidally.	Neutralisation and burial if disposed onshore. No management required if disposed subtidally.
	Groundwater and surface water from adjacent land.	Migration of contaminants into marine environment.	Application of RAP, incorporating site controls such as installation of impermeable barriers and stormwater management methods.

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Sea Wall Construction	ASS	<p>Generation and release of acid residue if exposed to air at onshore disposal site.</p> <p>No acid generated if disposed subtidally.</p>	<p>Neutralisation and burial if disposed onshore.</p> <p>No management required if disposed subtidally.</p>
	Soils with residual contamination	<p>Release of contaminants to stormwater, air (as dust and odour), groundwater, and/or the marine environment.</p> <p>Potential soil, ground water and atmospheric impacts during transport, storage and treatment.</p> <p>Potential human health impacts.</p>	<p>Development of a RAP, which will form the basis of remediation which will allow future development of the site. Including clean-up, removal, containment, isolation or treatment of contaminated soils. The RAP will summarise contamination issues, including the extent of contamination requiring remediation or mitigating management controls; methodologies to protect human health and the environment; and waste handling and monitoring requirements.</p> <p>Development of a SMP, which will govern the design requirements for construction development and landscaping plans.</p>

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Excavation and Earthworks	Uncontaminated soils	Entry to stormwater system through erosion. Potential human health impacts and nuisance from dust.	Stormwater runoff controls. Implementation of dust suppression methods.
	Dust	Potential human health impacts. Nuisance.	Implementation of dust suppression methods.
Roadway Construction	Chemicals associated with placing pavement	Potential human health impacts. Contamination of stormwater.	Operational procedures, storage controls, spill and leak prevention, stormwater diversion.
	Stormwater	Release of contaminants to the marine environment.	Stormwater diversion, storage and treatment. Erosion control.
	Dust	Potential human health impacts. Nuisance.	Implementation of dust suppression methods.

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Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Building Construction	Excess non-hazardous building materials	Recycling/reuse opportunities.	Recycling and reuse where possible.
	Hazardous wastes (chemicals, solvents, paints, oils, etc.) and empty containers	Potential human health impacts. Contamination of soil, stormwater and/or groundwater.	Operational procedures, storage controls, spill and leak prevention, stormwater diversion. Disposal of containers to licenced treatment facility
	Stormwater	Release of contaminants to the marine environment.	Stormwater diversion, storage and treatment. Erosion control.
	Uncontaminated top soil	Entry to stormwater system through erosion. Dust generation.	Stormwater runoff controls. Implementation of dust suppression methods.

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Landscaping	Hazardous wastes (fertilisers, pesticides, insecticides, weedicides, etc.) and empty containers	Potential human health impacts. Contamination of soil, stormwater and/or groundwater.	Operational procedures, storage controls, spill and leak prevention, stormwater diversion. Disposal of containers to licensed treatment facility
	Stormwater	Release of contaminants to the marine environment.	Stormwater diversion, storage and treatment. Erosion control.
	Dust	Potential human health impacts. Nuisance.	Implementation of dust suppression methods.
	Excess non-hazardous landscaping materials.	Recycling/reuse opportunities.	Recycling and reuse where possible.

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Landscaping (cont'd)	Non-hazardous solid, liquid and putrescible waste.	Recycling/reuse opportunities.	Recycling and reuse where possible. Offsite disposal at landfill (solid and putrescible wastes) Liquid waste disposed offsite via licensed contractor
Construction (Personnel)	Hazardous liquid waste and containers.	Potential human health impacts Contamination of soil, stormwater and/or groundwater	Operational procedures, storage controls, spill and leak prevention Disposal offsite via licensed contractor
	Non-hazardous solid, liquid and putrescible waste, including green waste.	Recycling/reuse opportunities.	Recycling and reuse where possible. Offsite disposal at landfill (solid and putrescible wastes)

Table 8.4: Waste Management Register

Activity	Waste Types	Potential Impacts	Management Options
Site Operation and Maintenance	Hazardous liquid waste (sewage, pesticides, insecticides, weedicides, oils, fuels, paints, solvents, corrosion inhibitors, cleaners, etc. and containers	Potential human health impacts Contamination of soil, stormwater and/or groundwater	Operational procedures, storage controls, spill and leak prevention Disposal offsite via licensed contractor Sanitary waste disposed into sewerage system

8.5.3 Air Quality

Demolition and Remediation Works

The following best practice environmental safeguards will be implemented during demolition and remediation works.

- The RAP and SMP will address air monitoring and management issues.
- Water sprays will be used (as required) across work zones and unsealed areas to suppress dust.
- Any infrastructure demolition and removal works undertaken prior to the remediation of the site will be carried out with particular regard to the most current information from the Contaminated Site Assessment for each area across the site. Mitigation measures will be implemented for any such on-ground works that are appropriate for, and adequate to address, the level and type of contamination in each area.
- Demolition and removal works undertaken after site remediation will be carried out using all measures noted in the SMP for each location across the site.

During Dry season months, the direction of prevailing winds will be assessed in relation to the impact of dust on surrounding vegetation, housing and offices and suitable mitigation methods implemented (e.g. water trucks).

Construction

The potential for off-site dust emissions to occur during the construction phase will be minimised through the development and implementation of the construction EMP. The construction EMP will include the use of dust suppression measures such as:

- ensuring exposed surfaces and stockpiles are watered or sprayed where required during dry windy conditions;
- where possible, undertaking progressive clearing in stages to minimise the areas of exposed surface at any one time and the likelihood of dust generation from bare surfaces;
- using speed limits to minimise dust generated by vehicle movements;
- scheduling particularly dusty works under favourable meteorological conditions only, with the aim of minimising major works when winds have the potential to carry airborne dust directly towards the Darwin CBD or nearby residential areas;
- using minimum drop heights when loading and unloading soils and other excavated material;
- minimising areas of disturbed, exposed soils; and

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- providing training to employees and contractors to ensure that they are aware of the importance of minimising dust generation both for on-site Occupational Health and Safety and off-site impacts.

Regular checks will be made of dust levels being generated by the works and remedial action taken whenever visible off-site emissions occur.

Operation

Potential air quality impacts arising from vehicle emissions during ongoing operation of the redeveloped site may be mitigated through advocacy of public transport and traffic design/management principles in the final Development Master Plan. The conceptual design of the pedestrian connection with the CBD will provide the basis for Traffic Demand Management principles to be incorporated into the long-term planning for the Darwin Waterfront.

Air Emissions and Energy Efficiency

The energy efficiency of the components of the Redevelopment and the net greenhouse gas emissions cannot be determined at this stage. Once the Master Plan has been finalised, such an assessment can be made and should include analysis of building design and operation, public transport, non-vehicular access and energy efficient technology.

Emissions of and Exposure to Air Toxics

As noted in Section 6.3.8, the Concept Plan the NFI will continue to operate. Negotiations are currently underway with the Department of Defence in relation to the future of navy operations in the project area. It is likely that bulk tanker operations at the Iron Ore Wharf will cease in the future. The NFI may be a localised source of hydrocarbon odours and some hazardous air pollutants (air toxics).

Once the future operational lifespan of the NFI has been confirmed, the details of the future land uses in adjacent areas are clarified (e.g. building locations and heights) and the suitable guidelines are established from the Air Toxics NEPM, an assessment of the dispersion of fugitive emissions from the NFI may be a consideration.

8.5.4 Noise

Overview

This section provides an overview of some of the options to be considered. In reducing the noise impact of noise sources, the following order of noise control strategies should be adopted. Recommendations are presented in order of their ease of application and effectiveness.

- Remove noise source from noise sensitive locations.
- Increase the separation distance between the noise source and noise sensitive receiver location.

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- Effective orientation of noise sources and receivers to avoid creating a layout with noise sources directed towards surrounding receivers.
 - Reduce the noise level emitted from the noise source by:
 - selection of low noise equipment; and
 - implementation of noise treatment such as acoustic barriers, silencers, acoustic louvers and acoustic enclosures.
 - Reduce the impact of noise at receiver locations through the implementation of noise insulation treatments such as:
 - suitable external façade constructions including multiple glazed facades and suitable external wall types;
 - acoustic ventilation paths; and
 - minimisation of structure borne sound transmission paths.

Noise Management

The Northern Territory Government currently does not have formal noise regulations in place, although such regulations are being prepared by DIPE. Once these regulations are introduced, it is expected that all new developments, and to an extent existing facilities, will be required to comply. The following recommended noise criteria are not part of formal noise regulations. However, implementation of these recommendations should avoid future restrictions and possible penalties. Once site components and layout details are known for the Redevelopment and a noise survey completed, the necessary noise performance and construction details for each facility can be determined. Item specific noise limits can also be established and the cumulative effect of multiple noise sources clarified.

Residential Premises

Recent increases in the residential population within and near the Darwin CBD creates increasing noise sensitive receivers near the Redevelopment and other business activity. Developers of new residential facilities are responsible for incorporating suitable construction methods to ensure a satisfactory internal noise environment. Noise management should adhere to the standards required by Northern Territory Government regulators, and take into account:

- the more open architecture likely in Darwin residential premises; and
- appropriate counteractive measures to dampen significant noise generation points close to residences.

Noise management for specific buildings and components of the Redevelopment will also be assessed through the building approvals process.

Construction Noise

The NT Government allows noise from construction sites between the hours of 07:00 and 19:00 hours from Monday to Saturday to be controlled through the implementation of best practical means. All efforts are required to be made to reduce noise where feasible, to within the allowable levels. Written notice is to be issued, at least 48 hours before the proposed works, to the occupiers of all noise sensitive premises where the maximum allowable noise level of the site is likely to be exceeded. The notice is required to contain information relating to the proposed construction work and the times and dates at which the work is proposed to be undertaken, and include the contact details of the person to whom a complaint may be made about noise emission from the site.

Where construction activities are required between 19:00 and 07:00 hours (night-time), a Noise Management Plan (NMP) must be established for the works which justifies the timing of the proposed works. The NMP is to contain the proposed schedule of works and activities, and an explanation all noise control techniques planned to be undertaken.

Entertainment Noise

DIPE recommends that entertainment noise be controlled to ensure noise annoyance is not created. Any permanent entertainment facilities at the redeveloped site should comply with the standards required by Northern Territory Government regulators.

Guidelines for noise from outdoor entertainment events are not available. Any external entertainment events that may be held in the area should comply with the requirements of the Northern Territory Government regulators. It is recommended that all occupiers of noise sensitive premises, where a noise level of 60dB(A) at 1 m from the external façade is likely to be exceeded, receive written notice of the likely exceedance at least 48 hours before any proposed event.

A NMP should be prepared for the DCEC, due to its close proximity to the CBD and surrounding noise sensitive premises, such as Government House and private residences. The management of noise from external events should form an integral part of this document.

Internal Spaces

Table 8.5 shows the recommended internal noise levels. These levels should be used as targets for the design of the noise performance of facilities and external noise limits.

Development Layout

Traffic

Separation distance between main access roads and premises should be maximised where feasible, and the volumes of traffic passing these premises should be minimised. The external fabric of buildings within the development should be designed to achieve satisfactory noise reduction.

Table 8.5: Recommended Levels of External Noise Intrusion and External Noise Limits

Type of Occupancy / Activity	Recommended Design Sound Level, L_{Aeq} dB(A)	
	Satisfactory	Maximum
Public Buildings		
Exhibition Areas	40	50
Restaurants and Cafeterias		
Restaurant	45	50
Coffee Shops / Café	45	55
Accommodation Buildings		
Sleeping Areas	25	40
Living Areas	30	45
Common Areas (lobby etc.)	45	55
Commercial Buildings		
Small retail	45	50

Mechanical and Electrical Equipment

Mechanical and electrical plant equipment, and their associated noise generating equipment such as air inlets and outlets should be located away from noise sensitive premises and particularly bedrooms and balconies.

Wharf Activities

The noise impact associated with the servicing of navy and cruise liner vessels at the wharves (e.g. from refuelling) should be minimised through effective planning and layout design of residential premises.

Mechanical and Electrical Services

Noise should be controlled to prevent exceedance of the recommended noise limits at surrounding noise sensitive premises. All mechanical and electrical services generating noise that may affect public spaces should comply with the requirements of Northern Territory Government regulators.

Item Specific Noise Limits

Noise from continuously operating equipment should have item specific noise limits established (SVT, 2004).

8.5.5 Visual Characteristics and Values

Height controls for all structures should not exceed the view lines obtainable from the city unless such structures are designed for functional and visual integration of the site with the CBD.

Visual and functional integration with the CBD and the civic precinct should be achieved along the Smith Street axis.

Any dredging or engineering works on the foreshore of Kitchener Bay should incorporate aesthetic and environmental values and processes, particularly in relation to the low tide view of mudflats and any exposed dredged channels.

The heritage sites and artefacts within or close to the project site offer an attraction to visitors and have intrinsic landscape and visual value. They should be used to form a strong identity to the Redevelopment and strengthen the visual qualities and provide a major theme to the area. This is best achieved by linking the sites with signage and pedestrian walkways and trails. It will also allow linkage to the civic precinct.

The site of the former railway yards between Tiger Brennan and Frances Bay Drives is in a direct view line from Stokes Hill Wharf. Although outside the Redevelopment site, the eventual redevelopment of this area should seek to complement the Redevelopment in architectural style and form wherever possible.

8.5.6 Traffic and Transport

Traffic impacts may be mitigated by improvements in road capacity and changes to the layout of various parts of the road network. When the final design for the Redevelopment is finalised, the following issues will need to be addressed. These issues affect both private infrastructure within the site and public infrastructure outside the site.

Short Term Strategies

- Upgrading of Frances Bay Drive and McMinn Street to enable carriage of heavy vehicle loads during the preparation stages of the project. This may include strengthening of the road pavements and widening at junctions to cater for large turning circles
- Upgrading of the internal road network to conform to current design standards and to include footpaths and cycle lanes
- Review of the layout and priority at the junction of Kitchener Drive and McMinn Street
- Provision of separate right turn lanes at the junctions of Frances Bay Drive and Leydin Court
- Provision of a separate right turn lane on McMinn Street approach to the intersection with Tiger Brennan Drive

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- Assessment of the need for widening McMinn Street from Kitchener Drive to Tiger Brennan Drive
 - Upgrading of Kitchener Drive (if retained) to cater for vehicle access, bus stops and turning traffic in the vicinity of the DCEC
 - Investigation of the option of developing Hughes Avenue as a shared pedestrian-cycle path and /or shuttle bus route

Medium Term

- Widening and upgrading of Mavie Street , and upgrading of its junction with Frances Bay Drive
- Widening of Frances Bay Drive and upgrading of the junctions along its length
- Review, and upgrading if required, of the layout and operation of the intersection of Tiger Brennan Drive with Frances Bay Drive.

Longer Term

- Duplication of McMinn Street between Stuart Highway and Bennett Street
- Duplication of McMinn Street between Kitchener Drive and Bennett Street
- Upgrading of the intersection of Tiger Brennan Drive and McMinn Street, review of the signal phasing and provision of controlled right turns from McMinn Street
- Investigation of the need to widen Tiger Brennan Drive to four lanes in conjunction with reviews of other road improvement strategies

8.5.7 Unexploded Ordnance

Assessment of Risk

As noted in Section 6.5.2, high risk areas for UXO are those where the natural 1942 ground surface (including marine sediments) is exposed. In these areas there is a risk from UXO with any intrusive activities. Non-intrusive activities, such as clearing surface infrastructure, present a low risk. The area has been heavily developed the last 60 years (since UXO would have been deposited) and the lack of previous detonations from this activity indicates that the surface is stable. High risk areas include:

- the escarpment;
- the base of the escarpment along Kitchener Drive;

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- the former marine salvage area near Fort Hill Wharf (discarded munitions from the salvage operation);
 - the sides and base of Stokes Hill; and
 - marine muds.

Medium risk areas and activities include excavations into fill material (i.e., above natural ground level). Medium risk activities include pile-driving.

Low risk activities include all above-ground work, including grading to the natural soil layer.

General Site Procedures

The risk from UXO detonation is low. Nonetheless, the following general site procedures should be implemented and be part of any tender documentation for works on the site.

Awareness Training

Staff and equipment operators working on the site at any stage must be trained about:

- the nature of the UXO risk;
- the likely UXO that may be found and how to identify them; and
- the procedures and protocols to follow if a suspected UXO is uncovered or found.

General Operation Procedures

Operational procedures must include adequate provisions in case a suspicious object is uncovered. These procedures should be based on standard Occupational Health and Safety actions to protect personnel and include:

- definition of “stop-work triggers”;
- isolation of the object with a defined radius of exclusion;
- appropriate reporting procedures
 - externally to the NT Police and the Department of Defence to allow appropriate assessment and disposal if necessary, and
 - internally to maintain records to assist with refining UXO risk for future works.

Excavation

Any excavation into 1942 soil and sediment should only proceed with UXO clearance from qualified specialists. UXO specialists are unlikely to be able to scan for UXO for pile-driving because of the amount of metallic material in the fill, however this is considered a medium risk activity. Any excavation or trenching along Kitchener Drive should be undertaken in the following sequence to facilitate UXO clearance of works:

- removal of all surface infrastructure;
- clearing all metallic debris from the excavation route to minimise interference and masking by metallic objects (This is preferably done by removing the fill layer by grading or scooping to the natural soil layer.);
- assessment of the entire route prior to excavation with an imaging magnetometer; and
- technical support from UXO specialists during excavation.

Dredging Operations

Dredging carries significantly greater risk than other operations because of the possibility of exposing UXO away from the dampening effect of the substrate. The UXO may also become entrained in the dredging equipment and be transported closer to working personnel. Dredging will require:

- appropriate design of the dredge head to prevent uptake of UXO; and
- appropriate layout of the dredge to reduce the risk of a chance explosion (eg, by positioning personnel away from the dredge train and installing a barrier between the train and personnel areas.

UXO specialists will be able to image marine muds at high tide to characterise the intertidal and marine areas. This will assist in defining appropriate dredging procedures and equipment requirements in different areas. They can also scan the dredged material as it is processed to ensure the spoil is free from UXO and poses no further risk.

8.6 Cultural Environment**8.6.1 Aboriginal Cultural Heritage, Archaeology and Native Title**

Possible cultural heritage management strategies and mitigation measures have been formulated to avoid impacts upon significant Aboriginal cultural and heritage sites where possible. Preservation of important archaeological and cultural heritage sites will be the most appropriate outcome.

Acknowledgement of Aboriginal Cultural Significance

The cultural significance of the project site, particularly Stokes Hill, should be acknowledged and past and present Aboriginal land use of the wharf area be recognised. As part of the Redevelopment plans, interpretation of Darwin's Aboriginal archaeological sites and places of cultural significance should be developed and educational opportunities incorporated into the Redevelopment.

Recognition of Contemporary Values

The contemporary use of areas by Aboriginal people should be acknowledged. In particular, development of the escarpment base should be avoided and consideration of the indirect impacts of the proposal on this area discussed with the local Aboriginal community.

Ongoing Local Aboriginal Community Consultation

Consultation should be undertaken with the relevant Aboriginal community groups, the proponent and the Office of Environment and Heritage to determine possible future land uses for Stokes Hill.

Archaeological Investigations

Archaeological investigations could be carried out in specific areas, particularly in the vicinity of Stokes Hill, if these activities are compatible with the redevelopment timeframe for the site. However, given the heavily disturbed nature of the site, these investigations are not considered a priority

8.6.2 European Heritage

The primary potential impact from redevelopment of the site is the destruction of or damage to the identified heritage sites in the project areas. Mitigation measures should focus on retaining and protecting these sites, wherever possible within the Redevelopment. Further, the retained heritage features should be utilised in the Redevelopment through an integrated heritage interpretation program covering the whole precinct as part of the Redevelopment, which focuses on the various physical heritage elements in and near the project area. This program should also utilise any artefact material found during field surveys. This program should be supported by an Interpretation and Communication Plan to capitalise on the opportunities provided by the range of sites. This plan should be prepared in liaison with key stakeholders.

In addition to displaying individual sites, heritage interpretation should highlight major heritage themes across the project area by linking individual elements. This could include:

- maritime history (*Warrego* remains, Steam Pump House, Stokes Hill and Fort Hill Wharves) ; and
- World War II history (oil storage tunnels, No. 6 Tank, NFI, Japanese bombing raids).

Any identified heritage sites that are to be removed or destroyed should be thoroughly documented to the requirements of the Office of Environment and Heritage before any works are undertaken.

Both Goyder's Camp and Hughes Avenue have been nominated recently for inclusion on the Northern Territory Heritage Register. As a consequence of the nominations, these sites will be subject to research and archaeological investigations to clarify their heritage significance. These investigations may produce material useful for public interpretation of the site's heritage. Knight's Folly is expected to be investigated by a research student in the next 12 months, and any artefacts from this site could similarly be used for public interpretation.

Several sites outside the Redevelopment, such as the Oil Storage Tunnels, Traveller's (Chinaman's) Walk, could also provide thematic heritage features. In some instances, it may be possible to relocate heritage features close to the project site (e.g. the Goyder Memorial and the commemorative plaque for the Submarine Cable landing) without diminishing their significance, if their current location is incompatible with the Redevelopment.

8.7 Socio-economic Environment

The Redevelopment of the site is likely to result in generally positive socio-economic impacts. As noted in Section 6.7, the adverse impacts from the Redevelopment are not expected to be significant provided the final Master Plan is sensitive to socio-economic conditions, the the biophysical landscape and the heritage values of the site and construction activities cater for existing users of the site. Several

Potential impacts on existing businesses within, around, or using the facilities in, the project site are the most significant potential negative affect, particularly related to possible short term and transitional costs for businesses in the Darwin CBD. However, the Master Plan is expected to integrate CBD businesses and services into the Redevelopment, and provide connectivity between Redevelopment site and CBD. If those elements are included in the Master Plan, CBD businesses should, in the medium to longer term, benefit significantly from increased visitor numbers and consumption.

It is possible that, in the short term, construction activities will have some negative impact on Stokes Hill Wharf cafes and restaurants. Planning for continued access should minimise this impact. In addition, those businesses are likely to benefit in the longer term from greater visitation to the site.

8.8 Monitoring and Reporting

8.8.1 Hydrology

Surface water monitoring should be undertaken for baseline (pre construction) and construction/operational phases of the project.

Baseline and during construction monitoring protocols are effectively the same. Sampling at the surface water and marine sites and general monitoring for erosion is only required during the Wet season

(typically November to May) or during periods of rainfall outside those times and only when there is a risk of contamination. Contamination risks occur when bare areas or stockpiles or other erodible areas are present, as a result of decontamination activities, or from spills. The time of commencement of baseline sampling will be determined by the project timeline, but it should aim to characterise at least one Wet season. Sampling should continue until construction activities in the catchment above the sample point is complete.

Monitoring of ponds and swimming features will commence when they are constructed and in use and will continue indefinitely.

8.8.2 Groundwater Monitoring

A regular program of groundwater level monitoring and groundwater sampling and analysis from the groundwater monitoring wells on the proposed Redevelopment is required. These data will help to form the conceptual hydrogeological model of the proposed Redevelopment and thus assist in a number of groundwater-related matters, including quantification and movement of groundwater and groundwater contamination.

It is suggested that a groundwater monitoring program is designed to enhance the hydrogeological knowledge of the proposed Redevelopment.

8.8.3 Vegetation

Once a detailed design of the proposed development is available, an appropriate monitoring program can be devised that ensures the effectiveness of environmental safeguards and that monitors the difference between predicted and actual impacts on flora. For example, flora monitoring might include regular weed surveys or annual surveys of vine-forest habitat for species richness and weed abundance and diversity).

Monitoring of management actions, notably weed control, and changes in vegetation condition should be used to guide future management decisions. Establishment of permanent photo points is a simple method of monitoring such changes.

8.8.4 Fauna

The likelihood of encountering fauna of conservation significance during the construction or operation phases of the project is very low. This is primarily due to the lack of suitable habitat within the project site to support the specialised resource requirements of these species. Any fauna of conservation significance that are likely to be encountered will probably be primarily transitory (eg. birds).

A register of significant fauna that may from time to time be encountered within the study area will be maintained. Construction staff will be notified of the importance of recording such fauna in the register. This register will be made available to DIPE. Fauna that are obviously resident (breeding or foraging) will

be reported to DIPE. Transitory species, such as sea eagles, will be recorded on the register as sightings but not reported to DIPE unless these species take up residence.

8.8.5 Air Quality

Demolition and Construction

Considering the proximity of the project area to sensitive receptors close to site boundaries, it is recommended that a program of dust monitoring be implemented prior to major demolition and construction activities to obtain a pre-development baseline assessment of particulate emissions. This should be continued during major demolition and construction works. High-volume sampling of particulates is recommended. The dust samples collected may also be periodically analysed for metals concentrations if deemed necessary.

Operation

If the final Development Plan incorporates provision for a landmark residential development at the site of the former Stokes Hill Power Station, then an ambient monitoring programme of emissions from the neighbouring NFI should be designed and implemented in consultation with the OEH, the RAN and adjacent stakeholders.

8.8.6 Marine Environment

Marine monitoring programmes will be developed for each component of the Redevelopment as they are defined. The programmes will either be specific to individual components of the development (eg. dredging and spoil disposal) or broader to monitor the cumulative effects of several of the components (eg. sediment quality within Kitchener Bay). Specific monitoring programmes cannot be defined at this stage as the conceptual components are not sufficiently advanced.

8.8.7 Reporting Protocol

The reporting protocol for each of the above monitoring programmes will be determined as the various components of the Redevelopment are defined. It is likely that different components will require different protocols. For example, the frequency of reporting may vary from weekly through to annually, depending upon the magnitude of each component of the development and the duration of construction activities for each component.

8.9 Environmental Management Plans

A series of Environmental Management Plans EMPs, either have been developed or will be developed for the various stages of the Redevelopment. These plans include:

- the Pre-remediation Site Works Environmental Management Plan;

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- the Remediation Action Plan;
 - the Site Management Plan;
 - the framework for the Construction Environmental Management Plan; and
 - the framework for the Operational Environmental Management Plan.

These EMPs and their interrelationships are discussed in more detail in Sections 8.2.9 to 8.2.12.

The Framework for the Construction Environmental Management Plan is included as **Appendix T**. This plan is based on the Concept Plan for the Redevelopment, and consequently does not provide specific measures and should be adapted by construction contractors. The Framework for the Operational Environmental Management Plan (**Appendix U**) provides broad guidance about the issues to be addressed during on-going management of the redeveloped site.

The proposed DCWR has developed from several years of planning and consultation. Community consultation has occurred in three phases:

- as part of the broader planning mechanisms for the Central Darwin area in the late 1990s and early 2000s;
- during the initial feasibility assessment in 2002 and early 2003, and
- during the development of the project in late 2003 and early 2004.

Redevelopment of the area was proposed in the *Central Darwin Planning Concepts and Land Use Objectives* published by the then Department of Lands Planning and Environment in 1999. In November 2001, the Chief Minister announced that the Government would give priority to developing a world class waterfront and wharf precinct in Darwin and that planning proposals for the area in the *Central Darwin Planning Concepts and Land Use Objectives* would be taken back to the public for further comment. Thirty-two groups and individuals submitted written comments between November 2001 and March 2002. Follow-up interviews were conducted with these groups and individuals to allow them to expand on their written material. In June 2003, focus groups were convened with stakeholder and public groups to assess community attitudes towards the redevelopment of the waterfront, including the establishment of a convention centre. The results of these consultations were provided to the Northern Territory Government Cabinet.

Consultants assessing the feasibility of, and potential sites for, the convention centre (PricewaterhouseCoopers) advertised and held several public briefings in February 2003 to outline the terms of reference for the project and seek feedback. This included individual meetings with key stakeholders and a meeting with Darwin City Council. Focus groups were convened in June 2003 with the general community and targeted groups to explore options for, and views about, the redevelopment of the Darwin City Waterfront.

Consultation following the announcement in August 2003 by the Chief Minister of the siting of the Convention and Exhibition Centre at the Darwin City Waterfront site included:

- communications and community consultation strategies;
- a dedicated web site for the redevelopment project (www.waterfront.nt.gov.au);
- a newsletter to businesses;
- an information kit to key stakeholders with offers to conduct briefings;
- direct consultation with historical and heritage groups;
- establishment of an historical and heritage reference group, led by the National Trust;

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- a briefing for interested parties after the call for Expressions of Interest to develop the Master Plan for the site, including a bus tour of the site and a detailed briefing of site's community and historical importance;
 - briefings for key stakeholder groups by the DCWR project team, including historical and heritage organisations, Tourism Top End, Darwin City Promotions, Engineers Australia, the Property Council, Darwin City Council, the Capital City Committee, the Business Council and the Bridgeport body corporate; and
 - a meeting with Northern Territory Tourism Council to discuss the project.

Subsequent community consultation was based on the process developed for the Port Adelaide redevelopment project. Further consultation was undertaken in October 2003, including:

- an information evening on 31 October at Stokes Hill Wharf to inform the community about the project and the environmental impact assessment process, attended by about 50 people;
- establishment of a proponent liaison officer;
- distribution of a letter to all traders, residents and stakeholders within the project site to advise them of on-site environmental assessment activities;
- direct consultation with key stakeholders at critical times;
- public displays with DCWR project team staff at the waterfront area, Mindil Beach, Smith Street Mall and shopping centres, with a permanent display left at Stokes Hill Wharf for a month;
- establishment of an email group of people wanting to be kept informed;
- distribution of the second project newsletter in December;
- establishment of a reference group of business/tourism leaders, comprising the Northern Territory Tourism Council, Tourism Top End, the Hotels Association and the Northern Territory Chamber of Commerce and Industry, to provide a conduit for issues and information;
- correspondence from groups, such as Greening Australia NT, the Trades and Labour Council, the Planning Action Network (Plan) and the Environment Centre of the Northern Territory, about the project and issues of concern; and
- organisation of media coverage of the proposed development.

These activities sought to explain the development proposal and the objectives of the Draft EIS and elicit feedback from the community.

- A series of community workshops was held in January 2004 to identify the features and characteristics that a broad cross-section of the Darwin community wanted to see from the redevelopment of the site. These workshops were facilitated by community consultation specialist

Sheila O'Sullivan of SOCOM. Invitations to the workshops were sent to all key stakeholders and advertisements were placed in the NT News inviting members of the public to attend. Over 100 participants, representing many community groups, took part in the five workshops. A separate discussion was held with the members of the Darwin Arts community on 29 January. The outcomes included clarification of the trade-offs that may arise from the redevelopment and identification of a range of community expectations, with many consistencies among the different sectors of the community. The report from these workshops has been placed on the website and outlined the community aspirations identified in the workshops. In February 2004, an issues paper was developed from these workshops and was provided to the three short-listed consortia developing draft Master Plans for the redevelopment. This paper outlined community issues and aspirations to be taken into account in the master-planning. The outcomes from the workshops were also discussed with the Reference Groups between 2 and 4 March 2004. Other consultation activities during March included: meeting with the Chairman of the Larrakia Development Corporation; and

- follow-up meetings with the Reference Groups, Darwin City Council and Tourism Top End.

A public information session was held on 23 April 2004 at Stokes Hill Wharf to inform the community about the status of the project and the development of the Draft EIS. Invitations to the event were distributed by personal letters and emails to specific organisations and individuals and by advertisements in the NT News. About 120 people attended. Also during April, an updated newsletter was produced, and further presentations were made to individual groups, including the Australian Hotels Association (NT).

Community input was also obtained through the statutory consultation processes under the environmental impact assessment process. The Draft guidelines were advertised for comment by the Office of Environment and Heritage in October 2003, and this Draft EIS will be on public exhibition for six weeks.

Further public comment will be sought when the preferred Master Plan for the redevelopment is released in late 2004. On-going community briefings and forums on the vision for the redevelopment will be undertaken during the remainder of 2004, and public briefings and consultations will be carried out during the planning approval process in October and November 2004. In addition, further public displays will be made and newsletters prepared and distributed when appropriate.

10.1 Project Team

This document is the culmination of many investigations conducted between October 2003 and May 2004. Management and technical direction for these investigations was provided by Charles Johnston and Paul Lloyd of URS Darwin.

Special thanks goes to Pat Coleman, Terry O'Neill and Hannah Clement from the Darwin City Waterfront Team and Phill Piper and Graham Clarke from DIPE for their assistance in the preparation of the EIS.

The principal authors of the report are:

- Paul Lloyd (URS);
- Charles Johnston (URS);
- Warren Dodge (URS); and
- Ian Baxter (URS).

Other URS staff who contributed input into the document include:

- Chris Hughes (Reporting writing);
- Michael Haynes (Reporting writing);
- Damien Demunck (Reporting writing);
- Terry Chang (Land Use, Geology and Soils)
- Richard Vogwill (Hydrogology)
- Robin Connolly (Hydrology)
- Ian LeProvost (Marine Environment)
- Tim Mitchell (Air Quality)
- Jim Singleton (Visual Impact)
- Justin Dwyer (Graphics);
- Berniece Pritchard (Document preparation);
- Tim Dowden-Parker (Marine Environment);
- Bobak Willis-Jones (Acid Sulfate Soils)

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- Rochelle Bading (Acid Sulfate Soils); and
 - Chantal Wilson (Reporting writing).

10.2 Specialists

Specialists who conducted investigations and assessments included:

- Kristin Metcalfe (Terrestrial and Intertidal Flora)
- Indicus Biological Consulting (Terrestrial Fauna)
- Allan Warchot, NTG Medical Entomology Branch (Biting Insects)
- Bob Alford (European Cultural Heritage)
- Megan Mebason, Austral Archaeology (Indigenous Cultural Heritage)
- Preston Adams, SVT (Noise)
- Andrew Leedham, Connell Wagner (Traffic and Transport)

Abbreviation	Term
AADT	Annual Average Daily Traffic
AAPA	Aboriginal Areas Protection Authority
AASS	Actual Acid Sulphate Soils
ACM	Asbestos Containing Material
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AIMS	Australian Institute of Marine Sciences
ALARP	All as Low As Reasonably Possible
ANZECC	Australian and New Zealand Environment and Conservation Council
ARCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AQIS	Australian Quarantine Inspection Services
ARI	Average Recurrence Interval
ASS	Acid Sulphate Soils
AST	Above Ground Storage Tank
BFV	Barmah Forest Virus
BoM	Bureau of Metrology
BOOT	Build Own Operate and Transfer
BTEX	Benzene, Toluene, Ethyl-benzene, Xylenes
CAMBA	China Australia Migratory Bird Agreement
CB	Central Business
CBD	Central Business District
CBR	California Bearing Ratio
CDU	Charles Darwin University
CEMP	Construction Environmental Management Plan
CH ₄	Methane
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CSA	Contaminated Site Assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DB	Decibels
dB(A)	Weighted value of noise levels to account for the lower ability of the human ear to hear low frequency noise compared to high frequency noise

Abbreviation	Term
DCC	Darwin City Council
DCEC	Darwin Conference and Exhibition Centre
DCW	Darwin City Waterfront
DCWR	Darwin City Water Redevelopment
DEH	Department of Environment and Heritage (Commonwealth)
DEMP	Demolition Environmental Management Plan
DHAC	Darwin Harbour Action Committee
DHRPM	Darwin Harbour Regional Plan of Management
DIPE	Department of Infrastructure, Planning and Environment
DLPE	Department of Lands, Planning and Environment
DOTARS	Department of Transport and Regional Services
EARR	Environmental Assessment Report and Recommendations
EIA	Environmental Impact Assessment
EIL	Ecological Investigation Levels (for contaminated site assessment)
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EO	Explosive Ordnance
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation Act 1999
EPHC	Environment Protection and Heritage Council
EPO	Environment Protection Objective
ESCP	Erosion and Sediment Control Plans
ESD	Ecologically Sustainable Development
GHG	Greenhouse Gas
GMW	Groundwater Monitoring Well
G-tek	G-tek Australia Pty Ltd
HAT	Highest Astronomical Tide
HDPE	High Density Polyethylene
HIL	Health Investigation Levels (for contaminated site assessment)
IMO	International Maritime Organisation
ISPS	International Ship and Port Facility Security
IUCN	World Conservation Union (formerly International Union for the Conservation of Nature)
JAMBA	Japan Australia Migratory Bird Agreement

Abbreviation	Term
kn/hr	Knots (Nautical) per hour
KMP	Key Management Plan
KUNV	Kunjin Virus
L ₉₀	Noise level which is exceeded for 90% of the measured period
LAT	Lowest Astronomical Tide
LOPA	Layer of Protection Analysis
LPG	Liquid Petroleum Gas
LUO	Land Use Objectives
MEB	Medical Entomology Branch (of the Northern Territory Department of Health and Community Services)
MVEV	Murray Valley Encephalitis Virus
N	Nitrogen
NA	Not Applicable
NEPM	National Environmental Protection Measure
NES	National Environmental Significance
NFI	Naval Fuel Installation
NMP	Noise Management Plan
NO _x	Nitrogen Oxides
NO ₂	Nitrogen Dioxide
NOI	Notice of Intent
NPI	National Pollutant Inventory
NSESD	National Strategy of Ecologically Sustainable Development
NT	Northern Territory
NTG	Northern Territory Government
O ₃	Ozone
ODS	Ozone Depleting Substance
OEH	Office of Environment and Heritage
OH&S	Occupational Health and Safety
OSCP	Oil Spill Contingency Plan
P	Phosphorous
PAH	Poly Aromatic Hydrocarbons
PASS	Potential Acid Sulphate Soils
PER	Public Environment Report
PHA	Preliminary Hazard Analysis

Abbreviation	Term
PM _{2.5}	Particulate Matter with a Aerodynamic Diameter of 2.5 Micrometres or Less
PM ₁₀	Particulate Matter with a Aerodynamic Diameter of 10 Micrometres or Less
Ppm	Parts per Million
Ppt	Parts per Thousand
PSH	Phase Separated Hydrocarbons
PSP	Port Security Plans
QRA	Quantitative Risk Assessment
RAN	Royal Australian Navy
RAP	Remediation Action Plan
RRV	Ross River Virus
SMP	Site Management Plan
SO _x	Sulphur Oxides
SO ₂	Sulphur Dioxide
TBT	Tri-butyl Tin
TDS	Total Dissolved Solids
THS	Territory Health Services
TNT	Trinitrotoluene
TPH	Total Petroleum Hydrocarbons
TSHD	Trailer Suction Hopper Dredge
TSS	Total Suspended Solids
URS	URS Australia Pty Ltd
UST	Underground Storage Tank
UXO	Unexploded Ordinance
VIA	Visual Impact Assessment
VOC	Volatile Organic Compound
VPD	Vehicles per Day
WM&PC	Waste Management and Pollution Control Act 1998
WWII	World War Two

-
- Aboriginal Areas Protection Authority. *Sacred Sites Register*. Extract.
- Ahern CR, Ahern MR, and Powell (1998). *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998*. Department of Natural Resources, Indooroopilly, Queensland, Australia. DNRQ980124.
- Alford, Bob. *Darwin's Air War*. Aviation Historical Society of the NT. 1992.
- Alford, Bob. *A Heritage Assessment of the Naval Oil Fuel Installation, Stokes Hill, Darwin*. For GHD. 2002.
- Alford, Bob. *A Heritage Assessment of the former Vestey's Siding at Salonika, Darwin, NT*. For Osborne Family Holdings. April 2003.
- Alford, Bob. *A Report on the Salvage and Documentation of Artefact Material at Lot 6846 Town of Darwin*. For Matthews Kapetas Erlich Architects. 2002.
- Alford, Bob. *Southport - An Historical Overview*. For Heritage Conservation Branch, Dept. of Lands, Planning and Environment. March 2001.
- Alford, Bob. *A Report on the Potential of Select World War II Heritage Sites in the Areas of Tourism and Recreation*. For Parks and Wildlife Commission NT (via Deputy Chief Minister, Hon. Mike Reed MLA). 2000. *
- ANCA (1997) *A Directory of Important Wetlands in Australia* (2nd Edition) pp168-170
- Booth, R, Harwood, RK and Mangion, CP (2001). Field Key for the Monsoon Rainforest Flora of the Darwin Region. Northern Territory Botanical Bulletin, No. 28. Parks and Wildlife Commission of the NT. NTU Press.
- Australia ICOMOS. 1999. *Australia ICOMOS charter for the conservation of places of cultural significance [the Burra Charter]*. Australia ICOMOS, Canberra.
- Australian Heritage Commission. *Register of the National Estate*. Extracts of entries various.
- Australian War Memorial. *Enemy Air Raids on the Australian Mainland - Northern Territory - "Darwin Raids"*
- Bartlett, Mike. *Port of Darwin 150 Years*. 3 Vols. Darwin Port Authority. 1990.
- Bourke, P. 2000. *Late Holocene Indigenous Economies of the Tropical Australian Coast: An Archaeological Study of the Darwin Region*. Unpublished PhD Thesis, Northern Territory University.
- Brocklehurst, P and Edmeades, B (2001.) *The Mangrove Communities of Darwin Harbour*. Resource Capability Assessment Branch Technical Memorandum No 96/9. Department of Lands, Planning and Environment, Darwin NT.
- Buchanan, Sir George KCIE. *Report by Sir George Buchanan K.C.I.E., on the Ports of North and North-*
-

-
- Western Australia*. Victorian Government Printer. 30 April 1926.
- Burns, T. 1997a. *A report on Aboriginal Shell Midden Sites at Winnellie, Darwin Harbour*. Report prepared for the Department of Lands Planning and Environment.
- Burns, T. 1997b. *An archaeological report on results of an Aerial Survey of Darwin Harbour*. Report prepared for the Department of Lands Planning and Environment.
- Burns, T. 1996. *The Northern Territory Archaeological Survey Stage 1, Darwin Catchment Region*. Unpublished Report to the Australian Heritage Commission.
- Burns, T. 1994. *Mound Over Matter*. Unpublished Honours Thesis, Northern Territory University.
- Cannon, Michael. *The Exploration of Australia*. Readers Digest. 1999.
- Carment, David. *Looking at Darwin's Past. Material Evidence of European Settlement in Tropical Australia*. North Australian Research Unit. 1996.
- Carment, D, Maynard, R and Powell, A. (Eds.) *Northern Territory Dictionary of Biography, Volume 1: To 1945*. NT University Press. 1990.
- Carment, David; Wilson, Helen; and James, Barbara. *John George Knight: A Biography and Architectural Assessment*. For Conservation Commission of the NT. 1992.
- Chatto, R. (2003). *The distribution and status of shorebirds around the coast and coastal wetlands of the Northern Territory*. Park and Wildlife Commission of the Northern Territory, Technical Report 73.
- Christidis, L. & Boles, W.E. (1994). *The Taxonomy and Species of Birds of Australia and its Territories*, Monograph No. 2. Royal Australasian Ornithologists Union, Melbourne.
- Cilek, J. E., Kline, D. L., and Hallmon, C. F., (2003), *Evaluation of a novel removal trap system to reduce biting midge (Diptera: Ceratopogonidae) populations in Florida backyards*, *Journal of Vector Ecology* 28 (1): 23-30.
- Clinch, M. (ed) 1999. *The Old Darwin Port Area, Heritage and History Notes*. A Report to the Northern Territory Historical Society.
- Clinch, M. A. *The Old Darwin Port Area Heritage and History Notes*. Historical Society of the NT. 1999.
- Clinch, M. A. *Notes on the Historic Walkway to the Port: Its History Name Fabric and Recognition*. c. 1998.
- Cogger H G (1996) *Reptiles and Amphibians of Australia*. Reed Books, Sydney.
- Commonwealth Department of Works. *Port of Darwin Development. A review of a report upon the development of port and harbour facilities at Darwin*. For Department of National Development. 1969.
- Commonwealth of Australia (1999) *Environmental Protection and Biodiversity Conservation Act 1999*.
-

Commonwealth of Australia Act 91.

Conigrave, C. P. *North Australia*. Jonathon Cape. 1936.

Conservation Commission of the NT. *Signs of History*. For 1992 War Service Memorial Year. 1992.

Conservation Commission of the NT. *Trails of History*. For 1992 War Service Memorial Year. 1992.

Daly, Dominic Mrs. *Digging, Squatting and Pioneering Life in the Northern Territory of South Australia*. Sampson Low, Marston, Searle & Rivington. 1887. (Facsimile edition by Hesperian Press. 1984).

Darwin Port Authority Board. *Port Darwin Development*. Information booklet. 1987.

Debenham, M. L., (1983), *Australasian species of the blood feeding Forcipomyia subgenera Lasiohelea Dacnoforcipomyia (Diptera: Ceratopogonidae)*, *Australian Journal of Zoology Supplementary Series* 95, pp. 1 - 66.

De La Rue, Kathy. *An Historical Geography of Darwin*. For National Trust (NT). 1988.

Department of Environment (DOE), Western Australia (2003). *Acid Sulfate Soil Guideline Series – Acid Sulfate Soils and groundwater investigation*.

Department of Health & Community Services and Darwin City Council, Task Force Review (1989), *Mosquito control measures in Darwin*, DH&CS Darwin, NT.

Department of Infrastructure, Planning and Environment (2001) *Oil Spill Response Atlas*.

Department of Infrastructure, Planning and Environment (2004) *Making Darwin Harbour Mangroves a Conservation Zone*. www.nt.gov.au/environment/mangroves

Dermoudy, Peter and Cook, Penny. *East Point. A History of the Military Precinct, East Point, Darwin*. National Trust (NT) and Royal Australian Artillery Association. 1992.

Dermoudy, Peter. *Wartime Tanks and Tunnels of Darwin*. 1984.

Dermoudy, Peter. *Steam Pump House. Draft Conservation Management Plan*.

For Conservation Commission of the NT. C. 1998.

Dunlop, C (ed) (2003) *Checklist of Vascular Plants of the Northern Territory, Australia*. Conservation Commission of the Northern Territory.

Dyce, A., & Wellings, G. (1998), *Culicoides of Australasia (Morphology-Taxonomy-Systematics-Biogeography & Techniques)*. A Manual in four parts I-IV. National Arbovirus Monitoring Program, Gosford *Culicoides* Workshop 27-29 October 1998.

EcoSystems (1993) *The Mangrove Community. Darwin South Stage 1 Environmental Studies: Flora*. Report to Department of Transport and Works.

Environment Australia 2003. *Threatened species*. www.biodiversity.environment.gov.au

-
- EPBC (1999) *Commonwealth Environmental Protection and Biodiversity Conservation Act- Threatened Flora*.
- Estburgs, Elizabeth. Fort Hill Graves. *Lone Graves Survey of the Northern Territory*. Forrest, Peter. *Port Darwin Chronology*. 1992.
- Evans Ogden, L.J. (1996) *Collision Course: The Hazards of Lighted Structures and Windows to Migrating Birds*. World Wide Fund for Nature. Canada
- Evans, R. (undated) *Tropical Cyclone Climatology of the Northern Region*. Bureau of Meteorology, Darwin.
- Fogarty, P, Howe, D and Dunlop, C (1979) *The Land Resources of the Darwin Area*, Land Conservation Unit Technical Report No LC79/5. Conservation Commission of the Northern Territory, Darwin.
- Forster, Pat. *The Navy in Darwin. 1941-1943*. Museums and Art Galleries of the Northern Territory. 1992.
- Fysh, Sir Hudson. *Qantas at War*. Angus and Robertson. 1968.
- Garnett, S.T. and Crowley, G.M. (2000). *The Action Plan for Australian Birds*. Environment Australia: Canberra.
- GHD-Macknight (1997). Darwin Harbour wave study. Report to Bechtel Australia Pty Ltd.
- Goyder, G. W. *Diary of Surveyor General Goyder, 5th February, 1869*. Held NT Library
- Goyder, G.W. *Survey of the Northern Territory*. South Australian Parliamentary Papers. No. 128. 23 November 1869. Held by NT Library, NAC.
- Greening Australia/DIPE (1991) *Draft Remnant Vegetation Mapping – Darwin Region*.
- Greening Australian Northern Territory (unpublished) *Register of Significant Trees of the Darwin Region*.
- Greening Australia (NT) Inc. *Significant Tree Register*. Extracts various.
- Gregory, R. 1996. *Seashells by the Seashore: A Draft Management Strategy for Middens in the Darwin Region*. Heritage Conservation Branch, Department of Lands Planning and Environment.
- Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland* (1998). Acid Sulfate Soil Advisory Committee.
- Guse, Daryl. *An Archaeological Investigation of the Historical “Travellers Walkway”, Darwin City, Northern Territory*. For Matthews Kapetas Erlich Architects. 1996.
- Gunn, John. *The Defeat of Distance. Qantas 1919-1939*. University of Queensland Press. 1985.
- Hannan, Agnes. *All Out! The effects of evacuation and land acquisition on the Darwin Chinese 1941-1954. The Territory at War*. Australia Remembers Committee (NT). 1995.
-

-
- Hanley, J.R. and Caswell, G.M. (1995). *East Arm Port – Stage 1. Water Quality Monitoring Program. Report on Setup Phase and Baseline Data Collection*. Marine Ecology Technical Report 93/2.
- Harney, E. W. (Bill). *Brimming Billabongs*. Robert Hale. 1963.
- Harvey, J. Y. *Australian Railway Historical Society Bulletin*. No. 431. September 1973.
- Harvey, J. Y. *The Never Never Line*. Hyland House. 1987.
- Haultain, C. T. G. *Watch off Arnhem Land*. Roebuck. 1971.
- Hearne, D (1975) *Trees for Darwin and Northern Australia*. Department of Agriculture, Forestry and Timber Bureau. Australian Government Publishing Service, Canberra.
- Heritage Advisory Council. *Northern Territory Heritage Register*, Extracts various.
- James, Barbara. *Some Options for Telling the Story of the Port Darwin Wharf Precinct*. For Heritage Unit, Dept. Of Lands, Planning and Environment. 1999.
- Hill, Ernestine. *The Territory*. Angus & Robertson. 1995.
- Hiscock, P. 1996. *Archaeological Evidence for Environmental Change in Darwin Harbour*. In Hanley, J. and Gaswell, G.(eds). *The Marine Flora and Fauna of Darwin Harbour, Northern Territory*. Museums and Art Galleries of the Northern Territory.
- Hiscock, P. and Huges, P. 1996. *Prehistoric and World War Two Use of Shell Mounds in Darwin Harbour*. Unpublished Manuscript held by the Archaeology Section, Museums and Art Galleries of the Northern Territory, Darwin.
- Historical Society of the NT. *Looking Back The Northern Territory in 1888*. 1988.
- Hordern, Marsden. *Mariners be Warned! John Lort Stokes and HMS Beagle in Australia 1837-1843*. Melbourne University Press. 1989.
- Horton, David. (Ed.) *The Encyclopaedia of Aboriginal Australia*. The Australian Institute of Aboriginal and Torres Strait Islander Studies. 1994.
- ICOMOS Australia. *The Burra Charter. The ICOMOS Australia Charter for Places of Cultural Significance*. 1999.
- IUCN 2001. *IUCN Red List Categories: Version 3.1*. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.
- IUCN (2000). *Threatened Species – Plants*. Parks and Wildlife Commission of the NT. www.nt.gov.au
- James, Barbara. *No Man’s Land*. Collins 1989
- Jones, Timothy. *The Chinese in the Northern Territory*. NTU Press. 1997.
-

-
- Jones, Timothy. *Pegging the Northern Territory. A history of mining in the Northern Territory. 1870-1946*. Government Printer, Darwin. 1987.
- Kelsey, Dudley. (Ed. Ira Nesdale) *The Shackle*. Lynton Publications. 1975.
- Kerr, James Semple. *The Conservation Plan*. For National Trust . 1996.
- Kerr, Margaret Goyder. *The Surveyors*. Rigby. 1977.
- Lands and Survey, Department of. *G.W.Goyder. Leader of the Epic Northern Territory Survey Expedition of 1869. Biographical Notes on Goyder's Survey Expedition*. Mapping Division. 1984.
- Lee, D. J. (1944), *An Atlas of the Mosquito Larvae of the Australasian Region. Tribes-Megarhinini and Culicini*. Department of Zoology, University of Sydney.
- Lee, D. J. & Woodhill, A. R. (1944), *The Anopheline Mosquitoes of the Australasian Region*. Publications of the University of Sydney, Department of Zoology. Monograph No. 2.
- Lee, D. J., Hicks, M. M., Griffiths, M., Russell, R. C., & Marks, E. N. (1982), *The Culicidae of the Australasian Region Vol. 2*, Commonwealth Department of Health & Commonwealth Institute of Health incorporating School of Public Health and Tropical Medicine, Monograph Series, Entomology Monograph No. 2.
- Lee, D. J., Hicks, M. M., Griffiths, M., Russell, R. C., & Marks, E. N. (1984), *The Culicidae of the Australasian Region Vol. 3*, Commonwealth Department of Health & Commonwealth Institute of Health incorporating School of Public Health and Tropical Medicine, Monograph Series, Entomology Monograph No. 2.
- Lee, D. J., Hicks, M. M., Griffiths, M., Debenham, M. L., Bryan, J. H., Russell, R. C., Geary, M., & Marks, E. N. (1987), *The Culicidae of the Australasian Region Vol. 4*, Commonwealth Department of Health & School of Public Health and Tropical Medicine, Monograph Series, Entomology Monograph No. 2.
- Lee, D. J., Hicks, M. M., Debenham, M. L., Griffiths, M., Marks, E. N. Bryan, J. H., & Russell, R. C., (1989), *The Culicidae of the Australasian Region Vol. 7*, University of Queensland and University of Sydney in collaboration with Commonwealth Department of Community Services and Health, Monograph Series, Entomology Monograph No. 2.
- Lewis, Tom. *Wrecks in Darwin Waters*. Turton & Armstrong. 1992.
- Lewis, Tom. *A War at Home*. Tall Stories. 1999.
- Liehne, P. F. in consultation with Medical Entomology Branch (1985), *Mosquito and Biting Midge Investigations, Palmerston 1982-85*, Palmerston Development Authority.
- Lockwood, Douglas. *The Front Door. Darwin 1869-1969*. Rigby. 1984.
- Lockwood, Douglas. *Australia's Pearl Harbour*. Cassell Australia. 1966.
- McCarthy, Sophie. *World War II Shipwrecks and The first Japanese Air Raid on Darwin 19 February*
-

-
1942. Technical Report Series No. 1. NT Museum of Arts and Sciences. 1992.
- McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (1990). *Australian Soil and Land Survey Field Handbook, 2nd ed.*, Inkata Press, Melbourne.
- McInnis, R. A. *The Diary of R. A. McInnis Darwin 1940-44*. Department of Lands. 1981.
- McInnis, R. A. *A Town Planning Scheme for the Town of Darwin*. December 1940.
- McInnis, R. A. *The Post War Town Planning Scheme for the Town of Darwin*. December 1944.
- McLaren, Glen and Cooper, William. *Distance, Drought and Dispossession: a history of the Northern Territory Pastoral Industry*. NTU Press. 2001.
- McLaren, Jack. *My Crowded Solitude*. Unwin Books. 1926.
- Marquis-Kyle, Peter and Walker, Meredith. *The Illustrated BURRA Charter*. Australia ICOMOS. 1996.
- Merianos, A., Farland, A. M., Patel, M., Currie, B., Whelan, P. I., Dentith, H. &
- Smith, D. (1992), *A concurrent outbreak of Barmah Forest and Ross River virus disease in Nhulunbuy, Northern Territory*, *Comm Dis Intel*, vol. 16, no. 6, pp. 110-111.
- Pedersen, B. n. d. Darwin Wharf and Port Precinct Study.
- Morris, John. *A Brief History of Larrakia - Tiwi Feuds*. Historical Society of the Northern Territory. Circa 1965.
- National Trust of Australia (Northern Territory) *Register of Significant Places*. Extracts various.
- Northern Territory Government (2003). *Guidelines for preparation of an Environmental Impact Statement on the proposed Darwin City Water Front Redevelopment at the Darwin Wharf*.
- Northern Territory Government (1996) *Central Darwin Land Use Objectives*. NT Govt. Printer
- Northern Territory Government, Department of Lands, Planning and Environment (2001) *Oil Spill Response Atlas*
- Northern Territory Government, Department of Lands, Planning and Environment (2003) *Waterfront Revitalisation Concept Plan*.
- Northern Territory Library. Ephemeral files. *Goyder, Stokes Hill*.
- Northern Territory News. 25 March and 1 April 1977 editions. *The Way We Were/Looking at the NT's Past* series. Peter Forrest.
- Northern Territory News. Various editions.
- Northern Standard newspaper. Various editions.

-
- Northern Territory Times and Gazette. Various editions, 1873-1889.
- Oil Fuel Installation. *The Naval O.F.I. Darwin N.T. From April 1926 to 1976*. A photographic record compiled by Jim Keddie.
- Padovan, A. (2000). *National Pollution Inventory. Diffuse Water Emissions Study – Darwin Harbour and Surrounding Catchments*. Northern Territory Government, Department of Lands Planning and Environment, Report No. 30/2000D.
- Padovan, A. (2001). *The Quality of Run-Off and Contaminant Loads to Darwin Harbour*. Northern Territory Government, Department of Lands Planning and Environment, Report No. 29/2000D.
- Panton, WJ (1993) *Changes in post World War 2 distribution and status of monsoon rain forests in the Darwin area. Australian Geographer 24(2):50-58*
- Parry, D.L. and Munksgaard, N.C. (1995). *Physiochemical Baseline Data for Darwin Harbour-East Arm Port Development*. Northern Territory University, Darwin NT.
- Parkhouse, T. A. *Native Tribes of Port Darwin and its Neighbourhood*. In ANZAAS publication. 1895.
- Parks and Wildlife Commission of the Northern Territory (1999) *Charles Darwin National Park Plan of Management*. Parks and Wildlife Commission of the Northern Territory
- Parks and Wildlife Commission of the Northern Territory (2001). *The Territory Wildlife Regulations in force under the Territory Parks and Wildlife Conservation Act 2001*. Parks and Wildlife Commission of the Northern Territory.
- Parliament of the Commonwealth of Australia. *Northern Territory Railways and Ports - Reports of the Royal Commission 1914*. Government Printer, Victoria. 1914.
- Parliamentary Standing Committee on Public Works. *Report relating to the proposed Development of the Port of Darwin*. Commonwealth Government Printing Office. 1970.
- Parliamentary Standing Committee on Public Works. *Minutes of Evidence relating to the Proposed Extension of Wharf Facilities at Darwin, N.T.* Commonwealth Government Printer. 1955.
- Pearce, Howard. Alice Springs - Darwin Railway. Heritage Sites Impact Statement. November 1983.
- Pederson, Barbaramary. Darwin Wharf and Port Precinct Study. For Heritage Advisory Council. 2000.
- Pederson, Barbaramary. *Naval Oil Tunnels and Naval Oil Tanks*. For Heritage Advisory Council. 2000.
- Peterson, Nicolas. *Tribes and Boundaries in Australia*. Australian Institute of Aboriginal Studies. 1976.
- Phelts, Bev. *Stokes Hill Power Station: The Beginning to the End*. 1997. Pike, Glenville. *Frontier Territory*. Cosmos. 1972.
- Powell, Alan. *The Shadow's Edge. Australia's Northern War*. Melbourne University Press. 1988.

-
- Powell, Alan. *John Lort Stokes and the men of the Beagle - Discoverers of Port Darwin*. Library Services of the NT. Occasional Paper No. 1. 1986.
- Powell, Alan. *Far Country. A Short History of the Northern Territory*. Melbourne University Press. 1982.
- Price, O, Bach, C, Shapcott, A and Palmer, C (1988) *Design of Reserves for Mobile Species in Monsoon Rainforests. Final Report to Environment Australia for NRSP Project No. 602*. May 1988. Parks and Wildlife Commission of the Northern Territory.
- PWCNT (2003). management plan for Charles Darwin National Park
- Queensland Acid Sulfate Soil Technical Manual 2002, Soils Management Guidelines*, Queensland Acid Sulfate Soil Management Advisory Committee.
- Raupach, M. and Tucker, B.M. (1959). *The field determination of soil reaction*. Journal Australian Institute of Agricultural Science 25: 129-33.
- Rayner, Robert. *The Army and the Defence of Darwin Fortress*. Rudder Press. 1995.
- Rayner, Robert. *Darwin and Northern Territory Force*. Rudder Press. 1999.
- Richardson, N. 1996. *Archaeological Site Survey and Documentation - Darwin Region*. A report to the Australian Heritage Commission.
- Rohe, D. L. & Fall, R. R. (1979), *A miniature battery powered CO₂ baited light trap for mosquito borne encephalitis virus surveillance*, Bull Soc Vector Research, 4, pp. 24-27.
- Russell, R. C., (1986), *Dispersal of the arbovirus vector Culex annulirostris Skuse (Diptera: Culicidae) in the Murray Valley of Australia*, Gen Appl Ent, 18.
- Russell-Smith, J and Bowman, DMJS (1992) *Conservation of monsoon rainforest isolates in the Northern Territory*. Biol. Conserv. 59: 51-63.
- Rolls, Eric. *Sojourners. The epic story of China's centuries-old relationship with Australia*. University of Queensland Press. 1992.
- Russell, R. C., (1987), *Seasonal abundance, longevity and population age composition of potential malaria vectors in northern and southern Australia*. Aust. J. Zool.35:289-306.
- Sager, Eric. *Discovering Darwin the 1930s in Memory and History*. Historical Society of the NT. 1993.
- Searcy, Alfred. *In Australian Tropics*. George Robertson & Co. Pty. Ltd. 1909.
- Shivas, M., Whelan, P. I., & Webb, C. (1997), *The characterization of emergence sites of the biting midge Culicoides ornatus (Diptera: Ceratopogonidae) in mangroves near Darwin, NT, Australia*, in *Arbovirus Research in Australia, vol. 7*, Proceedings of the Seventh Arbovirus Research in Australia Symposium, & Second Mosquito Control Association of Australia Conference, 1996, pp. 275-279.
- Shivas, M. (1999), *The larval biology of Culicoides ornatus Taylor in mangroves near Darwin, NT*. PHD. Faculty of Science, Northern Territory University Darwin.
-

Shivas, M. (2001), Hervey Bay Biting Midge Review 2001. Previous studies and research priorities. Prepared for the Hervey Bay City Council, QLD.

Shivas, M., and Whelan, P. I. (2001), *Biting midge research project* (Study undertaken on behalf of Department of Lands, Planning and Environment). Territory Health Services.

Smith, N M (2002) *Weeds of the Wet/Dry Tropics of Australia. A field guide*. Environment Centre, NT Inc.

South Australian Parliament Reports. *Report on the Northern Territory, March 31st, 1885, 30th June 1885, and 31st December, 1885*. Held NTAS.

South Australian Parliament Reports. *Government Resident's Report for the Year 1886, 1888, 1889 and 1890*. Held NTAS.

Sowden, William J. *The Northern Territory As It Is*. W. K. Thomas. 1882 (Reprinted by NT Government Printer). c. 1983.

Standfast, H., Fanning, I., Maloney, L., Purdie, D., and Brown, M. (2003), *Field evaluation of Bistar 80 S.C. as an effective insecticide harbourage treatment for biting midges and mosquitoes infesting peri-domestic situations in an urban environment*. *Bulletin MCAA* vol. 15; 2, pp 19-33.

Stevenson, Ian. *The Line That Led to Nowhere*. Rigby. 1979.

Stokes, John Lort. *Discoveries in Australia*. Vols I and II. T & W Boone. 1846. (Facsimile edition by Libraries Board of South Australia. 1969).

Strahan R (1995) *The Mammals of Australia*. Reed Books, Sydney.

Tai, K. S., Whelan, P. I., Patel, M. S. & Currie, B. (1993), *An outbreak of epidemic polyarthrits (Ross River virus disease) in the Northern Territory during the 1990-1991 wet season*. *Medical Journal of Australia*, vol. 158, pp. 522-525.

Tindale, Norman. *Aboriginal Tribes of Australia*. University of California Press. 1974.

TPWC (2000) *Territory Parks and Wildlife Conservation Act. Section 27*, Northern Territory Government.

Tyler, M and Davies, M. (1986), *Frogs of the Northern Territory*, Government Printer, Northern Territory.

URS Australia Pty Ltd 2003, *Darwin Wharf Redevelopment Contamination and Geotech Assessment- Phase I*, Unpublished report prepared by URS Australia Pty Ltd for the Northern Territory Government, Department of Infrastructure, Planning and Environment, Construction Division.

URS (2003). *Detailed Site Contamination Investigation and Field Geotechnical Report – Darwin Waterfront Project*. Unpublished draft report prepared by URS Australia Pty Ltd for the Northern Territory Government, Department of Infrastructure, Planning and Environment, Construction Division.

-
- Welke, Adrian and Wilson, Helen. *Darwin Central Area Heritage Study*. For Conservation Commission of the NT. 1993.
- Whelan, P. I. (1988a), *Common mosquitoes in the NT*, NT Department of Health & Community Services.
- Whelan, P. I. (1988b), *Construction practice near tidal areas in the NT. Guidelines to prevent mosquito breeding*, NT Coastal Management Committee.
- Whelan, P. I. (1991a), *Biting midge investigations near Darwin and their implications for urban planning*, in *Proc. Nat. Conf. on Biting Midges*, Surfers Paradise, Qld, 8-9 Feb, 1990, pp. 39-50.
- Whelan, P. I. (1998a), *Summary of the Biology of Selected Culicoides Species in the Top End of the Northern Territory*. Medical Entomology Branch Handout, Territory Health Services.
- Whelan, P. I. (1998b), *Seasonal Prevalence of Selected Culicoides Species in the Top End of the NT*. Medical Entomology Branch Handout, Territory Health Services.
- Whelan, P. I. (2003a), *Biting midges or "sand flies" in the Northern Territory*. NT Disease Control Bulletin Vol 10, No. 3, September 2003.
- Whelan, P. I. (2003b), *Personal Protection from Mosquitoes and Biting Midges in the NT*, Department of Health and Community Services.
- Whelan, P.I., & Hayes, G.A., (1993), *Biting insect investigations Darwin South, Stage I* (Study undertaken on behalf of the Dept of Lands, Housing and Local Government), NT Dept of Health & Community Services.
- Whelan, P. I., Merianos, A., Patel, M., Tai, K. S. & Currie, B. (1993), *The epidemiology of arbovirus infection in the Northern Territory 1980-92*, Arbovirus Research in Australia, vol. 6, Proc. of the 6th Arbovirus Conference, 1993.
- Whelan, P. I. & Weir, R. P. (1993), *The isolation of alpha and flavi viruses from mosquitoes in the Northern Territory 1982-1992*, Arbovirus Research in Australia, vol. 6, Proceedings of the 6th Arbovirus Conference, 1992.
- Whelan, P. I., Montgomery, B.L., Hayes, G.A., Nowland, R.A. & Love, B.L. (1994), *Biting insect investigations Darwin South Stage II. Twelve month baseline study of species, abundance and distribution of biting insects in the Darwin South area*, Medical Entomology Branch report.
- Whelan, P. I., Hayes, G., Montgomery, B. L. (1997a), *Biting midge surveillance in Darwin Harbour, Culicoides ornatus (Diptera:Ceratopogonidae) abundance and dispersal*, in Arbovirus Research in Australia, vol. 7, Proceedings of the Seventh Arbovirus Research in Australia, & Second Mosquito Control Association of Australia Conference, 1996, pp. 326-336.
- Whelan, P.I., Merianos, A., Hayes, G., & Krause, V. (1997b), *Ross River virus transmission in Darwin, Northern Territory, Australia*, in Arbovirus Research in Australia, vol. 7, Proceedings of the Seventh
-

Arbovirus Research in Australia Symposium, & Second Mosquito Control Association of Australia Conference, 1996, pp. 337-345.

Whelan, P.I., Love, B., Montgomery, B., Nowland, R., Carter, J., Hayes, G., (1998), *Durack (Fairway Waters) Development and Biting Insects May 1996 - April 1997*. (Study undertaken on behalf of Department of Lands, Planning and Environment). Territory Health Services.

Whelan, P.I., & Warchot, A. (2003), *Biting midge investigation Archer Sporting Complex, Palmerston August 2003*. Study undertaken for Palmerston City Council, Department of Health and Community Services.

Whelan, P.I., Krause, V., Lamche, G. & Kurucz, N. (2004), *Aedes aegypti mosquitoes, vectors for dengue, found in Tennant Creek-Elimination Campaign in Progress*. NT Disease Control Bulletin Vol 11,1, March 2004.

Wie, Ronda. *Nobody did not want to own us*. (Manuscript). 1990.

Wightman, G.M. (1989), *Mangroves of the Northern Territory*, Northern Territory Botanical Bulletin No. 7 (Conservation Commission, Palmerston, NT, now Parks & Wildlife Commission of the NT).

Wightman, G and Andrews, M (1989) *Plants of Northern Territory Vine Forests*. Conservation Commission of the Northern Territory. NT Govt Printer.

Wightman, G (1989) *Mangroves of the Northern Territory*. Northern Territory Botanical Bulletin 7:1-130

Wirth, W., & Hubert, A. (1989), *Culicoides of South East Asia*. The American Entomological Institute, Florida U.S.A.

Woinarski, J.C.Z, Brennan, K, Dee, A, Njudumul, J, Guthayguthay, P, Horner, P. (2000) *Further records of the false water rat Xeromys myoides from coastal Northern Territory*. Australian Mammalogy **21**: 221-223

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Basis of this Report

The methodology adopted and sources of information used by URS are outlined in this report.

The findings, opinions, conclusions and recommendations contained in this report are based upon data received from third parties and representatives of DIPE, information gained during site inspection and fieldwork, visual observation of conditions at the site, sampling and analysis of soil and groundwater, employee interviews and information obtained from government authorities' records.

URS has made no independent verification of the referenced information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions in that information.

In addition, the environmental and subsurface condition of and contamination impacts on the site have been drawn from information referenced in this report. Those investigations of environmental/subsurface conditions and contamination impacts at the site are subject to certain technical limitations and are not yet final. Accordingly, any changes to the results of those investigations may have an impact on the findings, opinions, conclusions and recommendations made in this report.

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