



Volume I (Chapters 1 to 6)



Draft Environmental Impact Statement/Environmental
Review and Management Programme for the Proposed
Wheatstone Project

July 2010

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1.0

Introduction



1.0 Introduction

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1.0 Introduction

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1.0 Introduction

1.1 Overview

Chevron Australia Pty Ltd (Chevron), as developer of the proposed Wheatstone Project (Project), proposes to construct and operate a 25 million tonne per annum (MTPA) Liquefied Natural Gas (LNG) plant and a domestic gas (domgas) plant near Onslow on the Pilbara coast (Figure 1.1). The development is proposed to be part of the Ashburton North Strategic Industrial Area (SIA) proposed by the Western Australian Government. The Project will initially produce gas from Petroleum Titles WA-253-P and WA-17-R, which are held 100 per cent by Chevron companies, and WA-16-R, which is held by Chevron companies and by Shell Development Australia.

Under an agreement signed in October 2009, third parties will also provide natural gas from Petroleum Title WA-356-P, to supply onshore Trains 1 and 2 of the Project. Hydrocarbons from further third-party Petroleum Titles may also supply gas to the Project; the plant will act as a processing hub to facilitate development of additional offshore gas resources in the Carnarvon Basin and potentially other areas, from both Chevron operated leases and those operated by other parties.

The Project will require the installation of gas gathering, processing and export facilities in Commonwealth and State waters and onshore. The initial development is expected to consist of two onshore LNG processing trains, each with a capacity of between 4 and 7 MTPA. An offshore platform will provide initial treatment of the gas and natural gas condensate (condensate), which will then be transported via a subsea pipeline to the onshore LNG processing facility. The resultant LNG and condensate will be exported to worldwide markets via both dedicated and spot-cargo vessels. Export product will be loaded onto medium to large capacity vessels docking regularly at a Product Loading Facility (PLF) adjacent to the processing facility. An additional three to four onshore trains may be added in future development.

The Project includes common user infrastructure that may be utilised by other proponents operating within the Ashburton North SIA. Common user infrastructure includes a Materials Offloading Facility (MOF), channel and turning basin, and an Australian Quarantine and Inspection Service (AQIS) area. The development of the Project as a 25 MTPA multi-train LNG facility reduces the potential requirement for future expansion of Chevron's gas-processing facilities in the Ashburton SIA, and lessens the need for future LNG-related port developments in the Pilbara.

Gas from the Project will be made available to the Western Australian domestic market. A domgas plant will be developed within the main complex and will comprise a series of processing trains and an onshore pipeline installation to connect to the Dampier-to-Bunbury Natural Gas Pipeline (DBNGP).

This Draft Environmental Impact Statement (EIS) and Environmental Review and Management Programme (ERMP), hereafter referred to as the EIS/ERMP, has been prepared by Chevron. Its purpose is to assess the potential environmental impacts relating to the Project. The EIS/ERMP has been prepared in consultation with the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) and the Western Australian Environmental Protection Authority (EPA). For the purposes of this document, the word "Project" is interchangeable with the word "Proposal", as used by the EPA, and also the term "controlled action" as defined under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Guidance from the EPA (June 2009) and DEWHA (August 2009), which came in the form of approval of the Environmental Scoping Document (Scoping Document) and included issues raised by stakeholders, has been used in its preparation. This approval document is included in Appendix A1. Chapter 5, *Stakeholder Consultation* provides details of stakeholder engagement.

At the request of the EPA, Chevron agreed to trial the implementation of a risk-based approach to the environmental assessment of the Project. The objectives and draft methodologies for risk-based Environmental Impact Assessment (EIA), described in the EPA draft guideline *Paper 10 Application of risk-based assessment in EIA 2009*, have been applied in preparation of this document. Requirements of the EPBC Act (Cth), and the Western Australian *Environmental Protection Act 1986* (EP Act), have also been taken into consideration. Further detail of the legislation, policies and guidelines applicable to the Project are included in Section 1.12.

1.1.1 Project Title

The formal title of the action is the Wheatstone Project, referred to as the Project. All associated offshore installation and onshore construction activities, as well as commissioning, operation and decommissioning activities undertaken by Chevron and its contractors are considered part of the proposed Project.

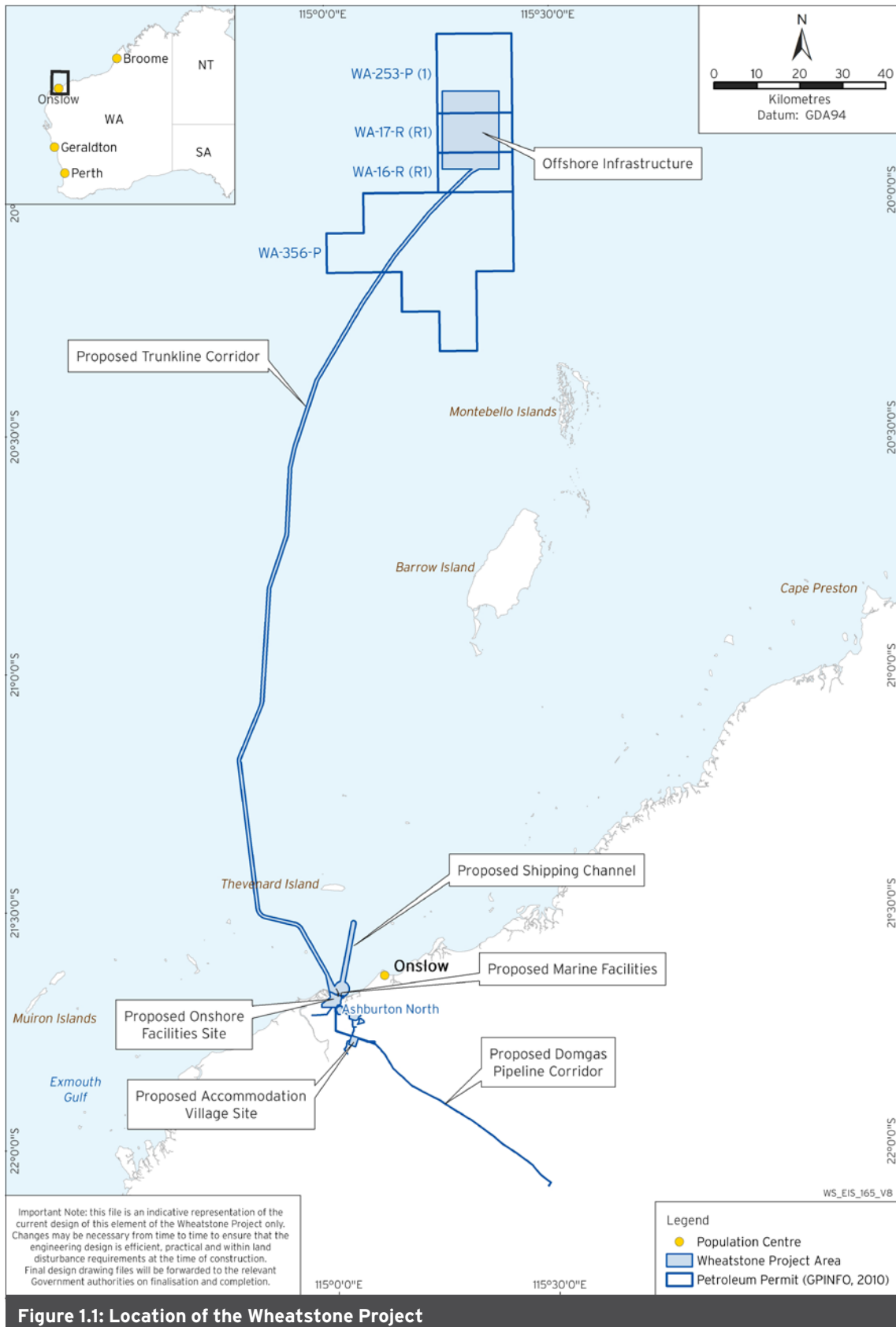


Figure 1.1: Location of the Wheatstone Project

1.1.2 Proponent Details

The proponent of the Project is Chevron Australia Pty Ltd.

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1.1.3 Chevron Australia Pty Ltd

Chevron Corporation is an integrated energy company whose businesses are involved in every aspect of the global crude oil and natural gas industry. In 2009, the Chevron Corporation companies produced 2.7 million net oil-equivalent barrels per day from operations around the world. As of March 2009, net production of natural gas was more than 141 Mm³ (5 billion cubic feet) per day.

Chevron Corporation's businesses also supports a network of more than 22 000 retail outlets on six continents and has invested in power generating facilities in the United States and across Asia. They employ a diverse and highly skilled global workforce of approximately 62 000 employees and about 5000 service station employees.

Chevron began exploration and production activities in Australia in 1951, when Chevron and Texaco began searching for oil in Western Australia (WA) under the Caltex banner. In 1952, Caltex and Ampol, an Australian petroleum company, formed West Australian Petroleum Pty. Ltd. (WAPET) to operate on their behalf. This venture made their first discovery, at Rough Range in WA, in 1953.

It was through WAPET that the Barrow Island Field was discovered in 1964. Production commenced in April 1967 and reached a peak of 50 000 barrels of oil per day in 1971. The Barrow Island operations have produced over 300 million barrels of oil since 1967 and loaded over 1000 tankers without a major environmental incident.

Importantly, Barrow Island is classified as an A-Class Nature Reserve for the protection of rare and endangered flora and fauna. It is rated as one of the most important wildlife refuges in the world with significant flora and fauna species. Chevron's environmental management of the island has received State, national and international recognition.

It was through WAPET that Chevron discovered the Gorgon gas field in 1981 and the Saladin oil field in 1985. Thevenard Island provides an island base for Chevron's facilities servicing Saladin and other nearby fields for the processing and storage of hydrocarbons. Chevron's operations have co-existed there with the Mackerel Island tourist resort since 1988.

In 1989, Chevron, along with partners in the North West Shelf Venture (operated by Woodside Energy Ltd.), began exporting LNG to neighbours in Asia, starting with Japan. Discoveries continued with more gas fields: Chrysaor in 1994 and 1995, Dionysus in 1996 and six more gas fields west of the central Gorgon area.

WAPET, with Chevron as technical adviser, continued as operator of the Barrow Island Joint Venture and Thevenard Island Joint Venture until 2000, when Chevron replaced WAPET as operator. Chevron and Texaco merged the following year.

In 2004, Chevron achieved a framework agreement with its Joint Venture Partners, Mobil Australia Resources Company Pty Ltd. (Mobil) and Shell Development (Australia) Pty Ltd (Shell), to develop the Gorgon LNG Project on Barrow Island. Chevron is the operator of the project and Chevron companies currently hold an approximate 47 per cent interest, while Mobil and Shell each hold 25 per cent. The remaining 3 per cent is shared by Osaka Gas Gorgon Pty Ltd, Tokyo Gas Gorgon Pty Ltd and Chubu Electric Power Australia Pty Ltd.

1.1.4 Wheatstone Project Objectives

The Project is aimed at bringing gas to international and domestic markets. It will be developed as a multiple-train gas project that will process gas for Chevron as well as third-party gas owners in the Carnarvon Basin and potentially other areas.

The primary objectives of the proposed Project are to:

- Commercialise the hydrocarbon resources within Petroleum Titles WA-253-P, WA-17-R, WA-356-P and WA-16-R, and efficiently and reliably recover these resources
- Manage all environmental, health, security and safety issues in accordance with Chevron Corporation standards and recognised global industry standards
- Create a processing hub to facilitate development of additional offshore gas resources in the Carnarvon Basin and other areas, from both Chevron operated leases and those operated by other parties

- Provide an acceptable return on investment
- Provide an alternative and reliable source of LNG to international markets along with an additional secure source of domestic gas for the local market.

1.2 Purpose and Scope of this Document

The purpose of this EIS/ERMP is to firstly describe the Project and its major components, regulatory requirements, and the existing marine, terrestrial and socio-economic environment. Secondly, the document identifies and assesses potential risks on the existing environment that may result from the Project during its lifecycle. Finally, this EIS/ERMP defines any planned mitigation and management controls required to reduce potential risks as a result of the Project.

The scope of this EIS/ERMP includes:

- Offshore production facilities, including wells, subsea installations, inter-field pipelines and offshore platforms in Petroleum Titles WA-253-P, WA-17-R, WA-356-P and WA-16-R
- An export pipeline to provide feed gas from the offshore production facilities to the onshore gas processing facility
- A gas processing facility, including LNG plant and domestic gas processing unit, LNG and condensate product storage, power generation, water supply, an accommodation village and associated support facilities
- Marine facilities including a shipping channel, MOF and PLF
- A multi-purpose infrastructure corridor that will incorporate the domestic gas pipeline connecting to the existing DBNGP.

A detailed project description is provided in Chapter 2, *Project Description*.

The scope of this document also includes an assessment of potential cumulative effects associated with both existing and reasonably expected projects located in, or in close proximity to the Project study area. Reasonably expected projects include those referred to either the State or Commonwealth governments.

Those items not considered in this scope include:

- Overseas and domestic fabrication yards
- Offsite quarries and waste disposal facilities
- Third-party gas supplier gas field wells, production facilities, pipeline tie-ins and waste disposal facilities.

1.3 Project Background

In August 2004, a significant gas discovery was made at the Wheatstone-1 well in Chevron's solely held WA-253-P Petroleum Title, located offshore approximately 225 km north of Onslow in WA. This complemented the discovery in 2000 of natural gas in Petroleum Title WA-17-R located approximately 10 km from WA-253-P.

Chevron declared its intention to develop an LNG and domgas project in March 2008. Since then, Chevron has completed a seven-well appraisal program to further understand the potential of Petroleum Titles WA-253-P and WA-17-R, the locations of which are detailed in Section 1.6. Third-party gas will also be processed by the first two Wheatstone LNG trains and by additional trains as they come online.

Referrals for the Project were submitted in September 2008 and included three alternative onshore site locations for further investigation. The EPA assigned an ERMP level of assessment in October 2008. This was followed by DEWHA deeming the Project to be a controlled action requiring assessment by an EIS. Further detail of the assessment process is included in Section 1.13.

Chevron submitted its Scoping Document for public review in April 2009. The Scoping Document was approved by the EPA in June 2009 and by DEWHA in August 2009. Table 1.1 provides a summary of the key EIS/ERMP milestones for the Project to date.

1.4 Current Status of the Wheatstone Project

The Project is currently undergoing Front End Engineering and Design (FEED), which commenced in 2009 and is planned for completion in 2011. Additional major project components for consideration include Final Investment Decision (FID), the commencement of offshore installation and early construction activities – all of which are scheduled for 2011, subject to the achievement of government and internal approvals.

An indicative schedule for the proposed development for the initial two LNG trains is provided in Figure 1.2.

1.5 Consequences of Not Proceeding

The consequences of not proceeding with the Project would be failure to meet the objectives detailed in Section 1.1.4. While not executing Wheatstone would eliminate any possible environmental impact, significantly increasing global requirements for LNG would remain. If future growth in energy demand could be satisfied through the increased consumption of coal, this would result in markedly higher

Table 1.1: Summary of Key Wheatstone Project Milestones

Date	Milestone
August 2004	Discovery of gas in Petroleum Title WA-253-P (Wheatstone-1 well)
March 2008	Announcement of Wheatstone greenfield development option
June 2008	Identification of three sites for further investigation, based on site screening study
September 2008	Referral submission including three alternate locations for further investigation
October 2008	EPA assigned an ERMP level of assessment
October 2008	DEWHA deemed the Project to be a controlled action to be assessed by an EIS
December 2008	Site screening and selection process completed
April 2009	Scoping Document approved for public review by EPA
June 2009	Scoping Document approved by EPA
August 2009	Scoping Document approved by DEWHA
Q3 2009	Commenced FEED
March 2010	Draft EIS/ERMP submitted to EPA/DEWHA
July 2010* (anticipated)	Draft EIS/ERMP approved for Public Review
Q1 2011 (anticipated)	Environmental Approvals Decision
2011*	FID
2015*	Upstream facilities construction completion
2016*	Downstream facilities construction completion (Trains 1 and 2)
2016*	First LNG production - Train 1
2016*	First LNG production - Train 2
2022*	Full LNG Capacity reached

* Dates are subject to change as the Project develops.

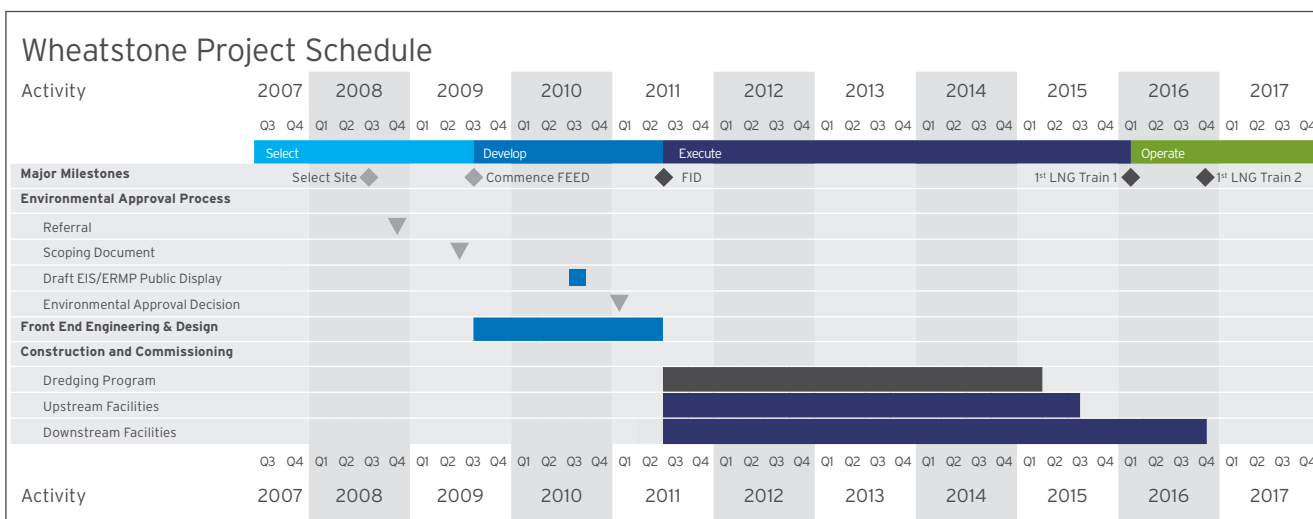


Figure 1.2: Indicative Schedule for Development of the Wheatstone Project (LNG Trains 1 and 2)

* Dates are subject to change as the Project develops.

** Project detailed design to continue after FID

greenhouse gas emissions. The International Energy Agency estimates that world energy demand will rise by roughly 40 percent by the year 2030, especially in Asia – a close market for Wheatstone LNG. The region is expected to account for 60 percent of the total growth in global energy demand through to 2030.

The primary consequence of not proceeding would be loss of economic benefits to the Pilbara region, to WA and to the nation. The short-term benefits of the Project include the creation of employment opportunities. The construction workforce is expected to be around 3000, although it could be as many as 5000. The Project is expected to create about 6500 direct and indirect jobs during the construction period, and result in locally purchased goods and services (local content).

With a predicted lifespan of between 30 and 50 years, the Project also holds significant medium-to-long-term benefits for WA. Western Australian consumers stand to benefit from more competitive domestic gas prices. The Project will also contribute towards providing a continuous and consistent gas supply to WA industries. A further key consequence is therefore the loss of a significant source of domestic gas supply to WA.

The consequences for the Pilbara region of the Project not proceeding include the loss of the above-mentioned jobs, as well as the loss of investments that would otherwise be made in local shared infrastructure, including road improvements and social infrastructure. It would hinder the creation of an LNG processing hub facilitating development of additional offshore gas resources and weaken the basis for common user infrastructure development in the area. Indirect economic benefits for regional companies both during the construction and operation phases of the Project would also be lost should the Project not proceed. The potential socio-economic benefits for the Pilbara region, the State of WA, the Commonwealth of Australia and Chevron would not be realised.

In addition, the Commonwealth Government would not receive personal taxation for wage and salary earners, and company tax on profits from the Project.

Refer to Chapter 10, *Social Impact Assessment and Outcomes* for a full social risk assessment.

1.6 Wheatstone Project Location

Petroleum Titles WA-253-P, WA-17-R, WA-356-P and WA-16-R are located approximately 145 km off the north-west coast of WA in the West Carnarvon Basin, approximately 100 km north of Barrow Island and 225 km north of Onslow. Potential third-party gas could be sourced from Petroleum Titles in the Carnarvon Basin or elsewhere.

The onshore components of the Project are approximately 12 km south-west of Onslow, within the Shire of Ashburton. Figure 1.1 shows the location of the onshore and offshore components of the Project.

The gas processing facilities are located within the proposed Ashburton North SIA. Figure 1.3 shows the location of the proposed onshore gas processing facility and associated infrastructure.

Detailed schematics of the proposed Project facilities are included in Chapter 2, *Project Description*.

1.7 Site Selection Process

Chevron identified possible sites for the onshore components of the Project via a desktop screening process, including literature reviews, database searches and constraint mapping against a number of environmental, social and technical criteria.

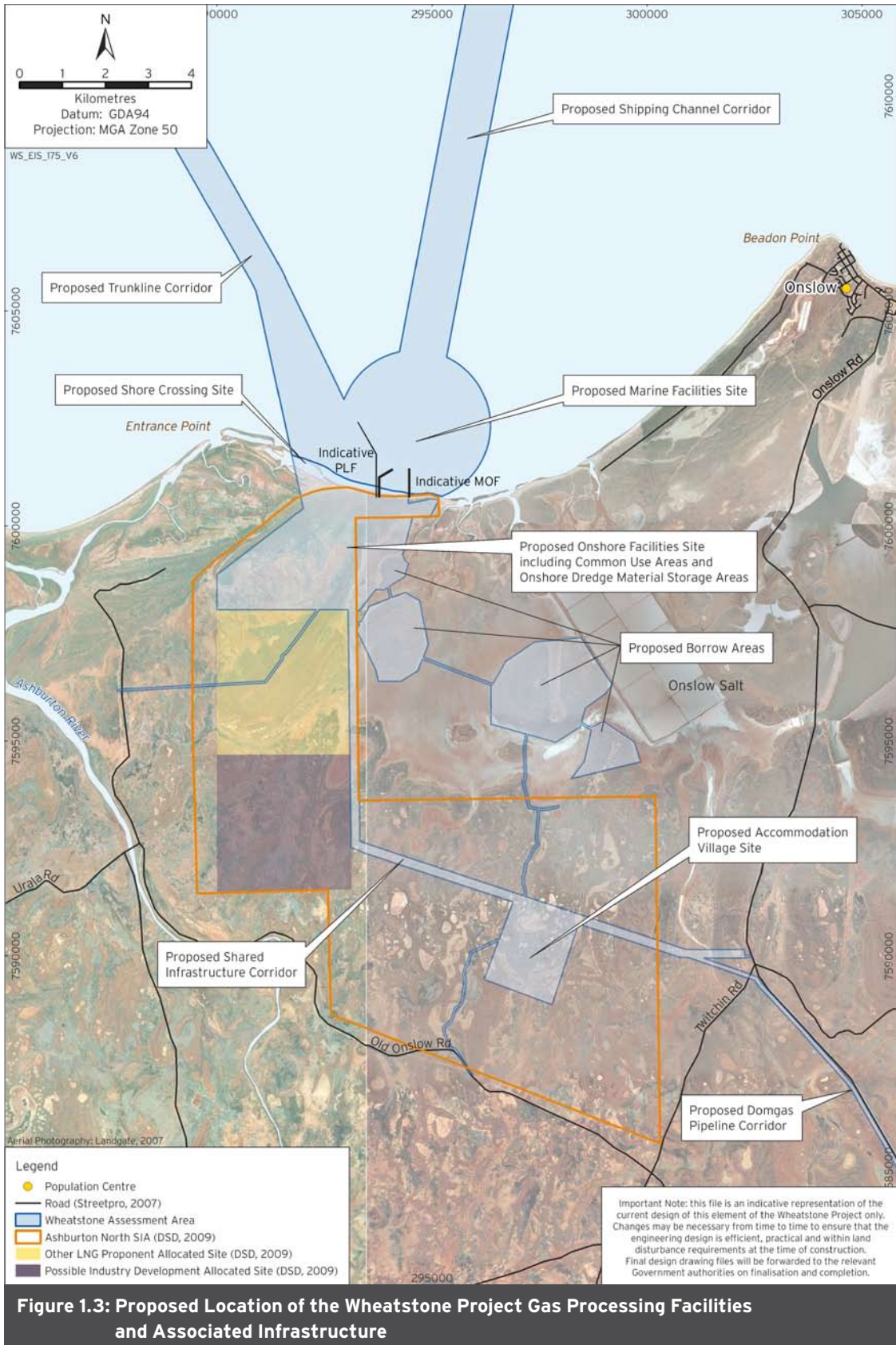
The use of existing, or currently proposed developments in the region were considered but discounted as they would be restricted in their capacity to process the required volume of gas in the near term and would result in higher incremental development costs for West Carnarvon gas resources. A site-screening and selection process was subsequently undertaken to locate a new greenfield site that would also be suitable for multi-user LNG infrastructure.

Initially six locations were identified, which were studied further and narrowed to three potential sites. The three locations—Ashburton North SIA, Onslow SIA and Cape Preston—were referenced in the State and Commonwealth Environmental Referrals for the Project.

Community and specific stakeholder groups were engaged to evaluate the site-screening process and the suitability of a preferred location. Identification of issues that warrant further consideration in the Project was also recorded. The approach adopted for this engagement exercise derives from and builds on prior LNG site-selection studies undertaken in the north-west of WA.

Two independent reviewers from the John Curtin Institute of Public Policy were contracted to observe the site consultation process and provide an independent opinion on the methodology used and transparency of the site-screening and selection process. These reports have been provided to the EPA and DEWHA.

Concurrent to this process, the State Government announced that a SIA would be created at Ashburton North (Ashburton North SIA). Development options for the Ashburton North site included new LNG facilities to aid the



development of gas reserves in the Carnarvon Basin and Exmouth Gulf.

As a result of the above described process, and in line with the plans of the Western Australian Department of State Development, the Ashburton North option, approximately 12 km south-west of Onslow, was selected as the most appropriate site.

Chapter 3, *Project Alternatives and Site Selection* provides more detail of the process of site selection for the Project.

1.8 Relationship to Other Projects in the Region

The Pilbara is one of the most vital and dynamic wealth-producing regions in Australia. It accounts for more than 44 per cent of WA mineral and energy production, at a value of more than \$32 billion per annum. The Project will make a valuable contribution to the Pilbara economy.

The region produced 16.3 million tonnes of LNG in 2008 from the only operating LNG project in WA: the Woodside operated North West Shelf Joint Venture, of which Chevron is a partner. The North West Shelf Joint Venture currently accounts for more than 40 per cent of Australia's oil and gas production including about 80 per cent of Australia's total LNG production and 65 per cent of WA's total domestic gas production.

The Project is one of a number of substantial oil and gas, mining and associated downstream processing developments planned for the Pilbara region. Table 1.2 provides a summary of major projects under construction and proposed in the region. Information has been obtained from the Department of State Development, Department of Mines and Petroleum and the Pilbara Development Commission.

The Project also has a relationship with a number of current or proposed projects in the region due to their proximity. These include the oil and gas and salt production industries. The BHP Billiton/Apache Macedon Gas Development (Macedon) and the Exxon Mobil/BHP Billiton project (Scarborough) are both planned for the Ashburton North SIA.

Onslow Salt is the nearest operating industrial facility to the proposed onshore facilities, located approximately 5 km east of the Ashburton North SIA. It incorporates 8000 hectares (ha) of salt ponds, port and loading facilities and a 10 km navigation channel for shipping in the nearshore area. The operation produces approximately 2.5 MTPA of salt.

Thevenard Island is located approximately 25 km from the proposed onshore facilities and is classed as a nature reserve. It is the hub for six adjacent oil and gas fields, four of which are currently in production. The first oil flowed

Table 1.2: Committed and Proposed Large-Scale Resource Projects in the Pilbara Region

Project	Estimated Project Value (A\$ million)	Employment - Construction	Employment - Permanent
Oil and Gas			
Woodside - Pluto LNG Plant	11 200	3000	200
Gorgon Joint Venture - LNG Project	43 000	3500	600
BHP Billiton - Macedon Domestic Gas	1000	300	50 (est.)
Apache Energy - Devil Creek Gas	800	200	20
Iron			
BHP Billiton - Rapid Growth Projects 4, 5, 6, 7	9300 +	3500 +	800 +
Citic Pacific - Cape Preston operations	5200	2500	500
Australasian Resources - Balmoral Project	2700	2500	800
API Mgmt - West Pilbara Project	3900	1300	700
Rio Tinto - Mesa A project	1067	650	250
Rio Tinto - Brockman 4 project	1800	700	300
Minerals			
Moly Minerals - Spinifex Ridge Molybdenum	1084	400	375

in 1989, with subsequent fields brought into production in a staged development. Currently operated by Chevron, oil is produced from 21 wells from two offshore locations and nine unmanned offshore structures. The facilities are capable of processing 120 000 barrels of oil per day and 510 000 m³ (18 million cubic feet) of gas per day. Oil is stored at a one million barrel storage facility on the island and exported via an offshore tanker mooring.

Macedon is a proposed WA domestic gas project designed to commercialise offshore gas reserves in Petroleum Title WA-12-R, approximately 100 km west of Onslow. The domestic gas processing facility is planned for location within the Ashburton North SIA. The current proposal is for a domestic gas facility that would compress gas brought ashore west of the Ashburton Delta. The sales gas pipeline will be constructed from the Ashburton North SIA along the access infrastructure corridor to Onslow Road. From its intersection with Onslow Road, the sales gas pipeline will follow Onslow Road to the DBNGP.

The proposed Scarborough project is located in Commonwealth waters in Petroleum Titles WA-1-R and WA-346-P, approximately 280 km north of Onslow. It can be expected that this proposal would include an LNG plant adjacent to the Project at the Ashburton North SIA and producing approximately 6 MTPA, an additional shore crossing for a pipeline and possibly another trestle and tanker berth to allow export of LNG. The potential pipeline connecting the LNG plant to the existing WA domestic gas pipeline network may follow or share existing pipeline easements. The gas will be transported to overseas markets by LNG tankers. It is reasonable to assume that the Scarborough project would use the common user infrastructure (such as the existing MOF and shipping channel); therefore additional coastal footprint would be limited.

Cumulative risk has been assessed as been completed as part of this EIS/ERMP. Refer to Chapter 11, *Cumulative Impacts*.

1.9 Proponent's Environmental Commitment

1.9.1 Chevron Corporation's Operational Excellence Management System

It is the policy of Chevron Corporation to protect the safety and health of people and the environment, and to conduct its operations reliably and efficiently. The systematic management of safety, health, environment, reliability and efficiency to achieve world-class performance is defined as Operational Excellence (OE). Chevron Corporation's commitment to OE is embodied in *The Chevron Way* value

of protecting people and the environment, which places the highest priority on health and safety, and the protection of assets and the environment. This is accomplished through disciplined application of the Operational Excellence Management System (OEMS). The OEMS consists of three parts:

- Leadership accountability
- Management system process
- OE expectations.

Leadership is the largest single factor for success in OE. Leaders are accountable not only for achieving results, but achieving them in the right way by behaving in accordance with Chevron Corporation values. Leaders direct the Management System Process (MSP) to drive improvement in OE results. The MSP (see Figure 1.4) consists of the following five steps:

- **Vision and Objectives** – Developing an OE vision, world-class objectives, metrics and targets based on corporate objectives, benchmarking data and other applicable critical business drivers.
- **Assessment** – Completing a comprehensive evaluation to identify priority areas in OE processes and performance against established objectives.
- **Planning** – Developing three-year plans to manage priorities and incorporating those plans into business plans and assigning accountabilities.
- **Implementation** – Implementing planned actions and monitoring plan progress and OE performance.
- **Review** – Annually evaluating progress on performance and identifying necessary adjustments to plans that result in the goal of achieving world-class results.

In 2008, Chevron Corporation received attestation from Lloyd's Register Quality Assurance that the OEMS meets all requirements of the International Standards Organization's 14001 environmental management system standard (ISO 2004) and the Occupational Health and Safety Assessment Series management specification 18001 and that OEMS is implemented throughout the corporation. These standards are international benchmarks and demonstrate Chevron's commitment to world-class performance.

1.9.2 Chevron Australasia Strategic Business Unit Policy 530 - Operational Excellence

Chevron Australasia Strategic Business Unit (ASBU) Policy 530-Operational Excellence sets the overall goal of protecting the safety and health of people and the



Figure 1.4: Chevron Australasia Business Unit Policy 530 – Operational Excellence

environment through the implementation of OE—the systematic management of safety, health, environment, reliability and efficiency.

This process is applied to Chevron ASBU projects, in order to:

- Achieve an injury-free work place
- Eliminate spills and environmental incidents, and identify and mitigate key environmental risks
- Promote a healthy workplace and mitigate significant health risks
- Operate incident-free with industry leading asset reliability
- Manage the efficient use of resources and assets.

The OE expectations are organised under 13 elements, outlined in Figure 1.4, and spell out specific requirements for the management of particular issues under the OEMS. The expectations are met through processes and procedures put in place by local business unit management. Among other matters, these expectations require that processes are in place to conserve natural resources, to inventory all emissions, releases and wastes and to mitigate and manage significant potential risks and impacts to human health and the environment associated with these emissions, releases and wastes.

1.9.3 Wheatstone Environmental Management Program

The Wheatstone Environmental Management Program (Program) is designed to facilitate the implementation of Chevron's ASBU OEMS and ABU Policy 530 - Operational Excellence and to meet legal requirements.

Chevron has developed a range of environmental management controls throughout the life of the Project using an outcome-based approach consistent with *Draft EPA Assessment Guideline No. 4 (Dec 2009)*. These are intended to mitigate, or reduce to an acceptable level, the potentially adverse environmental risks identified in this EIS/ERMP. On the basis of the risk assessment, and in accordance with the *Draft EPA Assessment Guideline No. 4 (Dec 2009)*, a set of proposed Outcome-based Conditions (OBCs) have also been developed.

The Program has been developed to incorporate each component of the Project. Figure 1.5 portrays the three tiers of the Program. The overarching component is the Chevron OEMS (Tier 1). Underneath this sits the Wheatstone Environmental Management and Assessment Program (Tier 2), which incorporates this statutory environmental

impact assessment process, using a risk-based approach, and resultant OBCs and Statutory Environmental Management Plans (EMPs). Finally, Tier 3 comprises a set of Subsidiary plans which are defined as those environmental plans which are required by and/or impose relevant legal obligations on Chevron under legislation, but are not legally binding under the Ministerial Approvals of this EIS/ERMP.

Refer to Chapter 12, *Environmental Management Program* for further details.

1.10 Chevron Guidance Policies

1.10.1 Environmental Stewardship

Environmental Stewardship is an element of the OE management system that provides a process to inventory all emissions, releases and wastes and to identify natural resources impacted by operations. Natural resources include air, surface water, ground water, soil and geologic resources, and local biological diversity.

Environmental Stewardship also allows processes to be applied to identify, assess, mitigate and manage significant potential risks and impacts to human health and the environment (including natural resources) associated with operations, emissions, releases and wastes.

1.10.2 Biodiversity Conservation

Performance relating to biodiversity conservation is driven by, and assessed against, key OE processes and expectations, such as Environmental Stewardship. Chevron undertakes activities to raise internal and external awareness of the importance of conserving biodiversity and the methods by which this is addressed. This includes:

- Communicating biodiversity-related activities to employees and outside audiences, such as through Chevron's Corporate Responsibility Report
- Engaging with government, local communities and others to understand and work to address significant biodiversity issues in areas where Chevron operates
- Participating in industry associations and other forums to share and promote best practice for biodiversity conservation
- Seeking to understand and, where appropriate, participating in development of external policy-making activities that affect our operations, such as those adopted under the UN Convention on Biological Diversity, and national, regional and local biodiversity policies and plans

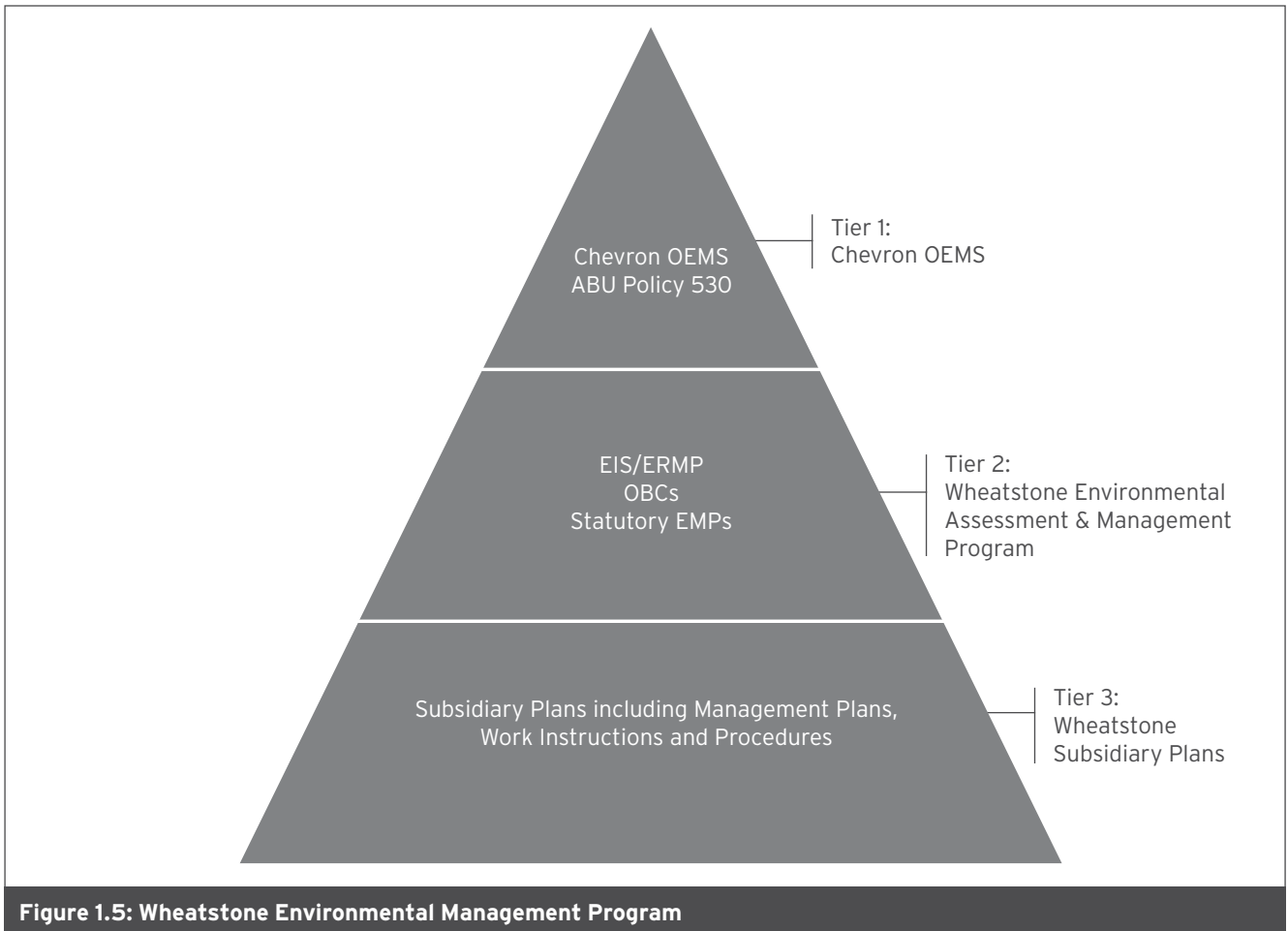


Figure 1.5: Wheatstone Environmental Management Program

- Working with a variety of external organisations to make positive contributions to biodiversity conservation in areas where Chevron operates, and globally.

1.10.3 Climate Change

Chevron’s Action Plan on Climate Change continues to guide development activities, including emissions reduction, efficiency improvements, research investments, business opportunities and advocacy positions. Despite continued business growth, Chevron’s total greenhouse gas emissions have remained relatively constant. During the conceptual design phase of the Project consideration has been given to how best to reduce greenhouse gas from the Project. A number of high impact design decisions that will have the effect of reducing Project emissions over the life of the Project are described in Chapter 3, *Project Alternatives and Site Selection*.

Since 2003, Chevron has reduced emissions from flaring and venting by approximately 15 per cent on an equity basis, and continues to work to reduce routine flaring and venting in its operations wherever technically and commercially feasible.

Refer to Chapter 3, *Project Alternatives and Site Selection* and Chapter 4, *Emissions, Discharges and Wastes* for further detail on the Project’s greenhouse gas emissions and management.

1.10.4 Human Rights Policy

Chevron’s commitment to respecting human rights is encompassed in *The Chevron Way* vision and values, the OEMS, and the Business Conduct and Ethics Code.

Although governments have the primary duty to protect and ensure fulfilment of human rights, Chevron recognises that companies have a responsibility to respect human rights, and can also play a positive role in the communities

Table 1.3: Objects of EP Act and EPBC Act

Principle	Aim	Requirement of	Project Goal
Integration	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	EPBC Act (Cth)	Financial sustainability to succeed, and in turn the financial capability to manage potential environmental impacts and to have a positive impact on the economy and social surroundings.
Precautionary	In the event that the Project poses environmental threats, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.	EPBC Act (Cth) EP Act (WA)	Identification of the range of procedures required to effectively manage potential environmental impacts through environmental management planning. Effective governance within Chevron to demonstrate a precautionary approach to the environment.
Intergenerational	The present generation should ensure continuation of health, diversity and productivity of the environment for future generations.	EPBC Act (Cth) EP Act (WA)	Environmental sustainability, addressing protection of the natural environment. The design to include provision to allow decommissioning that achieves a safe and stable site and desirable post-closure land use, for both the community and region.
Biodiversity	Conservation of biological diversity and ecological integrity should be fundamental in decision-making.	EPBC Act (Cth) EP Act (WA)	Conservation of biodiversity through integration into Chevron's business decision-making and management through Chevron's OEMS.
Valuation	Improved valuation, pricing, and incentive mechanisms should be promoted (e.g. "polluter pays", consideration of life cycle costs).	EPBC Act (Cth) EP Act (WA)	Financial viability through the planned Project life, and effective governance within Chevron to demonstrate accountability, transparency and fairness.
Waste minimisation	Take all reasonable and practicable measures to minimise waste generation and discharges to the environment.	EP Act (WA)	Use of reasonable and practicable measures to reduce emissions, discharges and wastes, and to protect environmental quality during all Project phases.

where they operate. Chevron conducts global operations consistent with the spirit and intent of the United Nations Universal Declaration of Human Rights, International Labor Organization Declaration on Fundamental Principles and Rights at Work that are applicable to business, and other applicable international principles, including the Voluntary Principles on Security and Human Rights.

1.11 State and Commonwealth Considerations for Sustainability

Principles of ecologically sustainable development are incorporated as objects in both the EP Act (WA) and EPBC Act (Cth). Table 1.3 sets out these principles and explains how the Project aims to meet them.

1.12 Relevant Legislation, Policies and Guidelines

The Project is subject to varied Australian Commonwealth and Western Australian State legislation, policies and guidelines. In addition, a number of international agreements, standards and guidelines may also be applicable. The following section describes the principal legislative framework for the Project. Appendix A1 lists key relevant acts, subsidiary legislation and regulations. The list is intended to highlight those statutes which are key or relevant to the Project but is not exhaustive.

1.12.1 International Agreements, Guidelines and Standards

Australia is a signatory to numerous international conventions and agreements that obligate the Commonwealth Government to prevent pollution and protect specified habitats, flora and fauna. Those of relevance to the Project are listed below:

- International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) as modified by the Protocol of 1996
- International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 (MARPOL 73/78)
- United Nations Framework Convention on Climate Change and the Kyoto Protocol
- Japan Australia Migratory Birds Agreement
- Republic of Korea-Australia Migratory Bird Agreement
- China Australia Migratory Birds Agreement.

A brief description of relevant international agreements is provided in Appendix A1.

1.12.2 Commonwealth Legislation, Policies and Guidelines

The EPBC Act (Cth) is the key piece of Commonwealth legislation governing the environmental approvals process for the Project. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places - defined under the Act as matters of National Environmental Significance (NES). The EPBC Act (Cth) focuses Commonwealth interests on the protection of matters of NES, with the states and territories having responsibility for matters of state and local significance.

Other key Commonwealth legislation includes the National Offshore Petroleum Safety Authority (NOPSA), the *National Greenhouse and Energy Reporting Act 2007*, the *Energy Efficiency Opportunities Act 2006* and the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*.

The Commonwealth Government regulates the conduct of offshore petroleum exploration and production primarily through the NOPSA. Coastal waters are regulated by the states and Northern Territory under a variety of acts that are designed to mirror NOPSA, although there are some minor differences between the regimes.

The *National Greenhouse and Energy Reporting Act* was enacted in 2007 and mandates the national reporting of greenhouse gas emissions, energy production and energy use. It is the intention that this legislation will provide all data required by all Australian governments in relation to greenhouse gas emissions.

The *Energy Efficiency Opportunities Act 2006* was implemented to improve the identification, evaluation and reporting of energy efficiency opportunities across Australian Industry. Participation is required for all corporations that use more than 0.5 petajoules of energy per year. The Act requires qualifying companies to submit five-year plans that set out proposals for assessing their energy usage and to identify, evaluate and report on cost effective energy savings opportunities.

The *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* falls under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006*. The object of these Regulations is to ensure that any petroleum activity or greenhouse gas storage activity carried out in an offshore area is:

- Carried out in a manner consistent with the principles of ecologically sustainable development

- Carried out in accordance with an environmental plan that has:
 - Appropriate environmental performance objectives and standards
 - Measurement criteria for determining whether the objectives and standards have been met.

Additional applicable Commonwealth legislation, policies and guidelines are listed in Appendix A1.

1.12.3 Western Australian Legislation, Policies and Guidelines

The EP Act (WA) and its associated regulations are the principal statute for environmental protection in WA. The EP Act (WA) sets out to “prevent, control and abate pollution and environmental harm, for the conservation, protection, enhancement and management of the environment”. The EP Act (WA) is administered by the Department of Environment and Conservation (DEC) and the Office of the EPA.

Two parts of the EP Act (WA) of particular relevance to the Project are Part IV, which governs the assessment of development proposals, and Part V, which deals with activities which may potentially cause pollution and environmental harm.

The EPA has developed a series of guidance statements for the assessment of environmental factors in accordance with the EP Act (WA). The guidance statements are designed to assist project proponents, and the public, to understand the minimum requirements for the protection of the environment under the EP Act (WA).

Additional applicable WA State legislation, policies and guidelines are listed in Appendix A1.

1.13 Environmental Assessment Process

The Project is subject to environmental approval from both the WA and Commonwealth governments under the EP (WA) and EPBC (Cth) acts, respectively. This document has been prepared to meet both the EPA Guidelines for Preparing a Public Environmental Review/Environmental Review and Management Programme (2007) and the DEWHA Guidelines for the Content of a Draft Environmental Review and Management Programme/Environmental Impact Statement (2008). It will be assessed in a parallel/coordinated approach by the EPA and DEWHA.

As outlined in Section 1.3, the Project has already achieved a number of milestones associated with the environmental assessment process. The key steps in the

environmental assessment process for the Project are summarised in Figure 1.6.

1.13.1 Referral to the Commonwealth Government

The Project was referred to DEWHA under the EPBC Act in September 2008. In October 2008, DEWHA determined that the proposal was a “controlled action” and the level of assessment was set at Environmental Impact Statement (EIS). In setting the level of assessment, DEWHA determined that the proposal may have significant impact on the following matters of NES:

- Listed threatened species and communities
- Listed migratory species
- Commonwealth marine areas.

These factors are described in Chapter 6, *Overview of Existing Environment* and assessed in Chapter 8, *Marine Risk Assessment and Management* and Chapter 9, *Terrestrial Risk Assessment and Management*.

1.13.2 Referral to Western Australian Government

The Project was referred to the EPA under the EP Act (WA) in September 2008. In October 2008, the EPA determined the level of assessment at Environmental Review and Management Programme (ERMP). This level of assessment is applied to projects considered to be of state interest and is a comprehensive and detailed level of assessment. Under the ERMP, Chevron is required to interact with the EPA to identify potential environmental impacts and develop mitigation and management measures to manage these.

A number of environmental factors that should be considered in the EIS/ERMP were identified and endorsed by the EPA through approval of the Scoping Document:

- Benthic Primary Producer Habitat (BPPH)
- Marine Fauna (includes EPBC listed, fish and benthic in-fauna)
- Marine Water and Sediment Quality
- Physical Marine Environment
- Flora and Vegetation (includes native flora species and native flora communities)
- Terrestrial Fauna
- Terrestrial Short Range Endemic Fauna¹
- Subterranean Fauna
- Soils and Landform

¹ Discussed under Terrestrial Fauna in the EIS/ERMP

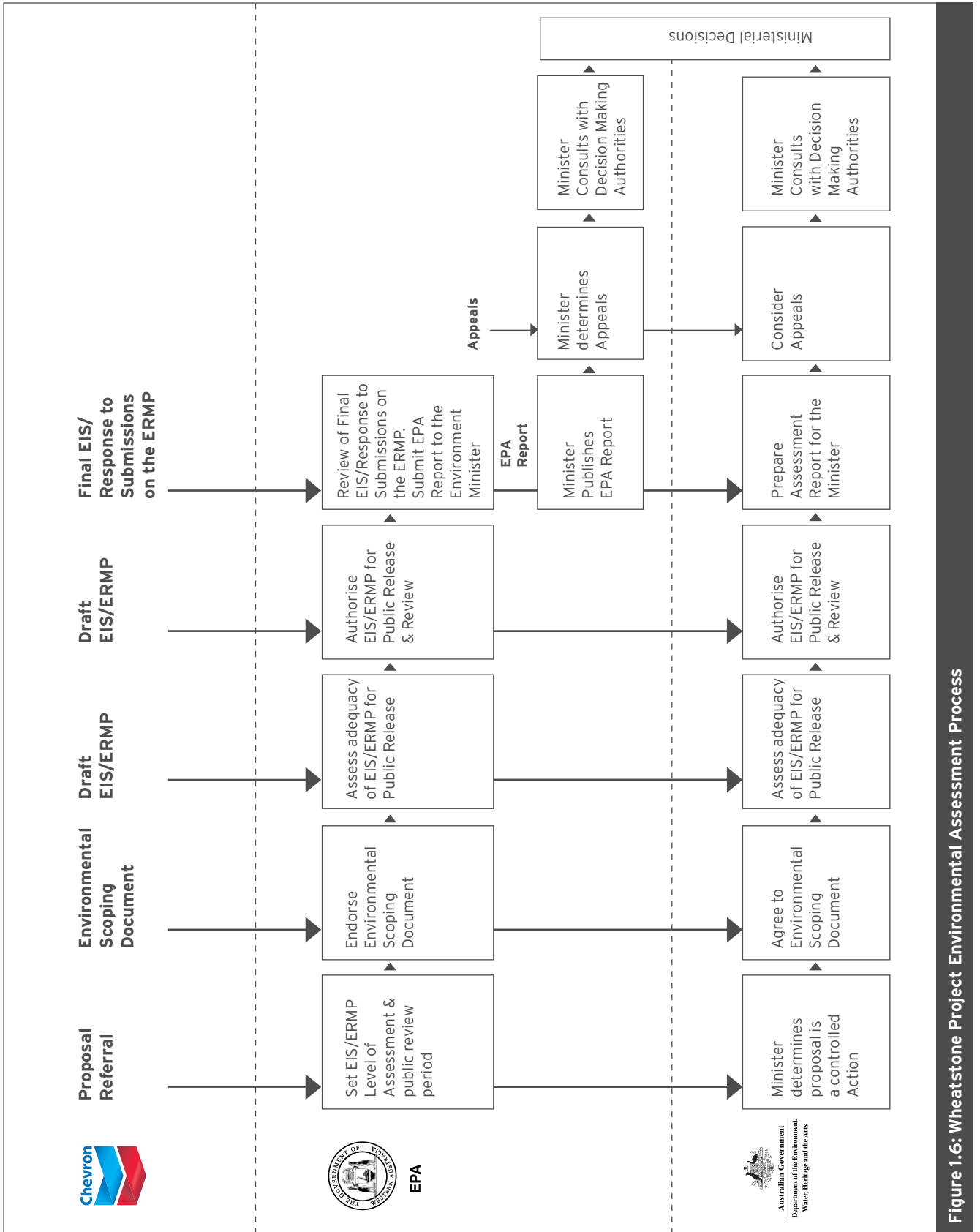


Figure 1.6: Wheatstone Project Environmental Assessment Process

- Ambient Air Quality
- Atmospheric Greenhouse Gas Concentrations
- Surface Water
- Groundwater
- European Heritage (Non-Aboriginal Cultural Heritage)
- Aboriginal Cultural heritage (Ethnographic and Archaeological)
- Local Fishing (Commercial and Recreational) and Pearling Industry
- Disturbance to Other Recreational Use
- Public Amenity
- Onslow Community (Risk)².

These factors are described in Chapter 6, *Overview of Existing Environment*. Chapter 4 discusses the *Emissions, Discharges and Wastes* that may be generated by the Project. Factors are assessed in Chapter 8, *Marine Risk Assessment and Management*, Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*.

1.13.3 Environmental Scoping and Draft Guidelines

In accordance with *Environmental Impact Assessment (Part IV Division 1) Administrative Procedures* (EPA 2002), Chevron produced a Scoping Document to identify the key issues that related to the proposal and determine the scope of investigations required to reliably resolve those issues. The document was developed following a series of facilitated risk-assessment workshops with key stakeholders.

The risk assessment workshops and subsequent development of the Scoping Document resulted in identification of three potentially high-risk aspects:

- The impacts of dredging on BPPH
- The impacts of dredging on the physical marine environment (coastal processes, marine water quality)
- The impacts of the presence of marine infrastructure on the physical marine environment.

The draft Scoping Document for the Project was released for public review and comment between 20 April and 8 May, 2009. Chevron addressed the comments received during the public review period and submitted a revised Scoping Document on 2 June, 2009. The Scoping Document was approved by the EPA on 23 June, 2009 and by DEWHA on 28 August, 2009 as tailored guidelines for the preparation

of the EIS/ERMP. The document is available to the public on Chevron's website:

<http://www.chevronaustralia.com/ourbusinesses/wheatstone/environmentalapprovals.aspx>
[Accessed 26 May, 2010].

1.13.4 Preparation of the EIS/ERMP

The overall approach to the preparation of this EIS/ERMP involved:

- Identification of all environmental and socio-economic factors considered relevant to the Project
- Identification of relevant Project aspects and activities that could result in impacts on those factors
- Identification of the temporal and spatial scale of likely impacts of Project activities
- Completion of detailed field surveys, studies and extensive data gathering relating to the environment at and adjacent to proposed Project components and activities
- Development of consequence definitions to determine the magnitude of potential impacts from relevant aspects on individual factors
- Completion of a detailed risk assessment to determine the level of risk for each environmental factor
- Development of strategies to avoid, mitigate or manage activities aimed at reducing risk to relevant factors
- Analysis of residual risks to the environment
- Stakeholder and community engagement
- Development of outcome-based management commitments.

Chevron identified a series of specialist studies necessary to address uncertainties in determining the potential environmental and socio-economic impacts from the Project. These studies and investigations, identified in the Scoping Document (Chevron Australia 2009), are referred to in appropriate sections of this EIS/ERMP document and are listed in the table of contents of Volume 2 *Wheatstone Project Technical Appendices*. Chapter 7, *Impact Assessment Methodology* includes a more detailed description of the risk-assessment methodology.

² Discussed under Health and Wellbeing in the EIS/ERMP

1.13.5 Government and Public Review of EIS/ERMP

The EIS/ERMP has been reviewed by EPA and DEWHA to ensure it conforms to the requirements outlined in the Scoping Document and guidelines. The document is placed on public exhibition for ten weeks for public comment.

At the conclusion of the public comment period the EPA and DEWHA, in consultation with Chevron will review the comments received on the EIS/ERMP to identify issues and matters requiring a response. Chevron will then respond in the form of a supplement.

Once the EPA and DEWHA are satisfied with the response to public submissions, an assessment report and recommendations based on the EIS/ERMP and the supplement is prepared for the relevant Commonwealth and State Government ministers. The Commonwealth Minister for the Environment, Water, Heritage and the Arts and the Western Australian Minister for the Environment will make a decision on whether the Project should be approved and, if so, under what conditions.

1.14 Subsequent Approvals

A list of key additional Commonwealth and State approvals that may be required for the Project after EIS/ERMP approval is provided in Table 1.4.

1.15 Structure of the Document

This EIS/ERMP is structured into the following chapters:

- *Executive Summary* – Outlines the background and the need for the proposal, as well as a summary of environmental factors, the key findings and proposed environmental management. The expected outcome of the development of the Project is described
- Chapter 1, *Introduction* – Introduces the Proponent, and the proposed Project and objectives. It also includes a brief description of the environmental assessment requirements for the Commonwealth and Western Australian governments
- Chapter 2, *Project Description* – Describes the Project including the key infrastructure, construction, operation and decommissioning activities and support infrastructure
- Chapter 3, *Project Alternatives and Site Selection* – Provides details of the processes Chevron undertook to select Ashburton North SIA as the preferred location and key project design considerations

- Chapter 4, *Emissions, Discharges and Wastes* – Details the planned emissions, discharges and wastes generated by the Project
- Chapter 5, *Stakeholder Consultation* – Describes consultation with stakeholders to date, as well as planned engagement
- Chapter 6, *Overview of Existing Environment* – Describes the receiving environment (marine, terrestrial and social) upon which the Project has potential to impact
- Chapter 7, *Impact Assessment Methodology* – Describes the methodology used to conduct impact assessments and establish the level of risk associated with aspects of the Project
- Chapter 8, *Marine Risk Assessment and Management* – Assesses the potential marine impacts and risks, and the management controls to be implemented as part of the Project
- Chapter 9, *Terrestrial Risk Assessment and Management* – Assesses the potential terrestrial impacts and risks, and the management controls to be implemented as part of the Project
- Chapter 10, *Social Risk Assessment and Management* – Assesses socio-economic impacts and risks, and the management controls to be implemented as part of the Project
- Chapter 11, *Cumulative Impacts* – Discusses the potential cumulative effects resulting from the Project and other related existing and reasonably foreseeable developments
- Chapter 12, *Environmental Management Program* – Provides details of the environmental management program to be implemented and a table of proposed outcome-based conditions for the Project.

The *Wheatstone Project Technical Appendices* of the EIS/ERMP include reports on legislation and regulatory guidance statements, stakeholder engagement and surveys and studies completed for the Project (Table 1.5).

Table 1.4: Key Subsequent Approvals that may be Required for the Wheatstone Project

Approval Required	Associated Statutes
Access Authorities	Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Authority to Excavate, Disturb or Alter Cultural Heritage Sites	Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Commonwealth) Aboriginal Heritage Act 1972 (WA)
Consent to Construct and Operate Pipeline (Safety Cases)	Petroleum Pipelines Act 1969 (WA) Petroleum (Submerged lands) Act 1982 (WA) Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Dangerous Goods Licences	Dangerous Goods Safety Act 2004 (WA)
Drilling and Workover Approvals	Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Groundwater Licences	Rights in Water and Irrigation Act 1914 (WA)
Infrastructure Licences	Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Land Lease and Tenure	Land Administration Act 1972 (WA)
Licence to Operate/Emit	Environmental Protection Act 1986 (WA)
Major Hazard Facility Safety Report (Operation)	Dangerous Goods Safety Act 2004 (WA)
Pipeline Management Plan (Safety Case)	Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Planning Approval	Shire of Ashburton Town Planning Scheme No. 7 (WA) Planning and Development Act 2005 (WA)
Ports Approvals	Marine and Harbours Act 1981 (WA) Shipping and Pilotage Act 1967 (WA) Jetties Act 1926 (WA)
Production Licence	Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Safety Case for Fixed and Mobile Units for Hydrocarbon Production	Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Commonwealth)
Sea Dumping Permit	Environmental Protection (Sea Dumping) Act 1981 (Commonwealth)
Sea Installations Permit	Sea Installations Act 1987 (Commonwealth)
Vegetation Clearing Permit	Environmental Protection Act 1986 (WA)
Works Approval Permit	Environmental Protection Act 1986 (WA)

Table 1.5: Wheatstone Project Technical Appendices

Appendix	Topic		Report	Title
A	Guidance Documents		A1	Legislation and Regulatory Guidance Documents
B	Stakeholder		B1	Stakeholder Consultation
C	Air Quality		C1	Air Quality Impact Assessment
D	Light Emissions		D1	Wheatstone Project Lighting Emissions Study
E	Noise Impact		E1	Environmental Noise Impact Assessment
F	Groundwater		F1	Wheatstone Project Groundwater Studies
G	Surface Water		G1	Wheatstone Project Surface Water Studies
H	Soil		H1	Baseline Soil Quality and Landforms Assessment
I	Flora and Vegetation		I1	A Vegetation and Flora Survey of the Wheatstone Project Area, near Onslow
			I2	Vegetation of the Wheatstone Addendum Area
J	Fauna		J1	Wheatstone Project Terrestrial Fauna Survey
K	Waterbirds		K1	Survey for Migratory Waterbirds in the Wheatstone LNG Area, November 2008 and April 2009
L	Claypan Invertebrates		L1	Claypan Ephemeral Fauna Survey
M	Subterranean Fauna		M1	Subterranean Fauna Assessment
N	Benthic Habitat	Subtidal	N1	Wheatstone Project Benthic Primary Producer Habitat Loss Assessment
			N2	Dredge Plume Impact Assessment
			N3	Tolerance Limits Report
			N4	Ashburton River Delta Mangrove System: Impact Assessment Report
		Justification of BPPH Units	N5	Justification of Benthic Primary Producer Habitat Loss Assessment Unit Boundaries
		Subtidal	N6	Wheatstone Project 20-70m Contour Habitat Survey Field Report
	N7		Baseline Coral Community Description	
	N8		Survey of Benthic Habitats near Onslow, Western Australia	
	N9		Deepwater Habitat Survey	
	N10		Survey of Intertidal Fauna on the Islands off Onslow, Western Australia	
		Intertidal	N11	Intertidal Habitats of the Onslow Coastline
		Subtidal	N12	Survey of Subtidal Habitat off Onslow, WA
	N13		Biota of Subtidal Habitat in Pilbara Mangroves, with Particular Reference to the Ashburton Delta and Hooley Creek	
	N14		Assessment of the Potential Impacts of the Proposed Pipeline Route through the Northern-Eastern Lagoon of the Ashburton Delta	
	N15		Benthic Primary Producer (Seagrass and Macroalgae) Habitats of the Wheatstone Project Area	

Appendix	Topic	Report	Title	
O	Marine Fauna	Light Emissions	O1	An Assessment of Light Emissions in Relation to Sea Turtle Nesting Beaches in the Wheatstone Project Area
		Noise Logger	O2	Sea Noise Logger Deployment: Wheatstone and Onslow – April to July 2009 Preliminary Analysis
		Marine Fauna Aerial Survey	O3	A Description of Mega Fauna Distribution and Abundance in the SW Pilbara Using Aerial Surveys – Mid-Study Field Report August 2009
			O4	A Description of Mega Fauna Distribution and Abundance in the SW Pilbara Using Aerial Surveys – Mid Study Report December 2009
		Fish Survey	O5	Survey of Fish in Hooley Creek and North-eastern Lagoon of the Ashburton Delta
		Marine Fauna	O6	Draft Protected Marine Fauna Management Plan
			O7	Wheatstone Project: Literature Review of Listed Marine Fauna
		Turtle Nesting Beaches	O8	Marine Turtle Beach Survey: Onslow Mainland Area and Nearby Islands 25 January - 6 February 2009
		Underwater Noise	O9	Possible Effects of Underwater Noise on Marine Fauna and Fish in the Wheatstone Project Area
		Prawn Fisheries	O10	Potential Interactions with the Onslow Prawn Managed Fishery
		Megafauna Turtles	O11	Marine Turtles Technical Report
		Megafauna Marine Mammals	O12	Marine Mammals Technical Report
P	Coastal Processes	Geomorphology	P1	Coastal Geomorphology of the Ashburton River Delta and Adjacent Areas
		Coastal Process Modelling	P2	Coastal Impacts modelling
Q	Water and sediment	Dredging	Q1	Dredge Spoil Modelling
		Hydrocarbon Leaks & Spills	Q2	Hydrocarbon Spill Modelling
		Discharge Modelling	Q3	Modelling of the Discharges to the Marine Environment
		Acid Sulfate Soils	Q4	Nearshore Acid Sulfate Soils Investigation (Turning Basin and Dredge Channel)
		Sediment Quality	Q5	Sediment Quality Assessment - Wheatstone Dredging Program
		Ashburton River Sediment Loads	Q6	Project Wheatstone Ashburton River Flow and Discharges Study
		Marine Water Quality	Q7	Baseline Water Quality Assessment Report
R	Biosecurity	R1	Desktop Study of Marine Biosecurity in the Wheatstone Project Area	
S	Dredge Management Plan	S1	Draft Dredging and Spoil Disposal Management Plan	

Appendix	Topic	Report	Title
T	Coastal Processes Management Plan	T1	Draft Coastal Processes Management Plan
U	Construction Environmental Management Plan	U1	Draft Construction Environmental Management Plan
V	Archaeological and Historical Study	V1	Archaeological and Historical Survey Report
W	Agency requirements	W1	DEWHA and EPA Requirements by Chapter

2.0

Project Description



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2.0 Project Description

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2.0 Project Description

2.1 Introduction

Chevron Australia Pty Ltd (Chevron), as developer of the proposed Wheatstone Project (Project), proposes to construct and operate a multi-train Liquefied Natural Gas (LNG) and domestic gas (domgas) plant on a greenfield site at the proposed Ashburton North Strategic Industrial Area (SIA). The Ashburton North SIA is south-west of Onslow on the Pilbara coast in Western Australia (WA). The Project will process natural gas from various offshore fields in the West Carnarvon Basin.

Petroleum Titles WA-253-P, WA-17-R, WA-16-R and WA-356-P are located approximately 145 km off the north-west coast of WA in the West Carnarvon Basin, approximately 100 km north of Barrow Island and 225 km north of Onslow. See Figure 2.1.

This chapter describes the offshore and onshore components of the Project. It explains how they are likely to be built, operated and ultimately decommissioned. As such, this chapter provides the basis for the risk assessment of the Project's potential environmental and social impacts.

Approval is being sought for the design, construction, commissioning, operation and decommissioning of:

- An LNG facility of a nominal 25 million tonnes per annum (MTPA) capacity
- A domgas plant which will produce a domestic gas volume equivalent to approximately 15 per cent of the LNG in ship (measured by higher heating value) to domestic supply specification
- Gathering and processing of natural gas and natural gas condensate (condensate) in offshore Commonwealth waters for the initial development
- Supporting offshore and onshore pipelines and infrastructure
- A Materials Offloading Facility (MOF), Product Loading Facility (PLF), shipping channel and turning basin
- Liquefaction of natural gas and storage and offloading of LNG for export
- Storage and export of condensate
- Compression and export of domestic gas via a domestic gas pipeline(s)
- Accommodation village, access road, and supporting infrastructure.

The location of the Project was chosen based on selection criteria that included, but was not limited to, the following:

- Public safety
- Operational safety
- Environmental factors
- Social factors
- Proposed SIA
- Shared access and reduced impact on other users
- Marine access.

The site-selection process and Project alternatives are discussed in more detail in Chapter 3, *Project Alternatives and Site Selection*.

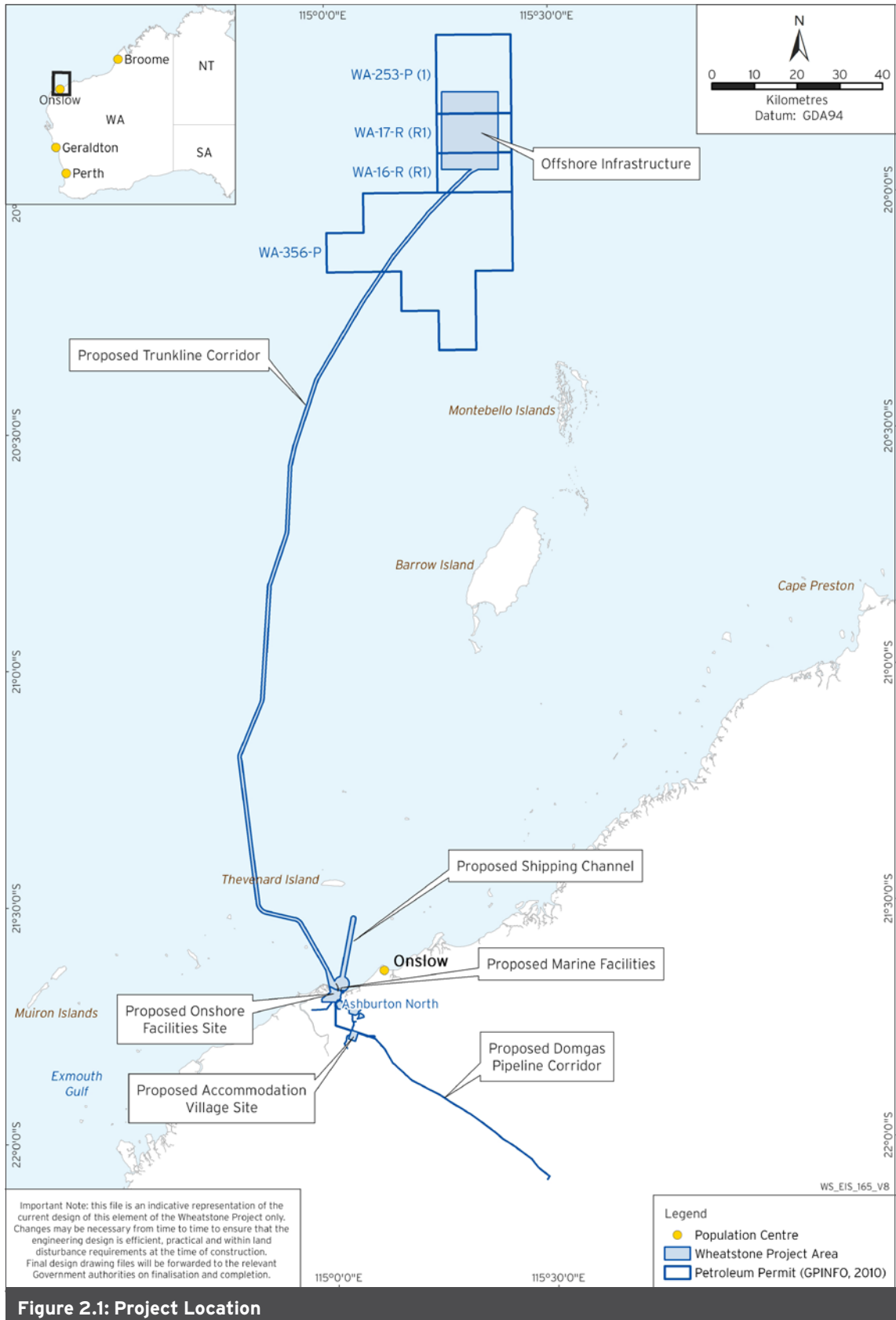
The description of the processes and layouts in this chapter are indicative and for the purposes of understanding the impacts of the construction and operation phases of the proposal. They are considered to be indicative based on current Project understanding and may be subject to further refinement and development as the Project design continues.

The Project aims to develop an LNG facility of five to six LNG process trains. These trains will be built in phases with the first two trains considered to be the Foundation Project. Natural gas supplies from the offshore fields will provide the feedstock for these first two LNG processing trains. Subsequent processing trains will be used to process gas from future Chevron and third-party fields. The co-located domgas plant(s) will supply gas to domestic markets via an onshore pipeline that will connect to the existing Dampier-to-Bunbury Natural Gas Pipeline (DBNGP). A single-train domgas plant is intended for the first two trains.

Gas sources for the subsequent trains and related design needs are yet to be determined. As such, a conservative approach has been taken to the Project description and hence assessment of potential environmental impacts. Where alternative Project designs are possible, the design with the higher potential for environmental impact has been assessed, and realistic but upper-case assumptions have been taken when describing and assessing the full 25 MTPA case.

The Project involves the following:

- General construction activities
- Installation of subsea production wells and associated infrastructure (manifolds, flowlines and umbilicals)



- Installation of a processing platform (Wheatstone Platform) connected to the subsea systems to process nominally 9 MTPA of LNG, that includes power generation and compression
- Possible installation of a compression platform
- Installation of a trunkline from the Wheatstone Platform (WP) to transport the gas and condensate to shore
- Installation of a telecommunication system
- Installation of trunkline shore crossings in the nearshore zone
- Construction of five to six LNG process trains to a total nominal capacity of 25 MTPA
- Construction of power generation and water supply infrastructure
- Construction of product storage facilities
- Construction of domgas facilities
- Construction of pipeline(s) to deliver domestic specification gas from the domgas facility to the DBNGP
- Construction of a MOF to service LNG Facility, nearshore and offshore activities
- Construction of an LNG and condensate PLF, with an associated dredged access channel and turning basin
- Construction of associated service infrastructure including access roads, and wastewater treatment facilities

Table 2.1: Key Project Characteristics

Aspect	Description
Subsea Wells	Up to 35 production wells
Domgas Plant	Capacity equivalent to approximately 15% of LNG Higher Heating Value One to two pipeline(s) up to 0.91 m (36") diameter and approximately 75 km long
Manifolds and interfield pipelines connecting wells to offshore platform	Up to 11 manifolds Multiple infield lines servicing wells
Wheatstone Platform (WP)	One central platform, with provision for additional support structures if required, in approximately 70 m water depth
Trunkline (from WP to onshore facility)	One pipeline, up to 1.2 m (48") diameter and approximately 225 km long from the WP to the shore crossing
Onshore LNG facility capacity	Up to 25 MTPA
LNG train size	4 to 7 MTPA
Number of LNG trains	Up to 6
Proposed number of storage tanks	Up to 4 x 180 000 m ³ LNG tanks Up to 4 x 120 000 m ³ Condensate tanks
PLF and MOF	Up to 2.5 km long with export facilities for up to 3 LNG tankers and up to 2 condensate tankers One MOF to accommodate onshore construction requirements and provide cyclone haven for tugs
Discharge pipeline	One produced water (PW) pipeline up to 0.51 m (20") diameter and up to 50 km long from the onshore facilities to approximately 20 m water depth contour Provision for treated wastewater discharge pipe(s) either at end of PLF and/or separate subsea line(s)
Dredging	Approximately 16 km long navigation channel with up to 45 000 000 m ³ of dredge material
Accommodation village	Up to 5000 construction workers Up to 400 operations personnel

- Commissioning, operation and decommissioning of the above facilities
- Construction of an accommodation village for construction and operational requirements.

Table 2.1 provides the key characteristics and dimensions of the Project.

2.1.1 Design Standards

Design standards for the Project incorporate, as a minimum, compliance with the Commonwealth and applicable WA State legislation. In addition, international agreements to which Australia is a party have been taken into account as well as Chevron Policies, Procedures and Standards.

The design of the Project facilities will adhere to sound engineering practice and applicable standards and/or codes.

2.1.2 Structure of the Chapter

This chapter is structured in the following manner:

- Major Infrastructure components - describing the Project aspects
- Construction activities
- Commissioning activities
- Operational activities
- Decommissioning.

Emissions, discharges and wastes generated by these aspects are described in greater detail in Chapter 4, *Emissions, Discharges and Wastes*.

2.2 Major Infrastructure Components

2.2.1 Offshore Facilities

The offshore facilities will enable access to and treatment of the gas and natural gas condensate (condensate) reserves before transport to the onshore facility for LNG and domgas processing. These facilities will be located in Commonwealth waters in water depths ranging from 70 to 300 m and may include; wellheads, manifolds, inter-field flowlines and risers, connecting to the WP. A separate Compression Platform may be required during the later stages of the gas field life to maintain flow in the trunkline. The treated gas and condensate will then be exported via a trunkline to the onshore processing facilities.

2.2.1.1 Wells and Subsea Components

The Project will utilise an all subsea concept for wells and manifolds. See Figure 2.2.

Up to 35 subsea production wells will be drilled for the Project throughout its production life. The wells will be directionally drilled from a small number of drill centres located across the field. Management of environmental impacts as well as efficient and reliable resource recovery will be taken into consideration in determining the final number of wells and their locations prior to drilling.

Each well will be fitted with an arrangement of valves, controls and instrumentation referred to as a “subsea tree”, which will be located on the seafloor. A subsurface safety valve is proposed to be installed in each well below the seabed to enable isolation of the gas reservoir. These valves (as well as the valves on the subsea tree) are designed to close automatically in the event of a mechanical failure or loss of system integrity. A “choke” valve will also be included to control the fluid flow and pressure from the well to the flowline.

Each group of wells will use “well jumpers” to connect them to their “cluster manifolds”. Each cluster manifold will serve between one and eight wells. From these cluster manifolds, tie-in spools will transfer fluids to the feed gas flowline(s). The production fluids (gas, water and some condensate) will be transported along the feed gas flowline(s) to the WP. It is proposed that these feed gas flowline(s) will be either corrosion resistant alloy clad carbon steel or carbon steel.

To support the operation of the wells and manifolds, as shown in Figure 2.3, they will be connected to the gas processing facility by an umbilical bundle. The umbilical bundle is likely to include:

- Electrical power and signal lines
- Control line (water-based control fluid)
- Chemical injection lines.

Separate Mono Ethylene Glycol (MEG) injection lines, utility lines and other essential service lines may also be required.

Hydrate inhibitors are required to prevent formation of hydrates, a crystalline structure of water and hydrocarbons. These have the potential to block the offshore flowlines when temperatures are low and pressures are high. MEG has been selected as the optimum hydrate inhibition chemical, although a combination of mono-ethylene glycol and a kinetic hydrate inhibitor (KHI) is also being considered. This has the potential to reduce chemical volumes.

The other chemicals considered include:

- Methanol, which has similar inhibiting characteristics to MEG but is highly flammable and hence a more dangerous chemical to store in large volumes offshore

- Di-ethylene glycol and tri-ethylene glycol (TEG), which are less suitable at the low seabed temperatures due to their lower inhibition abilities and higher viscosities. The latter causes flow and pumping risks.

MEG is the preferred hydrate inhibitor, and it will be stored at, and pumped from, the WP. It will be discharged to the ocean with the produced water (PW).

An electrohydraulic control system will control the valves on the subsea trees, with control fluid powering valve movements controlled by solenoid valves.

The control fluid will be selected to be suitable for release to the environment. The control fluid has been used in similar applications with regulatory approval. Small quantities of this fluid will be released to the ocean during operation of the well and pipeline control valves.

Corrosion inhibitors and other chemicals (such as methanol for hydrate remediation purposes) may also be injected

into the wells and flowlines in the future via the umbilical bundle, which will follow the path of the main feed gas pipeline. Other chemicals that may be required in the future include scale prevention chemicals, pH stabiliser, and acids for well maintenance.

2.2.1.2 Platform(s)

The WP will comprise either a four legged steel frame “jacket” or gravity based structure (which may be either concrete or steel) onto which the “topsides” equipment and living module units will be mounted (see Figure 2.4). The complex may include separate, bridge connected platforms, to accommodate crew quarters and flares.

The WP will be an occupied, normally manned facility and will provide services for operation of the subsea trees, flowlines, umbilicals and trunkline. A simplified process flow diagram is shown in Figure 2.5. Note compression is likely to be initially installed and by-passed until it is required.

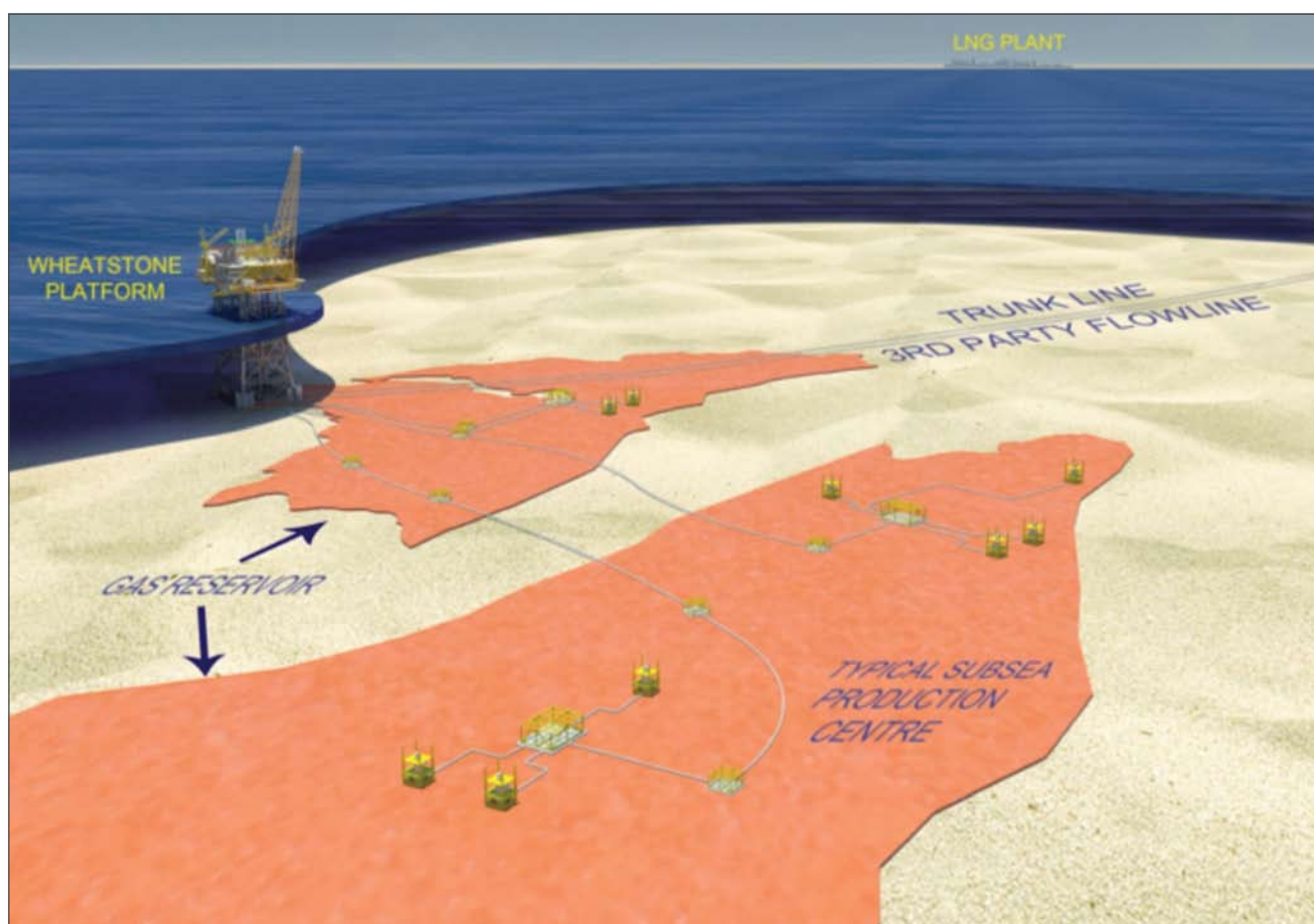


Figure 2.2: Indicative Offshore Layout

The facilities are expected to comprise:

- Two to three separation trains; each with an inlet separator and a liquids separator, and associated coolers
- Gas compression, including associated coolers
- Two to three gas dehydration trains, each with a TEG dehydration contactor and regeneration skid
- Two to three condensate dewatering trains using filtration and coalescence for free water removal
- PW treatment and disposal
- MEG handling and disposal
- Associated utilities including:
 - Seawater water system for closed-loop cooling medium, potable water generation, and firewater
 - Chemical storage and generation of hypochloride solution
 - Utilities, including fuel gas, instrument air, nitrogen cooling water (CW) and service/potable water
 - Firewater and distribution
 - Power generation and distribution
 - Flare (including purge and pilot systems)
 - Drainage systems including continuous process drains, maintenance closed drain system, hazardous open drains, and non-hazardous open drains
 - Living quarters and associated facilities.

The significant majority of hydrocarbons, gas and condensate, processed at the WP will be exported to shore for further processing and sale. A small flow is used as fuel gas for power generation and compression.

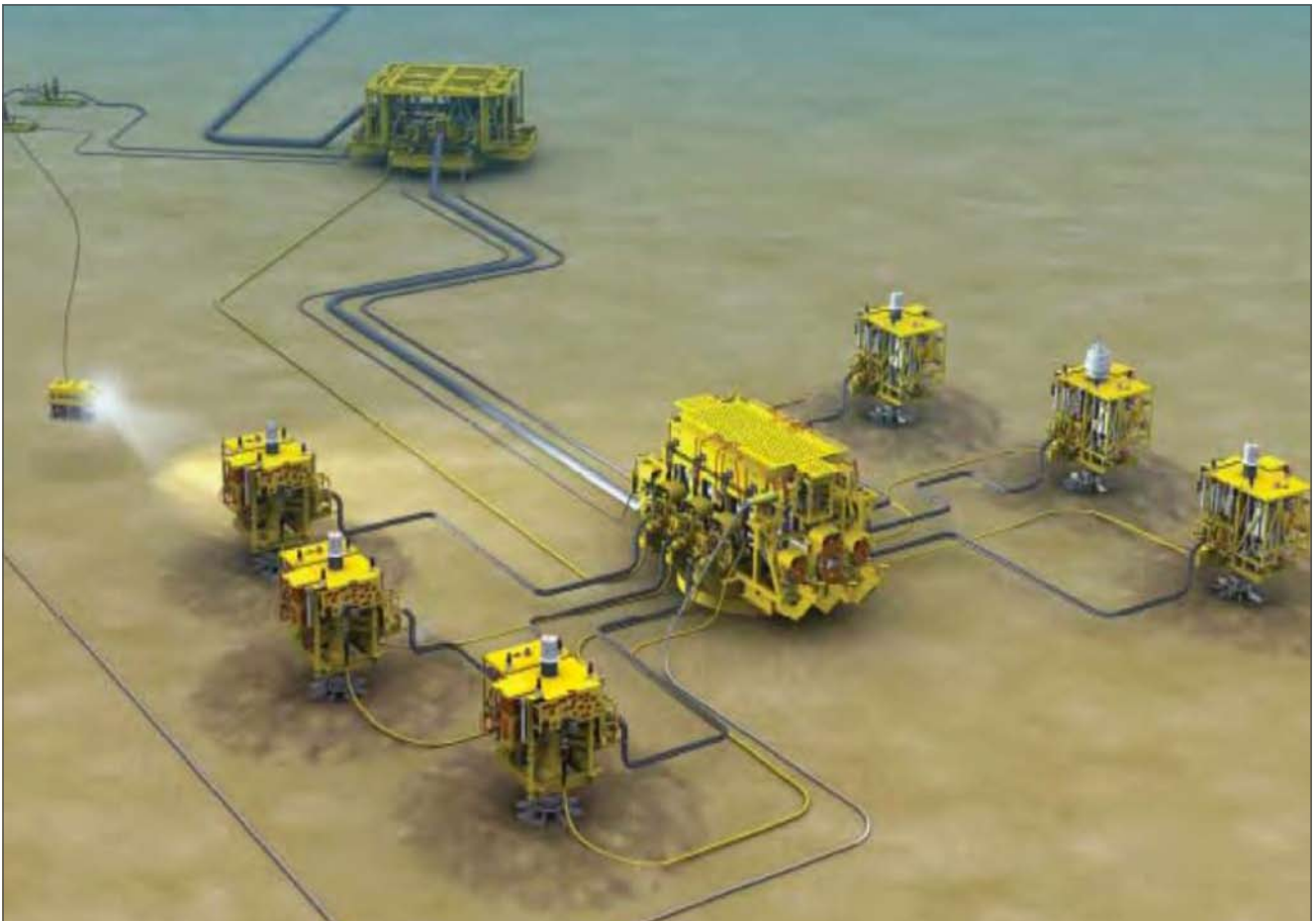


Figure 2.3: Indicative Subsea Infrastructure

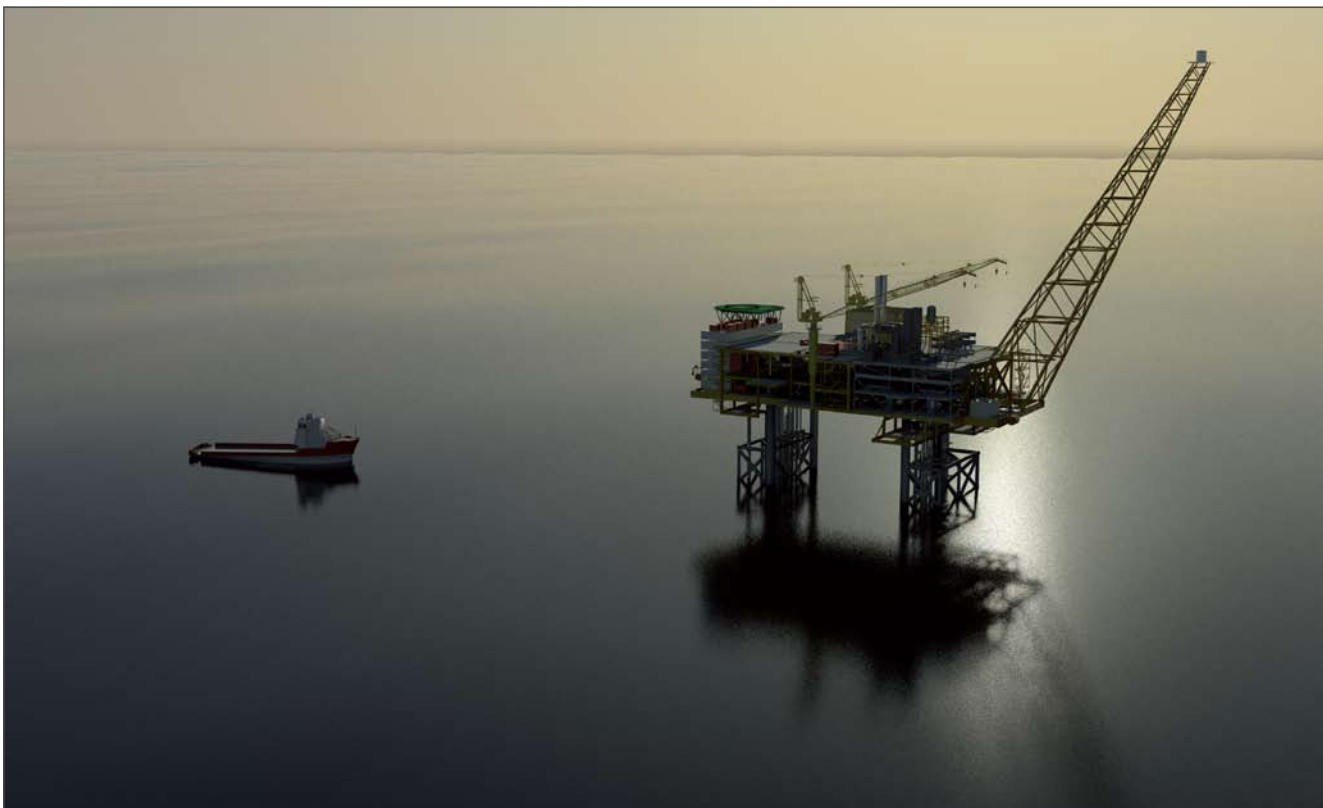


Figure 2.4: Wheatstone Platform (representation only)

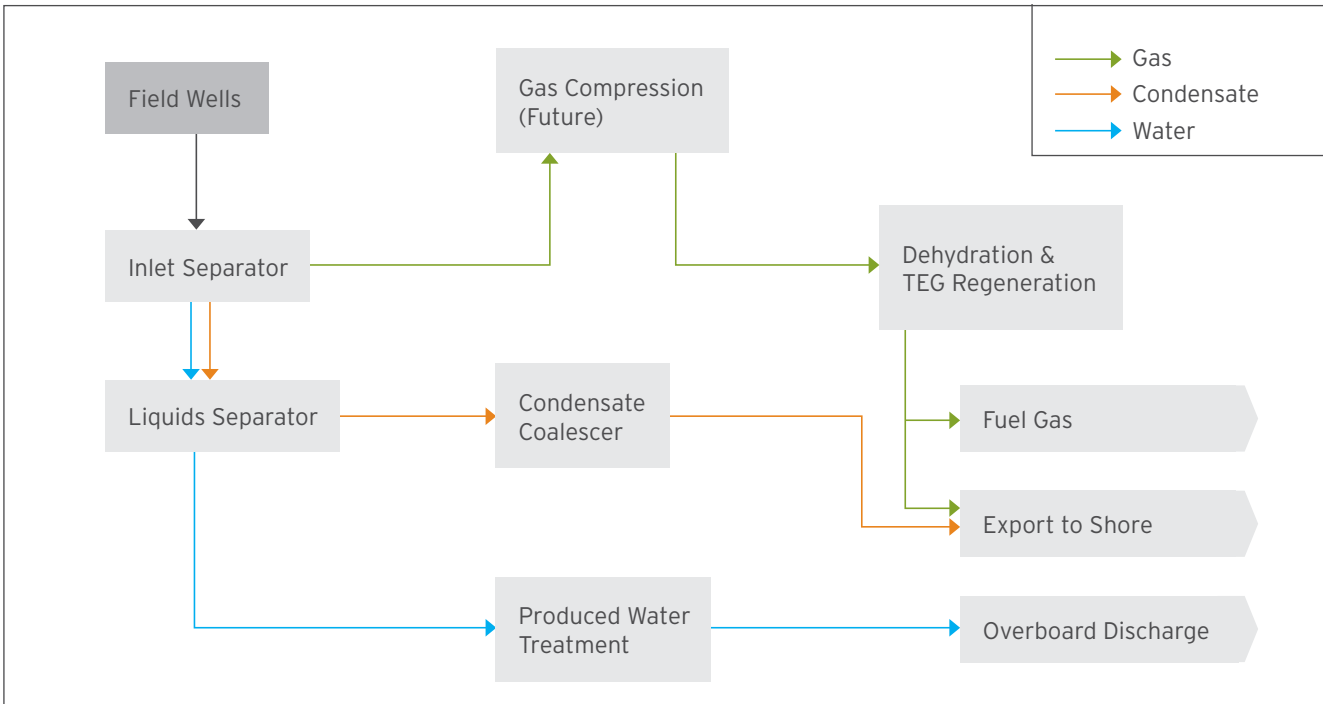


Figure 2.5: Simplified Offshore Process Flow Diagram

With the exception of some small consumption for safety purposes and minor flows from process sources, no gas is flared during normal operation. The safety procedures include flare purge and compressor seal gas. Both these applications prevent the build-up of flammable or explosive mixtures. Process sources may include minor flows from the water treatment systems and the TEG regeneration system. Some gas is flared during prolonged shutdowns and re-starts to prevent hydrate blockage of the production flowlines.

Separation

Well fluids from the fields will flow to a two-stage production separation system. The first stage is a gas-liquid inlet separator, where gas is separated and sent for processing, while the liquid component is sent to the second-stage liquids separator, which separates the bulk of the condensate and water. Separated condensate is sent for further processing, while the separated water is sent to the PW treatment system.

Gas Compression

Compression is likely to be required from five to 12 years following start-up, as the wellhead pressures decline. However, the compressors will be installed at start-up and be available in a by-pass "free-flow" mode.

The current basis for compression is for two approximately 35 MW gas-fired turbines or equivalent. These are expected to be high-efficiency aero-derivative turbines, which run on fuel gas. It is anticipated that these will be located on the WP; however, contingency has been allowed for a separate co-located compression platform.

Gas Dehydration

Once compressed (if required), the gas is sent to dehydration, where water is removed through contact with TEG. Dehydrated gas is sent to the trunkline, with a small amount diverted to the offshore fuel gas system. The TEG is regenerated through the TEG reboiler, which is presently designed to utilise waste-heat from the power generation system (as opposed to a stand-alone gas-fired heater or an electric heater). Stripping gas may be required for TEG regeneration on an infrequent basis to reach the required TEG purity (this is forecast to happen on some high flows, which is not considered to be a normal operating scenario). The TEG regeneration offgas, and any stripping gas used, are sent to the low pressure flare for combustion.

Condensate Dehydration

Condensate from the production separation system is cooled, filtered and sent through a condensate coalescer to remove water, before being sent to the trunkline and combined with the dehydrated gas for transport to shore. Booster pumps are included in the design for when the reservoir pressures decline, with variable speed drives currently under consideration to increase energy efficiency.

Produced Water Treatment

The PW will be treated and monitored to ensure compliance with legislative requirements, then discharged overboard through the seawater dump caisson. Alternative treatment methods will also be assessed during the detailed design phase for the Project.

Utilities

Key supporting utilities in the design of the offshore facility include:

- Support systems, including fuel gas, diesel, instrument air, nitrogen generation, CW and service/potable water
- Firewater systems
- Dual-fuel power generation and distribution, including waste heat recovery
- Low-pressure and high-pressure flares, including collection headers, drums, a separate flare structure and a flare tip
- Sewage and drainage systems
- Personnel living quarters.

2.2.1.3 Trunkline

One trunkline up to 1.2 m (48") in diameter is proposed to transport the co-mingled dry gas and condensate from the WP to the onshore plant. See Figure 2.1.

The pipeline route to shore will cross the shallow nearshore shelf between Thevenard and Bessiers islands, and skirt Ashburton Island before coming ashore at the plant site. The route descends for about 25 km from the WP, from a water depth of about 70 m to approximately 120 m before following the 110 m water-depth contour for most of its length until 60 km from shore. From there it gradually slopes up to a shelf for about 30 km to level off at about 10 m water depth and then rises to the onshore plant in the last few kilometres. The pipeline will require stabilising to prevent excessive movement. This stabilisation is likely to be a combination of ploughing, dredging and mechanical

trenching and the placement of engineering rock berms on the pipeline. From the 20 m contour to the nearshore crossing it is likely that the pipeline will require some form of rock stabilisation.

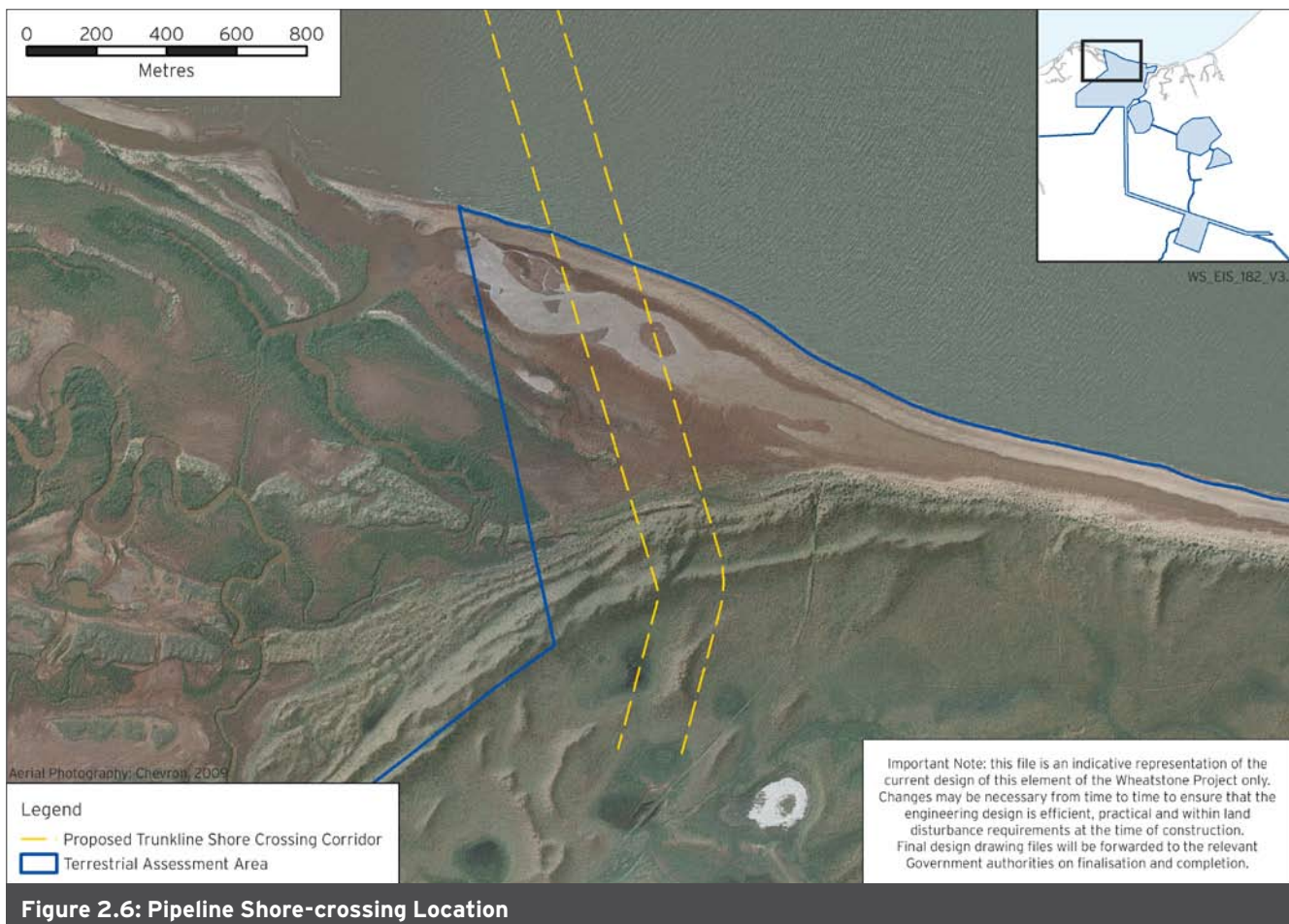
Where practicable the Trunkline nearshore will be trenched and covered with engineered backfill in order to minimise impact on shipping, stabilise the pipeline under cyclonic conditions and protect the pipeline from hazards. Trench backfill could protrude slightly above the seabed in areas depending on protection requirements and the depth of the pipeline below the surface. However, in regions along the Trunkline route where the seabed is too hard to effectively pre-trench or post trench the Trunkline, it is proposed to leave the Trunkline on the seabed and rock dump (see Section 2.3.1.3).

The potential impacts of the Trunkline routing and secondary stabilisation methods to shipping crossing the Trunkline route are currently being evaluated. This evaluation will include a shipping study to look at recommended shipping tracks that cross the Trunkline

route as well as the frequency and type of vessels operating in the area. The results of the study will be discussed with the key stakeholders in order to determine the requirements for the development of anchor exclusion zones and recommended shipping tracks. Depending on the results of the shipping study and assessment of the seabed conditions it may be necessary to update the existing recommended shipping tracks crossing the Trunkline route in order to ensure maximum flexibility for shipping.

An extensive geotechnical investigation along the Trunkline is currently underway, along with trenching trials to further determine the feasibility and extent of trenching along the route. This information will also feed into the shipping and secondary stabilisation studies to determine the optimum overall design. This study will also further optimise the Trunkline route. Section 8.2 provides further instruction on possible route options.

The pipeline corridor will be approximately 20 m in width in the offshore area (beyond 20 m water depth) but will be wider nearshore (up to 50 m).



Section 2.3 provides further details on pipeline installation and stabilisation.

2.2.1.4 Offshore Support Facilities

The offshore facilities will be supported by supply vessels and helicopters, which will transport materials and personnel to and from the WP. During construction, specialist vessels, such as a mobile offshore drilling unit, installation vessels (which deliver the larger components from their construction yards), lift barges and pipe laying barges, will also be required.

2.2.1.5 Fibre Optic Telecommunications Cable

Chevron is currently investigating the options to provide a standard, reliable, integrated offshore telecommunications infrastructure. One of the proposed alternatives is a subsea fibre loop, part of which could be laid in the same corridor as the trunkline. This telecommunications cable may also connect to Gorgon Project facilities or third-party operations.

2.2.2 Nearshore Marine Components

2.2.2.1 Pipeline Shore-crossings

The proposed location of the pipeline shore-crossing is shown in Figure 2.6.

In addition to the pipeline from the WP for the Foundation Project, additional future pipelines may be installed. If the micro-tunnelling option is chosen then these pipelines, outfalls, and control umbilicals would be installed in four to six tunnels. These tunnels would be completed during each phase of the construction and will not be installed at the same time.

Further pipelines may be laid from the offshore gas fields to the LNG and domgas facilities in future, but these would be subject to separate Commonwealth and State approvals obtained by future offshore proponents.

2.2.2.2 Nearshore Infrastructure

The Project will require two types of port facilities: a MOF and a PLF.

The MOF's primary function is to provide an offloading facility for heavy-lift ships, Roll-on, Roll-off (RORO) vessels, heavy-lift carriers and barges all delivering pre-fabricated modules, equipment and bulk material (steel fabricated pipe, piles and other construction bulk materials) and vessel access for marine contractors during construction. During the operations phase it will provide a base and cyclone shelter for marine operations craft (tugs, security and line handling vessels). See Figure 2.7.

Breakwaters will be provided on both the east and west side of the MOF entrance to create calm conditions inside the basin during normal conditions and a safe haven for the tugs during a cyclone.

The proposed PLF will provide berthing for LNG and condensate carriers.

The PLF is likely to carry a roadway and a double pipe rack from the shore to the PLF operations platform, from where loading operations will be controlled. The pipe rack would accommodate LNG and condensate loading lines, an LNG vapour return line, fire water pipework and communications cabling. The PLF may also accommodate an outfall line to service the Project. This outfall would be at approximately 5 m water depth.

A navigation channel and a turning basin will also be required to enable the LNG and condensate carriers to safely access and depart the berths at the PLF. The channels and basin may need to be dredged periodically to maintain the required depth.

2.2.3 Onshore Facilities

Once onshore, the gas and condensate will be processed and stored before being exported via carrier vessel, or distributed to the existing domgas network.

The majority of the gas will be processed into LNG using the ConocoPhillips Optimised Cascade® LNG technology or equivalent, with propane pre-cooling and using ethylene and methane as refrigerants for liquefaction and sub cooling. Two process trains would be constructed initially with additional trains constructed over time as further gas supplies are brought online to a total nominal capacity of 25 MTPA. A conceptual layout is shown in Figure 2.8.

A portion of the feed gas will be processed in the domgas plant to produce pipeline quality natural gas for the domestic market. The capacity of the domgas production facilities will be designed to be equivalent to approximately 15 per cent of the annual LNG export capacity, on a high heating value basis.

As the source of gas for the additional trains is not yet known, provision has been made for removal of produced formation water from this future gas source, its onshore treatment and discharge to sea via an offshore outfall. This outfall is anticipated to be along the same corridor as the trunkline and is expected to discharge via a diffuser at a nominal 20 m water depth.

In addition to the process trains, the onshore site will also include power, water supply and wastewater treatment facilities, storage for process chemicals, fuel (diesel) and

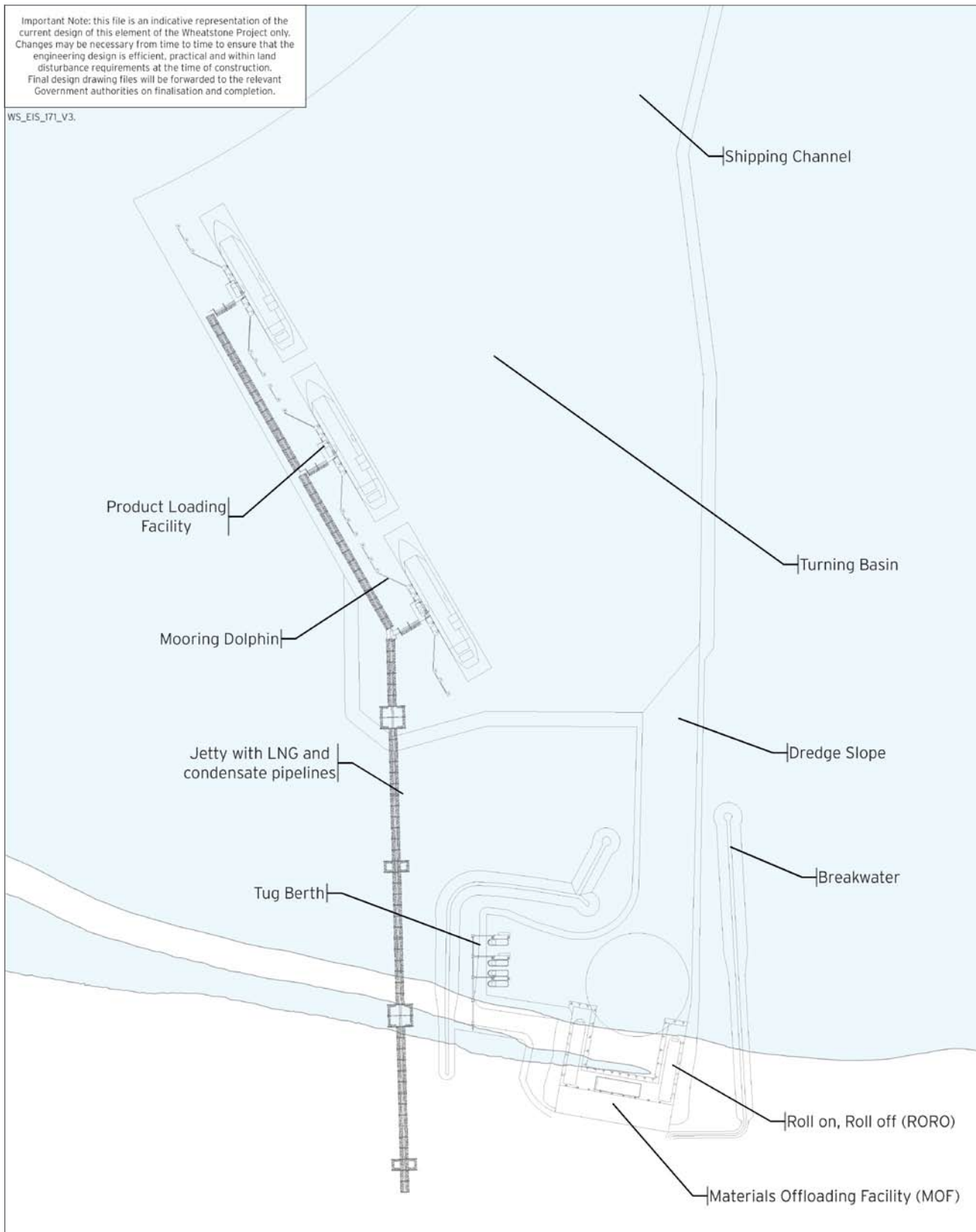


Figure 2.7: Marine Facilities

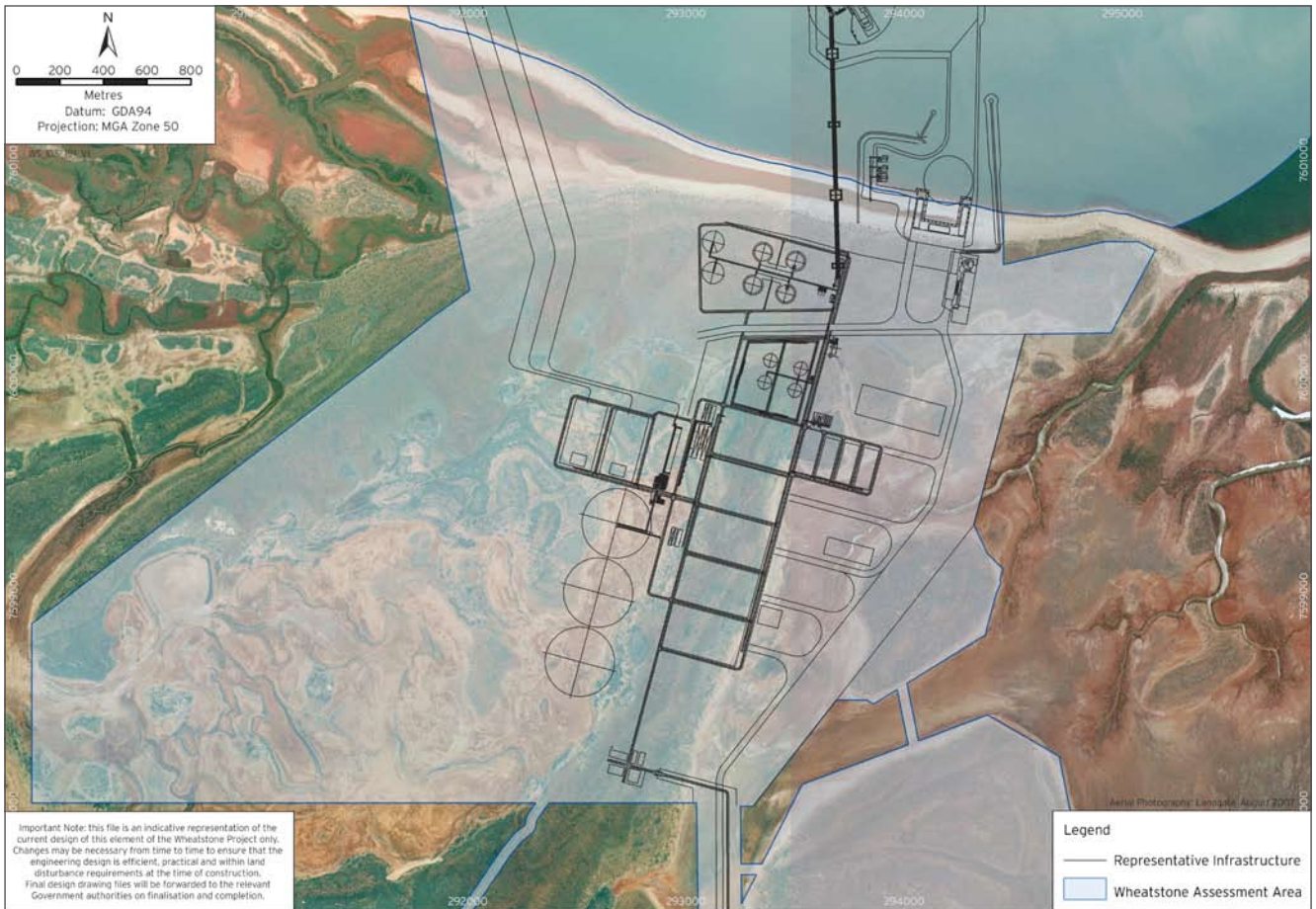


Figure 2.8: Conceptual Facility Layout

equipment spares, and lay down areas for the initial and future construction works. A separate Accommodation Village will be built, at an appropriate distance from the process plant, to house both construction and operations staff.

2.2.3.1 LNG Facility

A simplified process flow diagram is shown in Figure 2.9.

The following list summarises the various process units that are expected to comprise the LNG facilities:

- Inlet facilities/stabiliser systems
- MEG recovery (future trains)
- Acid Gas Removal Unit (AGRU)
- Dehydration and mercury removal
- Liquefaction and methane compression, including Nitrogen Rejection Unit (NRU)
- Heavy hydrocarbon removal and fractionation
- Flare and vent systems

- Refrigerant storage
- Diesel storage and distribution
- Fuel gas
- Condensate storage and loading
- LNG storage and loading
- Pentane storage and handling
- Process and stormwater treatment
- Power generation
- Firewater
- Heat medium
- Plant and instrument air
- Water
- Inlet air humidification
- Nitrogen.

The key elements of these process units are described in more detail in the following sections.

Inlet Facilities/Stabiliser System

The pipeline gas received from the offshore fields flows through a slug catcher and is separated into feed gas, hydrocarbon condensate, and wastewater. The feed gas then flows to the LNG trains and domgas plant(s). The hydrocarbon condensate is stabilised in the condensate stabiliser, which strips off light ends to meet the condensate vapour pressure specifications. The stabilised liquid is then sent to one of the condensate storage tanks. The stripped gas is compressed and transferred to the main gas feed line of the LNG train for processing. The wastewater will be sent to the effluent treatment unit. Some wastewater (from Trains 3, 4 and 5) may contain MEG. If this is the case the MEG would be separated from the incoming gas and recovered from the wastewater. The MEG may then be transported back to the offshore producing facility via a subsea line. The wastewater will be sent to the effluent treatment unit.

Acid Gas Removal

The AGRU removes acid gas components such as carbon dioxide (CO₂) and hydrogen sulfide (H₂S) from the feed gas, which would otherwise freeze during the LNG liquefaction process, potentially damaging the plant and causing plant shutdown. The AGRU system is designed to use a conventional activated methyl diethanolamine (aMDEA) solvent. During this treatment process CO₂ and H₂S that is present in the feed gas are removed in an absorber. These are then stripped from the amine solution during the solvent regeneration process and sent to a thermal oxidiser, while the regenerated amine is returned to the absorber via a closed loop system. Some of the benzene, toluene, ethyl-benzene and xylene (BTEX) in the feed gas will also be absorbed by the aMDEA in the absorber. This BTEX will be stripped out during solvent regeneration and will be sent to the thermal oxidiser along with the acid gas. A 99% BTEX destruction efficiency can be expected in the thermal oxidiser.

Dehydration and Mercury Removal

To ensure that the final traces of water are removed from the gas stream, it is passed through a molecular sieve dehydration system. Water from this process is recycled to the inlet facilities and AGRU and the dehydrated gas stream progresses through activated carbon beds to remove any traces of mercury that could otherwise corrode the aluminium heat exchangers used in the gas cooling process.

Liquefaction

The treated gas then passes to the refrigeration system, which progressively cools it to -160°C at which point

it liquefies into LNG. This process uses a "cascade" of successive refrigerant steps to progressively cool and liquefy the feed gas into LNG. There are three refrigerant services used: propane, ethylene and methane. As the gas passes through these systems, it gives up heat to the successive refrigerants and cools. The cooled gas is then flashed (allowed to expand into a separator or drum) to atmospheric pressure, cooling it further. The resulting LNG is then pumped to the insulated LNG storage tanks and stored at atmospheric pressure and -160°C.

After going through the successive refrigeration cooling steps a slip stream from the feed gas circuit is sent to the NRU, where nitrogen is removed so that LNG product specifications can be met. The nitrogen is cryogenically separated from the methane via a series of fractionators and vented to the atmosphere.

Heavy Hydrocarbon Removal and Fractionation

Condensed hydrocarbon liquid from cooling of the feed gas is fractionated to remove the heavier hydrocarbon components. This prevents freezing of hydrocarbon in the low temperature liquefaction section while satisfying the specifications of the LNG product. These heavy components are comprised of natural gas liquids or condensate and are blended with the condensate from the inlet facilities to produce the final condensate product. There are also facilities to re-vaporise some of these liquids for use as fuel gas if needed.

Flare

Wet and dry service flare systems will be provided to support start-up, shutdown, emergency and maintenance venting requirements of the process facilities. A marine flare is provided to support the LNG marine requirements. The flare system is likely to consist of three wet, three dry and two marine flares for the 25 MTPA case. These will be high efficiency elevated (approximately 125 m for the wet and dry flares) flares that have been designed for reduced smoke and particulate emissions as well as for reduced emissions of CO, volatile organic compounds (VOCs) and partially combusted hydrocarbons. Elevated flares reduce the possibility of thermal radiation exposure to the workforce and facilities and assure combustion products are well dispersed.

Acid Gas Thermal Oxidiser is provided to incinerate any impurities contained in the acid gas produced from the AGRU. An Acid Gas Thermal Oxidiser is part of each LNG train and domgas train.

Waste Heat Recovery Units

Waste heat recovery units (WHRU) are expected to be installed on the refrigeration compressor gas turbines. The WHRUs utilise the waste heat from the refrigeration compressor gas turbines exhaust streams to provide the heat required for the LNG and domgas process equipment. Installing WHRUs improves fuel efficiency due to the elimination of direct fired heaters. This results in less air pollutant emissions and less greenhouse gas emissions. The WHRUs in the first two trains use hot exhaust gas from the gas turbine drivers within the LNG train to heat a circulating heat medium and are sized to use as much as practicable of available waste heat and to fully supply the heat duty needed for all the heat exchangers that are normally in operation. In addition, the WHRUs are also equipped with separate heating coils to intermittently heat the regeneration gas for the regeneration of the molecular sieve in the Dehydration Unit. In the future WHRUs may also be used to generate steam for electric power generation and process heat requirements for future LNG trains.

Product Storage and Export

The LNG will be stored at atmospheric pressure in tanks of approximately 180 000 m³, which are insulated to prevent the LNG from warming, rather like very large vacuum flasks. Even with insulation, a small proportion of

the LNG regasifies as Boil Off Gas (BOG). BOG is captured by a vapour recovery system which compresses the gas and returns it to the LNG facility. Two tanks are initially proposed to be constructed with additional tanks being added in line with the increasing annual throughput of LNG up to a maximum of four tanks. A typical full containment tank is shown in Figure 2.10.

For export, the LNG is pumped from the storage tanks to the loading arms at the LNG carrier berths and into LNG carriers for delivery to foreign or domestic markets. As this transfer process absorbs heat from the ambient environment, a small portion of the LNG regasifies as BOG during the loading operation, which is captured by a vapour recovery system. To help reduce the generation of BOG, and keep the unloading piping systems cold between ship loading operations, LNG is circulated through the loading lines.

Condensate will also be stored at atmospheric pressure in tanks of approximately 120 000 m³ and pumped to the condensate berth to transfer to tankers via the loading arms. These condensate tanks may have floating roofs to minimise the roof cavity where excess gas can accumulate. Initially, two tanks are proposed with additional tanks being added as throughput increases over time, up to a maximum of four condensate storage tanks.

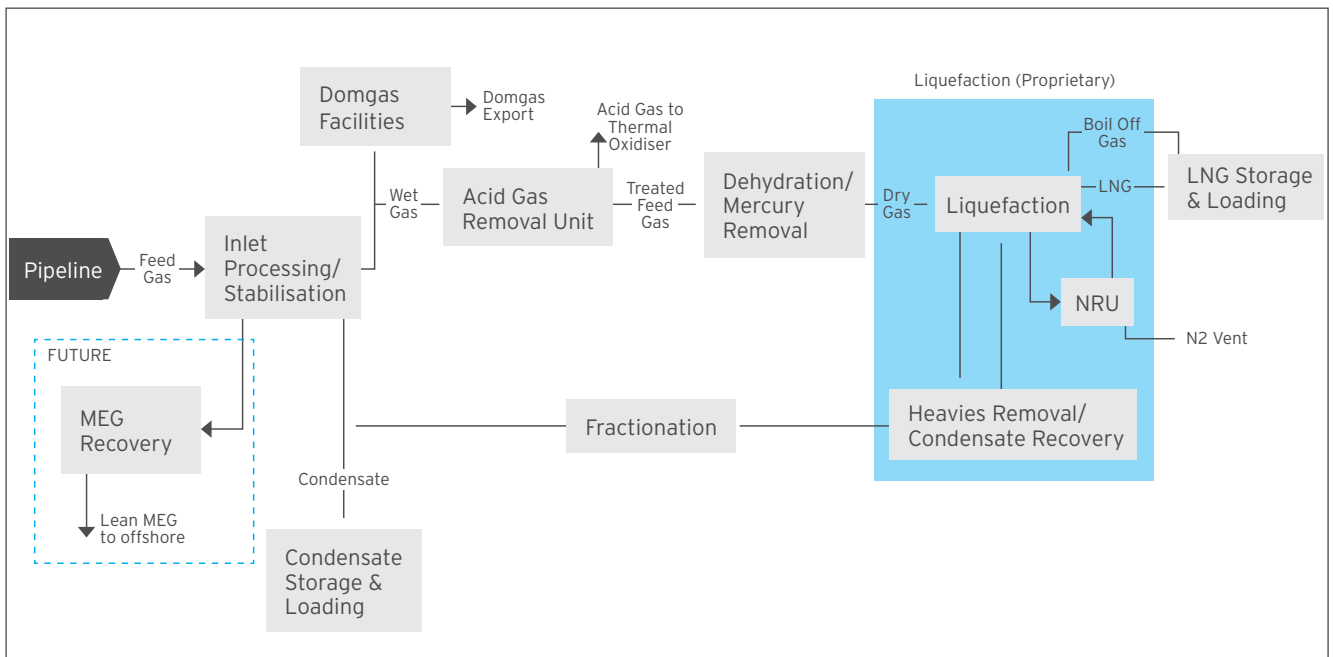


Figure 2.9: Simplified Process Flow Diagram

Power Generation

The production of LNG and domestic gas (see below) requires power. It is anticipated that gas turbine generators (LM6000 or equivalent) will be used. These are likely to be fitted with Dry Low Emissions (DLE) technology. The number of turbines required is anticipated to be a nominal nine for power generation of the 25 MTPA case.

A discussion on power generation is provided in Chapters 3 and 4.

2.2.3.2 Domgas Plant

Plant Characteristics (Process Description)

Initially one domgas plant is proposed for the two-train Foundation Project. Additional domgas plants may be required when the Project reaches capacity.

The main processes associated with the proposed domgas plant(s) are illustrated in Figure 2.11.

Inlet Facilities

Gas will normally flow to the domgas plant from the feed heater of the LNG train. If an LNG train is out of service, the domgas feed will be taken directly from the outlet of the Slug Catcher and will be heated by hot oil circulation.

Acid Gas Removal Unit

The AGRU for the domgas plant works in a similar manner to that described above for the LNG plant. The AGRU system is designed to remove acid gas components such as CO₂ and H₂S from the feed gas using an aMDEA system. The removed acid gas will be routed to a thermal oxidiser for destruction of any sulfide acid gas components and BTEX if present.

Dehydration and Mercury Removal

TEG or molecular sieves may be used to dehydrate the gas stream to meet the sales gas water specification and prevent hydrate formation. If a cryogenic nitrogen rejection unit is required for the domgas plant, dehydration by molecular sieves following by mercury removal will be provided upstream of the NRU.

Hydrocarbon Dew Point Control

To prevent the formation of liquids when the gas is transported by pipeline, it is necessary to control the hydrocarbon dew point. The gas will be cooled and flashed (allowed to expand by reducing pressure) possibly through a Joule-Thompson Valve (or equivalent process) to drop out hydrocarbon liquid and meet the product specification. The

hydrocarbon liquid will be routed back to the inlet facilities. Alternatively, if the nitrogen content of the gas is high, the gas will be processed in a NRU with integrated dewpoint control utilising refrigeration from the low temperature streams in the NRU.

Compression and Metering

Once treated, the domestic supply gas is compressed, metered and sent to the distribution pipeline.

2.2.3.3 Domgas Pipeline

The proposed route of the domgas pipeline(s) to the DBNGP runs from the domgas plant to the Onslow-to-Mt. Stuart Road. It then runs parallel to the road direct to the DBNGP, then 1 km south, parallel to the DBNGP easement. The route is shown in Figure 2.12. It is possible there may be up to two domgas pipelines. The pipeline(s) will be up to 0.91 m (36") diameter and will be approximately 75 km long.

The pipeline corridor is expected to be approximately 30 m wide. In areas of environmental significance this corridor width may be reduced to reduce impacts. Additional turn-around bays and laydown areas are likely to be required to allow for stringing of the pipeline.

2.2.3.4 Onshore Support Facilities

Access

The site will be serviced by a 20 km Shared Infrastructure Corridor (SIC), which includes an access road off Onslow Road servicing both the accommodation village and the plant site.

Power Supply

The Project will have an independent power generation and distribution system. Power will not be imported from the local grid. The primary power supply is likely to be provided by a series of gas turbine driven generators. Essential power during outages, emergencies, and start-up will be provided by separate diesel engine driven generator units. See Chapters 3 and 4 for further details on power supply.

Water Supplies

Water will be required for various applications during construction, installation and operation of the onshore facility. Water requirements for potable and non-potable usages for construction and operations are discussed in the Construction and Operations subsections of this chapter. A review of various water sources is considered in Chapter 6, *Overview of Existing Environment*. It is likely that any water sourced will require treatment to remove salinity. This will result in the production of brine, which would be

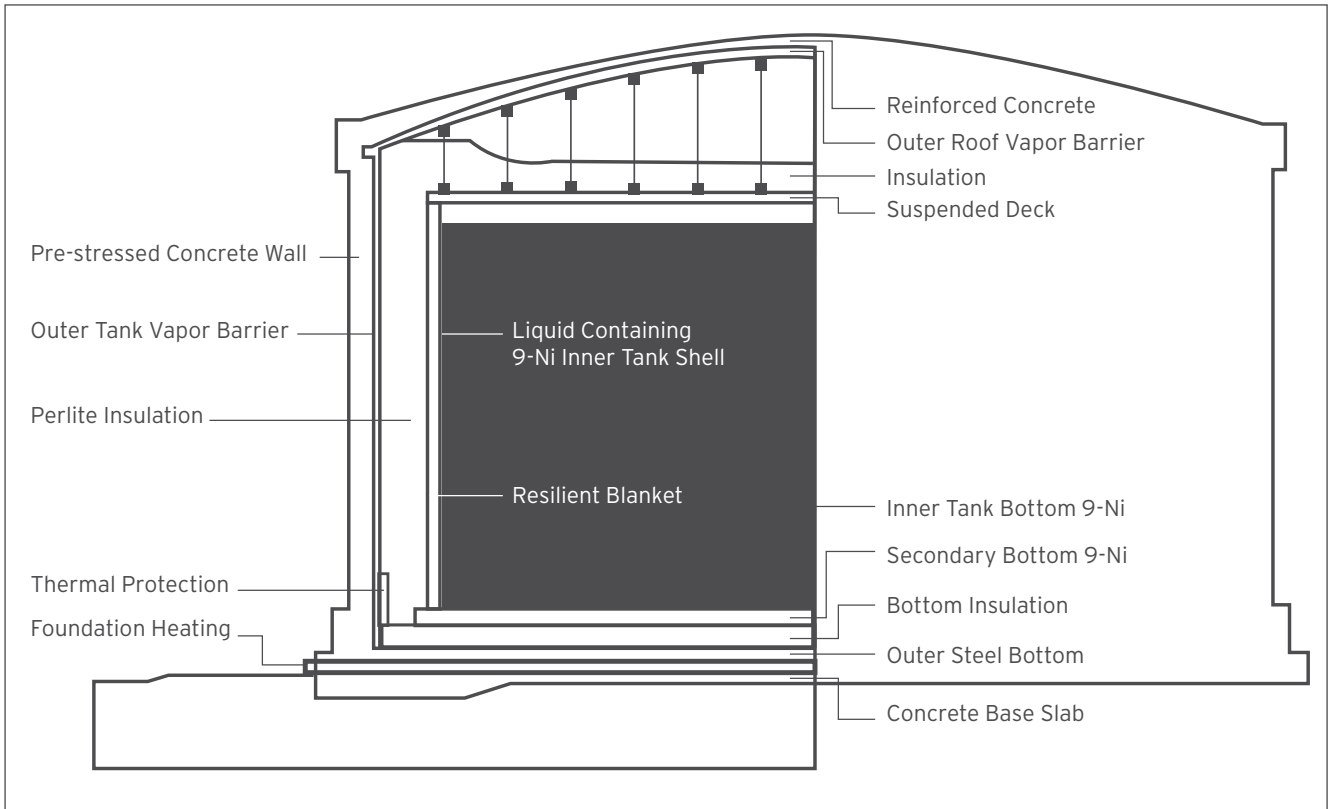


Figure 2.10: Typical LNG Tank Cross Section

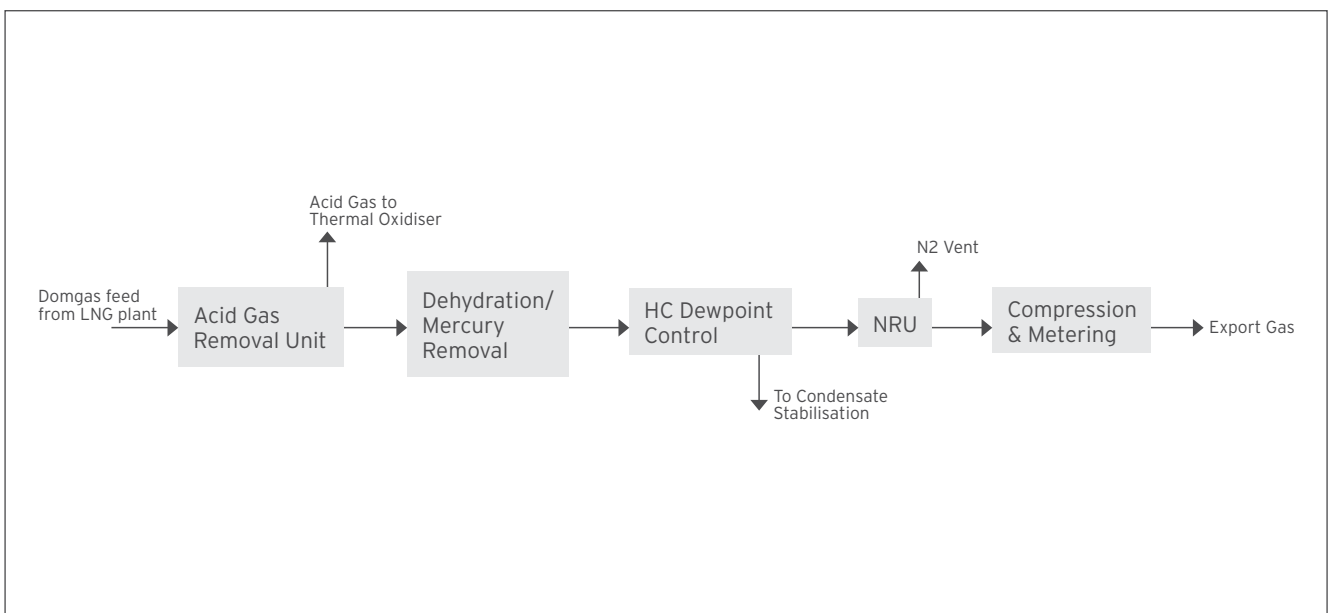


Figure 2.11: Typical Domgas Facility Units

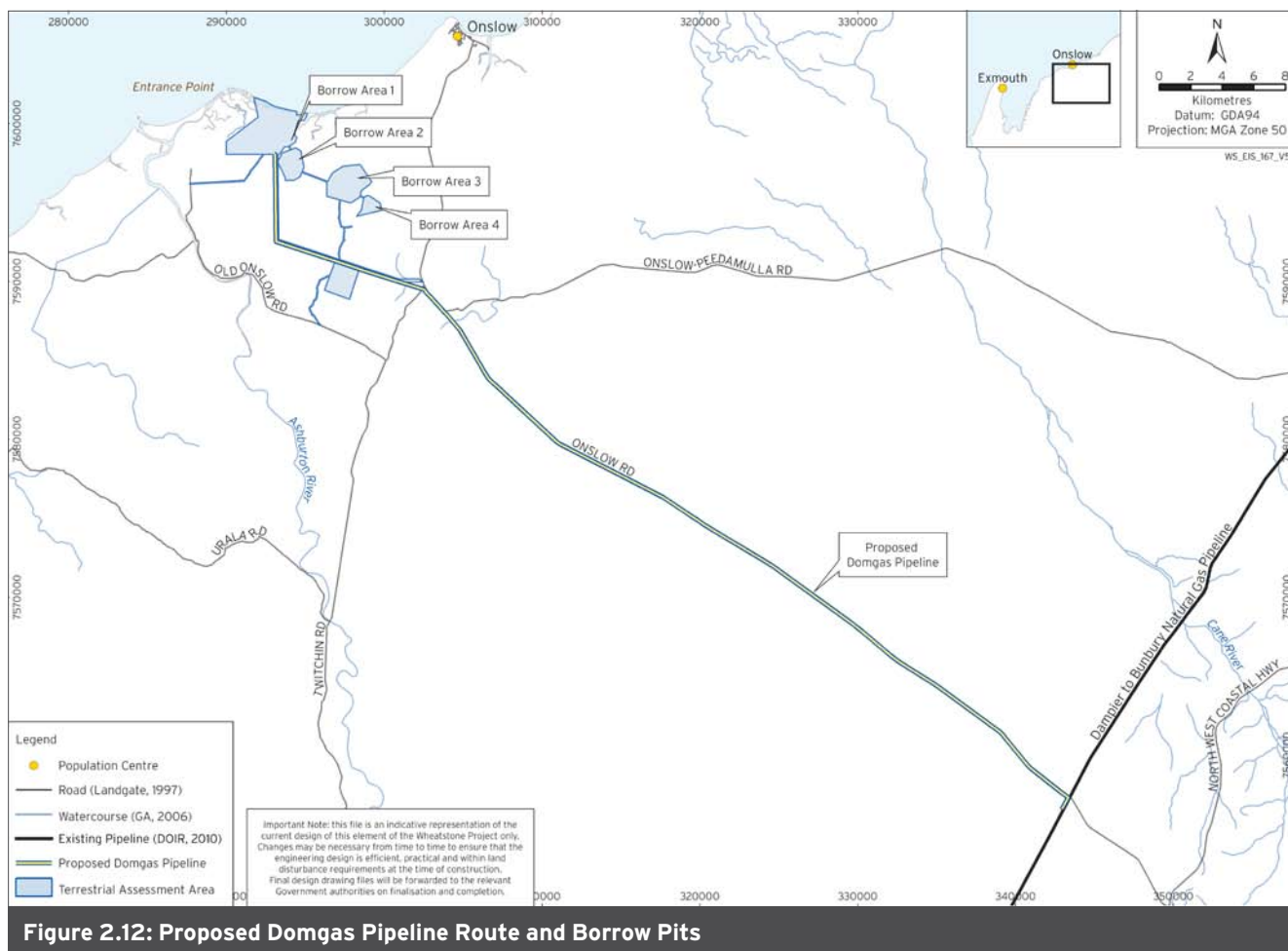


Figure 2.12: Proposed Domgas Pipeline Route and Borrow Pits

discharged to sea via a discharge outfall. The volumes of brine are discussed further in Chapter 4, *Emissions, Discharges and Wastes*.

Surface Water Management and Wastewater Treatment

Areas of the plant will be segregated to provide separate drainage systems for each category of surface run-off. These consist of contact (potentially contaminated) stormwater and non-contact (not contaminated) stormwater.

Clean (non-contact) stormwater from non-process areas and undeveloped portions of the site will be routed to sedimentation ponds. Clean stormwater volumes will vary due to the erratic local rainfall patterns, but may be up to 9,600 kL/day. Potentially contaminated (contact) stormwater from general process areas will be routed to “first flush” retention basins to capture oily or other types of potential contamination from the first 25 mm of rainfall on these areas. The retention basins may be equipped with oil skimmer devices, and with pumps to

transfer the contents to process wastewater treatment if significant contamination is found. Contaminated stormwater from known oily areas (pump pads, etc.) will be routed to collection sumps and pumped to process wastewater treatment.

Process wastewater from the production areas will be treated at an onshore treatment facility prior to being discharged to the sea via an outfall pipeline.

Waste Management

The potential wastes generated and their proposed treatment is discussed in Chapter 4, *Emissions, Discharges and Wastes*.

Additional Onshore Infrastructure

The onshore facilities will have several buildings to support the daily operation of the onshore process facilities and associated marine infrastructure. The following is an indicative list of buildings needed for the

Foundation Project, with the requirement to add extra warehousing and maintenance workshop capacity upon expansion to 25 MTPA.

- Operations centre building comprising reception area, administration (offices), central control room, training centre, canteen and emergency command centre
- Main gate security
- Maintenance centre workshop
- Laboratory
- Telecommunications and fibre optic line
- Fire station
- Warehousing and lay down
- Medical centre.

Roads and Transport

Chevron has identified the potential need to upgrade a number of local roads proposed for use for the Project and other proposed industrial developments associated with the Ashburton North SIA. All road upgrade works would be compliant with all relevant regulations.

Airport

The Onslow airport is located south of the town of Onslow (see Chapter 5, *Stakeholder Consultation*) and is owned and operated by the Shire of Ashburton. The airport runway was upgraded and extended in 2000 and 2004 (information provided by the WA Department of Planning). The runway is suitable for smaller aircraft and is approximately 1600 m long. See Chapter 10, *Social Risk Assessment and Management* for additional information in regard to the Onslow airport.

2.3 Construction Activities

2.3.1 Offshore Construction

2.3.1.1 Drilling and Well Completion

The wells for WA 253-P, WA-17-R and WA-16-R will be subsea, with the drilled hole diameter reducing sequentially with depth from the seabed to the reservoir depth, which is about 3000 m total vertical depth below sea level.

The length of the well within the gas reservoir will be maximised by drilling through the reservoir at an inclination instead of vertically. The wells will also be drilled directionally to access various locations within the reservoir with horizontal step-outs of about 2500 m from the wellhead to the toe of the well. The total drilled length for each well could be about 4400 m.

The wells are expected to be clustered around subsea manifolds in groups of four to six wells, with each well taking approximately 65 days to drill and complete.

The full field development involves returning to the field for several drilling campaigns to install additional wells and undertake well maintenance throughout the life of the field.

The wells are likely to be drilled and completed utilising mobile offshore drilling units (MODUs).

Typically a MODU comprises the following main elements:

- Main rig including the derrick, draw works, substructure, top drive, and rotary table system
- Mud system (mud pumps, mud tanks and centrifuge)
- Solids control equipment (shale shakers, hydroclones, de-silters)
- Cementing unit
- Electrical power generators
- Stores, offices, workshops, bulk storage hoppers, office/administration modules
- Accommodation.

The rig may be anchored at the drill location via seabed anchors and mooring lines.

The wells are drilled with rotating bits that chip off small pieces of rock (cuttings) as rock formations are penetrated. The drill bit is connected to the surface by lengths (known as joints) of hollow drillpipe, collectively known as the drill string.

Drilling fluids (drilling muds) are used to control subsurface pressures, lubricate and cool the drill bit, stabilise the well bore and carry the cuttings to the surface. Drilling muds are pumped from the surface to the well bore through the centre of the drill string and returned to the surface through the space between the drill string and the rock formations or casing (known as the annulus) together with drill cuttings produced from the grinding of rocks by the drill bits.

Well drilling generally involves two types of muds, classified by their base fluid-water based mud (WBM) and synthetic based mud (SBM), with SBMs used on the deeper and more challenging well sections. WBMs are usually discharged to sea, whereas SBMs are recovered and returned onshore for recycling or disposal. SBMs have been used in Australia for numerous drilling programs in the Browse Basin, the North West Shelf (NWS) and the Timor Sea.

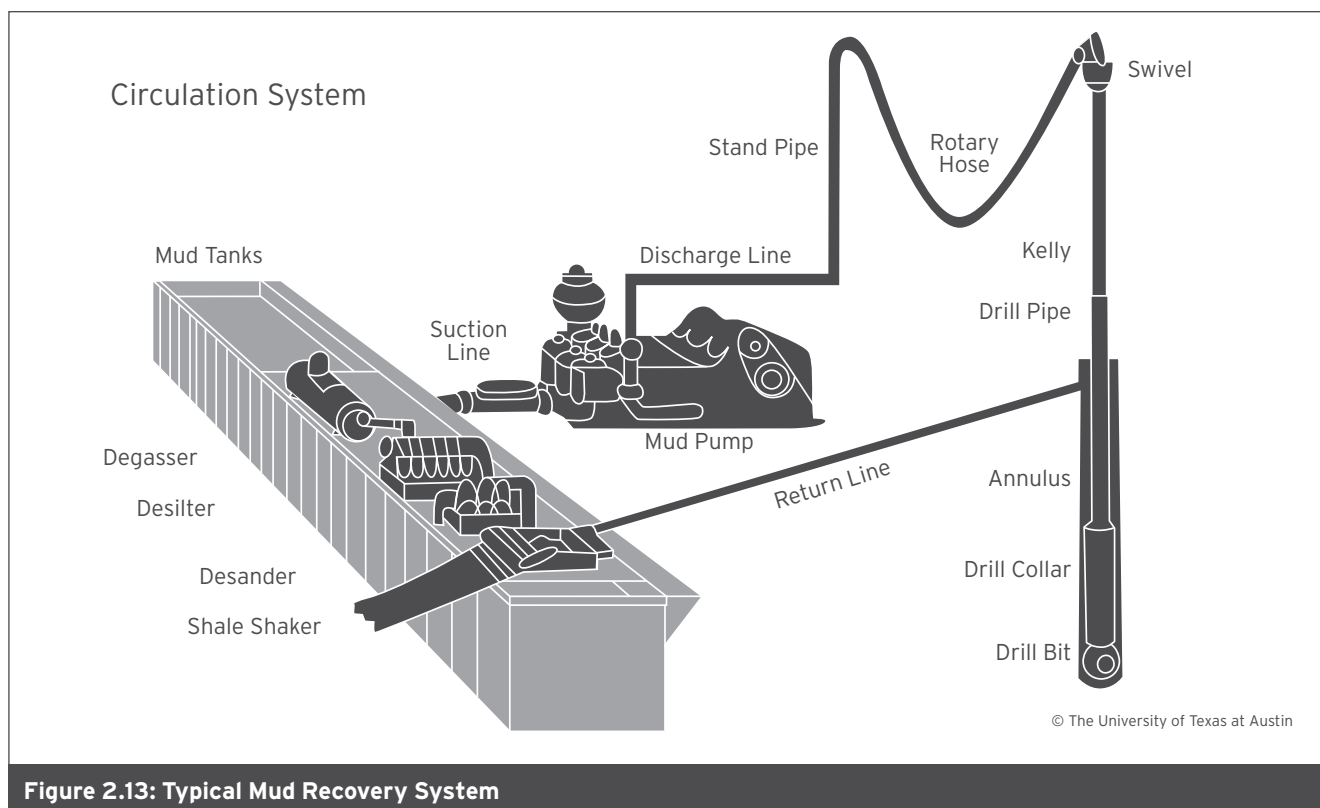


Figure 2.13: Typical Mud Recovery System

The drilling fluid is circulated in a closed loop system that recycles the drilling fluid and removes the drilling cuttings. During drilling, the returns from downhole (mud and cuttings) are routed to the shaleshakers and hydrocyclones that physically separate the drill cuttings from the drilling mud. The drill mud is collected for re-conditioning and re-use while the separated cuttings are discharged overboard. Between 500 and 700 m³ of cuttings could be produced per well and these drill cuttings will be discharged to the sea.

Although SBM is collected and prevented from being discharged to sea after use, the drill cuttings will retain a coating of mud after processing with the MODUS shale shakers.

Casing

As the well is drilled, steel casings are progressively placed inside the hole to line it and prevent it from caving in. The casing also isolates the aquifers and hydrocarbon bearing zones through which the well passes, thus preventing liquids or gases from entering the well prematurely. After each casing string has been installed, cement is placed in the casing annulus.

Once the gas reservoir has been reached, the well will be “completed” by installing sand control equipment across the reservoir section and production tubing back to the seabed. A surface controlled subsurface safety valve and subsea tree will be installed to enable the well to be safely suspended until it is hooked up to the WP.

Before it is suspended, the well may be flowed back to the MODU to prove well deliverability and to remove completion brines and debris from the well, referred to as “clean up”. Well clean-up may also involve flaring, under controlled conditions, for a period of several hours to a few days.

2.3.1.2 Platform Installation and Connection

The WP is likely to be a fixed facility. The legs of the facility will be fixed to the seabed either by piles or by a gravity base. The topsides (the processing facilities) are likely to be modularised and transported to the platform location by barge. The topsides will then be secured to the legs and the subsea infrastructure connected.

Specialised installation vessels will be used to install the subsea flow lines and umbilicals. Crane vessels will be used to install the subsea manifolds. A subsea construction vessel will be used to hook-up and connect the wells, subsea systems, flow lines and umbilicals to the WP.

The vessels likely to be required during this phase of the development may include:

- A topsides modules delivery vessel
- WP (and possibly compression) platform jackets tow vessels
- Lift and derrick barges
- A pipe-lay/crane vessel
- A subsea construction vessel
- An umbilical installation vessel
- Support vessels and tug boats.

2.3.1.3 Trunkline Installation

The trunkline will be laid directly onto the seabed for the majority of the route. The trunkline will cross between 14 and 22 other pipelines and umbilicals, with the bulk of these crossings occurring offshore in relatively deep water. At these offshore crossings, the trunkline will be separated from the existing pipelines/umbilicals by separation mattresses or structures and may also be rock dumped depending on stabilisation and protection requirements in the crossing area. Rock volumes at each crossing location will range from 10 000 to 100 000 tonnes depending on the number and size of lines involved. In total, up to 150 000 tonnes of rock may be required for crossing stabilisation.

There will be a single trunkline crossing in shallow water, in approximately 10 m water depth, where the trunkline crosses the existing buried Roller Skate pipelines. At this location, it is planned to further lower the Roller Skate lines using mass flow excavation equipment to ensure that when the trunkline is laid it is at seabed level and not significantly elevated (which may create a vessel draft limitation in this area). After lay, the crossing is likely to be rock dumped for stability; hence there may be a small reduction in vessel draft. The crossing area impacted will be approximately 100 m along the Roller Skate pipelines.

Pipeline Approach to Shore

The trunkline will approach the Ashburton North SIA from the north-west, and will be routed to avoid nearshore shallow water areas, reefs and other obstructions. It will cross the Roller Skate pipelines between the Roller and Skate platforms and approach the shore at an angle as close to perpendicular as possible. A key consideration in defining the pipeline approach is water depth, as the shallow water laybarge will be limited to water depths of approximately 6 m. This will dictate the length of the pipeline shore pull from the barge, which currently is approximately 3 km. Any increase in this shore pull length

will directly impact the overall feasibility of the approach as pull tensions are critical.

As the trunkline will need secondary stabilisation in shallow water (from approximately 40 m water depth to shore), the pipeline will, where possible, be routed to follow areas of softer sediments which will enable easier lowering of the pipeline below seabed by either dredging, ploughing or trenching. Where seabed conditions are not compatible with lowering, the use of rock placement or gravity weight installation may be used to stabilise the pipeline.

Pipeline Stabilisation

The conventional method of stabilising large diameter pipelines in shallow water on the NWS is to use a combination of concrete weight coating and rock dumping. Concrete weight coating is effective for the trunkline in water depths beyond approximately 40 m. In shallower water, the concrete thicknesses required exceed practical application limits and secondary stabilisation by rock dumping is required. This involves initially laying the pipeline on the seabed and then dumping rock in a continuous profile over the pipeline to prevent movement in storm/cyclonic conditions. For the trunkline, rock dumping may be required from approximately 6 m water depth to 40 m, a distance of approximately 35 km, depending on the final selected secondary stabilisation method. Between 760 000 tonnes to 1 850 000 tonnes of rock may be required depending on the secondary stabilisation methods adopted, for a continuous full cover berm over the pipeline. The berm itself will vary in profile according to depth, but may have a width of up to 20 m and height of 1 m to 2 m above the crown of the pipe (2 m to 3 m above nominal seabed).

An alternative to rock dumping is to use large clump weights along the pipeline to anchor the pipeline at intervals rather than using distributed rock to provide continuous stability. This method may be suitable in deeper areas, beyond the 40 m water depth where the seabed is not subject to scouring, but in general is not considered to be a practical solution for the anticipated conditions along the trunkline.

A more effective and practical alternative to rock dumping is to lower the pipeline below the seabed by creating a trench, by dredging, ploughing or mechanical trenching as follows:

- Creating a dredged trench over 35 km is feasible but would require removal of substantial amounts of material. For this option, the pipeline is laid into the trench after excavation. A combination of cutter suction

(CSD) and trailing suction hopper dredges (TSHD) will undertake the dredging depending on the seabed geology. Local pre-fragmentation of the seabed by blasting may also be required in areas where the seabed is too hard for the CSD to trench. Prior to pipelay the trench may need to be cleaned up to remove sediment from the bottom of the trench using a mass flow dredger, or other suitable equipment. After the pipeline is laid, it may still be necessary to backfill with rock or engineering fill materials to assist stability as the shallow angle of the dredged trench does not provide very efficient stabilisation. The excavated width of trench may be up to 25 m, with removed volumes of up to 3 million cubic metres (Mm³). In addition, backfill rock volumes of up to 1.85 million tonnes could be required to provide the necessary stabilisation.

The engineered fill materials may consist of dredged material recovered from the spoil grounds, the post lay trenching machine spoil heaps immediately adjacent to the pipeline or may be sourced from sand borrow areas offshore that provide sand with the necessary grain size and low silt content required to stabilise the line under cyclonic and seismic conditions.

- Ploughing with optional use of a secondary backfill plough is feasible, and would take place after the pipeline is laid. The plough is deployed on top of the installed pipeline, and is towed by a surface support vessel to create a narrow V- trench into which the pipeline is lowered by the plough. Spoil from the plough is sidecast over a width of approximately 15 m, approximately 5 m either side of the plough. This spoil may either disperse naturally or may be backfilled into the trench by a secondary backfill plough if considered suitable/feasible. Alternatively, engineered backfill/rock may be dumped into the trench to complete the stabilisation works (depending on trench depth achieved). This method is very reliant on having compatible geotechnical conditions. From investigations to date in this area, and from past ploughing experience on the NWS, this method is unlikely to be effective for more than 30 to 50 per cent of the pipeline route where lowering is required. Hence this method must be combined with either dredging or mechanical trenching, or may require rock dump where the required trench depth is not achieved.
- Mechanical trenching involves the use of a large mechanical cutting machine which is deployed after the pipeline is laid onto the seabed. The machine is deployed on top of the pipeline, and then lifts the pipeline while cutting a narrow V-trench beneath, and then lowers the pipeline into the trench as the

machine moves forward under its own power (hydraulic, supplied via surface umbilical from support vessel). Spoil and rock from the trench is ground to smaller pieces and is cast to the side of the machine over a total width of approximately 20 m. As with ploughing, the spoil may either disperse naturally or may be backfilled into the trench by a secondary backfill plough if considered suitable/feasible. Alternatively, engineered backfill/rock may be dumped into the trench to complete the stabilisation works (depending on trench depth achieved). Mechanical trenching is far more effective than ploughing in a wider range of soil conditions but to date has not been undertaken in the hard calcareous soils of the NWS. A new trenching machine has been recently developed which is considered suitable for these NWS conditions and will be trialled by Chevron in 2010 to verify that it can effectively undertake the required trenching works in hard and soft soil conditions.

It is currently envisaged that mechanical trenching will be utilised to undertake the bulk of the stabilisation works for the trunkline if the offshore trials in 2010 prove successful. However, if this trial is unsuccessful in both hard and soft soils, it will be necessary to revert to the more conventional approaches of dredging and backfilling and/or rock dumping to stabilise the trunkline. While these methods have a greater environmental impact, they are considered the only practical alternative to mechanical trenching and have a significant track record within the region.

Pipeline Protection

In the nearshore and onshore areas, the pipeline will be lowered below nominal seabed/ground level for both stability and protection. From approximately the 40 m water depth contour to shore, lowering of the pipeline to achieve minimum cover above the crown of the pipe of approximately 1 m will be targeted. This implies creating a trench of approximately 2.5 m depth. As the pipeline approaches the shore line, the depth of cover above the pipeline may be increased to provide protection from third-party impacts and also to protect against uncovering of the pipeline by increased seabed mobility/erosion and coastal processes. It is anticipated that a cover of 2 m to 3 m above the crown of the pipe will be achieved in the shore crossing area. The final cover depth in the nearshore area will be established during Front End Engineering Design based upon detailed assessment of mobility/erosion processes and risk assessments based upon pertinent design code requirements (AS 2885/DNV OS F101).

Laybarge Activities and Impacts

For all nearshore and offshore pipelay activities associated with the trunkline, it is anticipated that one or more anchored lay barges will be required. In the nearshore area, from shore to approximately 20 m water depth, a flat bottom second generation laybarge may be used, which is likely to have an eight point anchor mooring system. These anchors will be placed and recovered by dedicated anchor handling vessels as the barge uses these anchors to move along the pipeline route whilst laying pipe. For the offshore portion of the trunkline it is anticipated that a third generation laybarge using a twelve point mooring system or potentially a fourth generation dynamically positioned vessel may be used depending on availability of suitably rated vessels.

The pipelay operations are likely to commence nearshore, with the barge mooring approximately 3 km from shore to perform the shore pull operation. This may entail setting of all eight anchors and welding pipe on the barge. As the pipe is welded, it is pulled to shore using a shore based winch system, along the prepared seabed trench and through the installed open cut or micro-tunnel shore crossing. This shore pull operation is a 24 hour activity and may take up to ten days depending on weather conditions and operational issues.

Once the shore crossing operation is complete, pipelay will then commence towards the offshore platform location, with the barge moving on anchors as it lays additional pipe onto the seabed. The pipe will either be laid into a prepared seabed trench as described previously, or laid onto the seabed awaiting future trenching/lowering/rock dumping for stability/protection.

The nearshore pipeline is not stable on the seabed when un-flooded during cyclonic conditions prior to stabilisation being completed. It may, therefore, be necessary to temporarily flood the nearshore pipeline during pipelay should a cyclone occur during or after installation to ensure the pipeline is not damaged. It is envisioned that a contingency flooding spread will be set-up at the shore crossing site to flood the pipeline from onshore out to the subsea laydown area. The pipeline will be flooded with filtered seawater containing chemicals to control oxygen levels and biological growth. It will also be necessary to partially or fully dewater the pipeline after the cyclone has passed before the pipeline can be safely recovered onboard the lay vessel.

The availability and schedule of suitable nearshore and offshore pipeline installation vessels may result in the

offshore portion of the trunkline being installed prior to the nearshore portion. In such a scenario an above-water tie-in or subsea tie-in would be required to connect the two halves of the trunkline.

2.3.2 Marine Nearshore Construction

2.3.2.1 Beach Crossing Location

The beach crossing location will be selected for reduced impacts on the defined Common User Coastal Access (CUCA) layout configurations, and to provide a robust, feasible and safe method of pipeline construction. The pipeline will land to the west of the CUCA area at the periphery of the mangrove habitat, and will cross the inland dunes directly to the west of the storage tank area. It is intended that the pipeline will remain buried until it is inside the dune line within the CUCA, at which point it will be terminated either above or below ground at a beach valve station. From the beach valve station, the pipeline will be again routed underground to the Plant Pig Receiver Facilities, remaining below ground when crossing access roads.

2.3.2.2 Beach Crossing Design Concept

The preferred beach crossing concept will be selected to provide the best overall outcome in terms of technical feasibility, risk, cost and environmental impact. In general, for large diameter shore crossings of this type, particularly on the NWS, open cut is the principle method used and is the most conventional, field proven option available. For the selected beach crossing location at the periphery of the mangroves, an open cut trench is feasible but not considered technically optimum due to the length of open cut excavation required and the nature of the environment. This option may have a negative impact on the immature mangroves in this area and although it is considered likely that this area could be reinstated successfully, environmental assessments have not been undertaken to support this position.

An alternate concept that has been assessed is micro-tunnelling (see Figure 2.14), which would entail creation of a tunnel beneath the dunes system and mangroves, exiting in approximately 2 m water depth. This tunnel may be used to pull the pipeline underneath the beach, avoiding any significant environmental disturbance. The micro-tunnel concept involves creation of an entrance shaft up to 10 m diameter close to the LNG plant (inside the dune line) and subsequent creation of a tunnel of 2 to 3 m diameter using a combined drillhead/thrust system to install successive tunnel sections out to the exit point (a distance of



Figure 2.14: Micro-tunnelling

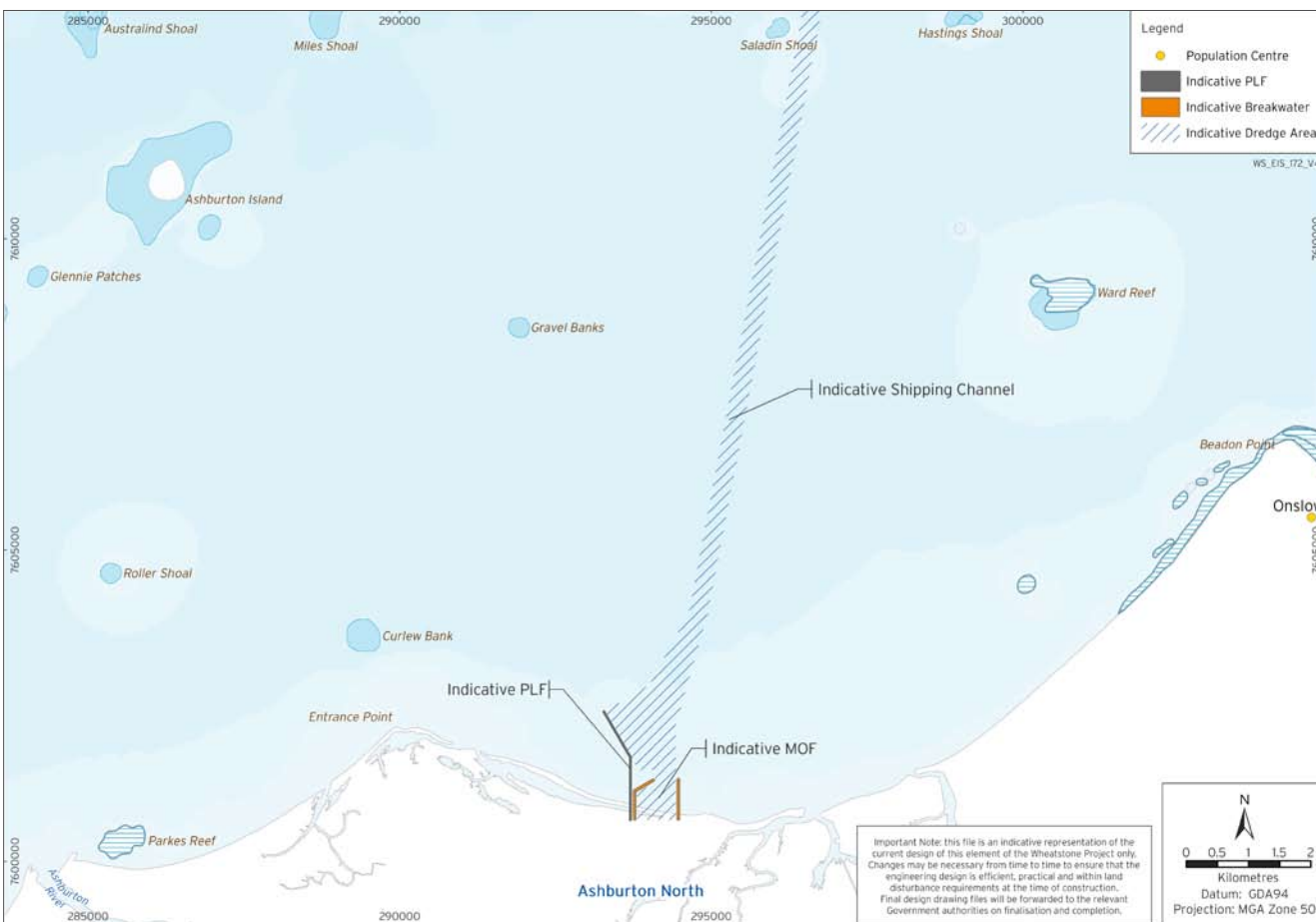


Figure 2.15: MOF Location and Shipping Channel

approximately 1200 to 1400 m). The key environmental issues associated with micro-tunnelling include:

- Disposal of excavation materials from the entrance shaft and tunnel, and cleaning of the drill cuttings prior to disposal. The volumes involved are estimated to be in the order of 20 000 m³
- Excavation by dredging will be required at the exit point for the tunnel in 2 m water depth, to create a pit into which the drill head can exit prior to recovery
- Bentonite drilling fluid is required to be injected outside of the tunnel wall during construction to reduce ground friction as the tunnel sections are thrust forward
- Some loss of Bentonite drilling fluid to sea is possible during recovery of the drill head at the tunnel exit.

At present the micro-tunnel concept is not fully defined and will require further study before its feasibility can be confirmed. However, on the basis that this method has been used for several outfall systems around Australia and for similar pipeline shore crossings worldwide, it is anticipated that it will prove viable assuming that ongoing geotechnical investigations and engineering studies progress to plan. In the event that unforeseen technical issues arise that make this concept untenable, it is likely that a field-proven, alternative open-cut shore-approach concept will need to be used.

2.3.2.3 Material Removal and Disposal

For both the open-cut and micro-tunnel concepts discussed, the construction requirements from the 2 m contour to approximately the 10 m contour (a distance of approximately 8 km) are similar, in that a dredged trench will be constructed prior to pipelay, with the pipeline laid into it. This trench will be created using conventional dredging equipment and will vary in depth from 5 m to approximately 2 m, with total excavated volume of approximately 700 000 m³. After pipelay is complete, the trench will be backfilled with rock or engineered backfill volume to achieve a relatively flush reinstated seabed. If rock is used then approximately 184 000 tonnes may be required. If engineered backfill is used then the volume placed will be similar to that removed during dredging.

In the event that mechanical trenching is not feasible for the stabilisation of the pipeline from 10 m to approximately 40 m water depth, dredging will be required with subsequent backfill using engineering material or rock. This will increase the removed spoil volumes up to approximately 3 Mm³.

Disposal of the excavated spoil from the micro-tunnel may be managed onshore, after cleaning of the drill cuttings. The spoil may ultimately be removed from site to a suitable disposal location, if the spoil is not acceptable as landfill on site. Temporary storage on site is planned to enable appropriate management and handling of the spoil.

2.3.2.4 Future Pipeline Approaches

It is anticipated that further trunkline systems will be installed adjacent to the Wheatstone trunkline at some later date, hence the pipeline approach corridor and offshore routing will be selected to accommodate a further two similar systems. Shore crossing concepts and allocated space envelopes/footprints will be selected to enable such expansion. Where open cut trenching is employed, facilities may be pre-installed to reduce the need for future environmental disturbance, particularly where reinstatement of shore line and mangroves is considered sensitive. Such pre-installed facilities may encompass conduits across the shore line to simplify pull-in of future lines or allocated space for future tunnels etc. For a micro-tunnelling concept, no pre-investment is required as a future pipeline tunnel can be created when required without significant impact upon the mangrove system or shore line.

2.3.2.5 Materials Offloading Facility (MOF)

The MOF will require two solid fill breakwaters, each extending approximately 500 m from the shoreline, and a dredged navigation berth-pocket. The breakwaters will probably be constructed from the shore using earthmoving equipment to place core material from a quarry into the nearshore waters. The breakwater is likely to be protected by heavy rock or concrete armour units. Wharves, pens and berths may be piled. The proposed MOF location and shipping channel are shown in Figure 2.15.

The MOF quay may be constructed by driving piles from onshore pile driving rigs and placing a concrete deck on top of the piles. Plant and equipment required for the construction of the MOF quay may include:

- Mobile crawler cranes
- Pile driving hammers.

It is anticipated that the MOF could take 18 months to fully complete. It is expected to receive the first delivery to site in month 15 and is likely to be in continuous use. In terms of plant construction of the initial trains, it is estimated that approximately 100 module barge shipments could be required, based upon the proposed amount of modularisation for the Project.



Figure 2.16: Typical Cutter Suction Dredge

Typical construction traffic is expected to comprise up to two module transport vessels per week utilising a RORO offloading method. Time in port is likely to be in the order of three days per vessel.

General cargo is expected to start arriving at the MOF from month 18 and will continue over the whole plant construction and operations period.

Because of the shallow nearshore bathymetry (the -15.0 m contour is located approximately 23 km offshore), both the MOF and the PLF will require dredged access channels. The MOF will require a marine access channel approximately 1 km long, 120 m wide and 7 m deep, which provides access to the main navigation channel. The MOF will also require two breakwaters.

A combination of cutter suction (CSD) and trailing suction hopper dredges (TSHD) will undertake the dredging of the MOF and the PLF channels and turning basins. A typical CSD is shown in Figure 2.16.

2.3.2.6 Product Loading Facility (PLF)

To enable the LNG and condensate carriers to access and berth at the PLF, a navigation channel and turning basin will be required. This channel is expected to be approximately 16 km long, 260 m wide and ~13.5 m deep. The turning

basin, MOF, PLF and channel may require up to 45 Mm³ of excavation. Up to 10 Mm³ of this material may be placed on shore. Dredge material may also require disposal in the marine environment. This is discussed in detail in Chapter 8, *Marine Risk Assessment and Management*. The proposed dredge execution plan is also presented in Chapter 8, *Marine Risk Assessment and Management* which shows the duration of the dredging.

The PLF and access trestle is likely to be constructed by driving piles. This may be achieved by driving piles from a crane located on a temporary work platform alongside the trestle. Alternatively, the access trestle could be completed in part using floating plant.

The following components of the PLF; the loading platform, moorings, the berthing dolphins and the Marine Operations Platform could be constructed using floating plant. The floating plant and equipment required for the construction of the access trestle and these elements may include:

- Flat-deck barges
- Cranes mounted on barges
- Mobile crawler cranes (shore based construction and loading out materials)

- Pile driving hammers
- Tug boats and other support craft
- Air compressors, generators and welding equipment.

It is anticipated that berth 1 of the PLF will take about two years to complete. A further 18 months may be required to complete berths 2 and 3.

The approximate volumes of material that may be dredged from each of the above work locations are given in Table 2.2.

The location of the dredge material disposal sites has been selected on the basis of:

- Low potential for secondary re-suspension after placement
- Relocated material should be comparable to the naturally occurring sediment
- Relocated material should not be a significant source of sediment back into the channel
- Reduced loss of benthic primary producer habitat (BPPH) species
- Less potential for damage of corals communities which occur adjacent to the grounds
- No significant impact on the current Onslow Salt channel
- No interference with navigation
- Placement should not have a negative effect on the hydrodynamics within the area and or the shore line processes
- Dredging practicalities.

This is discussed in detail in Chapter 8, *Marine Risk Assessment and Management*.

Figure 2.17 shows an indicative artist impression of the proposed PLF and the MOF.

2.3.2.7 Onshore Placement of Dredge Material

Up to 10 Mm³ of the dredge material may be placed at the onshore site.

Bunds may be constructed by earthmoving equipment and utilise sand and fills, aggregates and rocks imported to the site from as yet undefined quarry locations. The onshore disposal area will be subdivided into a number of cells to provide stilling basins for settlement of sediments in tail water before it is discharged back to the environment.

If dredge material is brought onshore it will be placed in this specially constructed reception area. There may be up to 50 Mm³ of transport water associated with this operation, thereby generating peak decant water discharge of up to 6 m³/s for the period of placement activity. This discharge will be pumped back to the shoreline for disposal to the west of the MOF location. After the onshore placement activity has been completed there may be a need to manage large volumes of decant water. See Chapters 8, *Marine Risk Assessment and Management*, and Chapter 9, *Terrestrial Risk Assessment and Management* for further details on dredge material disposal.

2.3.3 Onshore Construction

2.3.3.1 Onshore Site Preparation

The site is located in an area of low lying land immediately behind the fore-dunes between the mouth of the Ashburton River and Hooley Creek. The LNG facility will be positioned behind these existing fore-dunes, and east of the mangroves associated with the Ashburton River. Additionally, the existing fore-dunes will be maintained with any reinforcement necessary for the protection of the plant and associated offices and personnel quarters being constructed on the land side of the dunes.

Site preparation works will involve clearing the site of vegetation and establishing drainage catchments to reduce offsite silt migration. The processing facility will be constructed on a pad that may include some bunding,

Table 2.2: Approximate Dredge Material Volumes

Dredge Area	Total for Area (m ³)
Temporary access channel	935 000
MOF areas	1 580 000
PLF areas	16 445 000
PLF Approach	20 160 000
Total Capital Dredge volume	39 120 000
Design uncertainties	5 880 000
Estimated total Capital Dredge volume	45 000 000

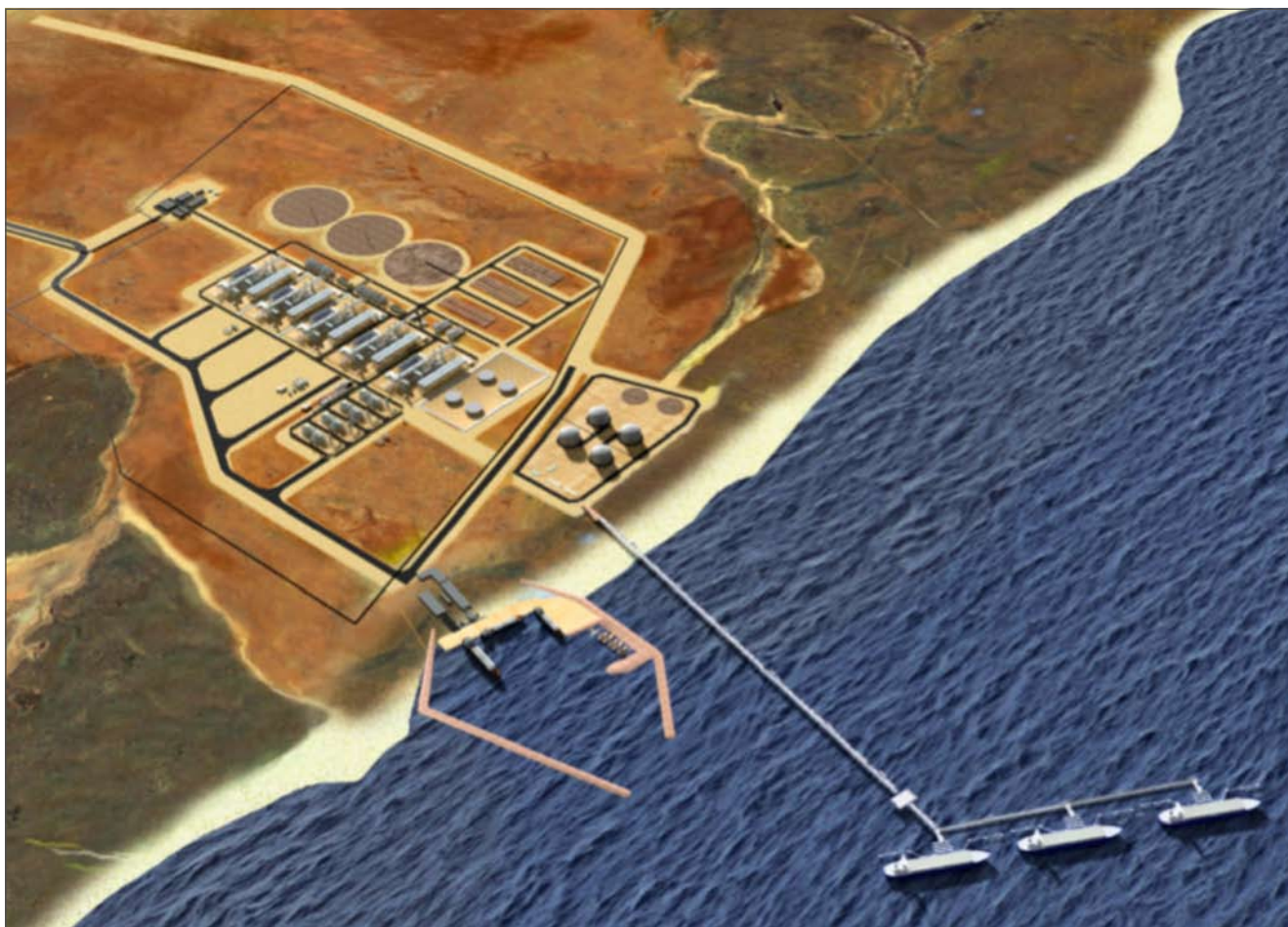


Figure 2.17: Artist Impression of a Representative PLF and MOF Concept

to provide protection of the plant to a 1:1000 year flooding event. The accommodation village pad and SIC will be designed for a 1:100 year flood event. Imported fill will be needed to achieve the required levels. This may range from large armour stone to core material.

In the backshore area and longitudinal dune system area, filling will typically be achieved using a conventional earthwork process comprising the removal of vegetation and topsoil, proof rolling of the exposed surface and placement and compaction of fill in layers up to the finished levels.

In some areas, ground improvement and/or excavation and replacement may be required prior to the placement of fill. In particular, the low lying clay pans and supratidal flats have weak surface materials and are in close proximity to the groundwater which will hamper earthworks. Site preparation in these areas is likely to involve the removal of weak material and its replacement with structural fill.

Onshore fill material may need to be sourced from a third-party quarry, if it cannot be sourced locally from on-site borrow-pits. This material will initially be transported to the site by road. The proposed quarry locations are yet to be determined and will form part of a third-party contracting strategy. The offsite quarries used to source the fill material will have the appropriate government licences and approvals.

The excavation of four borrow pits may be required to provide fill for the Wheatstone Plant Pad (see Figure 2.18). Two construction roads will be designed to allow access to these borrow pits and the Plant Pad. The methodology for clearing, stockpiling, excavation, and transportation of fill material from these borrow pits may include the following:

- Providing access to the initial borrow area by utilising temporary fill material obtained by a subcontractor - either from the site or from off-site - from an approved supplier of fill material

- Road access, which is likely to require clearing and grubbing of the access road, placement of appropriate geo-fabric for stabilisation followed by placement and compaction of fill material
- Subsequent borrow areas access to utilise fill material from previously accessed borrow areas
- Once the borrow area is accessible, a survey will be conducted to locate areas to be stripped, cleared and grubbed prior to commencing excavation of material for fill. The required storage areas for storage or disposal of material will also be identified
- Borrow areas are expected to be excavated to approximately 1 mAHD (consistent with the height of the adjacent tidal plains)
- Fill material will be transported to the Project site, placed, compacted and tested.

See Chapter 8, *Marine Risk Assessment and Management* and Chapter 9, *Terrestrial Risk Assessment and Management* for further details on the onshore site preparation.

2.3.3.2 Onshore Construction Facilities

With the completion of the site development works, construction of the temporary and permanent onshore facilities will commence. These are expected to include:

- Access road(s) to the site
- Power generation
- Sewage treatment plant
- Water treatment plant/desalination plant
- Development of accommodation village facilities
- Solid waste management area, potentially including a construction waste incinerator
- Control building
- Operations offices and permanent housing
- Installation of permanent underground utilities and pipework
- LNG process trains
- LNG and condensate storage tanks
- Domgas plant and onshore pipelines.

Materials and equipment will initially be delivered via road. Upon completion of the MOF, materials will also be delivered via barge and chartered vessels.

2.3.3.3 Estimated Water Use and Water Source

Water source options for the Project are currently being evaluated. Freshwater supplies for the construction works may be provided by a desalination reverse osmosis (RO) plant which converts seawater or saline groundwater to drinking water. Water may be sourced from an open-sea or nearshore intake, a deep-water bore, or a combination of these.

The preferred water source for construction is via a nearshore intake. The open seawater intake for construction would be built separately from the operational water intake structure, however detailed design of the structure is still being finalised. The nearshore intake has been taken as the base case for this EIS/ERMP and is assessed in Chapter 8, *Marine Risk Assessment and Management*. Should alternative water source options be required, deep and/or shallow water bore options will be evaluated. If they are considered to be a viable option then further assessment work will be undertaken in accordance with relevant WA State guidelines.

Based on previous experience, it is anticipated that the volumes of water as shown in Table 2.3 may be required during the construction phase (based on a maximum of 5000 personnel).

This equates to a peak demand of 5600 m³/day of raw water and 1800 m³/day of potable water during the construction of the first two trains.

Water conservation measures will be investigated and these may include the following:

- Raising employee awareness of the importance of water conservation
- Reuse hydrotest water
- Provide spring loaded shut-off valves for hoses
- Install high pressure, low-volume nozzles on spray washers
- Providing water conservation toilets and showers.

Hydrotest water from the first LNG tank may be used for testing the second tank and pipelines. It would then be returned back to hydrotest ponds prior to disposal. The total volume of hydrotest water is anticipated to be approximately 450 000 m³ for the first two trains. See Table 2.3.

2.3.3.4 Stormwater and Wastewater Treatment

The construction of the sediment ponds is expected to start simultaneously with site clearing and will be in place as soon as practicable during earthworks activities.

Table 2.3: Indicative Water Demand During Construction

Use	Units	Total for 25 MTPA
Personnel Water ¹	m ³	2 900 000
Batch Plant ²	m ³	212 000
Hydrotest ³	m ³	450 000
Dust Control ⁴	m ³	500 000
Compaction ⁵	m ³	2 000 000
Firewater ⁶	m ³	2000
Quarantine Washwater ⁷	m ³	70 000
Total	m³	6 134 000

Notes:

1. Based on the peak number of construction workers for the first two trains of 5000 and assuming per capita requirement of 375 L/person/day.
2. Batch plant water usage based on water consumption of 345 L/m³ of concrete.
3. Hydrotest water usage based on no recycling of water for testing of LNG and condensate tanks.
4. Dust control consumption is based on 0.5 to 2 trucks/hour requirement.
5. Water usage based on a requirement of 10% water by weight required for compaction taking into account a 10% evaporation rate.
6. Firewater for accommodation village is provided as spare capacity.
7. Quarantine washwater usage based on average requirement of 700 m³ washwater/month.

Stormwater collection ditches and outfall structures will also be constructed as soon as practicable to convey stormwater to the sediment ponds. The sediment basins will collect and hold run-off to allow suspended sediment to settle out. Erosion controls will be used at the outfalls of the sediment ponds and for the stabilisation of stream banks and ditches, as required.

Construction wastewater volumes are based on desalination plant and construction personnel employed. Maximum rate of 433 m³/hr of brine is expected from the desalination plant. Maximum sewage is estimated to be 76 m³/hr, based on 5000 workers during construction of the first two trains.

2.3.3.5 Waste Management

An onsite waste management area will be established during the construction phase. This is likely to be in the accommodation village area. This waste management area will be used to segregate and temporarily store wastes.

Hazardous waste will be managed offsite at a licensed hazardous waste facility. Non-hazardous waste may be managed via the onsite construction waste incinerator and/or an appropriate offsite facility. Waste management options are discussed further in Chapter 4, *Emissions, Discharges and Wastes*.

2.3.3.6 Power Supply

Temporary construction power requirements at the site are estimated at 15 MW. Power will be provided via onsite diesel generators.

2.3.3.7 Accommodation Village

The accommodation village is likely to be developed in stages over a period of approximately 12 months, beginning with accommodation for about 450 site workers at an initial pioneer village and expanding to accommodate about 5000 workers at peak. It is anticipated that personnel will work a fly-in, fly-out roster, commuting to and from the Project area by air from Australian metropolitan areas. Operating during the construction, commissioning, start-up and early operational periods of the LNG and domgas plants, the village will essentially be self contained with its own water and power supplies, waste management, medical and fire services. It will also provide workers with recreational and entertainment facilities as well as dining, laundry and other domestic requirements. The village will be designed to provide a safe haven in the event of a cyclone event, so that personnel can remain on site.

Accommodation village temporary construction power for the initial trains is estimated to be approximately 10 MW. This will be provided by onsite diesel generators.

Alternative sites for the accommodation village are currently being evaluated. The preferred location for the village is shown in Figure 2.18.



2.4 Commissioning and Start Up Activities

2.4.1 Offshore Facilities

The WP offshore facilities comprise:

- Sub-structure (piled or gravity base) and floatover topsides integrated deck
- Sub-sea equipment of wellheads, manifolds, umbilicals, flow lines and trunkline.

The main interface between the Upstream and Downstream is the onshore beach valve.

2.4.1.1 Subsea Wells and Flowlines

Commissioning of the subsea wells and flowlines will include testing, adjusting and monitoring the following systems:

- Wellhead controls
- Safety systems
- Flowlines and support systems
- Control and communication systems.

2.4.1.2 Topside Fabrication Yard Commissioning

Due to the nature of the Integrated Deck topside a significant amount of commissioning will be undertaken at the fabrication yard. All utility systems without a Hook Up component will be completed in the fabrication yard. The utility systems and the Hook Up component will be partially commissioned onshore, where practicable. Process systems will be pre-commissioned and partially commissioned as far as practical. The process systems shall be Nitrogen/Helium leak tested for leak tightness.

2.4.1.3 Installation, Hook Up and Static Testing

Post the topside sub-structure installation and topside float-over mating, the splash zone interface connections are completed for legs, caissons, J tubes, utility lines and risers weld out.

The sub-sea wellheads, manifolds, umbilicals, flow lines and trunkline are installed. Following this the associated sub-sea tie-in hook up spools to the topsides are installed. Hydrotesting is likely to be staged, with a final system leak test on systems where applicable.

2.4.1.4 Offshore Facilities Pre-commissioning, Commissioning and Start-up

Prior to commencement of start-up activities, detailed plans and procedures will be developed in consultation with the regulator regarding the operations, inspections,

maintenance, monitoring and reporting requirements for all the facilities. The duration is expected to be over several months.

The following offshore hooked-up systems will be pre-commissioned and commissioned:

- Flow line and trunkline de-watering, vacuum drying and inerting
- Topsides to sub-sea wellhead, with remotely-operated vehicle (ROV) verification
- Seawater cooling
- Fire pumps and fire water systems
- MEG and chemical injection
- Open drains
- Sewer system
- Third-party platform shutdown, emergency shutdown and fire and gas certification demonstrations
- Power generation and “black” start demonstration.

The completion of these activities will bring the WP to “Ready-for-Start-Up” (RFSU).

After RFSU, the initial start-up commences. The sub-sea well(s) is opened, flow displacing nitrogen purge through the process topside to the flare. Well ramp up is a careful balance of production rate, hydrate management, and onshore requirements.

This will produce the following emissions and discharges:

- **Temporary diesel generators.** Until the gas fired power generators are operational, the diesel generators will result in minor elevations in air pollutants such as NO_x, SO_x and particulate matter.
- **Hydrotest water.** This is discussed in detail in Chapter 4, *Emissions, Discharges and Wastes*. It is proposed that the flowlines and pipelines will be flushed to the ocean in deepwater.
- **Flaring/Venting.** Prior to start-up, the flowlines and the export pipeline may be left nitrogen dried. This nitrogen will be vented during ramp-up. Initially hydrocarbon rich gases from the topsides facilities will be flared until the product gas and liquids are of appropriate quality for export to shore. The start-up sequence will be calculated to establish process stability as soon as possible with the least amount of flaring and to reduce the need for further shutdowns, associated flaring and cold venting. Planned platform depressurisation is likely to occur two to three times during initial commissioning. A further allowance for two to three unplanned process

trips will be included in the start-up / commissioning emission estimates (Chapter 4, *Emissions, Discharges and Wastes*).

- **Produced water.** It is likely that online water quality monitoring will be pre-commissioned before start-up and calibrated during the commissioning process. Initially the PW may contain higher than normal levels of oil-in-water during the commissioning of the water treatment facility. These levels are expected to fall rapidly to within the normal operating range. High MEG concentrations during start-up may lead to temporarily elevated BTEX concentrations. Immediately following the initial operation of a new gas well the PW may contain small volumes of well completion fluids. The type of completion fluid will depend on the drilling fluid selected.
- **Miscellaneous wastes.** During start up/commissioning various hazardous and non hazardous process and domestic wastes will require disposal in compliance with legislation and the waste management plan. Typically these may include process wastes (filters, sludges, etc.), packaging (wooden pallets, plastic etc.), grinding/ painting/welding consumables, domestic wastes from the accommodation (sewage, food scraps, office waste etc.). Storage, segregation and disposal requirements and volume estimates are discussed in Chapter 4, *Emissions, Discharges and Wastes*.

2.4.2 Onshore Facilities

Commissioning and start-up will be undertaken once construction and pre-commissioning activities have finished. The selected contractor will be responsible for all commissioning and start-up activities until final handover to Chevron.

2.4.2.1 Commissioning

Commissioning activities make plant equipment and systems ready to receive gas for processing, liquefaction, storage, and domestic gas sales.

Some systems will be entering the commissioning phase while other systems are still in the construction or pre-commissioning phase. The safe and efficient coordination of all systems to make utilities available and produce LNG and domestic gas products at the right time is critical.

The source for commissioning gas is not yet defined. The primary objective is to find the optimal method and source for gas supply to the downstream plant for commissioning gas needs, focusing on de-risking gas supply availability in support of schedule requirements. The Project team is researching a wide array of alternative sources, ranging

from producing fields to LNG shipments to a supplier on the domestic gas system and other opportunities. The Project will perform a risk assessment specific to the commissioning and start-up process. Factors that affect the source of commissioning gas include, but are not limited to, Project schedule and market availability.

2.4.2.2 Initial Start-up

The sequence of events for the initial start-up of the LNG facilities are discussed below and include; purging, dry-out, cool-down and finally manufacture of product. These activities will result in some flaring, which is discussed in Chapter 4.

Purging

The initial purging activity occurs during the displacement of nitrogen from the feed gas system, the production of "sweet and dry gas" from the AGRU and dehydration systems and the initial regeneration of the molecular sieves.

Dry-out

This is the process of ensuring the cryogenic feed/ methane/propane/ethylene circuits are dry which requires a defrost procedure. After the defrost procedure the propane and ethylene circuits have to be charged and purged to flare in order to achieve the required purity.

Cool-down - Heavies Removal

This procedure entails the operation of the plant at very low rates until the required pressure and temperature profiles are established, this necessitates the flowing of the gas stream to the flare.

Making Product

During this activity the plant is still operating at very low rates with some flaring while the LNG tanks and associated pipework are in cool-down. This normally takes three days. After cool-down the plant rates will be increased and flaring stopped.

For the start-up of the subsequent trains the cool-down of loading lines and storage facilities is only required for additional storage tanks and or LNG loading lines.

2.5 Operations Activities

2.5.1 Operations Philosophy

The onshore and offshore facilities are expected to operate continuously, 24 hours per day, 52 weeks per year. Qualified personnel will be employed by Chevron to

provide continual operations coverage. Dedicated Chevron maintenance personnel and qualified contractors will inspect and maintain all facility equipment and systems. Supplemental contractors will be brought in when major maintenance is necessary to supplement the core Chevron operations, maintenance and contractor workforce.

2.5.1.1 Health, Environment and Safety (HES) Policy
Chevron has a corporate vision *“to have a culture and work environment where we are injury and incident free”*. This based on a belief that:

- All incidents can be prevented
- There is always time to do the job safely
- All operating exposures can be safeguarded
- Employee involvement and HES training are essential
- Management is committed, visible and accountable
- Protecting our people, environment and assets makes good business sense.

These form the Chevron core values (see Chapter 1, *Introduction*).

2.5.2 Offshore Operations

The main offshore activities during Project operation will be the continual extraction of gas and condensate from the production wells, the removal of PW from the process stream at the WP, dehydration of gas, and the transport of the gas and condensate onshore via the trunkline. For the gas supply to the initial development's two LNG trains, this is expected to result in an average PW discharge to sea from the WP of 2390 m³/day, with a potential maximum discharge of 6530 m³/day. CW will also be discharged with a potential maximum of 182 000 m³/day.

Crew changes to the WP will be carried out by helicopter. Supply vessels will visit the platform on a regular basis to deliver supplies and replacement equipment and remove wastes and unserviceable equipment.

Other activities associated with operating and maintaining the offshore infrastructure includes the following:

- Start-up, ramp-up and shut-down of individual wells
- Monitoring of pressures, temperatures and flow rates from individual wells
- Well-testing of individual wells
- Flowline and pipeline pigging operations
- Hydrate mitigation during and following shutdown events by the intermittent injection of MEG into the flowline system and by the intermittent flaring of gas.

2.5.2.1 Hydrate Mitigation Strategy

Under certain conditions, the Project's gas has the potential to form hydrates. Hydrates are a crystal structure of water and hydrocarbons that form when operating temperatures are low and pressures are high. They have the potential to block the offshore flowlines.

The effective mitigation of hydrates is a key factor in the offshore design and its resulting operating characteristics. The Project's selected hydrate mitigation strategy is Insulate and Blowdown (I & B) with intermittent MEG injection. This proven strategy prevents hydrate formation by utilising three principles:

- Normal operation will be at temperatures above the maximum hydrate formation temperature - this will be achieved by the design of the flowlines' insulation.
- During and following shutdown events MEG will, on occasion, be injected intermittently into the flowline system to chemically inhibit the formation of hydrates. This MEG will be stored at, and pumped from, the WP.
- During and following shutdown events the flowlines will sometimes be operated at reduced pressures that are below the minimum hydrate formation pressure. Depending on the prevailing operating conditions this will, on occasion, be achieved by flaring some produced gas.

The volume of MEG injected during shutdown events varies widely for different events due to a number of event specific factors. These factors include the scope of the shutdown, the prevailing water cut and the degree of flowline cool-down. Cumulative volumes of MEG injected during a given shutdown event are currently expected to vary from virtually zero, for minor events, to approximately 1200 m³ (and possibly even as high as 2700 m³ for major events). During FEED both the frequency and volume of MEG injection events will be optimised. One engineering option being considered is to use MEG in combination with a kinetic hydrate inhibitor (KHI). The supplemental use of KHIs has the potential to reduce total chemical injection volumes.

The MEG combines with the PW (formation and condensed) that is present to form a single aqueous phase. This aqueous phase will be routed to the platform's PW treatment system and discharged overboard.

2.5.2.2 Alternative Hydrate Management Concepts Considered

The following alternatives to the selected hydrate mitigation strategy (I & B with intermittent MEG injection) have been considered for the Project:

- Insulate and blowdown with intermittent methanol injection
- Continuous injection of MEG
- Heat tracing and insulation
- Injection of low dosage anti-agglomerant hydrate inhibitors
- Safety.

Methanol was considered as an alternative to MEG for use with the selected I & B strategy. While methanol does have similar hydrate inhibiting characteristics to MEG, it also has a tendency to partition with the gas/condensate being exported from the WP. This means that it is unsuited for use in an LNG project, since it can both poison the catalyst within the LNG plant's molecular sieve dehydration beds and erode the sales value of the condensate. Methanol is also more hazardous to handle than MEG.

Continuous injection of MEG, with onshore recovery and reclamation of MEG, has been adopted for other developments and was considered for Wheatstone. The high formation water production rates that are anticipated from the Petroleum Titles would mean that MEG reclamation and regeneration plant would need to be large; larger than has been previously implemented elsewhere.

Heat tracing of the subsea lines, in conjunction with insulation, is being considered but it is novel technology and unproven in this application.

The injection of low dosage hydrate inhibitors, of the anti-agglomerant type, was determined to be unsuitable in this application because of the relatively high PW rates that are currently anticipated. It also tends to have greater toxicity than MEG and is less preferable on environmental grounds.

2.5.3 Marine Operations

2.5.3.1 Product Export

Operation of the marine facilities will mainly involve the loading of the LNG and condensate onto purpose built ships for export to the world's markets.

During loading, LNG carriers and condensate vessels will moor at the PLF berths to allow connection and transfer of products. Tugs, based at the MOF, will assist the vessels with docking, departure and transit manoeuvres.

The LNG will be transferred onto the carriers through up to four 0.41 m (16") diameter loading arms, with an additional 0.41 m (16") loading arm to collect the vapours produced in the loading lines and the ship's storage tanks as the LNG is warmed by the heat generated during loading, and return it to the BOG compressors. Vapour recovery

from condensate vessels is not required as the product is loaded at ambient temperature.

The frequency of shipments will vary as the Project develops. The estimated number of vessels is as follows:

- LNG: Approximately seven carriers per week
- Condensate: Approximately three vessels per month.

Depending on the size of the LNG carrier, loading may take ten to 17 hours, while loading time for a typical (75 000 m³) condensate vessel may be 21 hours.

During the LNG loading operation, the carrier needs to discharge water from its ballast tanks similar to the weight of the volume of LNG cargo it is receiving in its cargo tanks. This ballast water will be managed in accordance with Australian and Quarantine Inspection Service requirements. An LNG ship of 205 000 m³ capacity discharges approximately 83 200 m³ of seawater during the loading operation at a rate of approximately 13 600 m³/hr, assuming a loading time of 17 hours.

2.5.4 Operation of Port Facilities

The port facilities will service LNG carriers with cargo capacities in the range of 125 000 m³ to 220 000 m³.

The fleet serving the facilities will comprise a mix of different sizes. Table 2.4 provides an indication of the number of vessels and inter-arrival period by ship size.

The facilities will also service oil product carriers lifting cargoes of up to 650 000 barrels of condensate in ships that range in size from 80 000 to 120 000 tonne dry weight. Due to draught restrictions on these ships they may only be partly laden. It is anticipated that a two-train operation will require 12 vessels per annum, while a five-train operation will require 40 vessels per annum.

It is not proposed to fuel export vessels at the port. However, dedicated support vessels (tugs and work boats) will be refuelled with diesel at the MOF. A diesel fuel storage facility will be established.

Project operations at the MOF will generally involve pilot boat and tug movements associated with the arrival and departure of the LNG and condensate carriers. Specialist vessels may operate from the MOF periodically, such as ROV vessels during periods of inspection and maintenance for the subsea infrastructure. Some material reception and delivery may be conducted at the MOF on an as needed basis. All materials will be handled in accordance with quarantine procedures in compliance with applicable regulations.

Table 2.4: Ultimate Development - 5-Train Operation (25 MTPA exported)

Ship size (m ³)	No. of vessels per annum	Inter-arrival period (days)
130 000	434	1.0
165 000	342	1.1
205 000	276	1.3

In order to reduce environmental impacts from port operations, several practices will be implemented. These include providing training and equipment to address potential spills, providing adequate containment for any hydrocarbon-containing tanks in the MOF area, and specifying proper refuelling procedures for dedicated vessels to reduce the potential for spills. During Chevron control of the MOF, the facility is not proposing to accept third-party waste, bilge water or grey water from any vessels loading at the PLF and third-party vessels will not be allowed to refuel at the MOF.

2.5.4.1 Maintenance Dredging

To ensure that the shipping approach channels, turning circles and berth pockets remain at the required depth, periodic maintenance dredging will be carried out. Under average conditions the annual infill is likely to be modest. However, simulations of a direct hit from Cyclone Vance (1999) resulted in approximately 1 Mm³ of infill into the dredged areas from an individual event.

Annual dredging of the MOF channel may, therefore, be required. This may result in the removal of approximately 50 000 to 100 000 m³/year. Less frequent dredging may be required every three-to-five years for other dredged areas. This may be equivalent to approximately 300 000 m³/year. Estimate of total planned maintenance for 25 years of operation could be in the region of about 10 to 15 Mm³.

The maintenance dredging plan will therefore be based on annual dredging of the area, in the absence of a major cyclone event and a contingency plan developed to mobilise all available equipment to site immediately following a major cyclone event.

Dredging is discussed in more detail in Chapter 8, *Marine Risk Assessment and Management*.

2.5.5 Onshore Operations

Operation of the onshore Project components will principally involve the reception and treatment of gas either for conversion to LNG and storage prior to export, or transfer to the domestic gas supply network, and the

separation, storage and subsequent export of condensate. Apart from major turnaround maintenance periods, the facility will run as a continuous 24-hour operation. Individual LNG trains, systems, or equipment within the trains will be shutdown as required for routine scheduled maintenance or unscheduled repair work. During these periods, the remainder of the facility may operate at reduced throughput capacity. Emissions, discharges and wastes are discussed in greater detail in Chapter 4, *Emissions, Discharges and Wastes*.

2.5.5.1 Freshwater Requirements

During the operations phase a desalination plant may be required to provide fresh water. The average seawater demand rates for a RO desalination plant are expected to be 162 m³/hr for the initial two LNG train configuration, and 350 m³/hr for the full 25 MTPA development. These demand rates equate to freshwater output of 60 m³/hr and 125 m³/hr and brine discharges of 105 m³/hr and 230 m³/hr respectively. Water source options have been discussed further in Section 2.3.3.3 and in Chapter 9, *Terrestrial Risk Assessment and Management*.

2.5.5.2 Flaring and Venting

There will be no routine gas flaring from normal operations. Flaring may occur during planned maintenance activities, including equipment or system isolations, upset conditions, non-normal operating scenarios, shutdowns and start-ups. Flaring will also occur when a warm ship from dry dock needs to be purged and cooled down.

Flaring during abnormal operations shall be limited to only that essential for emergencies, process upsets, full train or full plant start-up and shutdowns either to meet safety requirements or where the alternative would result in increased greenhouse gas emissions. Other measures to reduce flaring may include:

- Avoiding blowdown of process units and compressors unless absolutely necessary to achieve a safe condition
- Use of a high efficiency flare to reduce the portion of unburned hydrocarbon to as low as reasonably practicable

- Liquids from fuel gas knockout vessels, compression suction scrubbers and flare drums shall be recovered as much as practical.

During normal operations, direct venting of hydrocarbon vapours to the atmosphere will be limited to the following:

- Fugitive emissions
- Hydrocarbon in Nitrogen vents from the LNG facility and domgas plant NRUs
- Residual BTEX from the AGRU thermal oxidisers exhaust vent
- Possible trace hydrocarbon emissions from process wastewater treatment.

Measures implemented to reduce venting include:

- Avoiding where practical the requirement to depressure hydrocarbons to atmosphere when preparing equipment for maintenance, for example by designing low point drains and vents on equipment and piping, piped to the Flare or Liquid Disposal System
- Low fugitive emissions control valves
- Full capacity vapour recovery system will be provided on LNG tanks and LNG loading/unloading facilities, sized to capture all the BOG produced during normal loading activities
- A thermal oxidiser for the destruction of most residual VOCs will be provided for CO₂ venting from the amine regenerator in both the LNG facility and the domgas plant
- Wastewater flash drum to flash hydrocarbon to flare from hydrocarbon containing wastewater streams.

2.5.5.3 Wastewater Discharges

Wastewater effluent sources during operations include:

- Process wastewater and drains
- Sewage treatment effluent from plant facilities
- Sewage treatment plant effluent from accommodation village
- Brine and filter backwash from desalination plant
- Potentially contaminated storm water from process units and wash-down water
- Potential PW from future Chevron or third-party offshore gas fields.

MEG is likely to be recovered through multiple processing steps (for Trains 3, 4 and 5) including MEG regeneration

system, MEG reconcentration, and MEG reclamation. The recovered lean MEG may be returned to offshore through one or two MEG pipelines for pipeline hydrate inhibition. The waste water produced during the future recovery process will be sent to waste water treatment. Storage will be provided for the rich MEG and lean MEG.

Wastewater discharges are discussed in more detail in Chapter 4, *Emissions, Discharges and Wastes* and Chapter 8, *Marine Risk Assessment and Management*.

2.6 Decommissioning

The Project is expected to have an operating life of at least 40 to 50 years. However, at a yet to be determined time, it will reach the end of its useful life and will need to be decommissioned. In the lead up to this point, reuse and recycling opportunities for the Project components will be considered. For example, removal of equipment for use by a third party, or use of equipment left in situ for alternative uses. Where no feasible or practicable alternatives can be identified, the Project components will be decommissioned.

Infrastructure above the seabed will be designed for full removal, however a full assessment prior to decommissioning will be undertaken to assess if full removal is the most environmentally feasible option.

Although it is technically viable to remove subsea trunklines, they are likely to be flushed and left in place to limit impacts to the marine environment associated with the removal operation.

Typically the decommissioning activities will include:

- Decommissioning production facilities
- Flushing subsea facilities including pipelines, flowlines, manifolds and risers
- Decommissioning, suspension, plugging and abandoning wells
- Removal and/or leaving in situ of facilities as agreed with the regulator.

The decommissioning requirements for the Project will be agreed with the regulatory authorities closer to the time of decommissioning. A Decommissioning Management Plan will be developed and will consider:

- Condition of the marine and terrestrial environment
- International, National and State regulatory legislation and standards at the time of decommissioning
- Health and safety legislation and standards
- The land zoning plans and future land use options.

3.0

Project Alternatives and Site Selection



3.0 Project Alternatives and Site Selection

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3.0 Project Alternatives and Site Selection

3.1 Introduction

In 2004, Chevron Australia Pty Ltd (Chevron) discovered natural gas in Petroleum Title WA-253-P, approximately 225 km from Onslow on the North West Shelf of Western Australia (WA). This complemented the discovery in 2000 of natural gas in Petroleum Title WA-17-R located approximately 10 km away. The proposed Wheatstone Project (Project) will initially produce gas from Petroleum Titles WA-253-P and WA-17-R, which are held 100 per cent by Chevron companies, and from WA-16-R, which is held by Chevron companies and by Shell Development Australia. Under an agreement signed in October 2009, third parties will also provide natural gas from Petroleum Title WA-356-P, to supply Trains 1 and 2 of the Project. In addition, third parties may also provide natural gas to supply the proposed Domestic Gas Plant.

In addition to these proven fields, Chevron holds significant acreage in the Western Carnarvon Basin. Chevron is confident that these areas hold similarly significant gas reserves to those in Petroleum Titles WA-253-P and WA-17-R, which in turn could be exploited, subject to local and global demand in the short-to-medium term.

Large-scale multi-field Liquefied Natural Gas (LNG) projects, such as Wheatstone, have complex, multifaceted impacts and future development implications for regional

and local environments as well as their associated communities. In consideration of this, Chevron conducted an assessment of the environmental, technical and socio-economic feasibility of the possible development of reserves in Petroleum Titles WA-253-P, WA-17-R and WA-16-R, including consideration of a number of project alternatives, possible future developments for the Western Carnarvon Basin and the non-development scenario.

The outcome of this process was a concept decision to develop a single onshore facility at a greenfield site on the Pilbara coast between the Burrup Peninsula and North West Cape to meet current and future energy demands. Soon after this decision, a site-selection community engagement strategy was conducted to assist the ongoing fact-finding, decision and design, and approvals processes. In addition to its community engagement, Chevron made the final decision on site selection in close consultation with the Australian Commonwealth and Western Australian governments.

This chapter describes the project alternatives that were considered for the development of the gas resources, and the site-selection process. Key Project design considerations are also described.

Figure 3.1 summarises the overall concept and site-selection process described in detail below.

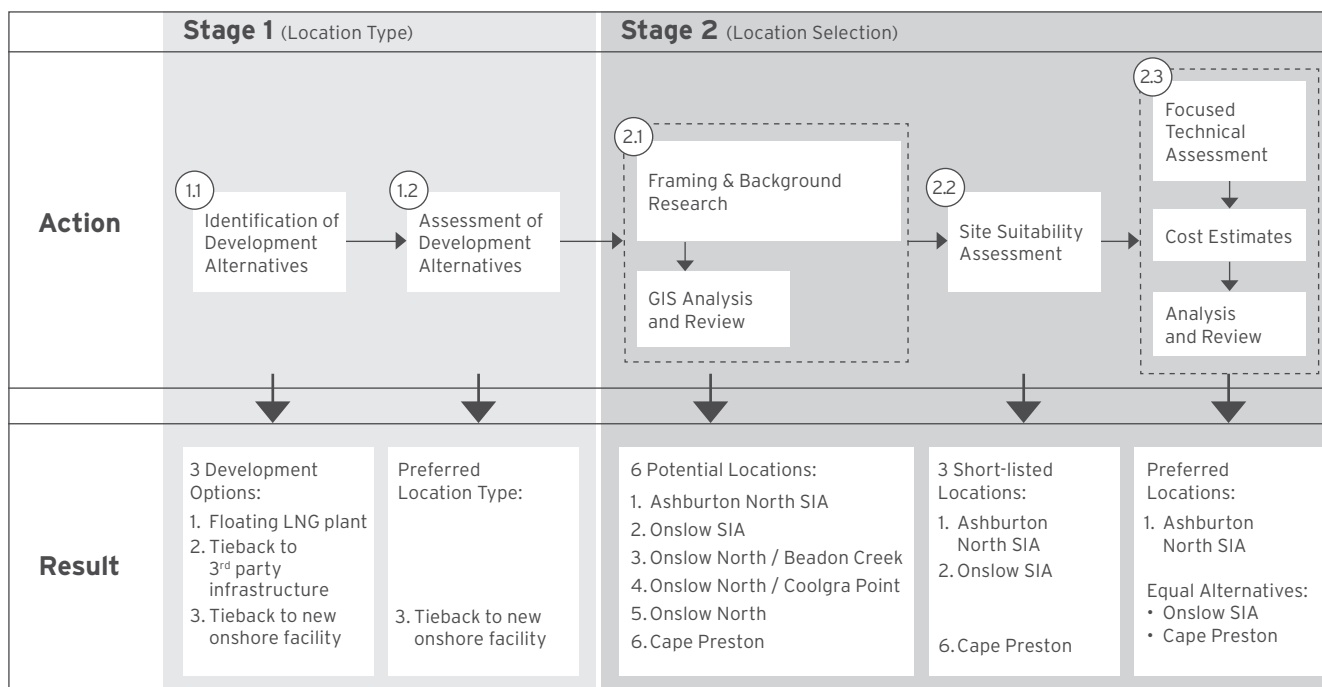


Figure 3.1: Concept and Site-selection Process

3.2 Project Alternatives

3.2.1 No Action Alternative

This section addresses the consequences of not developing the gas fields in Petroleum Titles WA-253-P, WA-17-R and WA-16-R (No Action Alternative). Although the No Action Alternative would eliminate any environmental impacts associated with the proposed action, the need for additional supplies of natural gas would remain. This option maintains the status quo. There is no positive or negative impact on the environment or matters of National Environmental Significance (NES). The benefits of the increased use of natural gas as a source of low-emissions thermal energy and petrochemical feedstock would not be realised. There are also no benefits to the economy from tax revenue and employment.

The consequences of not proceeding with the Project would be failure to meet the Project objectives detailed in Chapter 1, *Introduction*. The primary impact would be loss of economic benefits to the Pilbara region, the State of WA and the Australian Commonwealth. The short-term benefits of the Project include the creation of employment opportunities. The Project is expected to create about 6500 direct and indirect jobs during the construction period, and result in locally purchased goods and services (local content).

The Project also holds significant medium-to-long-term benefits for WA. Western Australian consumers stand to benefit from competitive domestic gas prices. The Project will also contribute towards providing a continuous and consistent gas supply to WA State industries. A further key consequence of not developing the Project is therefore the loss of a significant source of domestic gas supply to WA.

The consequences for the Pilbara region of the Project not proceeding include the loss of the above-mentioned jobs and investments that would otherwise be made in local shared infrastructure, including road improvements and other social infrastructure. It would hinder the creation of an LNG processing hub facilitating development of additional offshore gas resources and weaken the basis for common user infrastructure development in the area. Indirect economic benefits for regional companies both during the construction and operation phases of the Project would also be lost should the Project not proceed. The potential socio-economic benefits for the Pilbara region, the State of WA, the Commonwealth of Australia and Chevron would not take place.

In addition, the Commonwealth Government would not receive Project-related custom duties on imported plant

and equipment, personal taxation for wage and salary earners, and company tax on profits from the Project.

3.2.2 Development Alternatives

Once a decision was taken to develop these gas fields to support the domestic gas market and the export of LNG, various development options were investigated.

These included:

- Offshore only development—floating LNG plant
- Tie-back to third-party infrastructure—North West Shelf, Pluto LNG (under development), Gorgon LNG (under development after 2009 Final Investment Decision)
- Tie-back to a new onshore facility.

The tie-back options considered direct tie-backs (pipeline from the fields directly to shore) and offshore facilities for primary processing followed by tie-back to shore.

3.2.2.1 Floating LNG

This option gathers gas from the offshore fields and processes it on a floating gas facility. The process separates the gas, natural gas condensate (condensate) and produced water (PW) offshore. The gas is liquefied and stored offshore prior to export via an LNG tanker. The condensate is separated from the gas and stored prior to export. The PW and associated bi-products are treated and discharged to sea.

The key advantages of this option are that:

- It does not require large onshore infrastructure
- It does not require an export pipeline, and associated seabed infrastructure is restricted to a relatively small footprint
- All emissions and discharges are released in the offshore environment at a suitable distance from potentially sensitive habitats such as whale migration routes, seagrass meadows, mangroves and coral reefs
- Dredging for access is not required
- The facility can be easily decommissioned and reused and will result in significantly less artificial habitat remaining on the seabed.

The key disadvantages of this option are that:

- It is unproven technology
- It has significantly greater offshore fly-in, fly-out (FIFO) requirements

- It has limited LNG production capacity and cannot be expanded to concurrently handle additional discoveries
- Its distance and relative location make it unfeasible for tie-back to potential future fields in the West Carnarvon Basin
- It has limited design flexibility
- It is more vulnerable to severe offshore cyclone activity.

The potential impacts on this alternative on matters of NES are indicated in Table 3.2.

3.2.2.2 Tie-back to Third-party Infrastructure

The North West of WA currently has one operating LNG plant—the North West Shelf Joint Venture (NWSJV) in Karratha—and two plants under development; Pluto LNG and Gorgon LNG. Each alternative was assessed for a potential direct tie-back (with no offshore processing)

and for offshore primary processing (offshore facilities) tied back to shore. The potential impacts on these alternatives on matters of NES are discussed in Table 3.2.

The NWSJV LNG plant has been operating for 20 years and has been expanded to five-trains over that time. It currently produces approximately 16.3 million tonnes per annum (MTPA) of LNG. Though the Petroleum Title WA-253-P and WA-17-R fields could be tied in to existing infrastructure at a reduced cost to the Project, the NWSJV LNG plant is currently operating at capacity and is being fed by committed reserves from other fields. The environmental impacts of the plant are well documented and therefore represent a known and manageable set of environmental risks. However, the facility has limited potential for expansion in the short term and therefore this alternative would potentially threaten Chevron’s ability to develop these fields in a timeframe that satisfies the

Table 3.1: Advantages and Disadvantages of Third-party Alternatives

Third-party Option	Advantages	Disadvantages
S-Short, M-Medium, L-Long-term		
NWSJV LNG	<ul style="list-style-type: none"> • Existing facility (S, M, L) • Reduced cost of infrastructure development - tie-in to existing trains or development of new trains (S, M, L) • Environmental impact from facility well documented (S) 	<ul style="list-style-type: none"> • Plant is running at capacity and has committed gas supply that could result in Wheatstone failing to meet the Government’s “use-it or lose-it” requirements (S, M) • Difficulty in adding additional trains (S, M) • Does not assist strategic development in the West Carnarvon Basin (L)
Pluto LNG	<ul style="list-style-type: none"> • Two trains have planning approval (S) • One train will be completed by 2010, with first LNG in 2011 (S) • Reduced cost of infrastructure development - addition of new trains (M, L) 	<ul style="list-style-type: none"> • Approval only for two trains. Additional approvals required to expand capacity (S, M, L) • Difficulty in expanding the plant (M, L) • Potential environmental impacts of discharges into Mermaid Sound (M, L) • Does not assist strategic development in the West Carnarvon Basin (L)
Gorgon LNG	<ul style="list-style-type: none"> • Three trains have planning approval (S, M) • Will be operational in 2014 (S) • Reduced cost of infrastructure - additional new trains (M, L) 	<ul style="list-style-type: none"> • Approvals only for three trains - Gorgon has enough gas to fill these and is fully subscribed (S, M) • Does not assist strategic development in the West Carnarvon Basin (L)

government’s retention lease requirements. In addition, the plant and subsea infrastructure are located such that any option of tie-back for reserves in the West Carnarvon Basin are unviable. This alternative was therefore considered unfeasible as it did not present a significantly lower environmental risk than other alternatives, and despite potential cost-savings, the likely timing of “first gas to market” poses a risk to Chevron’s petroleum permit retention under current regulatory requirements.

The Pluto LNG plant is under construction and is located adjacent to the NWSJV gas plant. It will process gas from Woodside’s Pluto Field and has approvals for two LNG trains with a maximum capacity of 12 MTPA. The Pluto LNG plant has the potential for expansion from its initial two-train capacity but this expansion would require new environmental approval applications. The potential for cumulative impacts arising from further expansions at this location would also require significant assessment and consideration. This alternative also does not align with Chevron’s long-term commercial and strategic benefit strategy for the development of future Western Carnarvon Basin reserves. It therefore provides no real advantage in terms of environmental approvals or commercial benefits in comparison to the establishment of a new facility at a suitable greenfield site. While these fields could be tied back to the Pluto plant, as with the NWSJV LNG plant, any potential future reserves discovered in the Western Carnarvon Basin would be left relatively remote from suitable processing facilities and would therefore require the development of a new facility much closer to these fields.

Gorgon LNG has been approved for development; construction commenced in late 2009. The development

consists of three LNG trains with a maximum capacity of 15 MTPA and is fully subscribed. Gorgon LNG will be located on Barrow Island, approximately 70 km off the WA coast. The Gorgon project currently has sufficient committed gas reserves to ensure it operates at maximum capacity. While the Gorgon LNG plant will be located closer to the Western Carnarvon Basin than the NWSJV and Pluto LNG plants, the limited capacity for expansion to accommodate other gas reserves makes this alternative unfeasible.

The relative advantages and disadvantages of tie-back to these options are summarised in Table 3.1.

3.2.2.3 Tie-back to New Onshore Facility

The final alternative considered was a tie-back to a new onshore facility on the north-west coast of WA. This alternative was a new LNG facility at a greenfield site between the Burrup Peninsula and North West Cape. The key advantages and disadvantages of this alternative are summarised as follows:

- The key advantages of this option are that:
 - The LNG facility can be developed for the Project’s needs
 - The LNG facility can be strategically located to allow expansion from future gas discoveries in the West Carnarvon Basin, reducing the need for additional LNG facilities in the Pilbara
 - Development and environmental considerations can be appropriately matched
 - Development is not impacted by conflicting development priorities.

Table 3.2: Comparison of Project Alternatives on Matters of NES

Matter of NES	Potential Impact		
	Floating LNG	Tie-back to third party	Tie-back to new facility
World Heritage Sites			
National Heritage Places		●	
Wetlands of International Importance			
Nationally Threatened Species and Ecological Communities*		●	
Migratory Species*	●	●	●
Commonwealth Marine Areas	●	●	●
Nuclear Actions			

*Nationally threatened species and ecological communities/migratory species that may occur in or utilise the study area. These species and communities are described in more detail in Table 3.10.

- The key disadvantages of this option are that:
 - New infrastructure is required for onshore processing
 - There are additional development costs.

The potential impacts of this alternative on matters of NES are indicated in Table 3.2.

3.2.2.4 Matters of National Environmental Significance

A summary table has been provided to indicate whether a particular alternative was considered to have an impact on matters of NES (Table 3.2). This summary table is based on data obtained from the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA) webpage (DEWHA 2009). The data was used as a high-level screening tool for the review of alternatives. A more comprehensive review was undertaken during the site-selection process when a detailed assessment of the preferred site was undertaken. This is detailed in Chapter 6, *Overview of Existing Environment*.

3.2.2.5 Preferred Alternative

A detailed evaluation of the alternatives was undertaken and is summarised above. This evaluation concluded that the preferred alternative on environmental, economic and schedule grounds would be a tie-back to a new onshore LNG facility located at a greenfield site somewhere between the Burrup Peninsula and North West Cape.

The reasons for this decision were:

- A new facility provided the potential for a strategic development for discoveries in the West Carnarvon Basin
- A new development “hub” would facilitate synergies with other proponents
- A new facility was not constrained by other proponents either technologically or spatially
- A new facility could be developed with proven technology and linked back to the domestic gas market
- Environmental and cultural heritage impacts could be reduced relative to third-party locations.

Table 3.3: Multi-criteria used in the Site-selection Study

Criteria Category	Specific Criteria
Environmental	Marine benthic habitat Conservation estate Wetlands Avifauna Vulnerable species Terrestrial vegetation Acid sulfate soils
Social	Land use Shipwrecks Cultural and heritage sites Native title Mining site Land tenure
Engineering	Distance to navigable water Site road access Aeroplane/port access Distance to population centre Distance from Petroleum Titles to coast Drainage and flooding Erosion hazard and terrain Distance from coast to plant Interference with infrastructure

Once the preferred development concept was selected, a detailed site-selection process was undertaken. This process is described in more detail below.

3.3 Site-screening Study

Chevron undertook a structured five-step site-screening study to identify alternative locations in the coastal region between the Burrup Peninsula and North West Cape that would be appropriate as possible LNG development sites. This approach was not dissimilar to past and recent studies undertaken for LNG development on this coast. It involved early framing sessions, data gathering, development of evaluation criteria, multi-criteria analysis, a technical analysis and cost estimation of sites. Steps included in this process were:

- 1) Framing and background research, including the gathering of all available relevant data, review of literature and previous studies, and development of a concept design basis to provide guideline assumptions for the study.
- 2) A Multi-Criteria Analysis (MCA), consisting of three rounds:
 - Round 1 – A multi-disciplinary team developed and weighted a range of environmental, social and engineering criteria, which were applied to the area of interest using spatial Geographic Information Systems analysis technology. Least constrained areas along the coast were then identified as being “broadly suitable” for the Project facilities. Criteria used during this stage are listed in Table 3.3
 - Round 2 – Using the results from Round 1 and knowledge from previous studies, a number of potentially suitable sites were identified. These were short-listed to six specific sites that would be considered for further assessment
 - Round 3 – Each specific site was assessed for “site suitability” by specialists from Chevron and independent consultants. An environmental and social suitability index was initially calculated, followed by a technical and commercial suitability index. These were used to rank the sites, with three selected to be carried forward to the next step.
- 3) Following this, a focused technical assessment on the three short-listed sites was conducted, considering geological factors, port operability, onshore and marine layouts and supporting infrastructure requirements. The objective was to identify issues and insights for each site, as well as provide inputs for cost estimation.
- 4) Cost estimates (including dredging, earthworks, marine facilities, accommodation village and support infrastructure) for each short-listed site were then developed.
- 5) Finally, an analysis and review of all relevant information informed a recommendation for preferred and alternative sites. Key risks and recommendations for further work and mitigations were also identified.

3.3.1 Outcomes of the Five-step Process

Results of the five-step process identified the following locations:

- Ashburton North Strategic Industrial Area (SIA)¹– (option 1)
- Onslow SIA–(option 2)
- Onslow North/Beadon Creek (option 3)
- Onslow North/Coolgra Point (option 4)
- Onslow North (option 5)
- Cape Preston (option 6).

3.3.1.1 Specific Option Locations

Coordinates and a brief description of each specific alternate option identified within this site-screening study area are provided in Table 3.4.

Specific details of the preferred location, Ashburton North SIA (option 1), can be found in Chapter 6, *Overview of Existing Environment*.

3.3.1.2 Site-screening Study Area

A key consideration in this study was locating a mainland site that was within practical distance of offshore fields for a multi-train LNG development. This included the Clio Field in Petroleum Title WA-205-P and other Petroleum Titles and gas discoveries further west. The Pilbara coastline, which extends from the Burrup Peninsula in the north to Exmouth in the south, was evaluated. This area is shown in Figure 3.2.

As the site-selection study area was much broader than an individual location, impacts of each alternate location do not apply to the entire study area. A comprehensive impact assessment and details of associated mitigation measures relating to the preferred location are included in Chapter 8, *Marine Risk Assessment and Management* and Chapter 9,

¹ Concurrent to this process, the Western Australian State Government announced that a SIA would be created at Ashburton North. Development options for the Ashburton North SIA site included new LNG facilities to aid the development of gas reserves in the Carnarvon Basin and Exmouth Gulf.

Terrestrial Risk Assessment and Management respectively. Refer to these chapters for specific impacts of the preferred location.

Onslow SIA and Onslow North/Beadon Creek had initially been considered constrained due to their close proximity to Onslow settlement. Cape Preston had been considered constrained due to third-party tenure issues. However, Chevron decided that closer scrutiny was warranted.

Having identified six specific locations, additional data was gathered for each and a further analysis undertaken in order to consider:

- Conceptual onshore and marine footprints for each site
- High-level assessment of the impact of each footprint
- Key constraints identified for analysis in Round 3.

The outcome of Round 3 was that:

- Ashburton North SIA and Onslow SIA were deemed to be more suitable when considering environmental and socio-economic criteria
- Ashburton North SIA, Onslow SIA and Cape Preston were deemed to be more suitable when considering technical and commercial criteria.

The concluding steps in the site-screening study were to differentiate between the final three sites (option 1 - Ashburton North SIA, option 2 - Onslow SIA, and option 6 - Cape Preston). This differentiation was based on a comparison of each option against the others to determine which site had the least constraints. This step was undertaken through assessment against the following constraint factors:

- Relative environmental impact
- Native title

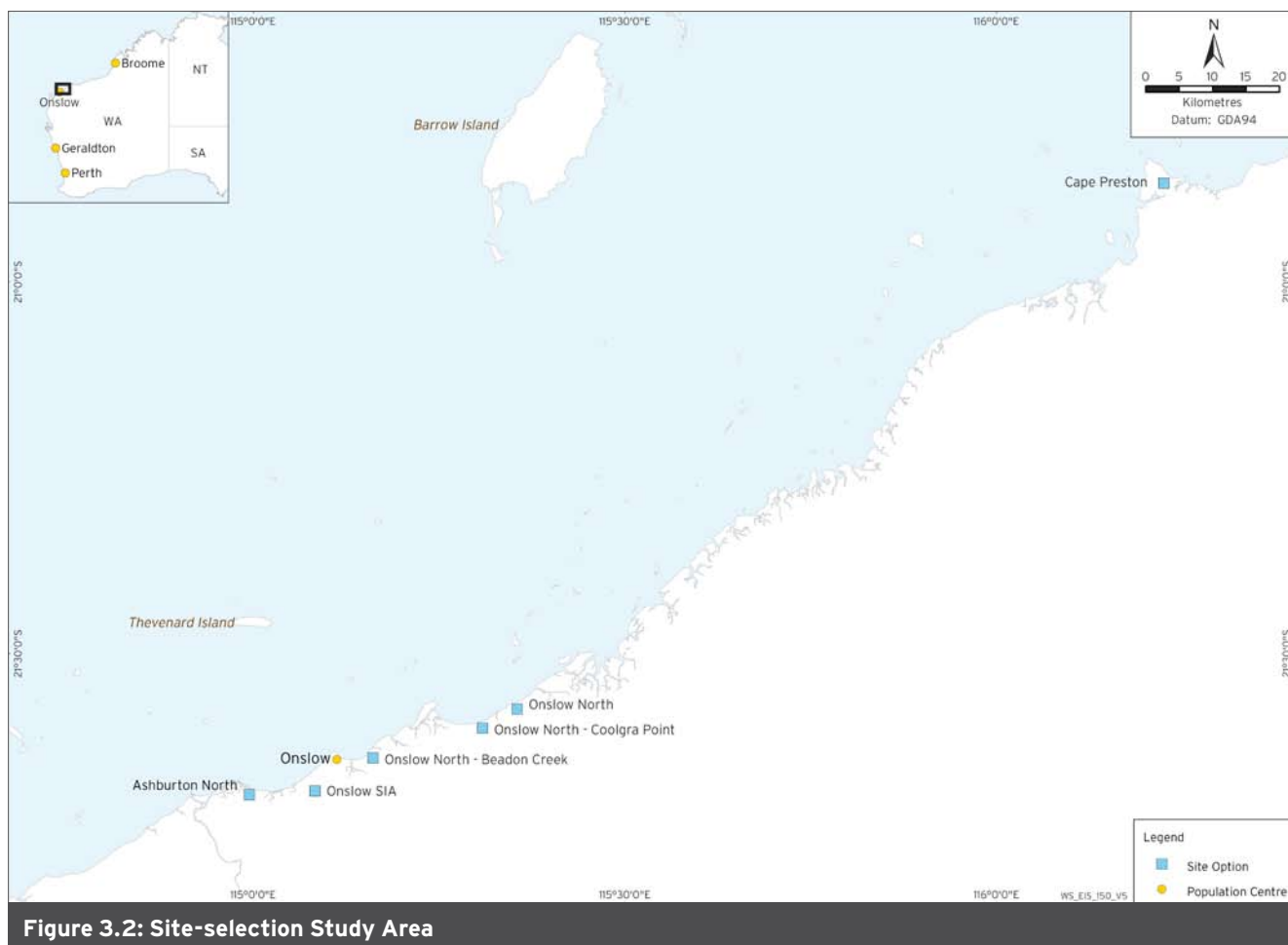


Table 3.4: Site-selection Study Area

Option	Description
1 - Ashburton North SIA	Situated near the Old Onslow Town Site, approximately 5 km north of the Ashburton River and 12 km south-west of Onslow. The footprint is rectangular and the (then) Project area covers a total 458 ha (entirely rural).
2 - Onslow SIA	Identified through the Department for Planning and Infrastructure's 2003 Onslow Structure Plan, the current SIA is approximately 475 ha in area and allows for a 3000 m buffer zone to other land uses. Located south-west of the existing town site, the SIA is loosely bound by the existing Onslow Salt haul road and ponds/crystallisers.
3 - Onslow North/Beadon Creek	Situated approximately 3 km east of Onslow, this option fronts onto Beadon Bay. The terrestrial footprint is rectangular and covers a total area of 787 ha (including 745 ha of Conservation, Recreation and Nature Landscape and 31 ha of rural land).
4 - Onslow North/Coolgra Point	The site is situated approximately 20 km from Onslow, 6 km east of Coolgra Point. The terrestrial footprint is rectangular and covers a total area of 625 ha (including 614 ha Conservation, Recreation & Nature Landscape and 9 ha rural land).
5 - Onslow North	The site is situated approximately 25 km east of Onslow, 10 km east of Coolgra Point. The terrestrial footprint is rectangular and has a total area of 558 ha (556 ha of Conservation, Recreation & Nature Landscape and 2 ha rural land).
6 - Cape Preston	Situated on Cape Preston, this option is located approximately 60 km west-south-west of Dampier, in the Shire of Roebourne. To the south, east and west of the site are the Mardie Pastoral Lease and the De Grey Stock Route. The footprint is rectangular and covers a total area of 558 ha (216 ha managed resource protection, 234 ha other minimum intervention use and 109 ha crown lease).

Table 3.5: Summary of Site-screening Factors

Factor	Ashburton North SIA	Onslow SIA	Cape Preston
Relative environmental impact	Lower	Lower	High - nearshore marine park
Native title	Lower - single claimant	Lower - single claimant	Higher - three claimants
European Heritage sites	One registered site	None	None
Social constraints	Lower - 12 km to Onslow	Higher - 4 km to Onslow	Lower
Third-party claims/ competing land use	2 x exploration, 1 x mining, 1 x pastoral, State agreement over part of footprint	2 x mining, 1 x general, competing land use (Onslow Salt)	Site agreement in place, competing land use (iron ore)
Inundation risk	High, requires engineering mitigation	High, requires engineering mitigation	Low
Available land	Available, requires fill	Available, set back 2 km from coast	Available, subject to third parties
Dredging volume*	45 Mm ³ cutter suction/ trailer suction hopper dredge	32 Mm ³ cutter suction	14 Mm ³ drill and blast likely
Berth operability	91 per cent	95 per cent	96 per cent
Cost	Mid cost, lowest uncertainty range	Highest cost, could be reduced by eliminating long cryogenic line	Lowest, but uncertainty over dredging

Key: Green = Favourable characteristic; Yellow = Moderate characteristic; Red = Less favourable characteristic

* = Early estimates only

- Heritage sites
- Social constraints
- Third-party claims/competing land use
- Inundation risk
- Available land
- Dredging volumes
- Berth operability
- Cost.

Outcomes of this five-step process are summarised in Table 3.5.

3.3.2 Final Results of Site-screening Study

This process identified Ashburton North SIA as the preferred site, with the following key attributes:

- Has the least relative environmental and social constraints
- Has native title and third-party constraints but with lower relative risks than other sites
- Carries an inundation risk from low ground levels but this can be mitigated by engineering solutions
- Is comparable in cost to other sites, but is lowest in the uncertainty range.

Both Onslow SIA and Cape Preston rated approximately equal as alternative sites, with the following key issues identified:

- Onslow SIA is a suitable site, but is challenged by distance from the beach, and proximity to the Onslow settlement and Onslow Salt operations. Cutting off access to an important community beach was a major issue
- Cape Preston is a suitable site, but is challenged by third-party claims on land, dredging uncertainty and diverse environmental issues—in particular, its proximity to a proposed marine park.

3.4 Community and Stakeholder Engagement Process

It is important to note that the community and stakeholder engagement process described here is only one part of Chevron's ongoing and comprehensive community and stakeholder consultation program, which began at the start of the Project, and continues. These activities are covered in Chapter 5, *Stakeholder Consultation*.

The engagement process undertaken during the site-selection process sought to engage stakeholders in the site-screening study findings and in the identification of preferred sites (as described above). It also sought stakeholder views and feedback on the screening study and its outputs and findings. Engagement occurred at the same time as continuing investigations into environmental assessment and approvals, cultural heritage, socio-economic impact and engineering aspects of the preferred alternative.

3.4.1 Outcomes of the Community and Stakeholder Engagement Process

The approach adopted for this engagement process was derived from and built upon current industry best practice, which in turn derives from prior LNG site-selection studies undertaken in the north-west of WA. The engagement process involved a dual approach:

- 1) Community members and stakeholders were invited to three open forums where they heard a comprehensive explanation of the site-selection study, and had opportunities to discuss and challenge the selection criteria (outlined below), and ask questions or voice concerns.
- 2) A single focussed ranking workshop was also developed for a smaller number of community members, referred to as a Perspectives Group (PG), to participate in a multi-criteria assessment-based ranking exercise to determine their preferred ranking of Chevron's LNG development site options.

Details of forums and workshops conducted are listed in Table 3.6.

3.4.1.1 Criteria Development

Criteria developed for this process, which was tested with community members and used by the PG to rank the various alternative sites, was based on the site-screening study (and was weighted accordingly). Criteria used included those set out in Table 3.7.

3.4.1.2 Perspectives Group Membership

The PG consisted of seven individuals, invited to participate on the basis of their membership of Chevron's Onslow and Karratha reference groups. The membership of the group was designed to bring the broadest possible range of Pilbara perspectives to the table in order to review and comment on the site-selection process and make its own site-preference judgement.

Table 3.6: Project Community and Stakeholder Engagement Process Summary for Site Selection

Engagement Session	Date	Location	Attendee Numbers	Attendee Representatives
Community Open Forum	Nov 18, 2008	Onslow	44	Community members (mainly residents) Local Government business Local organisations
Community Open Forum	Nov 19, 2008	Karratha	20	Community members Chamber of Commerce and Industry State Government agencies Local Government business Local organisations
Perspectives Group Workshop	Nov 26, 2008	Onslow	7	Perspective Group members
Stakeholder Open Forum	Dec 3, 2008	Perth	15	State and Commonwealth governments Fishing industry Non-government organisations were invited but did not attend

Table 3.7: Multi-criteria used in the Project's Site-selection Process

Criteria Category	Specific Criteria
Environmental	Coral communities Vegetation Wetlands Light pollution Greenhouse gas emissions Marine benthic habitat Vulnerable species Emissions (gaseous)
Socio-economic	Impact on local business Direct and indirect employment Development of community services/infrastructure Geographical position Heritage (Aboriginal and European) Landscape values Land use

Table 3.8: Summary of Discussions from Onslow and Karratha Forums

Environmental Considerations	
Marine ecosystems	<ul style="list-style-type: none"> • Concerns over the disposal location of dredge material and how often dredging would need to occur • Concerns over jetty in terms of marine impacts and beach access—it was noted that Ashburton North SIA may be more appropriate due to less coral and Cape Preston’s proximity to marine conservation areas • Concerns over increased recreational pressures and therefore impacts on fishing industry
Vegetation	<ul style="list-style-type: none"> • Concerns raised over number of hectares that might need to be cleared and suggested replanting of coastal vegetation to offset impacts • Little is known about Ashburton North SIA coastal mangroves—more studies would be required
Wetlands and coastal processes	<ul style="list-style-type: none"> • Considered that migrating birds, flooding and tidal surges would need to be investigated in relation to wetland areas and that these areas should generally be left untouched
Light pollution	<ul style="list-style-type: none"> • Participants called for investigations into turtle populations and reducing light pollution • An associated concern was the impact of light pollution on settlements, with Ashburton North SIA considered by some Onslow forum attendees to be remote enough
Greenhouse gas	<ul style="list-style-type: none"> • Generally wanted more information and a rigid policy for offsetting emissions • Concerns were also raised about other forms of emissions and proximity to town
Other	<ul style="list-style-type: none"> • Other points raised included consideration of sustainable water and energy supply, and consideration of the general lifestyle and landscape values of people in the areas
Socio-economic Considerations	
Impact on local business	<ul style="list-style-type: none"> • Onslow participants preferred sites closer to Onslow due to opportunities to provide direct economic benefits to the town • Karratha participants raised the issue of competition for human resources • The forums reflected a common desire for Chevron to support and enhance the local economy and a belief in opportunities for promotion of tourism in the region
Direct and indirect employment	<ul style="list-style-type: none"> • Both noted the need for Indigenous opportunities and the use of local contractors • Issues surrounding FIFO, accommodation and general impact of new people on existing services and community fabric were raised as concerns
Development of community services/ infrastructure	<ul style="list-style-type: none"> • Issues surrounding “the Pilbara is too stretched”—limited services and infrastructure, particularly health, education (including childcare), recreational, emergency services, housing/water/energy supply were discussed at length • Participants saw opportunities for Chevron to improve services and infrastructure (such as building a boat ramp, air link and/or public transport) • Participants in Karratha saw housing issues as the main concern
Geographical position, landscape values and land use	<ul style="list-style-type: none"> • Comments on possible location inevitably related to localised service and infrastructure as well as environmental values • Onslow participants preferred sites closer to them and saw Cape Preston as a “no-go” area • Karratha participants favoured development closer to their town • Issues raised in Onslow included interference with popular local beaches, access to Ashburton River, Hooley Creek and False Entrance for recreation and fishing. Concerns were also expressed over the Project’s potential impact on future expansion/land development and whether it might open the door to other industrial development

Socio-economic Considerations	
Heritage	<ul style="list-style-type: none"> Onslow participants raised concerns that the Old Onslow Town Site should be protected, preserved and promoted for tourism Indigenous consultation regarding heritage was recommended
General impact on community	<ul style="list-style-type: none"> Participants in both forums expressed desire for companies such as Chevron to “give back” to the community in which it operates Karratha participants suggested transparency, consultation and open governance as key factors for the success of any development

The final PG members, who had professional or employment affiliations with government, business and community organisations, were approximately equally split between Onslow and Karratha. Importantly, all individuals were identified as being highly informed on the social and economic context and physical setting of the region (including Onslow and Karratha).

3.4.2 Final Results of the Community and Stakeholder Engagement Process

The overall result of the community and stakeholder engagement exercise was the identification of Ashburton North SIA as the preferred site. The engagement process was highly successful in communicating the idea of the Project and providing a feedback mechanism for community members/stakeholders.

A summary of the outcomes is listed below.

3.4.2.1 Results of Onslow and Karratha Forums

Participants of both the Onslow and Karratha forums expressed similar concerns regarding the Project and tended to focus on social impacts. A summary of discussions from both forums can be found in Table 3.8. A similar review was also undertaken at a forum in Perth.

3.4.2.2 Results of the Perspectives Group Rating Workshop

The core element of the community and stakeholder engagement exercise—the PG workshop to rank the three prospective sites identified by former site-screening study—supported the study conclusions that Ashburton North SIA was the preferred site.

Results of the ranking workshop are illustrated in Figure 3.3.

Results of the workshop were relatively clear, indicating that the Ashburton North SIA site was rated as having the least negatives or disadvantages against environmental

criteria and the most positives or advantages against socio-economic criteria.

The environmental positives for Ashburton North SIA concerned vegetation (due to the area being affected by introduced weeds, having a lack of notable vegetation communities and a relative lack of wetlands of significance). It was noted that the weed issue may in fact be effectively managed through an industry presence. The other major environmental advantage was the site’s distance from the SIA and Onslow, and hence the prospect of effective dispersion of gaseous emissions.

The socio-economic advantages were consistent across all criteria, with major advantages for landscape values impact (distance from known lookouts, settlements and recreational visitation areas), lack of conflict with other land uses, and geographical position. The latter included consideration of the potential for subsequent growth, and hence as a potential hub site. Ashburton North SIA was seen as promising in this regard. Relative distance from Onslow was also seen to be particularly advantageous; Onslow is close enough to be an effective service centre, but the proposed site is distant enough to preclude any significant visible physical intrusion on the town.

Onslow SIA attracted the highest number of neutral scores against environmental criteria, with one major disadvantage owing to disturbance of the coastal/foreshore reserve during construction. It was also ranked strongly negative/disadvantageous against geographical position, landscape values and land use. The latter negative ratings were largely due to the SIA’s proximity to Onslow.

Cape Preston ranked slightly better than Onslow SIA against environmental criteria, but scored two major negatives/disadvantages due to construction-stage disturbance to the marine environment. However, Cape Preston ranked less favourably against socio-economic criteria given the lowest level of positive/advantages. It is noted that the PG considered the potential for disturbance

of heritage to be a major negative issue and that the geographic distance from Karratha was considered a major (though not strategic) problem that would result in excessive dependency on FIFO workers.

3.5 Independent Peer Review

A peer review provides credibility and validity in its scrutiny of the engagement process. Chevron, therefore, established an Independent Peer Review to report on the community and stakeholder engagement process.

Two academics with expertise in this process (McKenzie & Singleton 2009) were subsequently nominated and engaged. The terms of reference for the Peer Review included:

- 1) Provision of independent peer review advice on the approach, method and implementation of the community consultation process undertaken

- 2) Attendance, as circumstances allowed, of any internal (Chevron) briefings, or external stakeholder forums/workshops that were undertaken to observe and record (discretionary) the activities being undertaken
- 3) Provision of any advice on how the consultation process might subsequently be improved
- 4) Provision of a brief summary report commenting on the validity or otherwise of the consultation process and methodologies applied.

3.5.1 Results of the Independent Peer Review

The major conclusions drawn by the independent peer reviewers included:

- Participants often asked for more technical information which, at that time, was not available

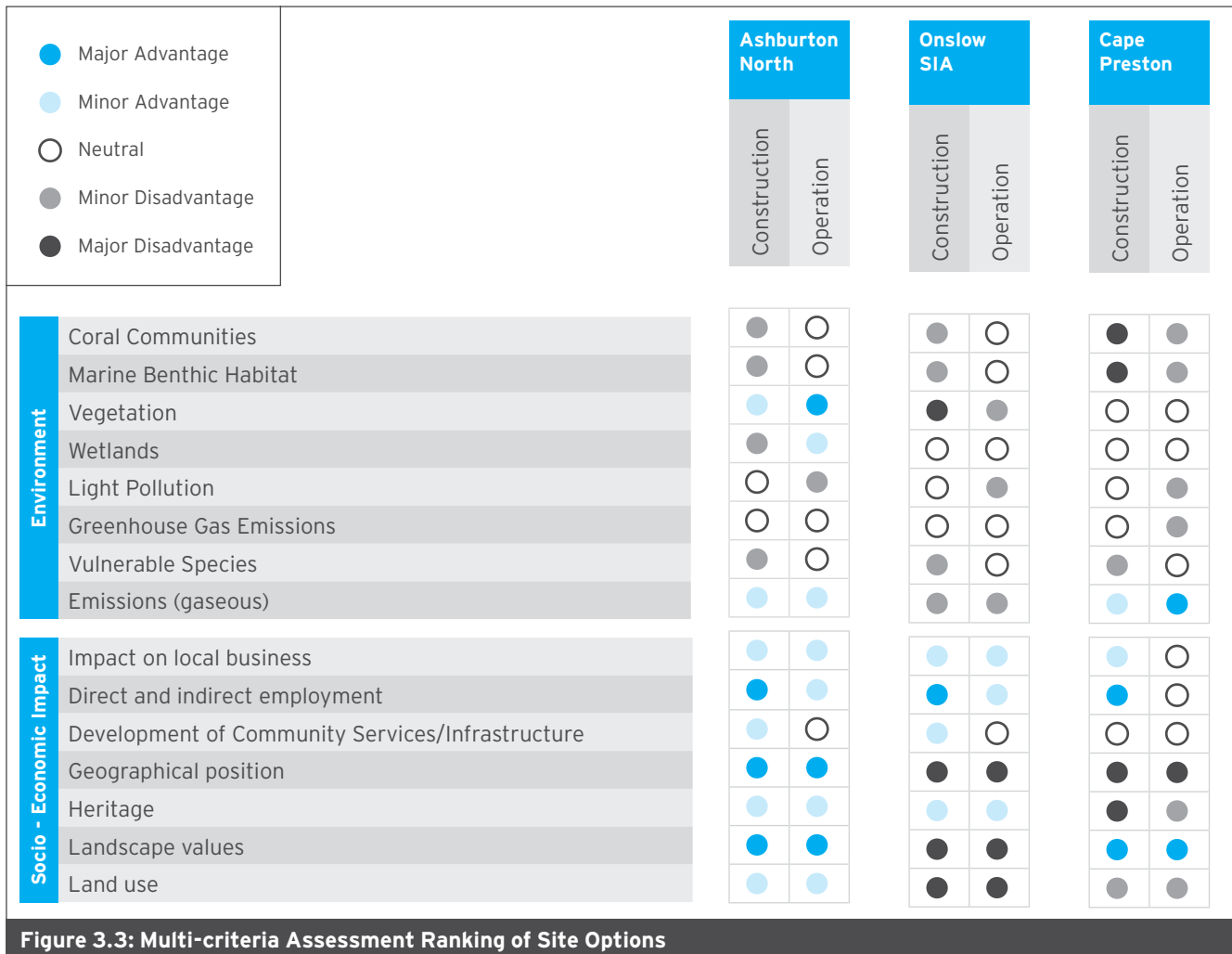


Figure 3.3: Multi-criteria Assessment Ranking of Site Options

- Responses regarding the conduct and availability of some technical, environmental and socio-economic information were provided during meetings, but in several instances the technical experts had to admit that information or findings were not yet available
- It appeared that the stakeholders were willing to accept this, information requests were recorded, and there was a general expectation that once work was completed, Chevron would report back to stakeholders
- It appeared that (in the eyes of the independent peer reviewers) “trust” and “admiration” was building among stakeholders and Chevron representatives and there was a willingness to share information in the future.

3.6 Matters of National Environmental Significance

A screening assessment of the alternatives was undertaken in regard to matters of NES. This assessment provided a very broad “yes” or “no” finding as to whether a particular alternative could have an impact on matters of NES.

Once the preferred alternative was selected, a more detailed site-selection process was undertaken. This included a more detailed assessment of the proposed sites and their potential impact on matters of NES.

Table 3.9 summarises matters of NES under the Commonwealth *Environmental Protection Biodiversity Conservation Act 1999* that are relevant to the entire study area and compares the six alternate sites. Table 3.10 breaks down site by site nationally threatened and migratory species/ecological communities that may occur in or utilise the study area; and Table 3.11 provides a description of existing and proposed marine parks in the study area.

In summary, due to the close proximity of each of the alternate sites, there is little or nothing to differentiate them with regard to matters of NES.

3.7 Project Design Considerations

Chevron considered various design configurations and options for the proposed Project. This section describes key elements with significant potential strategic, environmental or commercial influence.

Table 3.9: Matters of National Environmental Significance Relevant to the Study Area

Matters of NES	Option 1 Ashburton North SIA	Option 2 Onslow SIA	Option 3 Onslow North/ Beadon Creek	Option 4 Onslow North/ Coolgra Point	Option 5 Onslow North	Option 6 Cape Preston
World Heritage Sites	There were no World Heritage Property sites listed for the study area at the time of writing. It is important to note however, that the Ningaloo Marine Park (part of which lies in the study area) is listed as a Commonwealth Heritage Place and the Government has filed an application for World Heritage listing. This is relevant for all options.					
National Heritage Places	There are no National Heritage Places.					
Wetlands of International Importance	According to DEWHA, there are no identified Ramsar wetland areas within the study area. It is important to note however, that the mainland coast of the study area has a thin fringe of mangroves, flanked by intertidal and supra-tidal sand and mudflats, broken periodically by rocky headlands and beaches.					
Nationally Threatened Species and Ecological Communities*	11	11	11	11	12	12
Migratory Species*	26	24	26	26	24	24
Commonwealth Marine Areas	Several protected areas in the form of Marine Parks and Marine Management Areas occur in the study area which covers all options. These are detailed in Table 3.8.					
Nuclear Actions	None					

*Nationally threatened species and ecological communities that may occur in/utilise the study area. These species and communities are described in more detail in Table 3.10.

Table 3.10: Nationally Threatened Species/Ecological Communities Relevant to the Study Area

Threatened Species	Status	Type of Presence	Option 1 Ashburton North SIA	Option 2 Onslow SIA	Option 3 Onslow North/ Beadon Creek	Option 4 Onslow North/ Coolgra Point	Option 5 Onslow North	Option 6 Cape Preston
Birds								
Southern Giant-petrel (<i>Macronectes giganteus</i>)	Endangered	Species or species habitat may occur within area	•	•	•	•	•	•
Mammals								
Blue Whale (<i>Balaenoptera musculus</i>)	Endangered	Species or species habitat may occur within area	•	•	•	•	•	•
Mulgara (<i>Dasyercus cristicauda</i>)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•
Humpback Whale (<i>Megaptera novaeangliae</i>)	Vulnerable	Species or species habitat known to occur within area	•	•	•	•	•	•
Pilbara Leaf-nosed Bat (<i>Rhinionictis aurantius</i>) (Pilbara form)	Vulnerable	Community likely to occur within area				•	•	•
Reptiles								
Loggerhead Turtle (<i>Caretta caretta</i>)	Endangered	Species or species habitat may occur within area	•	•	•	•	•	•
Green Turtle (<i>Chelonia mydas</i>)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•

Leathery Turtle, Leatherback Turtle, Luth (Dermochelys coriacea)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•	•	•	•
Hawksbill Turtle (Eretmochelys imbricate)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•	•	•	•
Flatback Turtle (Natator depressus)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•	•	•	•
Fish											
Sawfish (Pristis spp.)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•	•	•	•
Whale Shark (Rhincodon typus)	Vulnerable	Species or species habitat may occur within area	•	•	•	•	•	•	•	•	•

Table 3.11: Existing and Proposed Marine Parks in the Study Area

Protected Area	Description	Distance from Project Area
Barrow Island Marine Management Area	Offshore and relatively remote. Covers 114 500 ha and includes most of the waters around Barrow Island and the waters around the Lowendal Islands. Significant breeding and nesting area for marine turtles and its waters support important coral reefs and a diversity of tropical marine animals.	70 km
Barrow Island Marine Park	Established by the State Government in 2004. Significant breeding and nesting area for marine turtles, waters support important coral reefs and diverse tropical marine animals.	105 km
Montebello Island Marine Park	Beaches, bays and lagoons fringed by mangroves in places. Forms one of the most important marine areas along the WA coast. Adjacent waters provide habitat for large marine animals such as Humpback Whales, Dugongs and several species of marine turtles, and are stopover areas for rare and protected migratory wading birds. Significant breeding and nesting area for marine turtles and its waters support important coral reefs and diverse tropical marine animals.	135 km
Muiron Islands Marine Management Area	28 000 ha marine management area at the Muiron and Sunday islands, approximately 15 km north of North West Cape. Established by the State Government in November 2004. Protects one of the region’s most biodiverse underwater wilderness areas. Island group consists of the larger South Muiron and North Muiron islands, which are separated by a deep-water navigable channel and both run in a north-easterly direction; and Sunday Island, which is smaller and lies further to the east. The island group is one of the most popular areas for dive charters from Exmouth.	55 km
Ningaloo Marine Park	Abundant whales, dolphins, Dugongs, manta rays and sharks occur on the 300 km-long Ningaloo Reef. World-class diving. Sheltered lagoons, corals.	70 km
Proposed Dampier Archipelago Marine Park	Dampier Archipelago is the richest area of marine biodiversity known in WA, with a biodiversity comparable with that of northern Queensland. The area also supports a wide variety of recreational and commercial activities.	175 km

3.7.1 Strategic Industrial Area Concept - Common Use Coastal Access

The Department of State Development (DSD) of WA has plans to establish Ashburton North as a Strategic Industrial Area (SIA). Within the Ashburton North SIA, the DSD has also designated a “Common Use Coastal Area” (CUCA) which is intended to be used for infrastructure including, but not limited to, gas supply pipelines, LNG storage tanks and multi-user marine facilities by Chevron and other third-party proponents.

Chevron’s selection of the Ashburton North SIA provides a significant contribution to the overall reduction of environmental impacts across the Pilbara region. The placement of multiple industrial facilities within a concentrated development area reduces overall cumulative impacts and ensures localised environmental impact over a broad region by reducing the need for multiple infrastructure development.

The Ashburton North SIA provides multi-user infrastructure and access to the CUCA to all proponents of the SIA. Multiple proponents can utilise a single multi-access infrastructure corridor (access roads, utilities, pipelines) and a single port and navigation channel, greatly reducing overall environmental impact by eliminating the need for multiple infrastructure corridors, ports and dredged channels.

As the initial proponent in the Ashburton North SIA, Chevron agreed with the DSD to develop key aspects of the CUCA (primarily the port, dredged channel and infrastructure corridor) needed to support the Project and include the related CUCA assessment as part of the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP). The Project may also develop subsequent aspects of the CUCA infrastructure on behalf of, and as required by the DSD.

A potential disadvantage of utilising the SIA is that each proponent would be required to accommodate SIA and CUCA restrictions in their design.

3.7.2 Offshore Field Development (Gas Wells)

Chevron evaluated two primary alternatives for the offshore gas field development; the installation of a dedicated well head production platform or an all subsea well development. Initially, Chevron proposed a dry-tree development (well heads on a dedicated platform, or “well head platform”). As subsurface definition matured, it became apparent that flexibility to modify well count and bottom hole location was needed and would bring higher value to the Project than a dry-tree development. As such, the decision was made to proceed with the all subsea well development.

Chevron's decision to utilise the all subsea well development eliminated the need for an additional, dedicated platform anchored to the seafloor. The elimination of the well head platform option diminishes the environmental impact of the offshore development by reducing additional flaring, discharges and emissions. The elimination of the well head platform also reduces the risk of weather or cyclone impacts to the wells infrastructure.

3.7.3 Dredging and Dredge Material Management Considerations

One of the key benefits of an SIA is realised with the creation of a single navigation channel and turning basin serving multiple proponents to accommodate the LNG and condensate carrier vessels. This eliminates the need for individual proponents to create (or expand existing) separate navigation channels, reducing the overall dredging impacts from gas development projects in the Pilbara region. The creation of the channel, turning basin and associated nearshore facilities will require the dredging and subsequent placement of approximately 45 Mm³ of dredge material. Dredging aspects are discussed in detail in Chapter 8, *Marine Risk Assessment and Management*.

Two primary alternatives have been considered for the placement of dredge material:

- Full offshore placement
- A combination of offshore and onshore placement.

Final selection criteria for dredge material placements are focused on the following key considerations:

- Reduction of environmental impacts
- Optimisation of cost and schedule impacts
- Optimisation of construction logistics
- Dredge material characteristics (i.e. sands, fines, clays etc.).

3.7.3.1 Full Offshore Placement of Dredge Material

Full offshore placement involves the dredging and placement of 100 per cent of the dredge material (approximately 45 Mm³) into offshore placement sites. The dredge material is loaded into hopper barges for transport to and placement into potentially four identified offshore placement areas (reference Figure 8.2). Full offshore placement of dredge material is the preferred option for the Project for reasons outlined in the following section.

3.7.3.2 Combination of Offshore and Onshore Placement of Dredge Material

This alternative involves the placement of up to 10 Mm³ of dredge material onshore, with the remainder being placed offshore as described in Section 3.7.3.1. The Project has evaluated the potential use of dredge material for beneficial use, primarily as a potential source of fill for the LNG plant site.

Current analysis of the geotechnical data indicates a disproportionately high volume of fine materials, rendering the material structurally unsuitable for use as fill material without extensive rework and cost escalation. Additionally, the geotechnical nature of the onshore Project site, which consists mainly of clay plains and tidal flats, indicates that it is not sufficiently stable to support the weight/construction of containment bunds. The proposed LNG Plant site, due to its low lying nature, demands large quantities of fill material that is not readily available in close vicinity. Onshore placement of dredge material will require bunds with significant height to provide sufficient air volume to manage the soils, protection against storm surges and soil stabilisation for construction of bunds. These requirements would result in the need for large quantities of imported fill material for building the bunds; hence significantly reducing the net recovery of suitable fill material.

Investigations also indicate that the cost of placing material onshore is relatively more expensive compared to the “all offshore placement” option. This is primarily due to the high cost of imported fill material for construction of containment bunds and the extensive amount of bunding required to recover the dredge material.

Schedule considerations also impact on the feasibility of onshore placement of dredge material. The initial dredging work is driven by the need to complete the MOF as this is a critical component of the overall Project schedule. During initial dredging work, access to the site will be limited and bunds will not be available for containment of dredge spoil onshore. Therefore, it is necessary to place the early dredge spoil offshore, further reducing the net recoverable fill material.

In all possible dredge placement scenarios, a considerable quantity of dredge material is required to be placed offshore. A combined approach utilising both offshore and onshore placement of dredge material introduces additional environmental risks, these include potential impacts on:

- Groundwater flow and quality
- Surface water drainage and quality
- Vegetation and fauna habitat
- Nearshore marine water quality.

Given the design, cost, schedule and environmental considerations outlined above, full offshore placement of dredge material is the preferred option for the Project. Onshore placement aspects are discussed in detail in Sections 9.3.5.1, 9.4.5.2, 9.5.5.9 and 9.7.5.2.

3.7.4 Material Offloading Facility

Another key benefit of the Ashburton North SIA is the creation of a single Materials Offloading Facility (MOF) serving multiple proponents and port users. The MOF will have several functions including the landing of materials needed to construct the LNG liquefaction plant and its subsequent expansions as well as providing a harbour for marine service craft such as tugboats, pilot boats, security craft and line handling boats. The MOF will also be designed and constructed to provide a safe haven for the service craft during cyclone events as there is no other appropriate facility in the vicinity. The MOF will be located behind a breakwater to provide a still basin for cargo offloading.

Chevron considered the following options for the MOF:

- An onsite MOF, comprised of either:
 - A coastal configuration located in the near offshore waters
 - or
 - An inland configuration that would be built on dry land then excavated and dredged to provide an access channel to the Indian Ocean
- An offsite MOF at a harbour in Onslow that would require enhancements such as dredging a channel to the required depth, an increase in land elevation to adequately operate during a cyclone and other improvement to offload heavy equipment
- Use of an existing harbour several hundred kilometres away.

Final selection criteria for MOF configuration focused on the following key considerations:

- Provision of a calm harbour for the offload of modules for plant construction
- Provision of a calm harbour for the offload of heavy-lift ships and barges
- Provision of berths for tugboats, pilot boat, work boats and other small craft
- Provision of lay-down and quarantine areas
- Optimisation of cost and schedule impacts
- Reduction of potential environmental impacts
- Design and construction of the LNG and condensate Product Loading Facility (PLF)
- Optimisation of the overall needs of the CUCA to accommodate State Government and other SIA proponent requirements.

3.7.4.1 MOF Location

The creation of an onsite MOF at the Ashburton North SIA was selected as the most practical alternative. The benefits of an onsite MOF include the diminished need for additional traffic over highways and local roads and reduced emissions from vehicles transporting equipment and materials from distant facilities.

An enhanced MOF at Onslow would incur the same impacts as the creation of an onsite MOF. It would also incur the additional impacts of increased traffic to deliver materials to the plant site and increased marine traffic in the immediate Onslow vicinity.

The use of an existing harbour at an offsite location would eliminate the impacts associated with the construction of a new MOF. However, it would incur significant vehicle impacts of increased traffic over substantially longer distances to deliver materials to the plant site. Marine traffic would also be increased substantially, and LNG and condensate carrier operations would not be supported by immediately available support vessels.

3.7.4.2 Coastal MOF

A coastal MOF was selected as the preferred alternative. The benefit of a coastal MOF includes the near proximity of support vessels servicing the LNG and condensate carriers, which improves the overall functionality of the CUCA.

The benefits of an inland MOF include reduced shoreline impact and reduced fill material (for breakwaters). However, State Government requirements to maximise

the amount of land dedicated for the CUCA could not be achieved with an inland MOF.

3.7.5 Pipeline Shore Crossings

In order to accommodate State Government and other SIA proponent requirements for envisioned land use of the CUCA, Chevron was required to relocate its originally planned trunkline crossing corridor to an area outside the designated CUCA. A combination of 19 alternative corridor locations and shore crossing method configurations were evaluated.

Final selection criteria for pipeline shore crossing location and method focused on the following key considerations:

- Reduction of environmental impacts, including impacts to Regionally Significant Mangroves and impacts on Benthic Primary Producer Habitats (BPPH)
- Optimisation of pipeline route and design
- Management of cost and schedule impacts
- Technical feasibility of alternative
- Associated Project layout design impacts

- Future pipeline shore crossing campaigns
- Operability and risk
- Accommodation of CUCA uses by State Government and alternative third-party proponents.

3.7.5.1 Pipeline Shore Crossing Corridor

Seven corridor routes were considered:

- Originally proposed route through the CUCA
- Two alternative routes through the CUCA
- Route immediately west of the CUCA through the Ashburton mangrove ecosystem
- Route east of the MOF and turning basin through the Hooley Creek mangrove ecosystem
- Route along the LNG and condensate PLF
- A western crossing parallel to the proposed Macedon pipeline corridor.

The shore crossing route alternatives are listed in Table 3.12.

Table 3.12: Shore Crossing Route Options

Route Option	Key Advantages	Key Disadvantages
Through CUCA	<ul style="list-style-type: none"> • Optimal cost and schedule • No direct impacts to either mangrove ecosystem • Reduced temporary disturbance to BPPH 	<ul style="list-style-type: none"> • Failure to satisfy State Government requirements for the CUCA by removal of valuable CUCA land from common use and relocation of proposed CUCA laydown areas
Eastern Route	<ul style="list-style-type: none"> • No impacts to CUCA • No impacts to Ashburton mangrove ecosystem 	<ul style="list-style-type: none"> • Impacts to Hooley Creek mangrove ecosystem • Impacts to BPPH • Significant pipeline rerouting across the LNG and condensate vessel channel • Significant cost escalation
West of CUCA	<ul style="list-style-type: none"> • No impacts to CUCA • Minimal impacts to Project layout 	<ul style="list-style-type: none"> • Direct impacts to the Ashburton mangrove ecosystem • Direct impacts to BPPH (both conditional to shore crossing method)
Route along PLF	<ul style="list-style-type: none"> • No impacts to either mangrove ecosystem • Reduced temporary disturbance to BPPH 	<ul style="list-style-type: none"> • Significant operational risk • Routing under future proponent's jetty
Western Crossing, Parallel to Macedon Pipeline	<ul style="list-style-type: none"> • No impacts to CUCA • No impacts to either mangrove ecosystem 	<ul style="list-style-type: none"> • Cost escalation • Significant schedule delay • Significant disturbance to terrestrial vegetation along the pipeline corridor

3.7.5.2 Pipeline Shore Crossing Method

Four pipeline shore crossing methods were considered:

- Open trenching
- Raised trestle
- Horizontal directional drilling (HDD)
- Micro-tunnelling.

These shore crossing methods were considered in various combinations with the above shore crossing routes. The key advantages and disadvantages of each shore crossing method is outlined in Table 3.13.

3.7.5.3 Alternative Selection

Consideration of the alternatives as outlined above resulted in the selection of the following preferred alternatives:

- Route the pipeline shore crossing corridor to the west of the CUCA
- Utilise micro-tunnelling for the pipeline shore crossing installation to avoid direct impacts to the designated Regionally Significant mangrove ecosystem.

Micro-tunnelling is under further review to confirm it is technically feasible for the proposed Project application.

Pipeline shore crossing aspects are discussed in detail in Sections 2.2.2.1, 2.3.2.1 and 2.3.2.2.

3.7.6 Greenhouse Gas Considerations

Chevron continues to explore options for reducing the overall greenhouse gas emissions from the Project. The greenhouse gas emissions from the onshore gas processing component of the Project are in large part dictated by design decisions around liquefaction technology and

process configuration taken early in the design of the Project. These design decisions are dependent on a number of interrelated considerations:

- Liquefaction process technology and vendor selection
- Capacity range for each LNG processing train including the size of the heat exchangers
- Liquefaction compressor driver selection as either direct-drive gas turbines or electric drive motors.

3.7.6.1 ConocoPhillips Optimized Cascade®

The ConocoPhillips Optimized Cascade® has been selected as the preferred liquefaction technology for the first two LNG processing trains for commercial and strategic benefits. This technology:

- Benchmarks favourably with existing LNG plants in terms of its process efficiency and reliability; it is a proven technology that has performed well and can easily process natural gas of varying composition, which is well suited to the development of a number of separate gas fields
- Is flexible, enabling plant through-put to be tuned to market demand and available gas supply
- Uses multiple, parallel compressor circuits within each liquefaction train which allows the use of smaller compressor process drivers for a given LNG through-put, which facilitates the use of high-efficiency aero-derivative gas turbines
- Uses parallel turbine configurations that allow continued operation (at reduced rates) during periods of planned and unplanned gas turbine maintenance, reducing the number of full plant shut downs and start-ups

Table 3.13: Shore Crossing Method Options

Crossing Method	Key Advantages	Key Disadvantages
Open Trenching	<ul style="list-style-type: none"> • After restoration, natural coastal processes will not be inhibited 	<ul style="list-style-type: none"> • Direct impact to mangrove ecosystems and BPPH (dependent on shore crossing route)
Raised Trestle	<ul style="list-style-type: none"> • Reduced impacts to mangrove ecosystems and BPPH 	<ul style="list-style-type: none"> • Cost escalation • Operational risk
Horizontal Directional Drilling	<ul style="list-style-type: none"> • Avoidance of impacts to mangroves and BPPH 	<ul style="list-style-type: none"> • Cost escalation • Distance and pipeline dimension limitations (particularly under mangrove ecosystems)
Micro-tunnelling	<ul style="list-style-type: none"> • Avoidance of impacts to mangroves and BPPH 	<ul style="list-style-type: none"> • Cost escalation

- Allows the process refrigerants to remain contained within the plant—as opposed to being flared during shut-downs—enabling much faster plant restarts.

Further details on the chosen liquefaction process are described in Chapter 2, *Project Description*.

3.7.6.2 Gas Turbine Driver Configurations

Processing trains with a nominal LNG through-put of 4, 5 and 6 MTPA LNG per train have been assessed along with various gas turbine and electrical drive configurations. These options were assessed for:

- Energy efficiency savings associated with larger LNG processing trains
- Operability, in particular the ability to operate each processing train at less than full capacity (turn-down) in order to match LNG output with customer requirements
- Technology maturity and risk.

As a result of these studies, Chevron has determined that the first two LNG processing trains will each have a nominal capacity of approximately 4.3 MTPA LNG and be powered by six, 43 MW² aero-derivative gas turbines.

The use of aero-derivative gas turbines will reduce greenhouse gas emissions from the Project by approximately 1.25 MTPA compared to the use of the industrial gas turbines, primarily due to the increased thermal efficiency of these types of turbines. The 43 MW turbines are more suited to the anticipated load of the selected LNG processing trains enabling them to operate at peak efficiency. This provides additional savings in annual greenhouse gas emissions of approximately 65 000 tonnes per year compared to smaller 34 MW aero-derivative turbines. To further optimise the overall efficiency the gas turbine drivers in the liquefaction trains will be equipped with inlet air humidification (cooling).

Decisions on the process technology and sizing of future LNG processing trains will be made as part of the design for those facilities. Chevron anticipates that the emissions intensity per tonne of LNG from future LNG process trains will be comparable and potentially lower than that of the first two LNG processing trains.

3.7.6.3 Electrical Power Supply

The onshore gas processing component of the Project requires electrical power to run pumps, cooling fans, utilities and other support systems. This electricity supply must be stable and reliable. A minor loss or interruption to

the electricity supply can result in the shut-down of a gas processing train, which would in turn necessitate the flaring of part of the train's gas inventory. This generally requires electrical power generation capacity to be designed with excess capacity such that the failure of any one generator will not impact upon gas processing operations.

During the initial design of the first two LNG processing trains, the following options were evaluated for the supply of electrical power:

- Four 43 MW open cycle aero-derivative gas turbine generator sets
- Five 43 MW open cycle aero-derivative gas turbine generator sets
- Six 33 MW open cycle aero-derivative gas turbine generator sets
- Four 42 MW open cycle industrial gas turbine generator sets
- Combined cycle generation using three 33 MW aero-derivative gas turbines fitted with a waste heat recovery to provide steam to drive two steam turbine generators of approximately 16 MW each³.

Early design engineering had selected the option of five, 43 MW aero-derivative gas turbine generators as this resulted in approximately 47 000 tonnes per year less greenhouse gas emissions compared to the six 33 MW aero-derivative option, and 118 000 tonnes per year less greenhouse gas emissions compared to the four 42 MW industrial gas turbine option. However, investigations continue as to whether only three generator sets are required to meet the total plant electrical load with a fourth machine as a spare.

The combined cycle option showed the potential to further reduce greenhouse gas emissions by approximately 200 000 tonnes per year but was discounted due to high capital cost and operability issues associated with transient stability. The level of technical risk associated with the stability of the combined cycle power generation option was not compatible with the desired reliability targets established for the Project.

To further improve the process efficiency and to reduce greenhouse gas emissions, expanders will be installed on the feed gas circuit within the gas liquefaction processing facilities. These turbo expanders will be used to generate approximately 5 MW of electrical power for each LNG process train.

² All stated power outputs are nominal rating at ISO conditions

³ All stated power outputs are nominal rating at ISO conditions

3.7.6.4 Carbon Dioxide Removal

As described in Chapter 2, *Project Description*, one of the first steps in processing the natural gas onshore is the removal of the carbon dioxide (CO₂) and other acid gas components, such as hydrogen sulfide (H₂S), that are naturally occurring in the reservoir gas. The volume of reservoir CO₂ that is removed will vary over the operational life of the Project due to the natural variability of the CO₂ content within the gas fields.

This acid gas vent stream containing the reservoir CO₂ is routed to thermal oxidisers in order to combust any contained methane, H₂S, benzene, toluene, ethylbenzene and xylene (BTEX) prior to release of reservoir CO₂ into the atmosphere.

The associated gas from the Wheatstone and Iago fields contains a relatively low volume of CO₂. Chevron evaluated the feasibility of CO₂ sequestration for the Project and has undertaken a number of screening studies to identify suitable geological storage sites within 300 km of the proposed Ashburton North site that could be used for the underground injection and storage of the extracted reservoir CO₂. Potential storage sites may exist offshore and some distance from the Ashburton North site. Economic analysis indicates these sites would not be commercially attractive. The low concentrations of CO₂ and the lack of a commercially viable geological reservoir for CO₂ reinjection currently make the option of CO₂ sequestration infeasible.

3.7.6.5 Waste Heat Recovery

Opportunities to reduce the Project's greenhouse gas emissions through the capture and use of waste heat have been evaluated during the design and engineering studies for the first two LNG processing trains. These studies determined that waste-heat recovery systems could be incorporated into the exhausts of the gas turbines within each LNG processing train in order to supply all the routine process heat requirements for the onshore gas processing facility. This will preclude the need for the routine use of heaters or boilers to provide process heat within the facility⁴. The use of waste heat to provide all routine process heat loads is anticipated to reduce greenhouse gas emissions for the 25 MTPA LNG Project by approximately 1.8 million tonnes per year.

In addition to the waste-heat recovery system for process heating, select compressor gas turbines in each liquefaction train are proposed to be fitted with separate

heating coils to heat and dry the gas which is used intermittently to regenerate the molecular sieves in the dehydration unit at the inlet to the LNG processing train.

3.7.6.6 Flaring and Boil Off Gas

As described in Chapter 2, *Project Description* some flaring of hydrocarbon gases will be required, primarily ensuring the safety of the facility during plant start-up and shut-down or due to unplanned events. All flares will be designed for efficient combustion of any hydrocarbons contained in the product being flared. A continuous flow of hydrocarbon purge gas may be required along with flare pilots to ensure the safe ignition of the flare. Alternatives to the use of hydrocarbon purge gas, such as N₂, will be examined during detailed Project design.

3.7.7 Domestic Gas Plant

Third parties may also provide natural gas to supply the proposed Domestic Gas Plant. Processing of third party gas is an example of the potential synergies available to gas producers at the Ashburton North Strategic Industrial Area. Chevron has accounted for the associated atmospheric emissions and PW of such an arrangement in the impacts assessment of the Project in this EIS/ERMP (discussed in Chapter 4, *Emissions, Discharges and Wastes*). Other potential environmental impacts from future third party actions have not been assessed in this EIS/ERMP, with the exception of those actions that are reasonably foreseeable (refer to Chapter 11, *Cumulative Impacts* for details). However, future gas industry projects will be subject to the regulatory environmental approvals process, which will be managed by the relevant third party.

3.7.8 Produced Water Handling

The expected maximum PW production rate for the offshore component of the Project is approximately 6 600 m³/day. Chevron conducted an alternatives analysis to evaluate PW disposal options. The alternative analyses resulted in a list of PW disposal options with an overall ranking of the disposal options.

Eight key PW disposal options were identified:

1. Send to shore and reinject
2. Send to Barrow Island or other existing facility to reinject
3. Treat and discharge offshore in accordance with regulatory limits (maximum 30 mg/L oil in water 24-hour average⁵)

⁴ Small gas fired heaters are proposed to be incorporated into the design of the waste heat recovery system to provide process heat during plant start-up and until such time as the compressor gas turbines are operating.

⁵ *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999*

4. Enhanced treatment to remove other contaminants (total petroleum hydrocarbons, BTEX, heavy metals) and discharge offshore below regulatory limits (maximum 30 mg/L oil in water 24-hour average)
5. Reinject into producing reservoir
6. Reinject into shallow disposal reservoir
7. Reinject into disposal zone, treat and discharge when reinjection is not available
8. Initially treat and discharge, then reinject when formation water rates increase.

Final selection criteria for PW disposal options focused on the following key considerations:

- Environmental quality of the receiving media
- Cumulative impacts
- Biological receptors
- Human receptors
- Human activities and uses
- Greenhouse gas
- Regulatory environment
- General public and other groups
- Operational feasibility and costs.

Further sub-surface work has indicated it is commercially infeasible to reinject PW into the Wheatstone or shallow reservoirs and that a separate disposal zone may be required. The remaining options were carried forward for further feasibility evaluation and concept selection.

The final selection resulted in the preferred alternative of providing enhanced treatment locally at the Wheatstone Platform (WP), removing further contaminants and discharging overboard at concentrations below the regulatory standard of 30 mg/L oil in water.

Assessment of the various treatment systems and technologies for meeting the enhanced treating target for PW are being conducted. The current base case assumes hydro-cyclones and a degasser for treatment of the PW prior to discharge.

3.7.9 Future Considerations

Overall approval is being sought for an LNG plant of 25 MTPA capacity. The initial development is for a nominal rate of 9 MTPA. The LNG plant will expand to its full capacity as additional offshore gas resources are developed. It is reasonable to expect further technological improvements

will evolve and various design contingencies will be needed to accommodate future needs.

3.7.9.1 Offshore Pipeline Installation - Subsea Pipeline Trenching Machine Trial

Chevron recently completed a trenching trial using a subsea pipeline trenching machine, known as "RT1" (shown in Figure 3.4) for use during subsea pipe laying for the Project.

The trial's main objective was to assess the suitability of RT1 to dig a 2 m-deep trench in seabed conditions representative of those expected to be encountered along the nearshore portion of the Wheatstone Trunkline.

Key characteristics of the trial comprised:

- A one-off trial of nominally 19 days
- A trial zone containing four sections of 6.9 km total length in water depths of between 13 and 36 m (shown in Figure 3.5)
- Dredge material volume of approximately 27 600 m³
- A trench depth of approximately 2 m.

The outcomes of the trial may also represent a potential opportunity to reduce environmental impacts compared to alternative methods of pipeline stabilisation.

Potential environmental advantages include:

- A reduction in the volume of rock dumping on the pipeline with a subsequent reduction in both the amount of foreign material introduced to the seabed and the amount of rock to be sourced
- Reduced water column disturbance and sediment plumes compared to cutter/trailing hopper suction dredging
- Reduced trench size compared to other forms of pipe lay resulting in reduced habitat disturbance.

The trial confirmed that the trencher is able to effectively trench through the cemented and un-cemented sand sections of the route. Performance through the rock portions of the route was variable depending on the strength, stratification and presence of voids within the rock. Certain areas of the rock seabed were able to be trenched to a depth of 2 m, albeit at low production rates, with the trencher being unable to penetrate down to depth in other areas.

Study work is now ongoing to determine which areas of the Trunkline route are viable for post lay mechanical trenching based on results of the trial in combination with geophysical

and geotechnical data, the results of which are expected in Q3/Q4 2010. Investigations are ongoing in parallel with the trenching machine designer and operator to determine if it possible to modify the design of the vehicle to improve the ability to trench through sections of the seabed which were unable to be trenched during the trial.

Due to water depth restrictions nearshore, the highly variable nature of the seabed along the Trunkline route and the presence of hard seabed areas (those outside of the ability of post lay trenchers to cut) it is unlikely that post lay mechanical trenching will provide a secondary stabilisation solution for the full nearshore route. It is therefore possible, pending receipt and evaluation of the geotechnical data, that the final secondary stabilisation solution may include a proportion of more conventional methods such as prelay dredging and rock dump.

This trial is not included in the scope of Project areas that will be assessed as an ERMP by the Environmental Protection Authority (EPA). The trial was referred on August 20 2009, under Section 38(1) of the *Environmental Protection Act 1986*.

3.7.9.2 Future Offshore Developments - Produced Water Handling

Future offshore gas developments may require that primary PW be brought directly into the onshore LNG plant with the natural gas and condensate. This would require the primary separation, treatment and disposal of the PW. The anticipated discharge will occur offshore at a minimum depth contour of 20 m. The discharge line (if needed) is likely to follow the export pipeline corridor. At present, the treatment plant will be designed to meet the applicable discharge regulatory requirements (current standard is 30 mg/L dissolved oil in water). Final discharge impacts of potential future PW streams entering the plant may be further evaluated as part of the specific offshore development assessment.

3.7.9.3 Waste Facilities

Controlled and restricted wastes that cannot be recycled or reused are typically disposed of at licensed, offsite managed facilities. With the exception of the Port Hedland hazardous waste incinerator, there is currently no waste management or disposal facility in the region that is

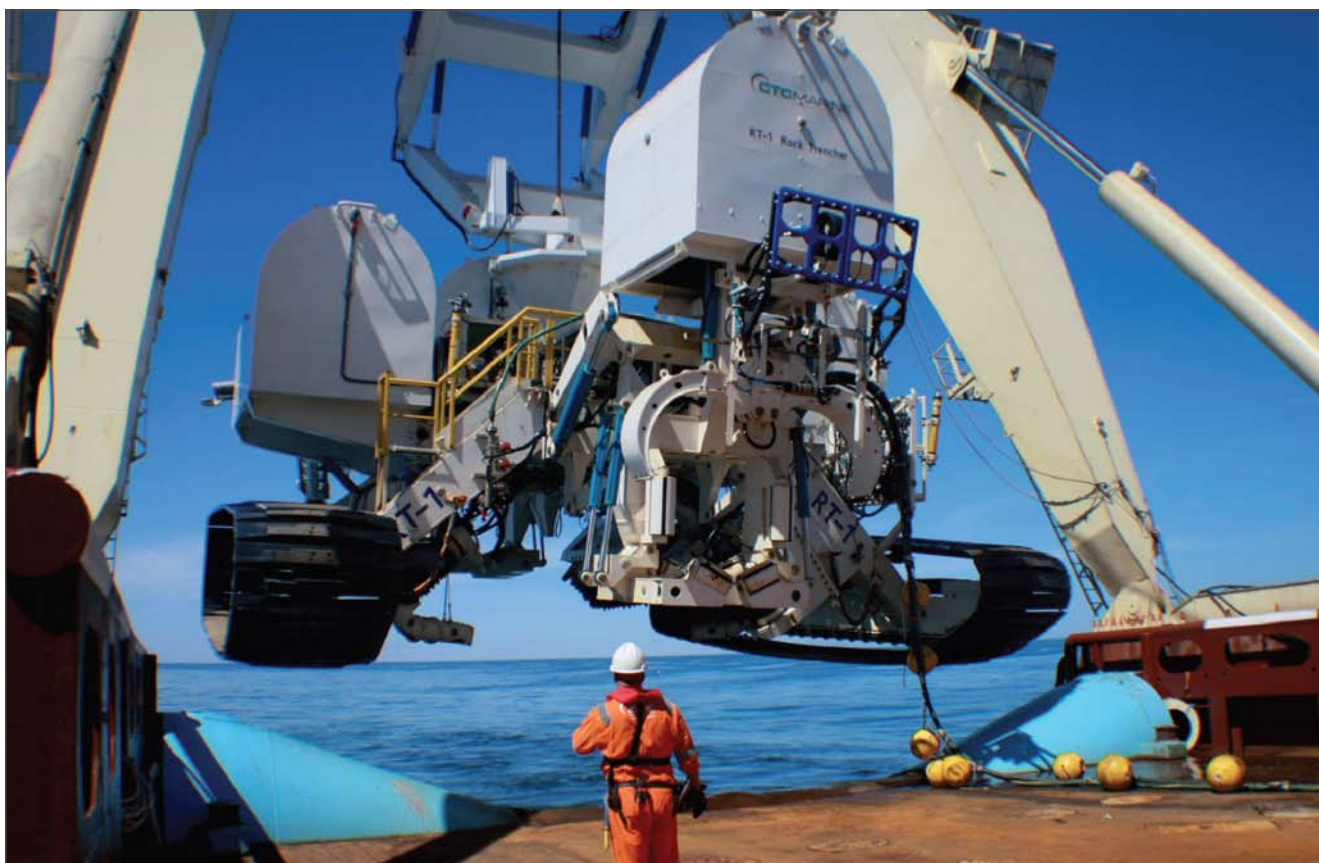


Figure 3.4: The RT1 Subsea Pipeline Trenching Machine

suitable for use by the Project. For non-hazardous waste, the only current option is for Chevron to transport waste to Perth for subsequent management and disposal. This is not an efficient or effective long-term solution. As such, a number of alternatives are being explored to address both short term (construction) and long-term (operations) waste management needs. These alternatives include third parties investigation opportunities to develop waste management facilities to support both industry at Ashburton North and the town of Onslow. It is Chevron's preferred option to utilise suitable third-party facilities developed in the region.

Should third-party facilities not be developed within a timeframe that supports Project construction and operations, Chevron is considering the option to develop waste management facilities. Such waste management facilities may include an incinerator to reduce the volume of waste disposed to landfill. Facilities may also include a lined landfill facility as well as facilities to support recycling of waste. Such waste management facilities, should they be required, will be subject to subsequent environmental approvals of the *Environmental Protection Act 1986*, which will address site selection, technical design and operational requirements.

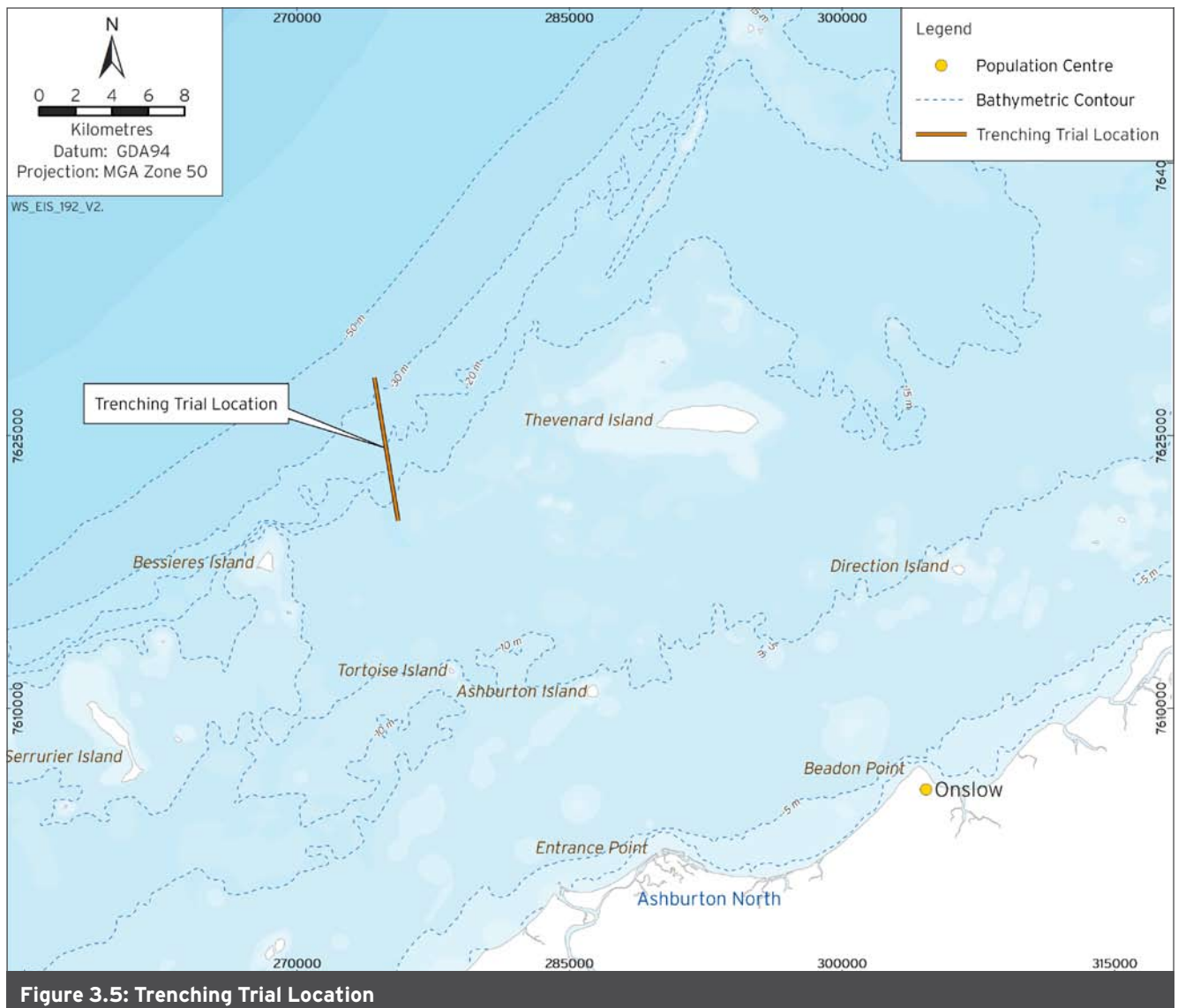


Figure 3.5: Trenching Trial Location

4.0

Emissions, Discharges and Wastes



4.0 Emissions, Discharges and Wastes

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4.0 Emissions, Discharges and Wastes

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4.0 Emissions, Discharges and Wastes

4.1 Introduction

Emissions, discharges and wastes will be generated during the drilling, construction, installation, commissioning, operation and decommissioning of the proposed Wheatstone Project (Project).

Emissions, discharges and wastes comprise the authorised or unauthorised release or deposition of material into the environment. These emissions, discharges and wastes may be in the form of gaseous releases, liquid discharges and solids. There will also be emissions of light and noise.

A Project emissions, discharges and wastes assessment has identified the potential sources and types of emissions, discharges, and waste that may be produced. The findings of this assessment are shown in Figure 4.1 and Figure 4.2.

The identification of the potential sources and types of emissions, discharges and wastes, combined with information on their potential toxicity has enabled the potential environmental impacts to be determined. It has also enabled the identification of areas where waste volumes could be reduced and will form management plans detailed in Chapter 12, *Environmental Management Program*.

This chapter discusses the following emissions, discharges and wastes that may be generated by the Project:

- Greenhouse gas
- Atmospheric emissions
- Light
- Noise
- Marine and terrestrial discharges
- Solid wastes
- Accidental releases (spills and leaks).

4.2 Greenhouse Gases Emissions and Management

4.2.1 Overview

This section outlines:

- The Commonwealth and Western Australian State government policy and regulatory framework for greenhouse gas emissions under which the Project expects to operate
- An estimate of the greenhouse gas emissions expected from the Project
- Impacts on State, national and global greenhouse gas emissions

- Comparisons of the greenhouse gas emissions intensity anticipated for the LNG component of the Project benchmarked against a number of similar projects
- Planned and possible future actions that may be undertaken by Chevron Australia Pty Ltd (Chevron) to further reduce greenhouse gas emissions from the Project.

During the conceptual design phase of the Project consideration has been given to how best to reduce greenhouse gas from the Project. A number of high impact design decisions that will have the effect of reducing Project emissions over the life of the Project are described in Chapter 3, *Project Alternatives and Site Selection*.

Proponents of major projects have for some time seen the introduction of a price on greenhouse gas emissions as inevitable and have factored in this price in their project decision making. This internalisation of emissions costs is driven by the reality that projects such as Wheatstone will operate over many decades and once constructed, opportunities to further reduce emissions are limited. This results in projects being designed in consideration of the possible price on greenhouse gas emissions applicable in ten to 20 years' time, as opposed to any particular policy around climate change during the project's early conceptual design.

4.2.2 Assessment Framework and Government Policy

Over the last three years there has been increasing recognition that the regulation of greenhouse gas emissions is best managed at a national level. This is reflected in the November 29, 2008 Council of Australian Governments (COAG 2008) agreement streamlining Commonwealth, State and Territory climate change related policy in advance of the introduction of the Carbon Pollution Reduction Scheme (CPRS).

While uncertainty currently exists around the implementation timing of the Australian Government's CPRS, the Australian Government has stated as recently as May 4, 2010, that it sees the CPRS as the lowest cost path to reducing Australia's greenhouse gas emissions. The proposed scheme would create a price on the atmospheric emission of greenhouse gas that reflects society's view (as represented by government in setting the emission scheme cap) of the true cost of emitting each additional tonne of greenhouse gas. The introduction of such a scheme has the potential to drive emissions reductions across the economy by providing a price incentive for industry and consumers to change behaviours that result in greenhouse gas emissions.

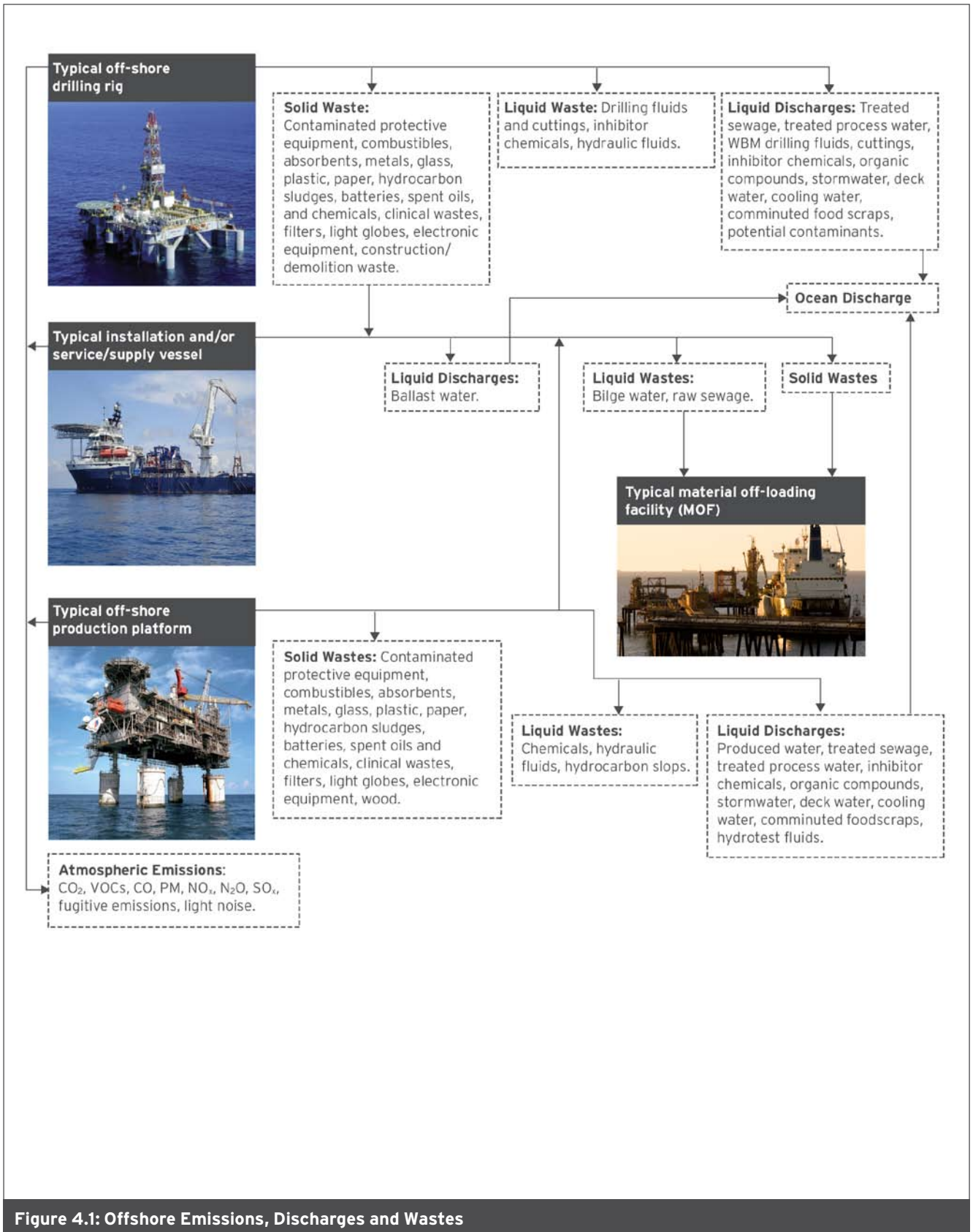


Figure 4.1: Offshore Emissions, Discharges and Wastes

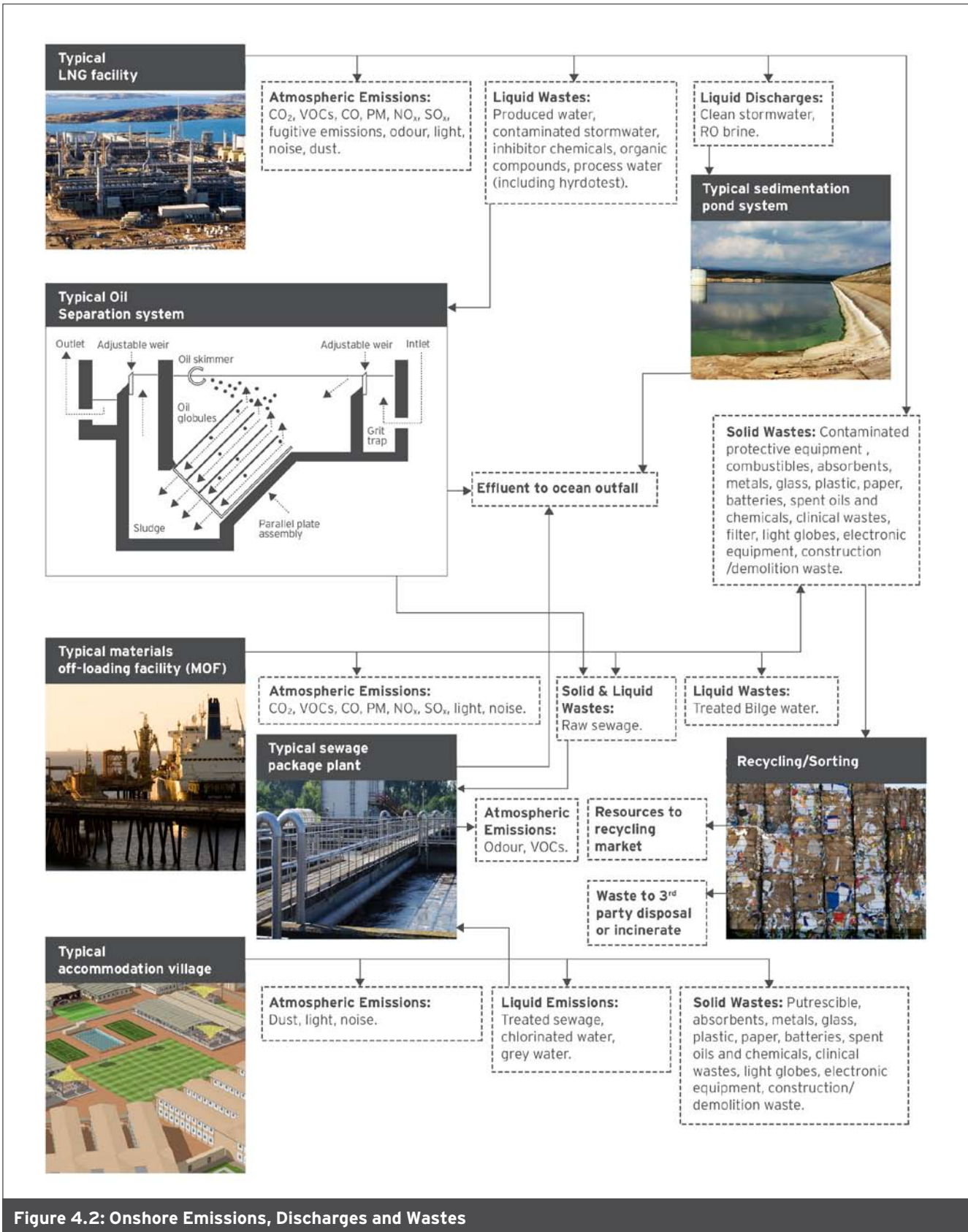


Figure 4.2: Onshore Emissions, Discharges and Wastes

4.2.2.1 Australian Government Policy and Legislation

Following a number of reviews across the Commonwealth, State and Territory governments, the Commonwealth Government's Carbon Pollution Reduction Scheme – White Paper was released in December 2008 (Australian Government 2008a). The White Paper documents a comprehensive set of policies dealing with the introduction of an emissions trading scheme in greenhouse gas, and the nature of complementary policies that should support such a scheme.

At the time of writing this Draft EIS/ERMP, legislation to give effect to the emissions trading scheme had been debated in the Federal Parliament but had failed to be passed by the Senate. In parallel to the debate on legislation in the Federal Parliament, the Department of Climate Change and Energy Efficiency has undertaken considerable work on the drafting of accompanying regulations and the establishment of required regulatory structures.

It is anticipated that the Project will be included within the coverage of the emissions trading scheme and may receive an allocation of emissions units under the emissions-intensive trade-exposed industry assistance program. This allocation is designed to preserve the full economic incentive provided by the scheme for the Project to manage its greenhouse gas emissions.

On April 27, 2010 the Australian Prime Minister announced (Department of Climate Change and Energy Efficiency, 2010) that the implementation of the emissions trading scheme would be delayed until the end of 2012, once the Kyoto commitment period ends. In making this announcement the Prime Minister quoted the difficulties in getting the emissions trading legislation passed by the Senate and delays in agreeing a comprehensive international agreement. While this announcement creates some uncertainty about the eventual regulation of greenhouse gases in Australia, it does not materially change the way Chevron has approached the management of greenhouse gas emissions from the Project.

Accurate and verifiable data on greenhouse gas emissions is important in considering how best to deal with the risks posed by climate change and is critical for the introduction of emissions trading. In 2007, the Commonwealth Government introduced the *National Greenhouse and Energy Reporting Act 2007*, which mandates the national reporting of greenhouse gas emissions, energy production and energy use. It is planned that this legislation will provide the data required by Australian State governments in relation to greenhouse gas emissions.

The Commonwealth *Energy Efficiency Opportunities Act 2006* was implemented to improve the identification, evaluation and reporting of energy efficiency opportunities across Australian industry. Participation is required for all corporations that use more than 0.5 petajoules of energy per year. The Act requires qualifying companies to submit five-year plans that set out proposals for assessing their energy usage and to identify, evaluate and report on cost effective energy savings opportunities.

4.2.2.2 Western Australian Policy and Legislation

Chevron is aware that the WA State Government is preparing a Climate Change Adaptation and Mitigation Strategy. At the time of writing this EIS/ERMP, consultation on the development of this strategy was yet to commence.

In 2002, the EPA released its Guidance Statement 12 on the minimisation of greenhouse gas emissions for projects being assessed under the WA *Environmental Protection Act 1986* (EPA, 2002a). The Guidance Statement requires proponents to clearly document in their environmental review:

- Greenhouse gas emissions inventory and benchmarking
- Measures to manage annual greenhouse gas emissions over the life of the project
- Carbon sequestration opportunities, such as bio-sequestration, geo-sequestration, chemical, soil uptake and reuse
- Benefits of reduced greenhouse gas emissions on a national or global scale.

The Guidance Statement also suggests that commitments are made to:

- Apply best practice to optimise energy efficiency and reduce greenhouse gas emissions
- Undertake comprehensive analysis to identify and implement appropriate offsets
- Undertake ongoing programs to monitor and report emissions and periodically assess opportunities to further reduce greenhouse gas emissions over time.

Chevron is aware that the EPA is in the process of revising its guidance on the management of greenhouse gas emissions for projects being assessed in light of the proposed introduction of the CPRS.

4.2.3 Chevron's Commitment to the Management of Greenhouse Gas Emissions

Chevron shares the concerns of governments and the wider community regarding climate change and recognises that the use of fossil fuels to meet the world's energy needs is a contributor to an increase in greenhouse gas in the earth's atmosphere.

Chevron is working to reduce greenhouse gas emissions from its operations and to expand its energy supply portfolio to meet the demands of customers for affordable, reliable and lower impact supplies of energy.

Chevron's response to climate change involves seeking ways to reduce greenhouse gas emissions from the production, transport and use of fossil fuels, expanding the use of alternative fuels, investing in renewable energy generation, and improving the energy efficiency of its operations.

Global demand for energy will increase over coming decades, and this rising demand presents significant opportunities for the increased supply of lower emissions energy sources such as natural gas.

4.2.3.1 Action Plan on Climate Change

In 2001, Chevron implemented its four-fold Action Plan on Climate Change. The four-fold plan is predicated on the following actions:

- Reducing greenhouse emissions and increasing energy efficiency
- Investing in research, development and improved technology
- Pursuing business opportunities in promising innovative energy technologies
- Supporting flexible and economically sound policies and mechanisms that protect the environment.

The four-fold plan of action on climate change reflects a balanced approach to addressing climate change through short and long-term measures. Further information on the global implementation of Chevron's Action Plan on Climate Change can be found at <http://www.chevron.com/globalissues/climatechange/>.

Chevron's Action Plan on Climate Change guides Chevron's overall approach to the management of greenhouse gas emissions from the Project through a focus on reducing greenhouse gas emissions and improving energy efficiency during the early design stages.

Chevron's Operational Excellence Management System (OEMS), Environmental Stewardship, and approach to Major Capital Projects are discussed in Chapter 1, *Introduction*.

4.2.4 Greenhouse Gas Emissions Estimation

Greenhouse gas emissions estimates provided in this EIS / ERMP are based on the current design status of the Project. The details of the proposed Project are discussed in Chapter 2, *Project Description*.

Key elements for the estimation of emissions (including greenhouse gas) are as follows:

- Design figures are nominal and based on current understanding; figures may be subject to change
- No allowance has been made for energy efficiency improvements that may occur during detailed design, and as operational procedures are developed
- Worst-case, realistic assumptions have been made, wherever alternatives have been identified
- Power outputs are nominal rating at ISO conditions.

The onshore plant is considered to be the full 25 MTPA case. The offshore facility is considered to be the nominal 9 MTPA case, as described in Chapter 2, *Project Description*.

The emissions documented relate to emissions sources anticipated to be under the operational control of the Project. The potential emission generating equipment are discussed in Chapter 2, *Project Description*.

Alternative equipment configurations and project design alternatives considered as part of an energy efficiency and emissions reduction review are discussed in Chapter 3, *Project Alternatives and Site Selection*.

4.2.4.1 Methodology and Assumptions

The emissions estimations contained in this report have been compiled in a manner that is consistent with methodologies prescribed by the Commonwealth *National Greenhouse and Energy Reporting Act 2007* and the accompanying Regulations, Technical Guidelines (Department of Climate Change, 2008) and the Measurement Determination (Australian Government 2008a).

Emissions of methane (CH₄) and nitrous oxide (N₂O) have a higher global warming potential than carbon dioxide (CO₂) and have been converted to CO₂ equivalents (e) using standard global warming potentials as described in the Part 2 of the *National Greenhouse and Energy Reporting Act Regulations (2008)*. In this document, one tonne of greenhouse gas equates to one tonne of CO₂e.

No perfluorocarbons are planned to be used in the gas processing facilities. Sulfur hexafluoride may be used in electrical switch-gear. However, this will be through a closed system, so total emissions of sulfur hexafluoride will be negligible (<0.01 per cent of the total greenhouse gas emissions) compared to the major emissions sources.

The onshore plant is designed to be capable of steady state operation over a range of design cases involving different inlet gas compositions and ambient operating temperatures (see Chapter 2, *Project Description*). As a consequence, the emissions estimated in this section represent an average of the anticipated steady state operating scenarios. It should be anticipated that actual emissions and emissions intensities on a daily, weekly, monthly or yearly basis will vary from the annual average estimates in this document.

4.2.4.2 Offshore Gas Production

It is estimated that at full capacity, the offshore component of the Project will emit approximately 0.45 MTPA of greenhouse gases. Table 4.1 provides a breakdown of the estimated greenhouse gas emissions from the potential offshore sources of emissions detailed in Chapter 2, *Project Description*.

The main source of greenhouse emissions from the Wheatstone Platform (WP) are the gas turbines. These are used for electrical power generation and to drive the gas compressors (once gas compression is required). Lower levels of greenhouse gas emissions will come from flaring and venting of hydrocarbons, fugitive emissions and the burning of diesel fuel for backup power generation and specific plant and equipment. These activities are discussed in Chapter 2, *Project Description*.

The configuration of the electrical power generation turbines on the WP is yet to be finalised and is dependent upon ongoing studies aimed at the increased use of waste heat and improved process efficiency. As this opportunity has not been finalised these emissions estimates assume the use of three (two running and one spare) 9 MW (ISO Rating) dual-fuelled gas turbine generators to provide electrical power for the offshore platform. It is proposed that these electrical power generation turbines would run primarily on natural gas but have the ability to also be fuelled by diesel during periods of low gas production, for example during plant start-up.

In the early years of the gas production operations, the pressure of the natural gas in the reservoir will be sufficient for the production of the natural gas and for its transport to the onshore gas processing plant. As the pressure in the reservoir declines, it will be necessary to use gas turbine driven compressors in order to transport the natural gas to the onshore gas processing facility. These compressors will be installed on the WP during construction; however, they may be bypassed (not operating) until required. Opportunities to reduce greenhouse gas emissions from the compressor turbines are ongoing with studies centred around optimising the compressor sizing and configuration based on expected operating conditions. These emissions estimates assume two compressors each driven by a gas turbine rated at 35 MW (ISO Rating).

Process heat may also be required on the platform (as discussed in Chapter 2, *Project Description*). The use of waste heat to regenerate Tri-Ethylene Glycol (TEG) could reduce the electrical load required on the WP by approximately 2.4 MW and reduce greenhouse gas

Table 4.1: Predicted Annual GHG Emissions from the Wheatstone Platform

Emissions Source	Approximate Offshore GHG Emissions Estimates (Tonnes Per Annum (tpa) CO ₂ e)
Gas turbines - (export compression)	232 000
Gas turbines - (electrical power generation)	100 000
Flare - pilots	1 000
LP - Flare	25 000
HP Flare	89 000
Fugitive emissions	1 000
Back-up Diesel Generators	1 000
Helicopters	1 000
Total	450 000

* Assuming three start-ups per year

emissions by 13 000 TPA. Options to further recover waste heat from the gas turbine exhausts to meet other process heat requirements will be considered as part of the ongoing design and engineering studies.

In order to avoid hydrate formation, the current reference case design includes flaring of natural gas at the WP during production start-up (see Chapter 2, *Project Description*). It is anticipated that such start-up conditions could result in approximately 19 000 tonnes of greenhouse gas emissions per event. Opportunities to reduce flaring associated with production start-ups and process upsets will be further investigated during ongoing design studies.

4.2.4.3 Onshore Gas Processing Plant

It is estimated that at full capacity, the onshore component of the Project will emit approximately 9.9 MTPA of greenhouse gas. The production from the onshore facilities

are expected to commence at low levels and ramp up to full capacity over time, dictated by market demand for the produced LNG and domgas. Figure 4.3 shows the anticipated production ramp-up in greenhouse gas emissions during the first ten years of project operations. The ramp-up in emissions shown in Figure 4.3 is based on assumptions about the commissioning of individual LNG and domgas processing trains. These emissions figures should be considered as indicative as the actual timing of commissioning of each processing train may vary from that currently planned.

Table 4.2 documents the estimated greenhouse gas emissions from the onshore component of the proposed Project at full capacity. This estimate is based on the equipment and operations detailed in Chapter 2, *Project Description*.

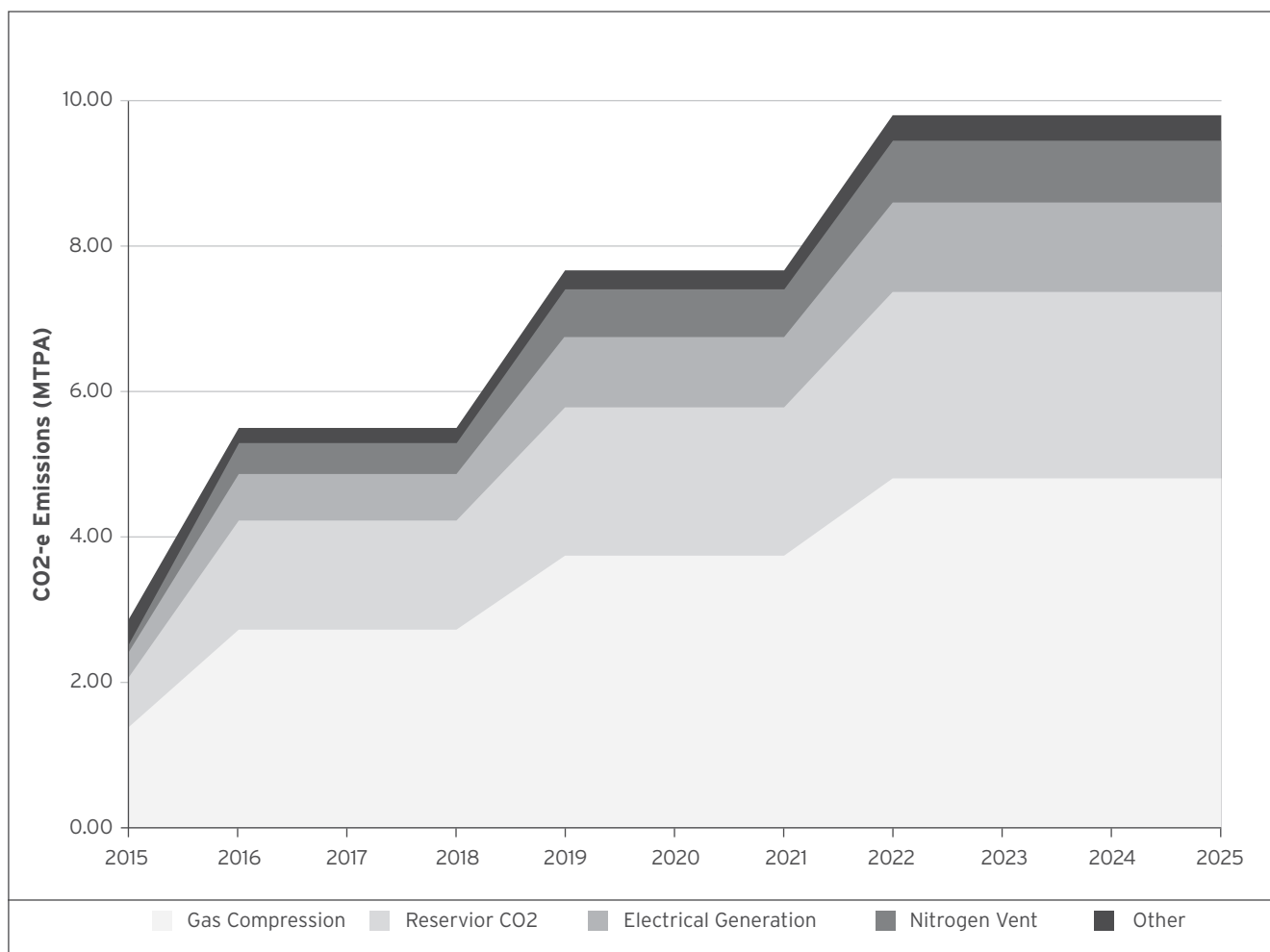


Figure 4.3: Estimated GHG Emissions from the Onshore Component of the Proposed Project

4.2.5 State, National and Global Greenhouse Emissions Impacts

Unlike other waste streams and releases, greenhouse gases do not have local impacts; however, they may impact upon global climate systems. This impact requires the consideration of State, national and global emissions impacts.

The estimated annual greenhouse gas emissions from the proposed Project may increase Australia’s and WA’s greenhouse gas emissions by 1.7 per cent and 13.5 per cent respectively, relative to Australia’s and WA’s emissions inventory for the 2006-07 financial year (Department of Climate Change 2009) as shown in Table 4.3.

While the Project will impact Australia’s and WA’s greenhouse gas emissions, this needs to be considered in the context of the impact on global emissions. The quantity of greenhouse gas emitted over the full energy lifecycle for an end use such as electricity production

includes the combined greenhouse gas emissions required to extract, produce, transport and burn the selected fuel. When full lifecycle emissions are considered, the emissions associated with electrical power generation from natural gas, supplied as either domestic gas or LNG, are considerably lower than the most common base load fuels such as coal.

To illustrate the potential lifecycle benefit of using natural gas, Woodside Energy commissioned WorleyParsons to undertake a study into the greenhouse gas emissions of Australian LNG. The study provides a comparison of Australian LNG versus Australian export black coal in terms of lifecycle emissions, from extraction and processing in Australia through transportation, to end use combustion for electrical power generation in China (WorleyParsons 2008). While the reference case in this study assumed LNG exported from the North West Shelf Joint Venture, the results are anticipated to be broadly comparable for LNG exported from the Project.

Table 4.2: Predicted Annual GHG Emissions from the Onshore Component of the Project

Emissions Source	Onshore LNG Processing (TPA CO ₂ e)	Onshore Domgas Production (TPA CO ₂ e)	Supporting Infrastructure (TPA CO ₂ e)
Gas turbines (direct process drive)	4 800 000		
Gas turbines (electrical power generation)	900 000	150 000	140 000
Venting of reservoir carbon dioxide	2 350 000	250 000	
Fired heaters/boilers	7 000		
Flare - pilots	45 000		
Flare - events	220 000		
Fugitive emissions	5 000		
Methane from N ₂ vent	920 000	50 000	
Diesel engines (stand-by pumps)	1000		
Marine tugs	40 000		
Total	9 288 000	450 000	140 000

* See chapters 2 and 3 for further details on the emissions sources

Table 4.3: Predicted GHG Emissions Relative to Australia's and Western Australia's 2006/07 Emissions

	Australia	WA
2006-07 greenhouse gas emissions (million tonnes CO ₂ e)	597.2	76.3
Estimated annual emission from the Wheatstone Project (million tonnes CO ₂ e)	10.3	10.3
Increase in greenhouse gas emissions relative to emissions in 2006-07	1.7%	13.5%

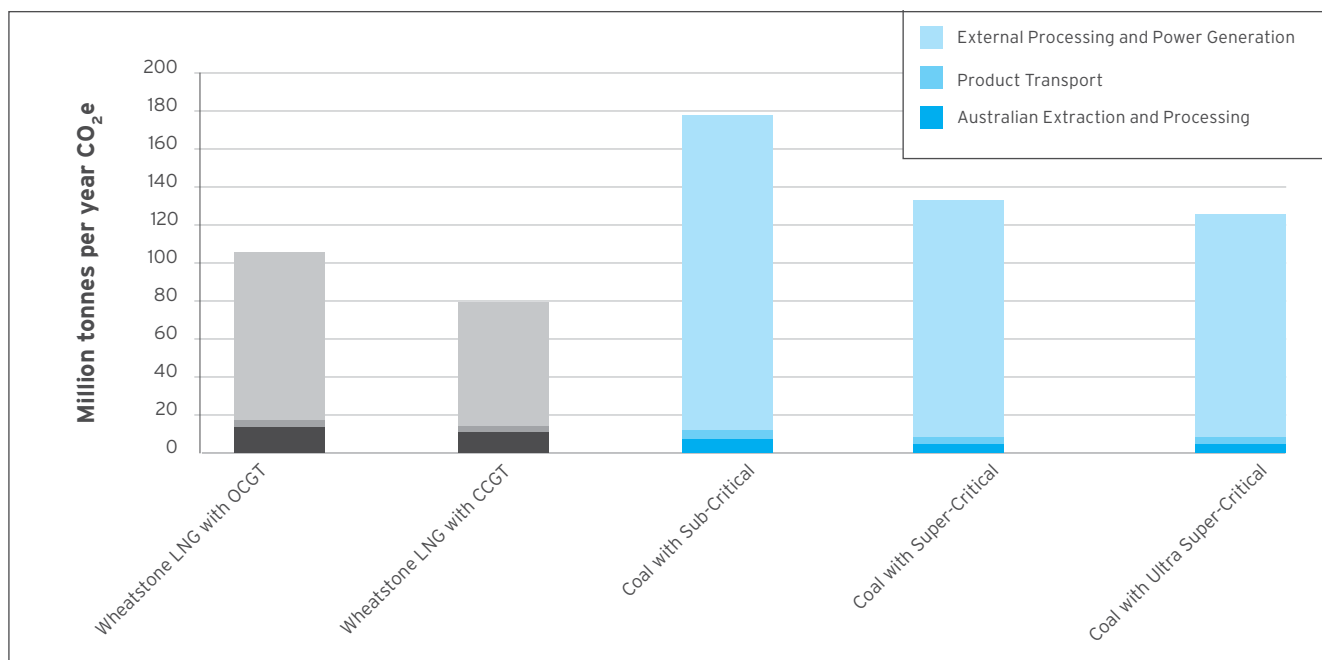


Figure 4.4: Annual Lifecycle Greenhouse Gas Emissions for Wheatstone LNG and Alternative Fuels for Electrical Power Generation¹

1. OCGT = Open Cycle Gas Turbine, CCGT = Combined Cycle Gas Turbine

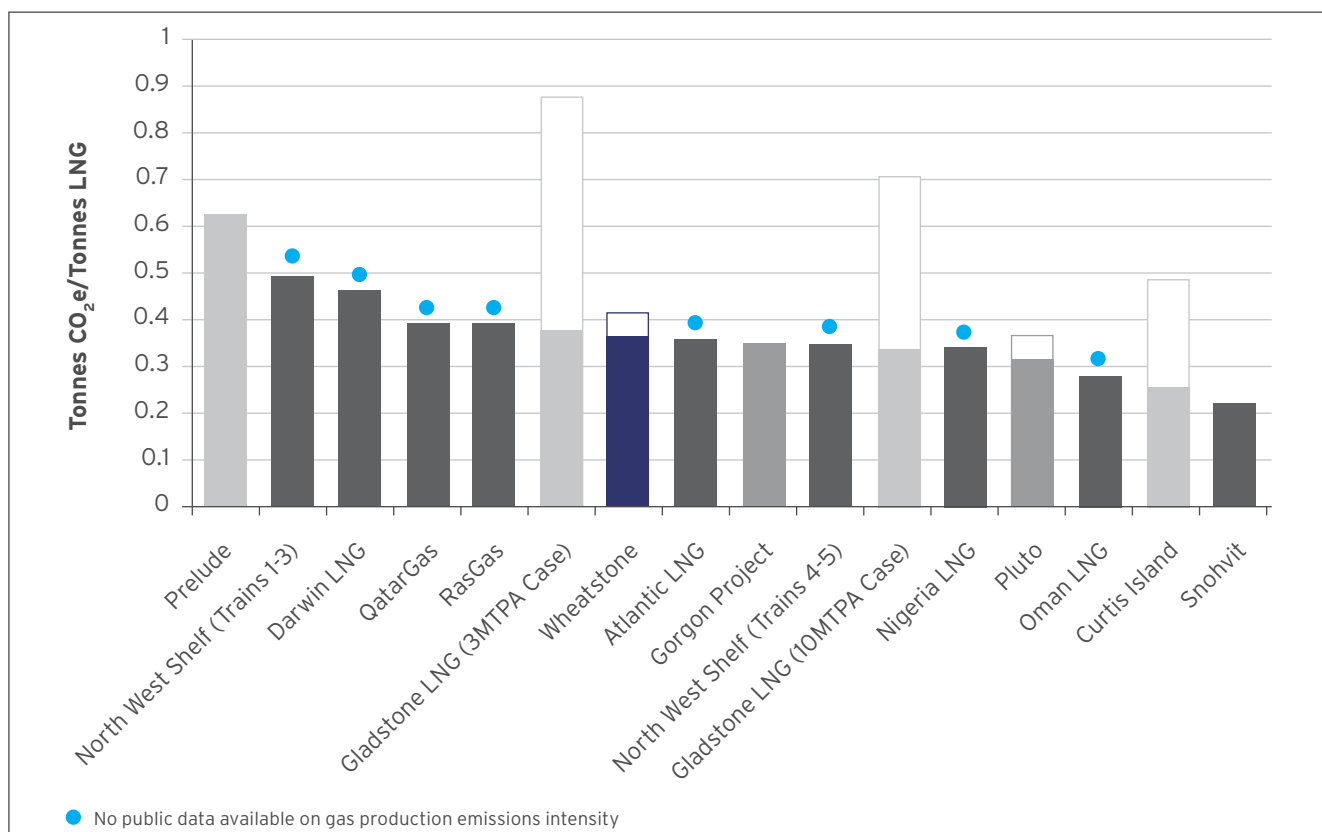


Figure 4.5: Benchmarked Greenhouse Gas Emissions Intensity

This analysis showed that for each megawatt hour of electricity generated in China using LNG as a fuel, between 440 and 600 kg of greenhouse gases were released to the atmosphere. The study also indicated that for each megawatt hour of electricity generated using Australian export black coal, range between 720 kg and 1020 kg, or approximately 40% higher.

Figure 4.4 shows a comparison of the annual global greenhouse gas emissions resulting from a range of electrical power generation technologies using both LNG and Australian export black coal. This graph shows the greenhouse gas emissions resulting from the use of a range of power generation technologies to produce 175 million megawatt hours of electricity (which is the amount that can be generated from 25 million tonnes of LNG using combined cycle power generation technology). For each power generation technology the emissions associated with the production of the relevant fuel in Australia, the transportation of that fuel and its consumption in China are shown.

This data shows the generation of electricity using LNG from the Project has the potential to reduce contribution to global greenhouse gas emissions by approximately half compared to the use of Australian export coal to generate a comparable amount of electrical energy. This lifecycle emissions benefit increases if lower quality coals or less efficient generation technologies are used.

Similar benefits can be achieved within Australia by increasing the supply of domestic natural gas. In the Australian market, it is estimated that the supply of domestic natural gas from the Project will result in a reduction in Australian emissions of between 6 and 15 MTPA when compared to coal.

Natural gas also has properties that make it suitable for high efficiency, low emission energy conversion devices such as fuel cells and as a potential feedstock for the production of hydrogen, which may replace petroleum as a potential future transport fuel.

4.2.6 Benchmarked Greenhouse Gas Emissions Performance

Data from other LNG projects in order to benchmark the Project, is not widely published. Much of the data that is available is restricted to estimates of emissions published in environmental impact assessment reports. Very little actual project data on emissions performance is available in the published literature. Where data is available it tends to be limited to LNG production with data on emissions associated with gas production being restricted to a few selected environmental impact assessment documents

for a number of Australian projects. Consequently, this benchmarking study has focused on the relative emissions intensities related to LNG production.

The volume of greenhouse gas emissions emitted for each tonne of LNG produced provides a benchmark by which to assess the greenhouse emissions intensity of an LNG plant. However, this metric is not a direct reflection of the efficiency of particular LNG plant. The emissions intensity of LNG processing operations is influenced by:

- The degree of any pre-processing undertaken as part of the gas production
- The composition of the incoming gas stream, particularly the concentration of reservoir CO₂ and nitrogen, as well as the level of ethane, propane, butanes and pentanes
- The use of air or water for process cooling
- The ambient temperature in which the gas plant operates
- The capacity for local electricity supply infrastructure to be utilised for electrical power.

Figure 4.5 shows the greenhouse gas emissions intensity associated with LNG processing for LNG projects currently in production (including the two existing Australian projects) as dark grey bars. The medium grey bars show the estimated LNG processing emissions intensity for the two Australian LNG projects that are currently under construction and the light grey bars show the estimate LNG processing emissions intensity for other Australian LNG projects that are currently undergoing environmental impact assessment. The estimated LNG processing emissions intensity of the Project is shown in dark blue.

Where data on the emissions intensity of the associated gas production operations is available it is presented as an additional white bar. Projects where publicly available data on gas production emissions is not available are indicated with a blue circle.

The Gorgon, Snohvit, and proposed Prelude projects utilise sub-sea production systems that may result in a slight increase in the emissions intensity for that project compared to a scenario where gas production for that facility had been undertaken at an offshore platform.

The Woodside operated North West Shelf Project has been constructed in a number of phases. The initial three LNG processing trains had an LNG processing emissions intensity of 0.59 when constructed in the mid 1980s but this was reduced to 0.49 with the retrofit of improved reservoir carbon dioxide removal technology in the early

2000s. The recently constructed LNG trains four and five have an estimated emissions intensity of 0.35 tonnes of CO₂e for each tonne of LNG produced (Woodside, 2004). Chevron is unable to identify any publicly available data on greenhouse gas emissions associated with offshore gas production for this project.

The Northwest Shelf Project shows how improvements in plant design and efficiency have evolved with over the past 20 years. This highlights that LNG processing technology is mature and that further gains in plant efficiency may be limited.

ConocoPhillips operate an LNG processing facility in Darwin which processes gas from the Bayu-Undan gas field in the Timor Sea. ConocoPhillips estimate that the Darwin LNG facility will have a greenhouse gas emissions intensity of 0.46 tonnes of CO₂e per tonne of LNG produced (ConocoPhillips 2005). The Proponent is unable to identify any publicly available data on greenhouse gas emissions associated with offshore gas production for this project.

Woodside Energy is currently constructing its Pluto LNG project in WA. Woodside has estimated that the project will have an emissions intensity associated with the processing of LNG of 0.32 tonnes of CO₂e per tonne of LNG produced. (Woodside 2009). Woodside has indicated that greenhouse gas emissions associated with the project will contribute an additional 0.05 tonnes of CO₂e per tonne of LNG produced once offshore compression commences six to twelve years after the commencement of operations.

Chevron has recently commenced construction of the Gorgon Project on Barrow Island, WA, which is estimated to have an emissions intensity of 0.35 tonnes of CO₂e per tonne of LNG produced (Chevron Australia 2008). This project utilises a sub-sea development concept negating the need for an offshore platform and its associated emissions.

Santos is proposing the construction of its GLNG Project to be located near Gladstone in Queensland. Santos estimate the greenhouse gas emissions intensity associated with the production of LNG from this project to range between 0.34 and 0.38 tonnes of CO₂e per tonne of LNG produced, for a project capacity of 3 MTPA LNG and 10 MTPA LNG respectively (Santos 2009). Santos has estimated that the greenhouse gas emissions intensity associated with the gas production feeding the GLNG Project at between 0.49 and 0.37 tonnes of CO₂e per tonne of LNG produced.

BG Group is also currently proposing the construction of its Queensland Curtis Island LNG Project near Gladstone in Queensland. BG estimate the greenhouse gas emissions intensity associated with the production of LNG from

this project to be 0.26 tonnes of CO₂e per tonne of LNG produced (BG Group, 2009). The BG Group has estimated that the greenhouse gas emissions intensity associated with the gas production feeding the Curtis Island LNG Project at 0.23 tonnes of CO₂e per tonne of LNG produced.

The Santos and BG Group projects both involve sourcing the natural gas from coal seam gas. This is an energy intensive process and significant contribution to the overall emissions intensity from these projects.

Shell has recently announced plans for an LNG Project centred on the Prelude field located off the Kimberley coast (Shell, 2009). This project is unique in that it is potentially the world's first application of floating LNG technology. Shell has estimated the emissions intensity of the Prelude facility at 0.63 tonnes of CO₂e per tonne of LNG produced. This facility is proposed to use a sub-sea production system avoiding direct emissions associated with gas production facilities.

Statoil commenced operations at its Snohvit LNG Project near the town of Hammerfest in northern Norway in 2007. Statoil estimated the greenhouse gas emissions intensity from the Snohvit Project to be 0.22 tonnes of CO₂e per tonne of LNG produced. Like the Gorgon Project, Snohvit utilises sub-sea production technology which negates the need for an offshore gas production platform and its associated emissions. The Snohvit Project has potentially the lowest greenhouse gas emissions intensity of any LNG plant in the world, predominantly due to the location of the LNG processing facility in a very cold climate. In addition the Snohvit Project is connected to the local electrical grid, removing the requirement for redundant electrical power generation capacity.

The Oil and Gas Journal has published a benchmarking study comparing LNG plant costs and greenhouse gas emissions of five relatively recent green field LNG projects (Yost, C., and DiNapoli, R., 2003). The five facilities and their locations are:

- Oman LNG - Qalhat, Oman
- Nigeria LNG - Bonny Island, Nigeria
- RasGas - Ras Laffan, Qatar
- Qatargas - Ras Laffan, Qatar
- Atlantic LNG - Point Fortin, Trinidad and Tobago.

The data provided for these facilities includes only the emissions related to LNG processing. No data is provided on the emissions associated with the production of natural gas.

4.2.6.1 Comparison to the Wheatstone Project

This benchmark analysis shows the LNG processing component of the Project ranks competitively with a number of Australian and international projects in terms of the greenhouse gas emissions intensity.

There remain some quite significant differences in emissions intensities, even for proposed new projects, which highlights the impact that environmental factors have on the overall emissions from a particular facility. For example, the Snohvit project shares a number of design features with the Wheatstone Project such as the use of aero derivative gas turbines. However, the Snohvit project is able to draw electrical power from the local electricity utility thereby avoiding the need for standby power generation. The proposed Prelude facility is estimated to have a significantly higher emissions intensity primarily as a result of having to process natural gas which is relatively high in carbon dioxide.

While the data on gas production emissions is limited it appears that LNG projects that source natural gas from conventional reservoirs have a significantly lower overall emissions intensity than projects that source natural gas from coal seam reservoirs.

4.2.7 Greenhouse Gas Emissions Management

Prior to commencing feasibility studies a high level approach was taken in addressing issues of environmental importance. This included requirements to reduce greenhouse gases through design.

4.2.7.1 Actions Taken to Manage Greenhouse Gas Emissions

The following actions have been taken to manage the Project's greenhouse gas emissions:

- Selection of aero derivatives for gas turbines
- Selection of Waste heat recovery units offshore from compressor gas turbines
- Selection of LNG process train technology and size so as to enable the consideration of aero derivative gas turbines
- The use of inlet air humidification (cooling) on the LNG process gas turbines in order to optimise gas turbine energy efficiency
- Waste heat recovery from the LNG compressor gas turbine exhausts to meet routine process heat requirements in the onshore gas processing facility
- Waste heat recovery from the gas turbine exhausts of the main generators on the offshore platform to meet specific heating requirements
- The use of sophisticated process control systems to ensure continuous optimisation and integration between various components of the gas processing system
- The capture and use of energy recovered from the pressure let down in the liquefaction section of the onshore gas processing facility.

Alternative technologies were also considered during the initial design. These are discussed in Chapter 3, *Project Alternatives and Site Selection*.

4.2.7.2 Possible Future Actions to Manage Greenhouse Gas Emissions

The following opportunities to further reduce the Project's greenhouse gas emissions have been identified and will be evaluated further during ongoing Project design and engineering:

- Offshore component of the Project
 - Opportunities for the alternative management of hydrate formation during process start will be considered with the objective of reducing emissions associated with flaring during cold production start-up
 - The electrical load requirements of the WP will be reviewed with the objective of reducing total electrical demand.
- Onshore component of the Project
 - Alternatives to the use of hydrocarbon purge gas to ensure the safe and effective operation of the flare, such as using nitrogen will be examined
 - Further consideration may be given to opportunities such as adding a liquid expander, or propane sub-coolers to improve the overall process efficiency of the plant
 - Opportunities to further reduce the potential release of methane in the Nitrogen Vent will be further investigated.

4.2.7.3 Consideration of Greenhouse Gas Offsets

Chevron has considered investing in a range of greenhouse gas offsets to assist in the management of emissions from the Project. This investigation highlighted that a credible industry exists, which invests

in land-use management plantations in Australia. These plantations also generate greenhouse gas emissions offsets in line with the Commonwealth Government's Greenhouse Friendly Program. This program is due to be closed by July 1, 2010 and replaced with a National Carbon Offset Standard. Consultation on the Carbon Offset standard was ongoing at the time of writing this EIS/ERMP.

The proposed introduction of an emissions trading scheme will set the level of greenhouse gas emissions each year for those sectors covered by the scheme, referred to as the "scheme cap". Any voluntary (or mandated action) that drives emissions reduction in a particular project, beyond that which would occur ordinarily under the scheme, does not lower the cap under the scheme and therefore does not result in any additional greenhouse gas emissions reduction. In effect, it allows others under the scheme to emit more greenhouse gases than would otherwise be the case.

Consequently, beyond opportunities undertaken as part of the management of the Project's liability under an emissions trading scheme, reduction of Project greenhouse gas emissions through the direct investment in offset generation projects or acquisition of greenhouse gas emission offsets is not proposed.

While voluntary or mandated action under an emissions trading scheme does not result in additional emissions reductions, offsets do have a role in the management of scheme liability for liable entities. Should such a scheme be introduced, it is possible that Chevron will purchase greenhouse gas emissions offsets or invest in emissions offset generation projects as a strategic element in the management of Chevron's liability under an emissions trading scheme.

4.2.8 Greenhouse Gas Emissions Performance Indicators and Targets

Greenhouse gas emissions from the Project will be determined and reported in line with the Commonwealth *National Greenhouse and Energy Reporting Act 2007*.

In addition, the Project team will track and report at least annually to senior management the following performance indicators:

- Tonnes of CO₂e emitted from the offshore component of the Project
- Tonnes of CO₂e emitted from the LNG processing operations
- Tonnes of CO₂e emitted from the domestic gas processing operations

- Tonnes of CO₂e emitted from logistics and support infrastructure under the operational control of the proponent.

As the Project is in the design phase, greenhouse gas emissions estimates are based on a number of design assumptions. It is envisaged that opportunities to further reduce emissions may be realised as detailed design progresses and operational procedures are developed. In light of this, a number of long-term performance targets related to greenhouse gas emissions have been generated to drive the ongoing reduction in emissions over the operational life of the Project. These performance indicators are shown in Table 4.4.

4.3 Atmospheric Emissions (excluding Greenhouse Gas)

4.3.1 Overview

This section discusses the possible atmospheric emissions from the offshore and onshore facilities. Potential sources of atmosphere emissions, during each phase of the Project, are summarised in Table 4.5.

The activities identified in the table are discussed in more detail in Chapter 2, *Project Description*.

4.3.1.1 Air Quality Criteria

The EPA requires that six key (criteria) air pollutants meet the national environment protection standards set by the Ambient Air Quality National Environmental Protection Measure (NEPM) (National Environment Protection Council 1998). The criteria air pollutants are:

- Ozone (O₃)
- Nitrogen dioxide (NO₂)
- Particulates less than 10 µm (as PM₁₀)
- Carbon monoxide (CO)
- Sulfur dioxide (SO₂)
- Lead (Pb).

These pollutants are known, or are strongly suspected, to be harmful to public health and the environment, causing photochemical smog, crop damage, and respiratory impacts.

NEPM was created to provide a benchmark to ensure that people throughout Australia have protection from the potential negative health effects of atmospheric pollutants. The standards were developed by considering current national and international health-related air pollution research and available information on the

Table 4.4: Proposed Long-term Performance Targets for GHG Emissions from the Project

Greenhouse Gas Performance Indicator	Value Stated in Draft EIS/ERMP	Longer Term Performance Target
Tonnes of CO ₂ e emitted from the offshore component of the Project	450 000 tCO ₂ e/year	428 000 tCO ₂ e/year
Tonnes of CO ₂ e emitted from the LNG processing operations	9 288 000 tCO ₂ e/year	8 824 000 tCO ₂ e/year
Tonnes of CO ₂ e emitted from LNG processing operations per tonne of LNG loaded on ship	0.37	0.35
Tonnes of CO ₂ e emitted from the domestic gas processing operations	450 000 tCO ₂ e/year	430 000 tCO ₂ e/year
Tonnes of CO ₂ e emitted from logistics and support infrastructure under the operational control of the proponent	140 000 tCO ₂ e/year	130 000 tCO ₂ e/year

Table 4.5: Summary of Sources of Atmospheric Emissions

Discharge	Discharge Location	Construction	Commission	Operation	Decommission
Drill Rig					
Diesel engines	Offshore	●			
Flare	Offshore	●			
Processing Platform					
Diesel engines	Offshore	●	●	●	●
Gas turbines	Offshore		●	●	
Flare	Offshore	●	●	●	●
Fugitive emissions	Offshore		●	●	●
Support					
Ship engines	Offshore	●	●	●	●
Helicopter engines	Offshore	●	●	●	●
LNG Facility					
Diesel engines	Onshore	●	●	●	●
Gas turbines	Onshore		●	●	●
Thermal oxidisers	Onshore		●	●	●
Vents	Onshore		●	●	●
Flares	Onshore		●	●	●
Incinerator	Onshore	●	●		
Fugitive emissions	Onshore	●	●	●	●

state of Australia’s major airsheds. The final standards represent a high degree of consensus among leading health professionals, adjusted to reflect what is realistically achievable in Australia.

The NEPM standards are intended to apply to general ambient air quality in both urban and regional areas. In 2003, NEPM was extended to include an advisory reporting standard for particulates as PM_{2.5} and in 2004, a (priority) Air Toxics NEPM was issued to facilitate the development of emissions standards. Air toxics include both volatile and semi-volatile organics and polycyclic aromatic hydrocarbons (PAHs) and are known or suspected carcinogens.

The EPA and the Western Australian Department of Environment and Conservation (DEC) routinely apply these NEPM standards and goals in (WA). The EPA does not have current State-wide standards for ambient ground-level pollutant concentrations. However, the EPA has released a Draft State Environmental (Ambient Air) Policy (EPA 2009a), where it proposes that the NEPM standards (Schedule 1A and 1B) be applied across all areas of WA, excluding areas where a current environmental protection policy exists. In the absence of other standards, relevant to WA, it is considered appropriate to use these Schedule 1A and 1B standards (Table 4.6) as the criteria for comparison in this air quality assessment.

The EPA’s draft State Environmental (Ambient Air) Policy, 2009, also proposes that the NEPM monitoring investigation levels for air toxics (Schedule 1C) be applied across all areas of WA, excluding areas where a current environmental protection policy exists, within industrial areas and residence-free buffer zones.

There is no Australia-specific standard for deposition rates for nitrogen and sulfur oxides. The World Health Organisation (WHO) provides “critical loads” for deposition of nitrogen in Europe. Critical load is an estimate of exposure in the form of deposition, below which significant harmful effects on specified sensitive elements of the environment do not occur (WHO 2000). The WHO critical load for nitrogen deposition is 15 to 20 kg N/ha/yr and 8 to 16 kg S/ha/yr for sulfur deposition on dry heathland. A more detailed discussion on WHO guidelines are provided in Chapter 9, *Terrestrial Risk Assessment and Management*.

Studies undertaken by CSIRO (Meyer *et al.* 2001) indicate that ambient nitrogen deposition rates range from 0.9 kg N/ha/yr (dry deposition) to 1.1 kg N/ha/yr (wet deposition) in remote natural environments. There is no available data to assess the impact of nitrogen deposition on flora in the Onslow region. Studies have shown that oxides of nitrogen can result in reduction in biomass in Eucalypt species (Murray *et al.* 1991). Australian studies indicate that crop yields can be affected by prolonged exposure to SO₂ at 50 parts per billion (ppb) and greater concentrations, while trees suffer leaf damage at 80 ppb (see Appendix C1).

4.3.2 Existing Environment

The Project location is in a remote area in the north-west of WA with limited anthropogenic sources. Existing industrial sources of air pollutants in the Onslow region are restricted to the Onslow Salt facility and other minor light industries in the Onslow township. Anthropogenic emissions are anticipated to be low, compared to biogenic and other natural emissions.

Table 4.6: Summary of the NEPM Standards used as Air Quality Impact Assessment Criteria

Criteria Pollutant	Averaging Period	Concentration (max)	Outcome
NO ₂	1 hour	120 ppb	Protection of human health
	1 year	30 ppb	
Photochemical oxidants (as O ₃)	1 hour	100 ppb	Protection of human health
	4 hours	80 ppb	
SO ₂	1 hour	200 ppb	Protection of human health
	24 hours	80 ppb	
	1 year	20 ppb	
Particulates as PM ₁₀	24 hours	50 µg/m ³	Protection of human health
Particulates as PM _{2.5}	24 hours	25 µg/m ³	Advisory protection of human health
	1 year	8 µg/m ³	

Due to the limited amount of activity in the area, historical air-quality data is limited to meteorological data collection. The meteorological data for the Onslow area is available from the Bureau of Meteorology site at Onslow Airport and from Onslow Salt.

Background data on atmospheric emissions is not readily available for Onslow, with the nearest air-quality monitoring data available from the Perth area and the industrial areas of the Kimberley and the Pilbara. Background air quality has, therefore, been estimated from secondary information sources and modelling undertaken by SKM (see Appendix C1).

Chevron is currently undertaking a monitoring study of baseline (existing) conditions for dust (Total Suspended Particulates–TSP–and PM_{10}), NO_2 , SO_2 and Volatile Organic Compounds (VOCs). Chevron has also installed a meteorological station at the proposed plant site to obtain site-specific data. Data from this monitoring is contained in Chapter 6, *Overview of Existing Environment*. It is proposed that this monitoring is continued through to the commencement of plant operations and into the Operations Phase. The existing equipment and monitoring locations may alter due to technical and construction requirements.

4.3.2.1 Dust

The soils in the Ashburton North Strategic Industrial Area (SIA) area are prone to wind erosion (see Chapter 6, *Overview of Existing Environment*) and subsequent dust production. This can occur when vegetation is removed, when the surface is disturbed by vehicles, bushfires, or sufficiently strong winds. Dust emissions are strongly influenced by the Pilbara's wet and dry seasons, with higher background levels experienced during the dry season. Seasonal bushfires can also contribute a large amount of dust to the atmosphere.

Background data on dust were not available for the Onslow region. A dust monitoring program has been commissioned (April 2009); however, a minimum of 12 months data were not available for this assessment. An estimate of dust emissions was, therefore, undertaken.

Baseline emissions of particulates (PM_{10} and $PM_{2.5}$) may be inferred from studies undertaken by CSIRO across Australia (Meyer *et al.* 2008). This study found that daily PM_{10} and $PM_{2.5}$ concentrations during the wet season averaged about 10 and 2 $\mu\text{g}/\text{m}^3$ respectively, while during the dry season the daily PM_{10} and $PM_{2.5}$ concentrations averaged about 20 and 15 $\mu\text{g}/\text{m}^3$ respectively. Peak daily PM_{10} and $PM_{2.5}$ concentration, during a bush fire event, were 52 and 48 $\mu\text{g}/\text{m}^3$.

4.3.2.2 Atmospheric Pollutants and Air Toxics

Data on ambient concentrations of both O_3 and NO_2 in the local area are also not available. Monitoring reports for WA, issued by the State Department of Environment and Conservation (DEC), show that monitoring (for reporting against NEPM criteria) has been concentrated around the most populated areas of the State and the industrial areas of the Kimberley and the Pilbara.

Baseline emissions of NO_x can be inferred from studies undertaken by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Meyer *et al.* 2001). These studies indicate that the annual Australian natural (biogenic and weather) emissions of NO_x are generated from soil emissions (approximately 50 per cent), lightning (approximately 8 per cent) and wild fires (approximately 17 per cent). The balance of approximately 25 per cent is contributed from anthropogenic sources. The average annual Australian emission rate of nitrogen approximates 3 kg/ha/yr. The NO_x concentration in clean Southern Hemisphere marine air is around 0.03 ppb, with NO concentration ranging from 0 to 0.01 ppb and NO_2 concentration ranging from 0.01 to 0.03 ppb. In remote rural environments, NO_x concentrations are higher ranging from 0.01 to 2 ppb. NO_x is mostly present as NO_2 (85 per cent) ranging from 40 per cent to 100 per cent, depending on the time of day and the prevailing wind direction.

Baseline levels of Air Toxics and O_3 may be inferred from studies undertaken by CSIRO across Australia (Meyer *et al.* 2008). This study indicates that for coastal locations with lowland scrub and savannah, the 1-hour ambient O_3 concentrations averaged about 10 ppb at the end of the wet season and 20 ppb at the end of the dry season after the impact of bush fires. Air Toxics were measured during the bush fire season. Results for benzene, toluene, ethylbenzene and xylenes were 0.16 ppb, 0.69 ppb, 0.095 ppb and 0.47 ppb respectively.

Based on these estimates SKM undertook a modelling assessment (See Appendix C1) to determine the existing "non-industrial" air quality in the area. The results for NO_2 , O_3 and SO_2 are shown in Table 4.7. NO_2 and O_3 are also shown in Figure 4.6, Figure 4.7, Figure 4.8 and Figure 4.9.

The air-quality assessment was carried out in line with DEC (formerly known as DoE) guidelines for Air Quality Modelling (DoE 2006). For this assessment, the atmospheric dispersion model TAPM (The air pollution model) was used. TAPM is a prognostic three-dimensional model designed by CSIRO that can be used to predict meteorological and air pollution parameters on an hourly basis (Physick and Blockley 2001).



Figure 4.6: One-hour Ground-level NO₂ (ppb) - Existing (Non-industrial) Sources

Table 4.7: Summary of Modelled Existing Air Quality

Compound	Period	Unit	Predicted Ground-level Concentrations at Onslow
NO ₂	1-hr max	ppb	0.8
	Annual	ppb	0.1
O ₃	1-hr max	ppb	19.5
	4-hr max	ppb	19.5
SO ₂	Annual	ppb	0.8*

Note: * CSIRO (2001) estimated “natural” background concentration

The model predicts flows that are of importance to local-scale air pollution such as sea breezes and terrain induced flows (Hurley 2005). The meteorological parameters predicted by the model have been compared to actual readings recorded during the Kwinana Coastal Fumigation Study (Hurley and Luhar 2000) and the Pilbara Air Quality Study (Physick and Blockley 2001). It was found that the model predicts both near-surface parameters and upper parameters well.

Due to the lack of available meteorological data for the Onslow region the CSIRO model TAPM (ver4) was also used to assess the potential ground-level concentrations of pollutants.

Biogenic emissions of VOCs have been estimated at 1.3 g/m² for native vegetation in the Onslow region.

Nitrogen deposition in ‘clean’ Southern Hemisphere marine air is around 0.001 kg N/ha/yr as NO₂ (dry deposition) and 0.13 kg N/ha/yr as NO₃⁻ (wet deposition). In remote rural locations, this rate increases to around 0.28 kg N/ha/yr as NO₂ (dry deposition) and to 0.94 kg N/ha/yr as NO₃⁻ (wet deposition) (Meyer *et al.* 2001). The predicted annual “non-industrial” nitrogen deposition rate has been modelled at less than 0.04 kg N/ha/yr (Figure 4.10) at Onslow. This number is much lower than the predicted ambient concentration in the CSIRO study discussed above.

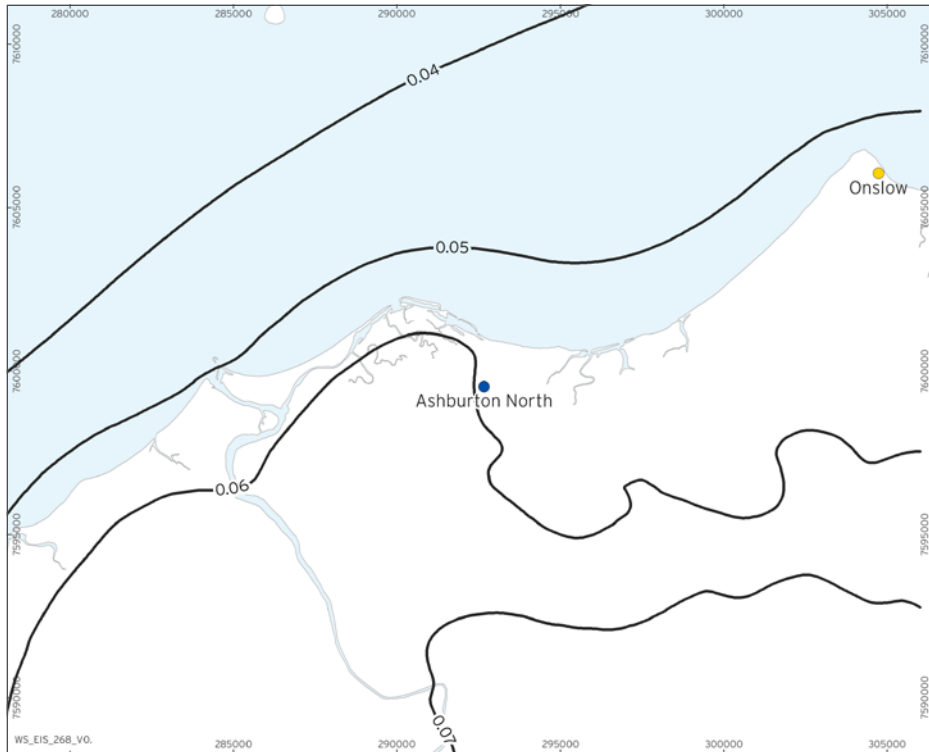
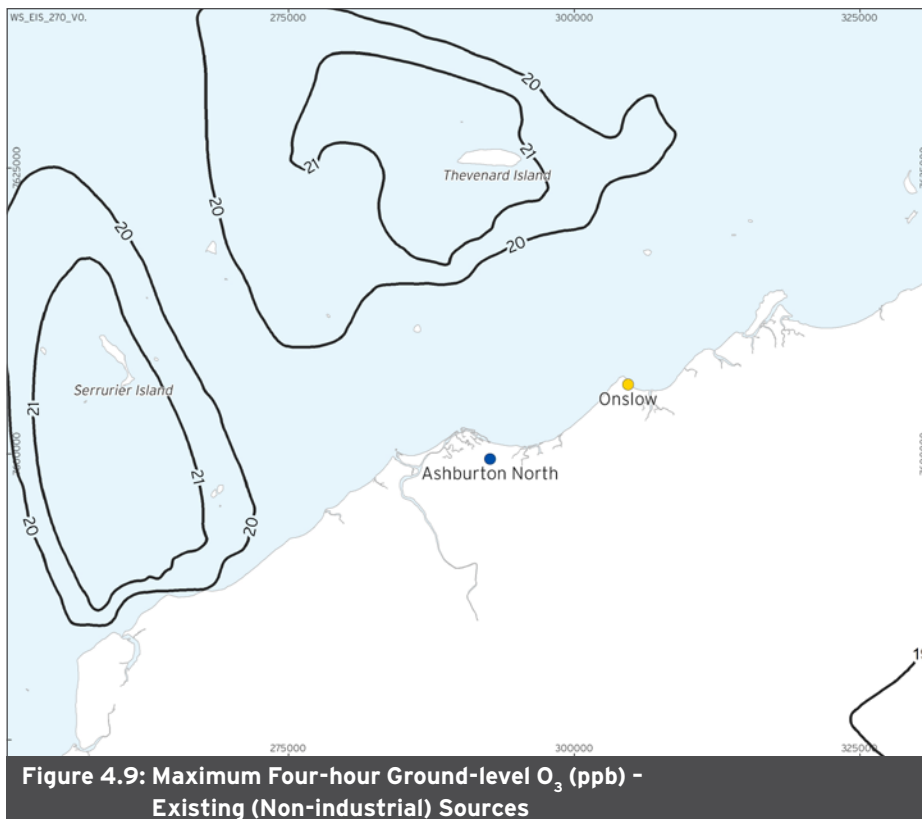


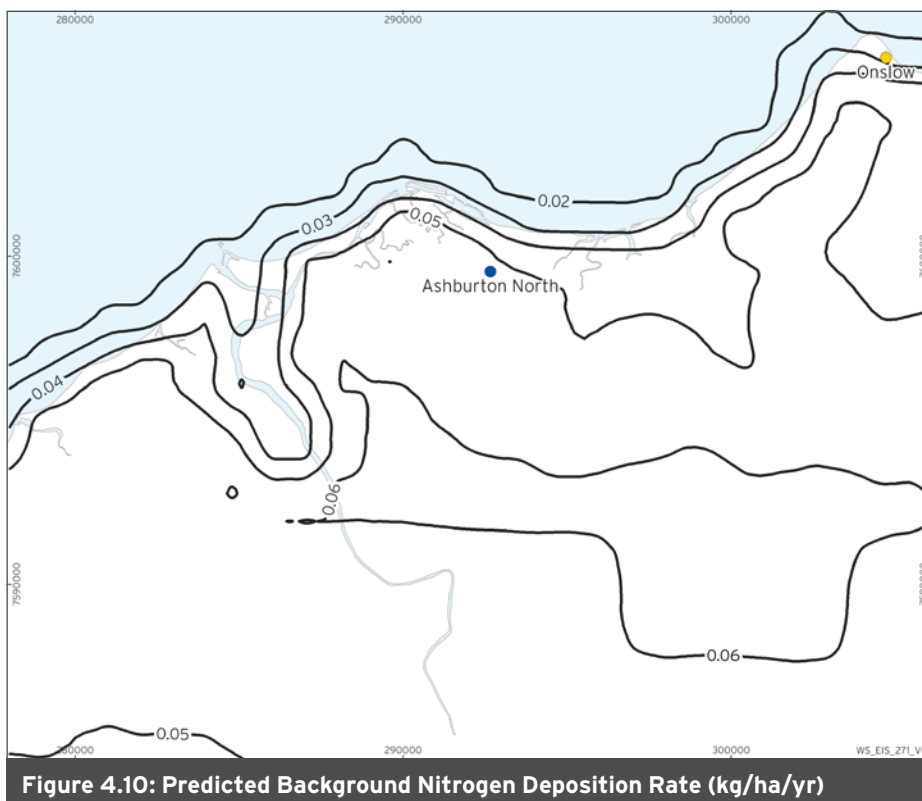
Figure 4.7: Annual Ground-level NO₂ (ppb) - Existing (Non-industrial) Sources



Figure 4.8: One-hour Ground-level O₃ (ppb) - Existing (Non-industrial) Sources



Source: SKM 2009



Source: SKM 2009

4.3.3 Offshore Emissions

4.3.3.1 Construction and Commissioning

The key activities that may generate atmospheric emissions during construction and installation will be associated with marine vessel engines (e.g. drilling rigs, pipe-lay barges, tugs, dredgers, hopper barges, supply boats and barges), well clean-up, and commissioning of the offshore facilities (see Chapter 2, *Project Description*).

The emissions from vessel movements during construction are transitory and have not been assessed. The vessels used will be maintained in accordance with a maintenance schedule and comply with Australian regulations on fuel (i.e. sulfur content in diesel).

Flaring during well clean-up is likely to be approximately 60MMscf/d over a 72 to 84 hour period.

The subsea wells and WP start-up sequence will be optimised to minimise flaring while establishing well performance and process stability as soon as possible, hence minimising further shutdowns, associated flaring and cold venting. Planned depressurising of the offshore system is likely to occur two to three times during initial commissioning; in addition, two to three unplanned depressurising operations have been included in the following estimate of commissioning flaring.

The volume of gas flared per depressurising event will vary, depending on the mode of operation, number of trains, sequencing etc. Typically a full blowdown and start up of the topsides would result in around 115,000 Sm³ of gas flared; while a blowdown and restart of the entire flowline system would result in around 8,500,000 Sm³ of gas flared.

Assuming that there will be four to six full depressurisation events during commissioning then the total volume of gas flared during initial start-up would be in the range 34 - 52 MMSm³. During the front end engineering phase detailed reliability studies and optimised commissioning and start up scenarios will be developed to minimise flare volumes and improve reliability to reduce the number of blowdown events.

During construction, commissioning and start-up procedures, diesel may be used to fuel generators and gas turbine starters, as an alternative fuel source. During well clean ups, increased well completion fluids may be encountered in the produced water (PW). Well clean up is not expected to have any significant impact due to the relatively short durations, location remote from sensitive habitats, and low volumes.

Should additional water treatment be considered, its susceptibility to solids entrainment during well clean up will be investigated and if necessary provision made for a by-pass.

4.3.3.2 Operations

Offshore, operational electrical and gas compression power will be generated by the combustion of an estimated 0.7 x 10⁶ Sm³ per day of raw field gas in turbines equivalent to the Solar MARS 90 and General Electric LM2500+ turbines.

Offshore operations are forecasting to lose just over 100 operating hours, from planned and unplanned stoppages, each year⁵, with flaring through both the low pressure and high pressure flares.

Estimated NO_x emissions from the offshore operations are summarised in Table 4.8. Greenhouse gas emissions have been discussed in detail in Section 4.2.

Planned Insulate and Blowdown (I & B) and re-start could comprise a full platform or train blowdown and start-up discharging in the order of 320 MMscfd. Conservatively assuming two to three such events (planned and unplanned) annually, emissions could range up to between 640 and 1000 MMscfd depending on the I & B strategies developed.

The nearest sensitive receptor is a significant distance from the WP; the nearest landfall is more than 100 km away. The potential impact of emissions from the WP based on the data in Table 4.4 and the distance to the nearest sensitive receptor means that the potential impact on air quality at that receptor location is considered insignificant.

4.3.4 Onshore Emissions

Onshore emissions will vary based on the phase of the activities. The proposed activities are discussed in detail in Chapter 2, *Project Description*. This section reviews the potential emissions from the Project during the phases of construction, commissioning, routine operations and non-routine (emergency) operations.

The atmospheric dispersion modelling of key air emissions was performed under different operating conditions to determine the predicted ground-level concentrations.

4.3.4.1 Construction and Commissioning

The key emissions during the construction phase are dust (see Appendix C1). In addition, there will be short-term releases during the commissioning of the plant. These emissions will be managed, wherever practicable.

There will also be some associate emissions from the temporary power generation equipment, which could elevate ambient ground-level concentrations of atmospheric pollutants. The details of the temporary power generating equipment are currently being determined. Potential emissions will be modelled once the details have been determined and will be submitted later as part of a works approval application.

Dust

Due to the current low levels of human activity at the Ashburton North SIA, existing sources of dust and other particulates are primarily due to wind erosion and bush fires. Recreational vehicles visiting the area contribute minor quantities of dust to the atmosphere.

The vast majority of dust generated during the construction phase will consist of coarse particles and particles larger than PM₁₀. An emission study conducted

by SKM in 2000 (SKM 2003) found that the Pilbara region emitted around 170 000 tonnes of windblown particulate matter in the 1998/1999 financial year. Additional research has also shown that background levels of dust in the Pilbara region often exceed the NEPM PM₁₀ standard of 50 µg/m³.

It is anticipated that site preparation will result in the largest generation of dust. Key dust generation sources during the construction phase are identified as:

- Clearing of vegetation and site levelling
- Earthworks, such as cut and fill activities and excavation
- Soil and fill material transfer from truck to stockpile and stockpile to footprint
- Wind erosion of stockpiled topsoils
- Wind erosion of dewatered dredge material (if placed on land)
- Vehicle movements on unsealed roads

Table 4.8: Indicative Offshore Emissions

Process Area	Phase 1 Initial Operations	Phase 2 Compression
	t NO _x / y	t NO _x / y
Export Compression	0	657
Flare - Pilot	0.2	0.2
LP Flare - Purge	0.0	0.0
LP Flare - Planned Streams	11	11
HP Flare - Purge	0.0	0.0
HP Flare - Blowdowns	38	38
Power Generation	283	283
Power Generation - Diesel	3	3
Emergency Power	0	0
Diesel Firewater Pumps	3	3
Diesel Cranes	3	3
Diesel Storage	0	0
Fugitive Emissions	0	0
Transport - Supply Vessels	0	0
Transport - Helicopter	2	2
Total	343	1000

Notes:
 1. Based on 200 MMscf start-up flaring, 100 MMscf blowdown and 4 MMscf topsides flaring, i.e. shutdown and blowdown once per year.
 2. Flare pilot rates to be confirmed. Purge rates from John Zinc.
 3. Firewater pumps based on 30 mins testing per week, emergency generator 30 mins per month.
 4. Based on assumption of diesel backup run for start-up (1 hour per start-up, two per year) and testing (30 mins per month).
 5. Transport/logistics emission sources are not considered only personnel helicopter travel.

- Sandblasting of infrastructure
- Operation of a crushing and screening plant
- Operation of a concrete batching plant.

The volume and duration of dust emissions generated during construction are expected to be variable and intermittent. The emissions are unlikely to be concentrated in a single location for any extended period. The impacts of dust on vegetation are likely to be limited to dry-season conditions—rainfall during the wet season will remove dust from leaf surfaces.

A management plan will be developed as part of the Construction Environmental Management Plan (CEMP), with the key objective of managing dust generation and dispersion in compliance with the EPA Guidance for the Assessment of Environmental Factors - prevention of air quality impacts from land development sites - No.18, 2000. As part of the CEMP a range of management controls and monitoring procedures will be developed and applied to various activities at the onshore development area.

Odour

During the construction phase, excavation of organic matter and onshore placement of nearshore dredge material, containing decomposing organic matter, may allow the emission of odorous compounds, such as hydrogen sulfide (H₂S), mercaptans (R-SH) and organic amines. These compounds are highly odorous with detection concentrations in the low-parts-per-billion range. Liberation of odorous compounds will normally peak during high temperatures and low wind velocity. Onshore dredge material placement, if performed, could last several months and will take an extended period before it dries adequately

to prevent odour generation. During this time, odour management may be required, although it is anticipated that odorous compound concentration will dissipate to below detection concentrations within the buffer zone indicated as required by the Project.

The potential for generation of anaerobic odours from the operation of a sewage treatment facility is likely to be managed by providing extended aeration. Operation of the facility to Project control requirements should reduce odour generation from this source.

Estimated Construction Emissions

Emissions from construction are very variable. They depend on the activity taking place, the type of equipment used, the maintenance of the equipment, and the equipment load. Indicative construction emissions from the Foundation Project are shown in Table 4.9.

For the construction of subsequent LNG trains, excess power from the operating plants will be used. In addition, fuel gas use will be maximised for stationary equipment. Therefore, air emissions for the construction of the subsequent LNG trains are expected to be lower than the emissions from the construction of first two trains.

Commissioning

The onshore commissioning schedule sequence is anticipated to be as follows:

- **Purging:** Initial purging activity occurs during displacement of nitrogen from the feed gas system and initial regeneration of molecular sieves. Commissioning gas from front-end units will be flared while the

Table 4.9: Indicative Construction Emissions from the Foundation Project [1]

Compound	Mobile Equipment Emissions [2,4]	Stationary Equipment Emissions [3]	Total Emissions
	Tonnes		
NO _x	271	3584	3855
CO	58	772	830
SO _x	18	236	254
PM ₁₀	19	252	271
VOC	21	284	306

Notes:

1. Based on 62-month construction period
2. Assumes all diesel vehicles/equipment will be used on site
3. Includes power generation for the accommodation village and at the construction site
4. Equipment spread and the numbers of vehicles are based on experience from previous projects of similar magnitude and durations.

cryogenic section becomes ready for service. Estimated flaring of feed gas during these sequential operations is 5000 kg/hr for six days.

- **Dryout:** Drying is the process of ensuring cryogenic feed/methane/propane/ethylene circuits are dry requiring defrost procedure. Hot dry gas is pressurised through the system to flare lines. The estimated flaring from this process is anticipated to be approximately 5000 kg/hr over six days. After the defrost procedure the Propane and Ethylene circuits have to be charged and purged to flare in order to achieve the required purity ≥ 98 per cent. Estimated flaring of propane is 1000 kg/hr and of ethylene 500 kg/hr for two days.
- **Cool-down of Heavies Removal Column:** This procedure entails the operation of the plant at very low rates until the required pressure and temperature profiles are established. Flaring is estimated to occur for three days at a rate of 20 000 kg/hr.
- **Cool-down of LNG Tanks:** Cool-down of LNG tanks is accomplished with LNG produced at very low rate

until the required pressures and temperatures are established. During this short period flaring may occur. Estimated flaring of gas is 5000 kg/hr during three days.

The above estimates are only a guide to the quantities flared as it is impossible to predict problems that occur during start-up of a new plant. The above quantities do not take into consideration any emergency or out of the ordinary flaring that may be required.

4.3.4.2 Operations

Predicted Routine Emissions

Routine operations are those activities that occur on a day-to-day basis during the production of LNG and gas for the domgas market. Typical, estimated point source emissions, from routine operations, are shown in Table 4.10. The equipment listed is located within and in close proximity to the LNG processing trains and power generation utilities. This infrastructure is described in detail in Chapter 2, *Project Description*.

Table 4.10: Typical Process Unit Annual Emissions - Routine Operations

	PM	SO ₂	NO _x	CO
	Tonnes per year			
Heaters/Flares				
Onshore				
Flare Pilots & Purge Gas	2	<0.1	30	26
Acid Gas Thermal Oxidisers - LNG	1	40	8	7
Acid Gas Thermal Oxidisers - Domgas	<1	6	1	1
Flares/Vent				
Onshore				
Nitrogen Vent - LNG	NA	<0.1	NA	NA
Nitrogen Vent - Domgas	NA	<0.1	NA	NA
Gas Turbines				
Offshore				
Gas Compressor/Turbines	ND	10	337	362
Power Generation Turbines	ND	6	163	180
Onshore				
Refrigeration Compressor/Turbines	246	<0.1	4,098	4,426
Power Generation Turbines	47	<0.1	746	806
Total	296	62	5,383	5,808

NA - not applicable; ND - not determined

During the storage and transfer of LNG some gas may vaporise (gas temperature increases above -161°C and returns to a vapour). This gas is referred to as Boil Off Gas (BOG). The two main areas where this can occur are in the LNG storage tanks and during the loading of LNG tankers. The LNG processing system is designed as a closed system so that BOG that is generated during normal operation is captured and returned to the liquefaction process or to the onshore marine flares only during upset conditions or when a warm ship from dry dock needs to be purged and cooled down.

A pilot flame will be maintained at each flare tip for safety reasons. This will allow for combustion of gases released during emergency or non-routine operations. The volume of gas used to maintain the pilot will be managed. Flaring and venting procedures are discussed in more detail in Chapter 2, *Project Description*.

Direct venting of hydrocarbons may be required to maintain the safety of the facility. Vented nitrogen from the nitrogen rejection unit may contain insufficient hydrocarbon concentration to allow combustion. This gas stream will, under these circumstances, be directly vented to the atmosphere.

The amine regeneration system within the acid gas removal unit will direct vented gases to thermal oxidisers for destruction. Some of the BTEX present in the feed gas will end up in the acid gas removal unit (AGRU) acid gas stream and will be sent to the thermal oxidiser. The thermal oxidiser will be designed to achieve a hydrocarbon destruction efficiency of about 99 per cent, which would result in a total of approximately 200 tonne of BTEX per year being vented from the thermal oxidisers in the LNG plant and domgas AGRUs.

Predicted Impact of Routine Emissions

Routine emissions have been modelled by SKM, and reviewed by URS, using the Australian TAPM model. This model has been used to predict ground-level concentrations of NO_2 , O_3 , SO_2 and PM_{10} . A full technical report is included in Appendix C1. A summary table is also provided in Table 4.14.

NO emitted from LNG processing equipment will be converted by the action of available atmospheric O_3 into NO_2 . Depending upon the time of day and amount of sunlight, NO_2 concentrations will vary due to the action of ultra violet light converting NO_2 back to NO and forming O_3 as a secondary pollutant.

Modelled ground level atmospheric NO_2 concentrations for routine operations are shown in Figure 4.11 and Figure 4.12.

A secondary pollutant, O_3 is not directly emitted from the process but forms as a result of additional chemical reactions. O_3 forms as a consequence of photochemical reactions between NO_2 and ultraviolet light. O_3 concentrations will fluctuate in the atmosphere due to incident sunlight and the concentration of water vapour, NO_x and VOCs in the atmosphere. O_3 concentrations will normally peak during the dry season and in the afternoon, and diminish during overcast weather and in the evening. Reactions on the surface of particulate matter and water vapour may lead to a decrease in the production of O_3 . Due to rate of flux in O_3 concentrations, predicted concentrations are based on short-term (one-hour and four-hour) results.

Modelled ground-level O_3 concentrations for routine operations are shown in Figure 4.13 and Figure 4.14.

The estimated annual "non-industrial" concentration of SO_2 has been assessed at less than 0.8 ppb at Onslow.

Modelled maximum ground-level atmospheric SO_2 concentrations during routine operations at Onslow are predicted to be less than 2 ppb.

Modelled ground-level atmospheric SO_2 concentrations for routine operations are shown in Figure 4.15, Figure 4.16 and Figure 4.17.

PM_{10} include the subset of particulates less than 2.5 micrometers ($\text{PM}_{2.5}$). PM_{10} emitted from LNG process equipment during routine operations will tend to peak during the afternoon and reach a minimum during the early hours of the morning. Existing PM_{10} emissions within the region are derived primarily from open-area erosion and bushfires. These particulate emissions have been excluded from this report due to the complexities of modelling short-term events that vary spatially.

Modelled 24-hour ground-level atmospheric PM_{10} concentrations during routine operations are shown in Figure 4.18.

Deposition of Nitrogen and Sulfur on Sensitive Environments

The rate of nitrogen deposition is controlled by wind velocity, the rate of chemical conversion of NO_x to secondary oxides and vertical mixing (ambient temperature and atmospheric turbulence). Deposition flux will tend to peak during the morning and then taper off during the rest of the day. Modelled deposition rates (Figure 4.19) predict

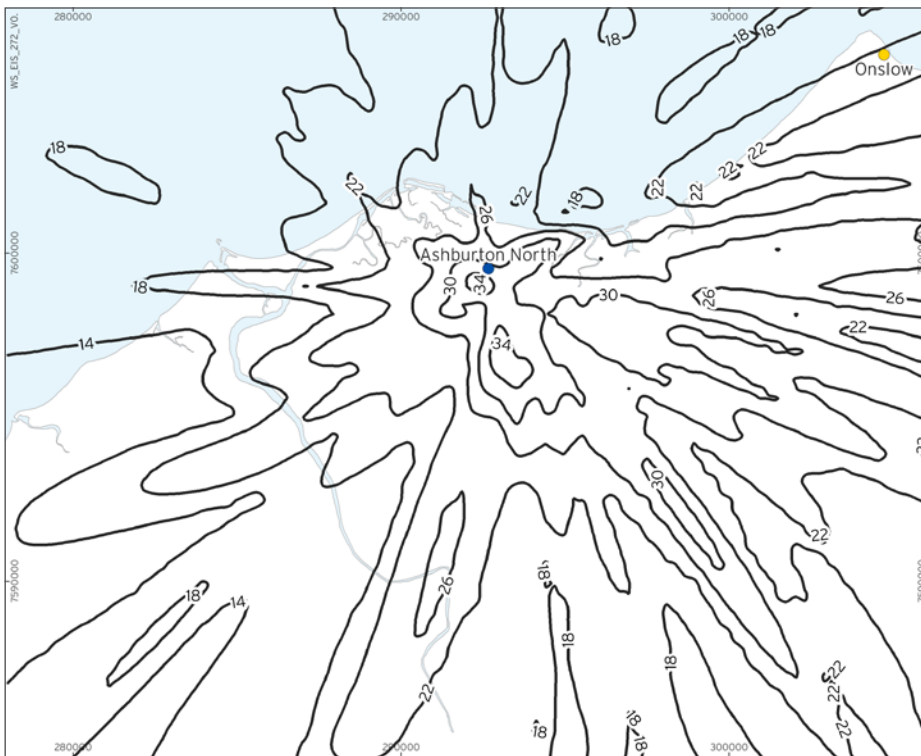


Figure 4.11: Maximum One-hour Ground-level NO₂ (ppb) - Routine Operation

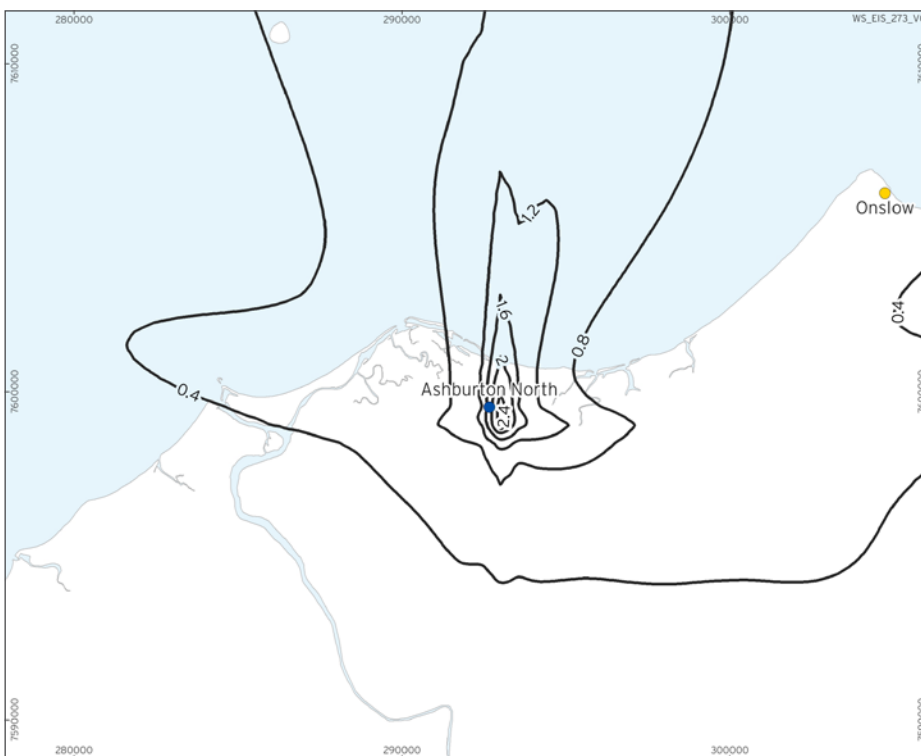


Figure 4.12: Annual Ground-level NO₂ (ppb) - Routine Operation

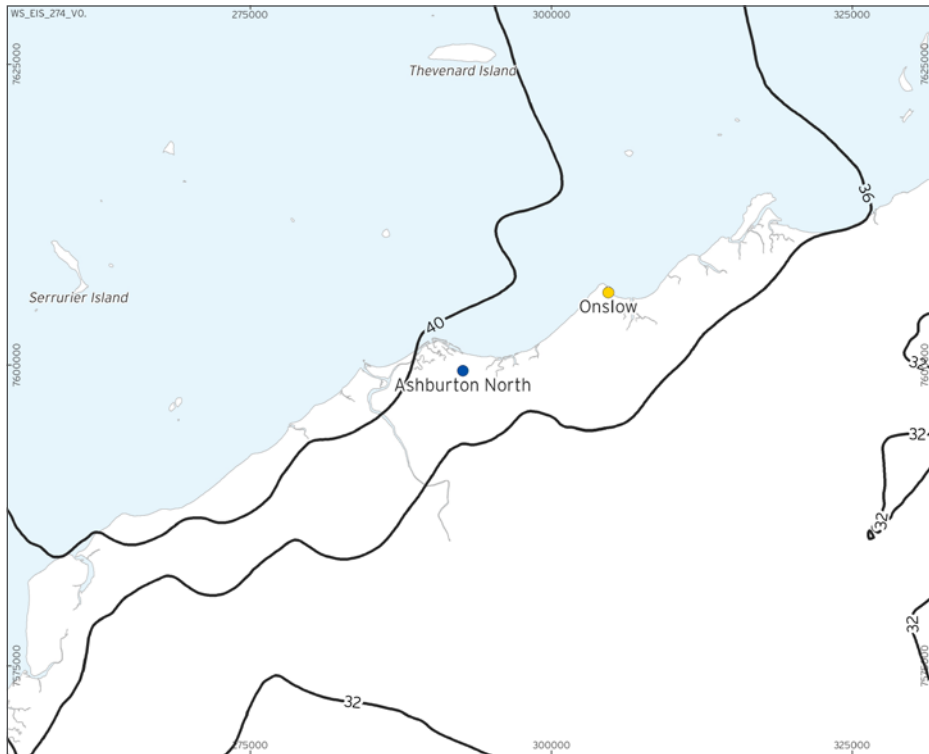


Figure 4.13: Maximum One-hour Ground-level O₃ (ppb) - Routine Operation

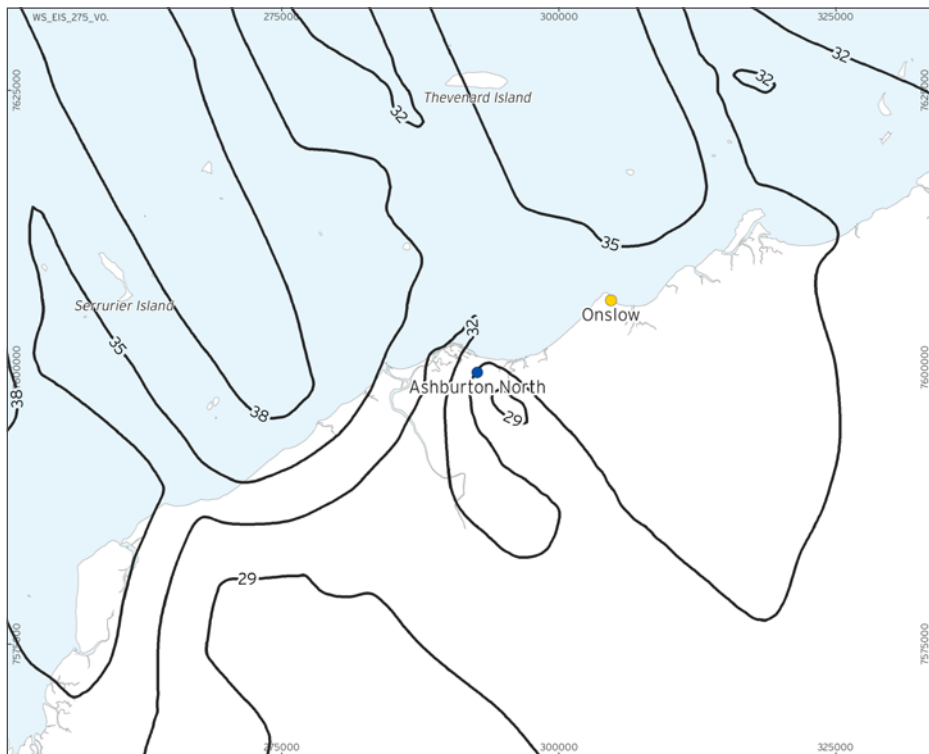


Figure 4.14: Maximum Four-hour Ground-level O₃ (ppb) - Routine Operation

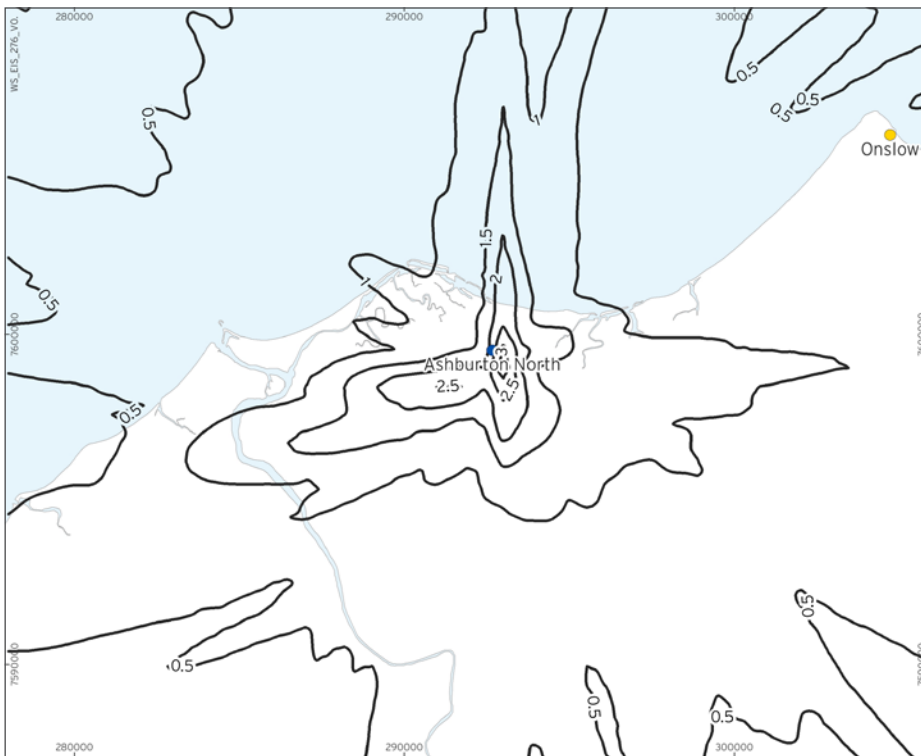


Figure 4.15: Maximum One-hour Ground-level SO₂ (ppb) - Routine Operation

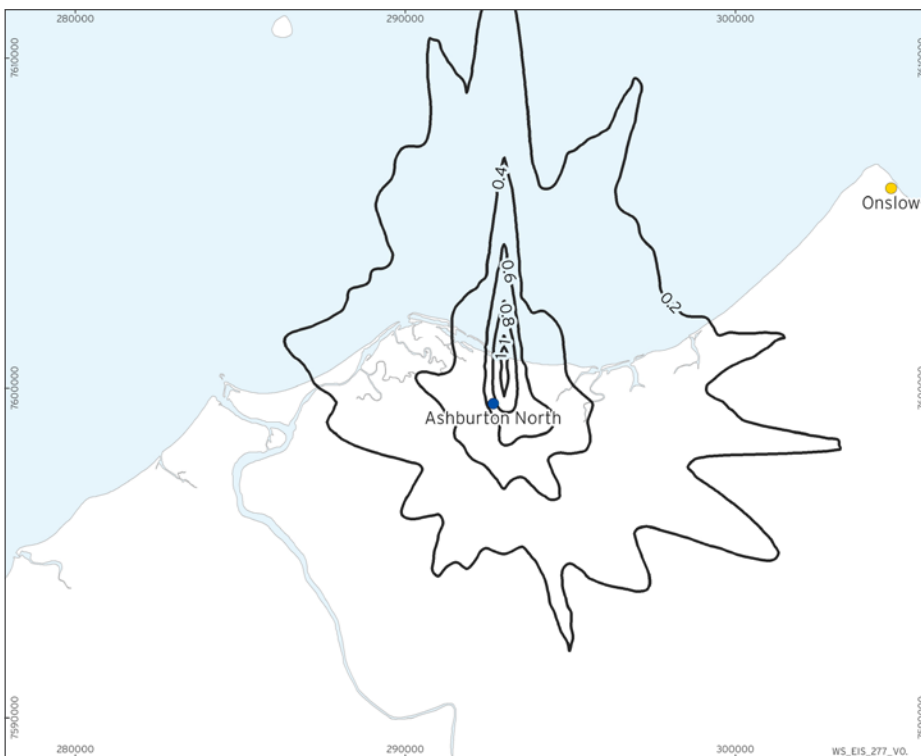


Figure 4.16: Maximum 24-hour Ground-level SO₂ (ppb) - Routine Operation

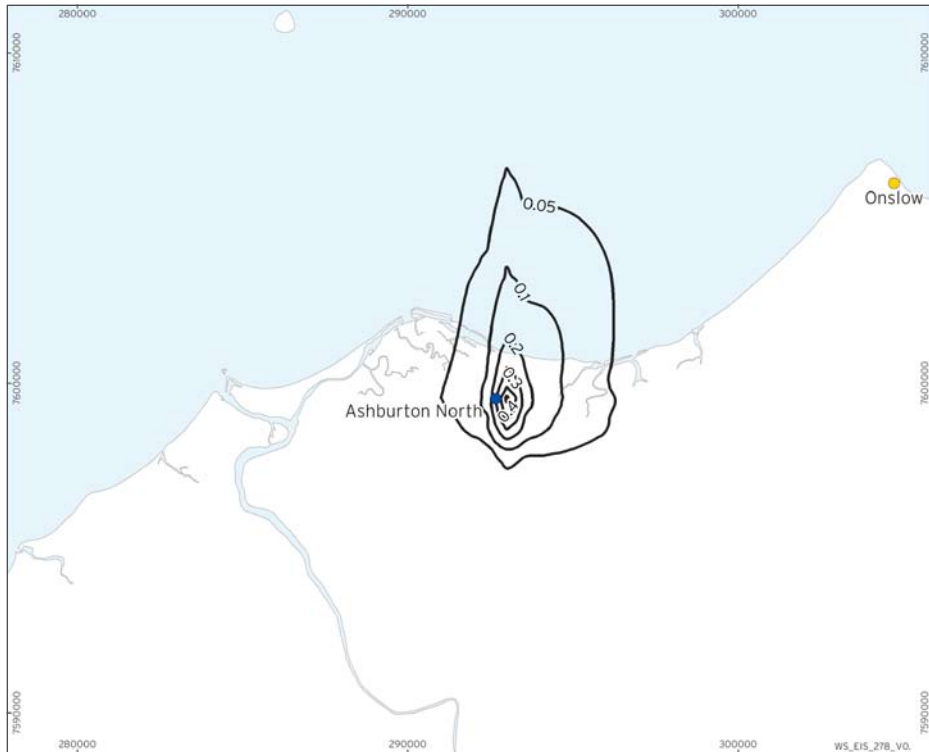


Figure 4.17: Annual Ground-level SO₂ (ppb) - Routine Operation



Figure 4.18: Maximum 24-hour Ground-level PM₁₀ - Routine Operations (µg/m³)

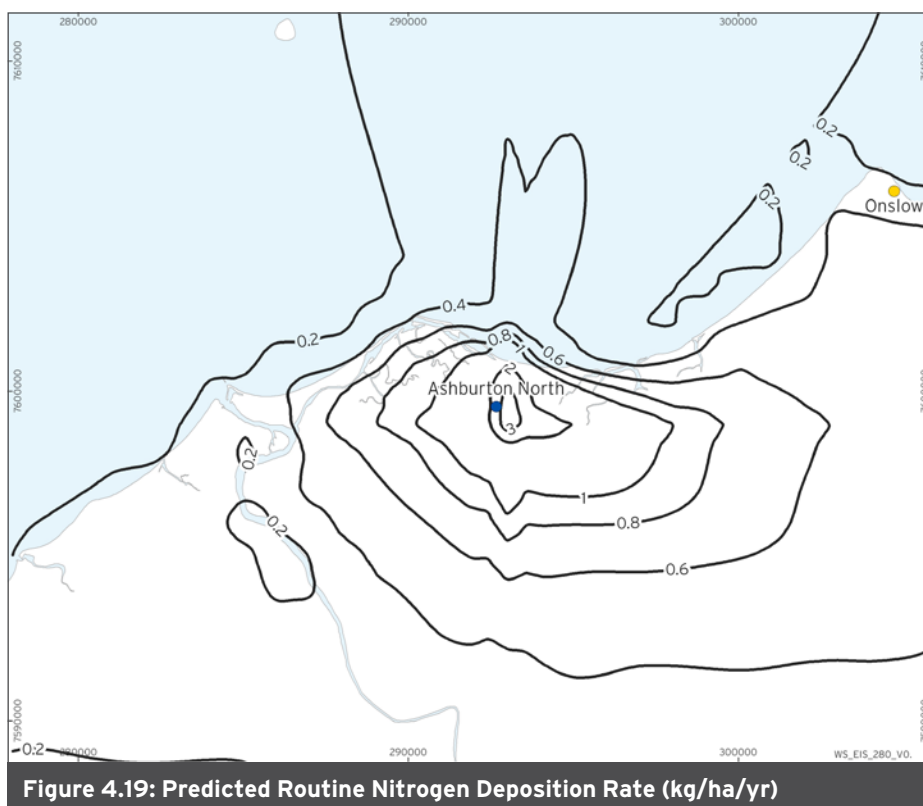


Figure 4.19: Predicted Routine Nitrogen Deposition Rate (kg/ha/yr)

that the LNG facility will increase NO₂ deposition rates from less than 0.04 to less than 0.3 kg N/ha/yr at Onslow.

O₃ deposition rates onto vegetation will be highest during daylight hours, although dry deposition may occur during the night and also during the active growing season. O₃ deposition rates have not been modelled as available data on O₃ uptake by endemic vegetation is insufficient.

Indicated sulfur content of raw gas from the Project is at insignificant concentrations. Third-party gas may contribute higher loads of sulfur, however, similar gas fields in the Carnarvon Basin also contain low concentrations of sulfur. It is anticipated that the volume of SO₂ emissions from the Project will therefore be extremely low and are unlikely to impact human health or the surrounding environment.

Visible Smoke

Visible smoke (soot) is an indicator of incomplete combustion or low-temperature combustion. Visible smoke may also occur during periods of high wind velocity due to formation of turbulent diffusion flame conditions. Under routine operating conditions, the gas turbines and

thermal oxidisers are unlikely to generate visible smoke. During non-routine operating conditions, particularly when gas turbines are operating at less than 60 per cent of full load or when flares are burning at greater than optimal burner fuel flow rates (rich mix), emissions of visible smoke may occur due to increased generation of particulates and VOCs. Flaring with visible smoke is anticipated during commissioning of each train, and during start-up conditions. Visible smoke is to be anticipated when wet gas—containing higher concentration of higher molecular weight compounds—is flared and will be managed to ensure compliance with the Environmental Protection (Unauthorised Discharges) Regulations 2004.

Air Toxics

Air toxics may be generated during incomplete combustion of hydrocarbons in the temperature range of 250 to 450°C. Formation may be highest during periods of low loading and during start-up and shutdown operations.

Emissions of benzene, toluene and xylene have been modelled and are discussed in detail in Appendix C1. The predicted maximum concentrations are presented

Table 4.11: Maximum Predicted Future Ground-level Concentrations for BTEX under Normal Operating Conditions

Pollutant	Modelled Grid	Averaging Period	Unit	NEPM Investigation level (ppb)	Maximum on Grid (ppb)	Percentage of Criteria
Benzene	1 km	Annual	ppb	3	0.3	8.4%
Toluene	1 km	24 hour	ppb	1000	1	0.1%
	1 km	Annual	ppb	100	0.5	0.5%
Xylene	1 km	24 hour	ppb	250	1.3	0.5%
	1 km	Annual	ppb	200	0.6	0.3%

Table 4.12: Fugitive Emissions - NPI Method 2 (tonnes/year)

VOC	n-hexane	Benzene	Toluene	Ethylbenzene	Xylenes
360	15	1.5	0.8	<0.1	0.2

in Table 4.11. From this table it is apparent that the predicted ground level concentrations of BTEX are very low with benzene having the highest predicted impact on the model grid at 8.4% of the NEPM investigation level.

Dust

During the operations phase, dust may be generated during routine maintenance and due to on-site traffic movements. A dust management plan will be developed as a section of the site's Operations Environment Management Plan. It is currently anticipated that the SIC is likely to be sealed. This would assist in reducing any dust generated by day-to-day vehicle movements.

Odour

Odour causing compounds in unprocessed gas are normally associated with VOCs, such as BTEX, and sulfur compounds, such as H₂S, R-SH and carbonyl sulfide (COS).

Gas from the offshore fields will generally be low in inorganic and organic sulfur compounds; however, these may be present in gas supplied for processing from third-party gas field operators. Such fields would provide feed gas to LNG Trains 3, 4 and 5.

A proportion of BTEX and most sulfur compounds will be removed from the gas stream in the AGRU of both the LNG and domgas processing lines and sent to thermal oxidisers for conversion to CO₂ and SO₂ respectively. Emissions of odorous BTEX and sulfur compounds will normally only occur during incomplete combustion in thermal oxidisers, venting and from fugitive emissions. Most process fuel

gas is sourced from processes downstream of the acid gas removal unit and consequently contains insignificant quantities of BTEX and sulfur compounds, reducing the potential of odorous emissions from the other areas of the plant.

Organic compounds recovered as solids from the mono-ethylene glycol (MEG) recovery unit may generate odours if not disposed of in a timely manner. Similarly, trace hydrocarbon odours may also be generated from the wastewater treatment system. It is anticipated that odorous compound concentration will dissipate to below detection concentrations within the buffer zone indicated as required by the Project.

The operation of the sewage treatment plant may have the potential for generation of anaerobic odours. Operation of the facility to Project control requirements should reduce odour generation from this source.

Fugitive Emissions

Fugitive emissions from gas service valves, oil service valves, oil/water service valves, pressure relief vents, flanges, pump seals, connectors and the natural gas condensate (condensate) tanks will result in simple hydrocarbons and other volatile organics being emitted to the atmosphere. Estimated annual fugitive emissions are shown in Table 4.12.

Fugitive emissions can be managed through design and maintenance controls. Chapter 2, *Project Description* provides details on the proposed design.

Non-routine Operations

Non-routine operations include planned maintenance and unplanned stoppages. It is anticipated that the gas processing plant will be shut down for sufficient time to require a warm start at least once a year, after commissioning. A warm restart is anticipated to take approximately fifteen hours, during which time approximately 25 per cent of the design flare flow rate may be directed to the flare as the LNG is brought to product specification.

The second upset condition scenario is based on a process emergency shutdown. It is anticipated that such circumstances will occur less than ten times in the first year of operation and be of less than one hour peak flaring, reducing to six events per year over the next five years.

During shutdown events, whether for maintenance or unplanned stoppages, the wet and dry flares, and vents will

be operated to maintain safe process operating conditions by reducing gas pressure in the facility.

Non-routine Venting and Flaring

The Project has a design requirement to reduce reliance on routine venting or flaring of hydrocarbons. However, overpressure situations, caused by incidents such as power failures, instrument air failures, equipment failure or incorrect operating procedures, will require emergency flaring to ensure the safe operation of the plant. The following paragraphs describe the non-routine (process upset or emergency) operation of the flare and vent system on the plant.

Wet “warm” vapours that contain water and condensate, either in vapour or liquid state, will be collected by the wet gas flare header system and sent to the wet gas flare knockout drum. Vapour from the drum will be sent to the

Table 4.13: Typical Process Unit Annual Emissions - Non-Routine Operations

	PM	SO ₂	NO _x	CO
	Tonnes			
Heaters				
Onshore				
Start-up Heaters	0.3	0.2	5	4
Flares/Vent				
Offshore				
Boom Flares				
Upset	ND	0.7	11	60
Onshore				
Marine Flares				
Warm Ship Cool-down	ND	<0.1	48	260
Upset	ND	<0.1	1	6
Wet Flares				
Upset	ND	<0.1	65	352
Dry Flares				
Upset	ND	<0.1	4	21
Total	0.3	0.9	134	703

NA - not applicable; ND - not determined

wet flare. The header system will be continuously purged with fuel gas or nitrogen, as backup.

Dry “cold” vapours, which contain no water but may contain other liquids, will be collected by the dry gas flare header system and sent to the dry gas flare knockout drum. Cryogenic liquids, which vaporise in the knockout drum will not be recycled to the process. The header system will be continuously purged with fuel gas or nitrogen, as backup.

Vapours from the LNG storage tanks and the LNG ships will be collected by the marine flare header and sent to the marine flare. The header system will be continuously purged with fuel gas or nitrogen, as backup.

The most significant periods of flaring will be during the start-up and shutdown of the LNG processing trains. Capacity for reducing the volume of gas flared during plant start-up is limited, as the gas flared will not meet the specification for LNG sales and may be outside specification for use as fuel. During a plant shutdown, it will be necessary to ensure the safety of specific facilities by depressurising and flaring the entire inventory of the process unit subject to the shutdown. The development of operating procedures for the facility may consider methods for reducing the amount of flared gas during shutdowns, to the extent reasonably practicable. Reducing unintended plant outages is fundamental to reducing flaring associated with plant shutdowns.

Flaring during commissioning may be limited by appropriate design and control of commissioning procedures. Most low-pressure hydrocarbon streams in the facility (including those from the various regeneration processes) may be redirected to either the fuel gas system or back into the LNG or domestic gas processes. Compressors and other systems in the LNG process may be designed to start up, operate continuously and shutdown on full recycle to reduce flaring.

Flaring during cooling down / purging of warm LNG tankers from dry dock may occur at a rate of 20 ships each year.

Extrapolated onshore operations forecasting indicates that approximately 500 hours of planned and unplanned maintenance downtime may be lost each year, with an estimated 200 hours of gas flaring, through one or more of the three wet gas flares and three dry gas flares.

The two marine flares are anticipated to operate for approximately 12 hours each year for planned maintenance. Typical atmospheric emissions from non-routine operations are shown in Table 4.13.

Non-routine flaring has the potential to be the most significant source of emissions. SKM have modelled (using TAPM) two non-routine upset conditions for NO_2 , O_3 , SO_2 and PM_{10} . These two non-routine upset conditions are:

- Non-routine operations–Upset Condition 1 – cold start of single process train taking six hours with 30 per cent of flow directed to flare. As this is a short-term event, results are reported for one-hour averages.
- Non-routine operations–Upset Condition 2 – process emergency shutdown resulting in peak flaring for approximately 15 minutes. As this is a short-term event, results are reported for one-hour averages.

The results from this modelling assessment are included in the technical appendices (Appendix C1). A summary of the ground-level concentrations is included below.

Modelled one-hour ground level concentrations of NO_2 at Onslow are predicted to be less than 24 ppb during Upset Condition 1 (Figure 4.20) and less than 23 ppb during Upset Condition 2 (Figure 4.21).

Modelled one-hour ground-level concentrations of O_3 at Onslow are predicted to be less than 38 ppb during Upset Condition 1 (Figure 4.22) and less than 37 ppb during Upset Condition 2 (Figure 4.23).

Modelled 24-hour ground-level concentrations of PM_{10} at Onslow are predicted to be less than $25 \mu\text{g}/\text{m}^3$ during Upset Condition 1 (Figure 4.24) and Upset Condition 2 (Figure 4.25).

4.3.5 Comparison of Predicted Air Emissions with Standards and Guidelines

Modelled criteria pollutants are all well below NEPM guideline values (see Table 4.14):

Particulate concentrations have the potential to exceed NEPM guideline values during periods of significant regional bushfires, followed by dust-storm events caused by erosion of the desiccated local soils. This scenario may arise independently of the Project’s development in the area.

A risk assessment of air-quality impacts is included in Chapter 9, *Terrestrial Risk Assessment and Management* and Chapter 10, *Social Risk Assessment and Management*.

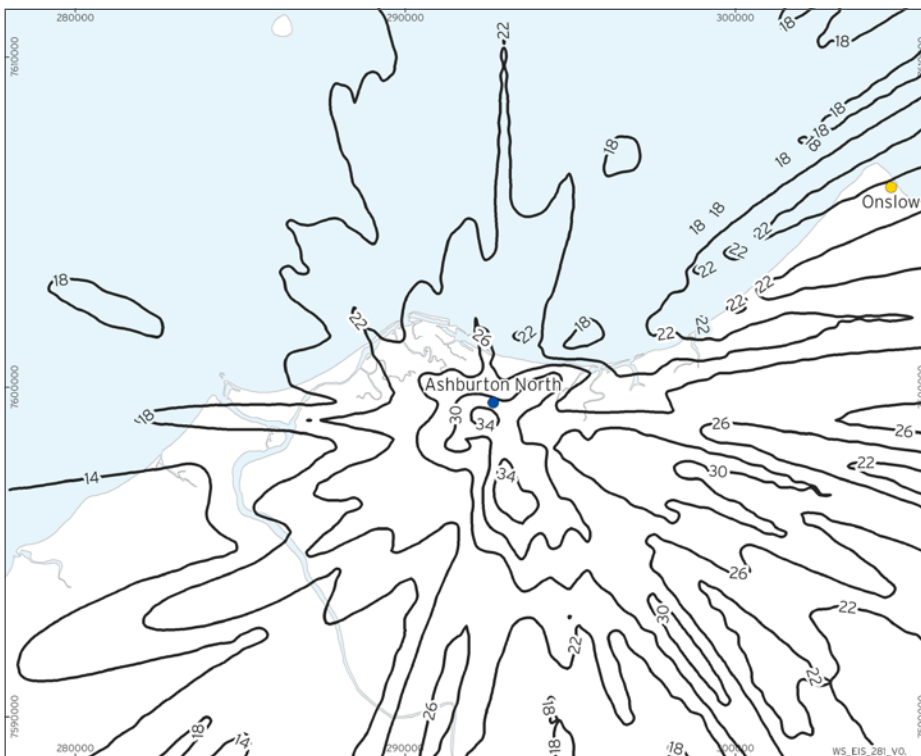


Figure 4.20: Maximum One-hour Ground-level NO₂ (ppb) - Upset Condition 1

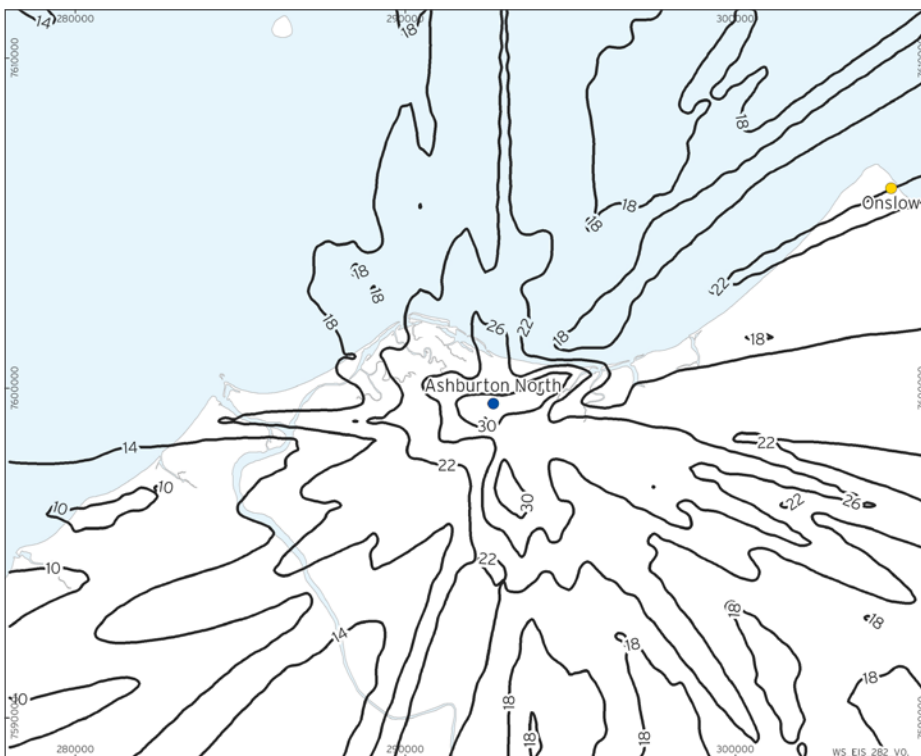


Figure 4.21: Maximum One-hour Ground-level NO₂ (ppb) - Upset Condition 2

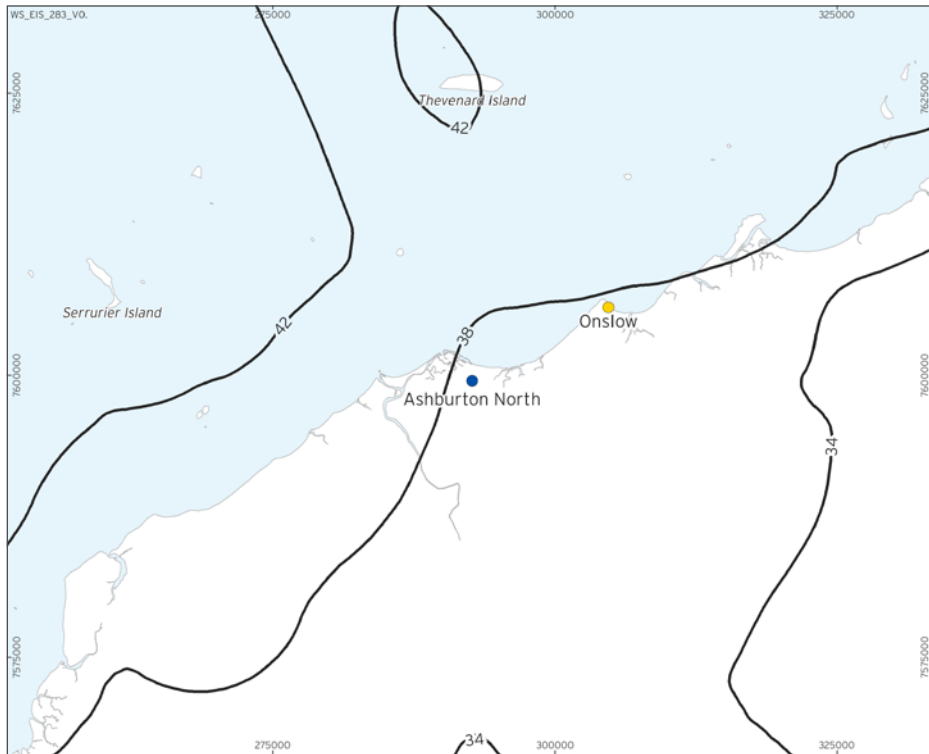


Figure 4.22: Maximum One-hour Ground-level O₃ (ppb) - Upset Condition 1

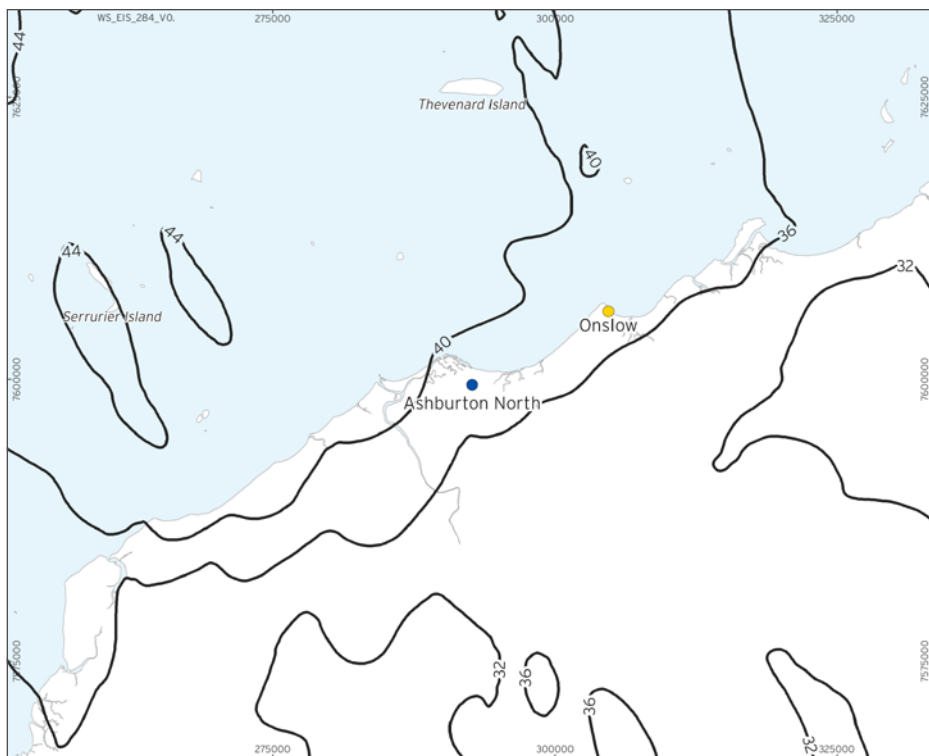


Figure 4.23: Maximum One-hour Ground-level O₃ (ppb) - Upset Condition 2

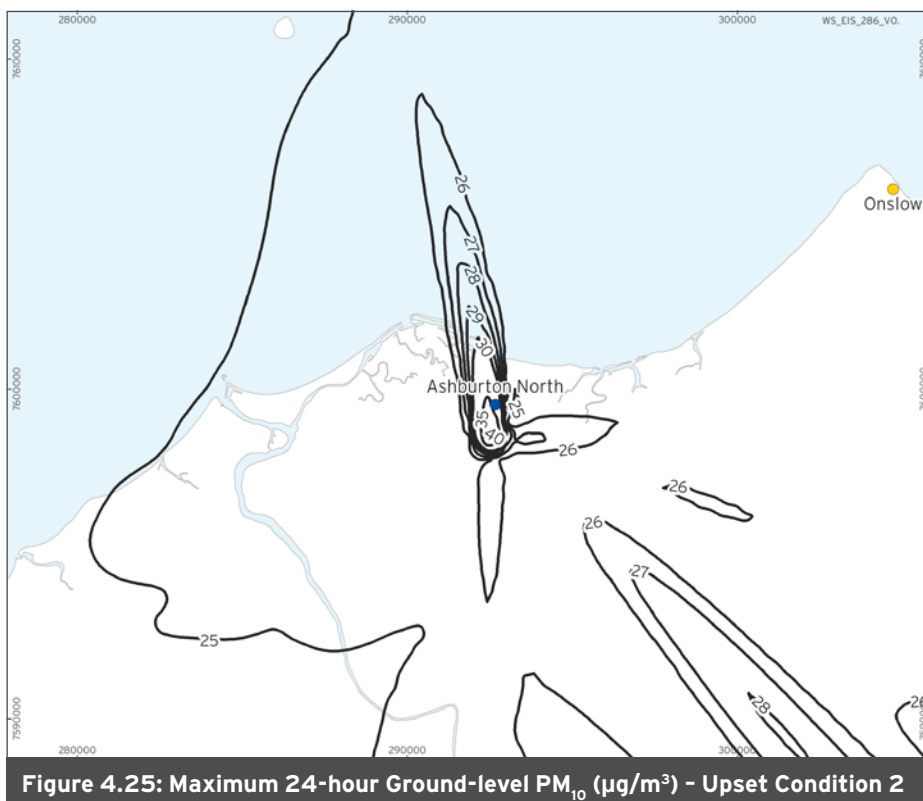
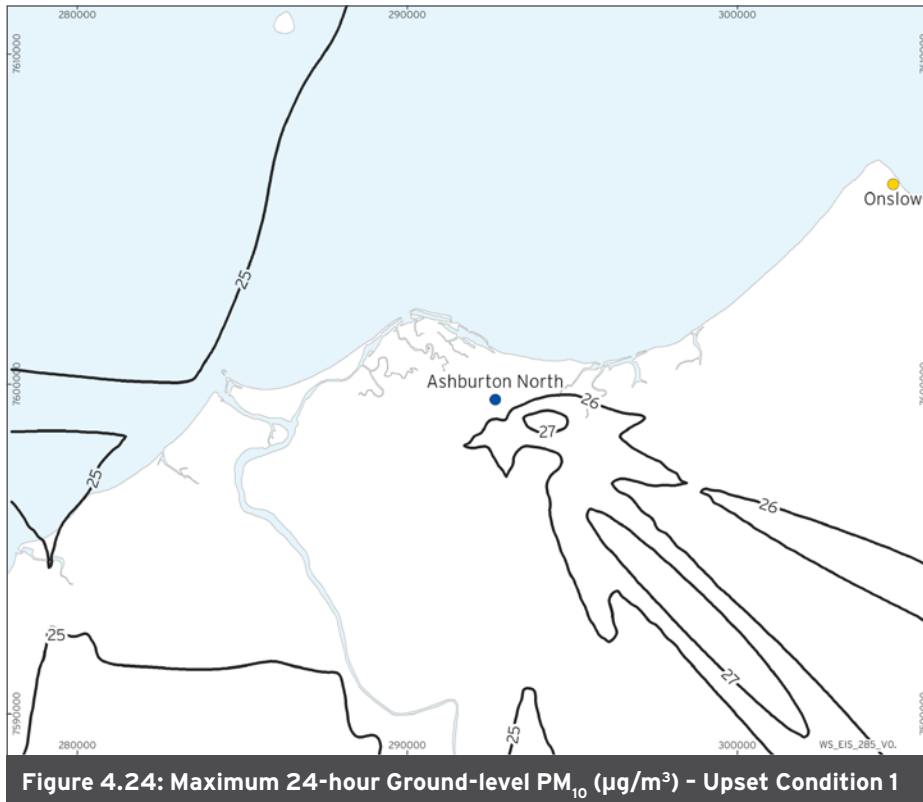


Table 4.14: Comparison of Modelled Criteria Pollutants to NEPM Guideline Values

Pollutant	Modelled Grid	Averaging Period	Unit	NEPM Criteria	Maximum on Grid		Percentage of Criteria	
					On Grid	Onslow	On Grid	Onslow
Existing Environment								
NO ₂	1 km	1-hour	ppb	120	1.2	0.8	1.0%	0.6%
		Annual	ppb	30	0.1	0.1	0.3%	0.2%
O ₃	3 km	1-hour	ppb	100	23.8	19.5	23.8%	19.5%
		4-hour	ppb	80	21.8	19.5	27.2%	24.4%
Future - Normal Operations								
NO ₂	1 km	1-hour	ppb	120	39	24	32%	20%
		Annual	ppb	30	3	0.4	9%	1%
PM ₁₀	1 km	24-hour	µg/m ³	50	27	25	53%	50%
SO ₂	1 km	1-hour	ppb	200	3.5	0.7	1.7%	0.3%
		24-hour	ppb	80	1.1	0.1	1.4%	0.1%
		Annual	ppb	20	0.6	0.0	2.8%	0.1%
O ₃	3 km	1-hour	ppb	100	44	38	44%	38%
		4-hour	ppb	80	40	34	50%	43%
Future - Ship Loading Conditions								
NO ₂	1 km	1-hour	ppb	120	39	24	32%	20%
		Annual	ppb	30	2.8	0.4	9%	1%
SO ₂	1 km	1-hour	ppb	200	3.5	0.7	1.7%	0.3%
		24-hour	ppb	80	1.1	0.1	1.4%	0.1%
		Annual	ppb	20	0.6	0.0	2.8%	0.1%
PM ₁₀	1 km	24-hour	µg/m ³	50	27	25	53%	50%
O ₃	3 km	1-hour	ppb	100	44	38	44%	38%
		4-hour	ppb	80	40	34	50%	43%
Future - Start-up (Condition 1)								
NO ₂	1 km	1-hour	ppb	120	39	24	32%	20%
SO ₂	1 km	1-hour	ppb	200	3.3	0.6	1.6%	0.3%
PM ₁₀	1 km	24-hour	µg/m ³	50	28	25	55%	50%
O ₃	3 km	1-hour	ppb	100	43	38	43%	38%
Future - Emergency Shutdown (Condition 2)								
NO ₂	1 km	1-hour	ppb	120	36	23	30%	19%
SO ₂	1 km	1-hour	ppb	200	2.2	0.6	1.1%	0.3%
PM ₁₀	1 km	24-hour	µg/m ³	50	44	25	87%	50%
O ₃	3 km	1-hour	ppb	100	44	37	44%	37%

* For full details of the modelling and any assumptions, please see Appendix C1.

4.4 Light

4.4.1 Overview

The Project will produce light emissions during construction, commissioning, operations and decommissioning. This light will be generated by Project activities, such as flaring and by lighting systems that provide safe areas of operation.

The amount of light generated is determined by the wavelength, intensity, orientation and location of the source, light loss factors and method of light switching. Intensity generally diminishes with the square of the distance (i.e. over a distance of 10 m intensity drops to 1/100th of the intensity at 1 m from the source).

Lux (lumens/m²) is the measure of luminous emitted and provides an indication of the human perception of brightness. For example, a lit living room in a house at night has an illuminance of around 50 lux, while light from a full moon is around 0.27 lux.

Lighting or illuminance of work areas is required for safety and security, to ensure that viewing conditions are optimised for complex or detailed tasks and to provide comfortable visual conditions.

Please note light emissions and the potential effects on turtles is discussed in detail in the marine chapter, Chapter 8, *Marine Risk Assessment and Management*.

4.4.2 Existing Environment

Background light levels in the coastal areas around Onslow are influenced primarily by moonlight and modest sky glow from the town site and adjoining light-industrial zone.

Recreational areas such as Five Mile Pool (used for camping) and the Old Onslow Town Site heritage area are located approximately 20 km south-west of Onslow. These areas attract tourists and campers who contribute to low-level light emissions in the area.

Onslow Salt is the main industrial activity close to Onslow. The operation contributes light emissions from security lighting and vehicle traffic.

Remote locations, outside the Onslow town site, will typically have light emissions equivalent to between full moon (0.3 lux) and new moon (0.002 lux) intensities. Background light intensity has been referenced against new-moon light intensity for this document.

The offshore location does not have any nearby light emitting sources and is considered to have the same light levels as remote onshore locations.

4.4.3 Offshore

The main sources of light during installation and dredging will be various vessels, drilling mobile offshore drilling units (MODUs) and installation platforms. Typically, white light such as fluorescent, metal halide and halogen is used on a 24-hour basis.

During commissioning and operations, the main sources will be vessels, platform facility lighting and the flare system.

Safe illumination of the work areas and accommodation modules will be provided. Levels and coverage will be determined as part of the Safety Case and in compliance with legislation, industry and Chevron standards and best practise. The design reduces light spillage through consideration of a range of techniques, typically:

- Electrical – such as automated devices, spectral/wavelength modification and delivered wattage minimisation
- Physical – such as shielding, placement, obstruction, directional, elimination and timers.

Flaring intensity during commissioning and operations will be low during normal operation and larger during non-routine events. During normal operation, the low pressure flare comprises minor offgas streams and minimal purge and pilot. During blowdown events, the high-pressure flare is designed to relieve the topsides equipment in as short a period as practical (nominally around 15 minutes); thereafter the flare duration will depend on additional upstream inventories being released. Flaring is also required to prevent hydrate formation during shutdown, which could cause flowline blockages and an inability to re-start some or all production. All reasonably practical steps will be taken to manage the duration and frequency of such events, although the expected frequency will be around ten times per year post commissioning, if system testing is included. Surplus gas is not flared and the likelihood of blowdowns is reduced through comprehensive integrity, reliability, monitoring, maintenance and control measures adopted in the design.

Vessels and MODUs will be onsite during installation, their durations varying from days to several months for offshore facilities and pipelay but likely longer for initial and maintenance dredging.

The platform location is more than 140 km from the nearest mainland. The site is not near any known critical aggregation areas for cetaceans, turtles or birds. The potential impacts of light on turtles, cetaceans and seabirds is further discussed in Chapter 8, *Marine Risk Assessment and Management*.

4.4.4 Onshore

4.4.4.1 Overview

Lighting or illuminance of work areas is required for safety and security. Operation of the LNG liquefaction facilities requires lighting to comply with Australian Standard AS 1680.2.4:1997, SIDS:Section-9 and API-540.

Emissions of light from the proposed LNG facility are required to meet AS 4282-1997 Control of the Obtrusive Effects of Outdoor Lighting. This standard sets out criteria related to the human perception of light and provides criteria for both pre-curfew and curfew hours (23:00 to 06:00). The standard recommends the following vertical illuminance criteria for curfew hours:

- 25 lux - at the boundary of commercial and residential areas
- 10 lux - in residential areas.

4.4.4.2 Construction

During construction, light may be emitted from temporary lighting structures, such as mobile light towers, and construction vehicles, as presented in Table 4.15. These sources of light will be mainly transient and will not provide a permanent light spill source.

4.4.4.3 Commissioning and Operations

During commissioning and operations, light will be emitted from lighting for safety and security and from the intermittent operation of gas flares.

The Project area will have a peak of illuminance, from lights, at the liquefaction facilities, with lower levels of illuminance radiating out from this central hub. Modelled lighting at the extremities of the Project area indicates a residual illuminance of less than 25 lux. In addition, intermittent operation of the flare system will increase peak illuminance across the LNG facility and into the surrounding environment.

Different locations in the Project area will have varying requirements for lighting. Table 4.16 provides an estimate of indicative lighting levels in different areas of the facility.

Modelled light emissions during flaring are predicted to be less than 5 lux within 1000 m of each of the flares (Figure 4.26), with a typical wavelength spectrum as presented in Figure 4.27.

Light spill along the beach and dunes south-west of Entrance Point has been modelled and predicts illuminance along the dune crest peaking at 0.2 lux, while illuminance across the beach will generally be less than 0.15 lux (Figure 4.28).

4.4.4.4 Light Spill

Light emissions from the onshore processing facility and nearshore infrastructure will be visible from the marine environment. The light emissions from the MOF and Product Loading Facility (PLF) will meet the requirements of Australian Standards, SIDS: 9, API-540 and Australian Maritime Safety Authority Marine Order, Part 32 and are anticipated to be less than 20 lux. The processing facility will be substantially brighter although the most prominent source of light will be infrequent flaring that is likely to be visible from a considerable distance.

Offshore illumination will include flares and artificial lighting on the offshore facilities.

Discussion of the potential impacts of light spill on the marine environment is included in Chapter 8, *Marine Risk Assessment and Management*.

4.4.4.5 Visual Impact

Viewshed analysis was performed for six agreed viewpoints of interest (see Chapter 10, *Social Risk Assessment and Management*) to provide a visual representation of the view of the processing facility from Onslow. This estimate accounts for the heights of major infrastructure within the onshore development area (e.g. buildings, tanks, flares, etc.) as well as the topography within the catchments of each viewpoint. Allowances were not made for average natural vegetation heights in areas of uncleared bushland. The results and discussion of the analysis are included in Chapter 10, *Social Risk Assessment and Management*.

From the results of the viewshed analysis and the lighting study it can be inferred that, under normal operating conditions at night, the onshore facility will be seen from Onslow as a dull glow on the horizon.

Flaring may be more visible but will be infrequent. The PLF and MOF will have low levels of illumination. The WP will not be visible from the mainland.

Further discussion of the social impacts of light emissions is included in Chapter 10, *Social Risk Assessment and Management*. The lighting emissions study is included as Appendix D1.

Table 4.15: Estimate of Lighting Levels during Construction and Commissioning

Source	Light at Source	Light at 1000 metres
	Lumens	Lux
Mobile light towers (each)	384 000	0.4
Construction vehicles	7000	0.007

Table 4.16: Estimate of Lighting Levels in the Project Area

Area	Lux
Roadway, jetty, pathways, perimeter fence	20
Security lighting for administration buildings	168
LNG and domgas trains	395
Condensate and other tanks	235
Flares*	100

* Source: Journal of Applied Ecology: Vol 13, Issue 1, p 177-187, 1976, Published by the British Ecological Society

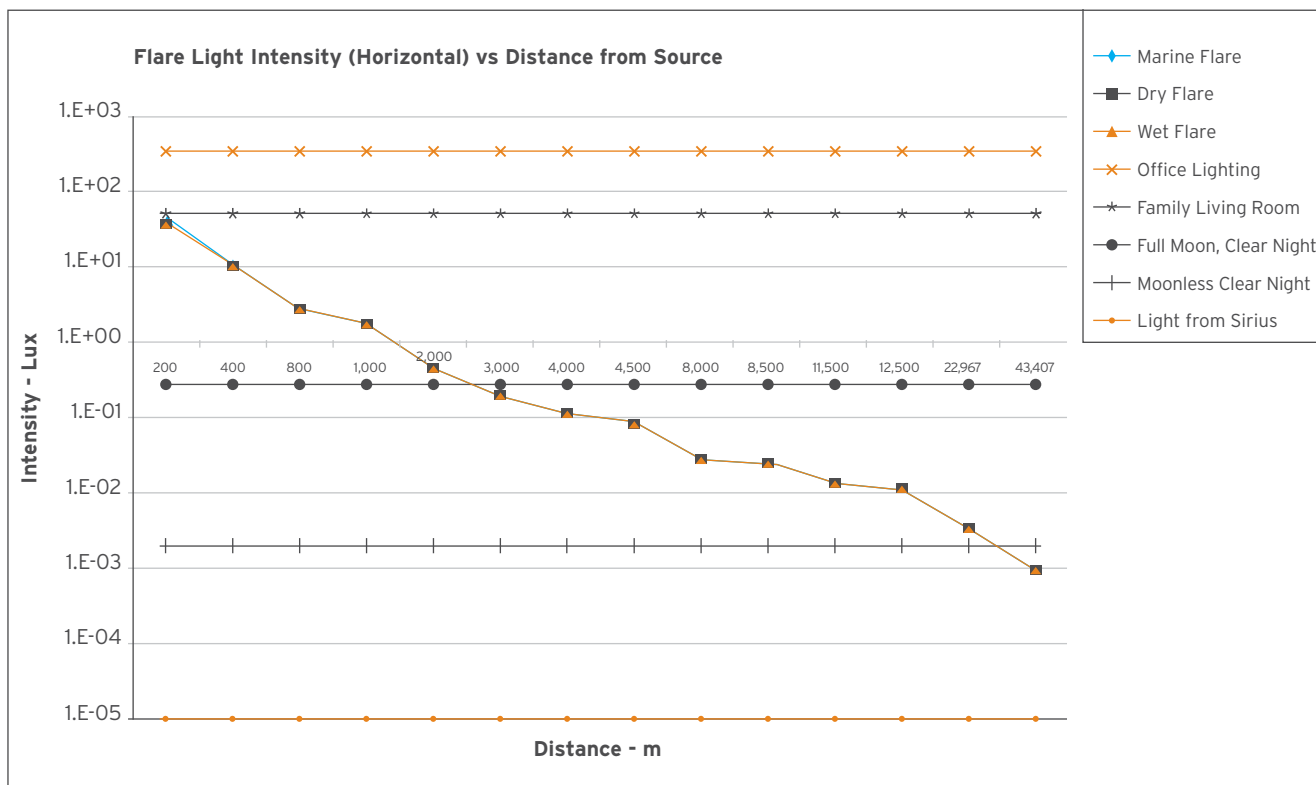


Figure 4.26: Flare Light Intensity with Distance from Source

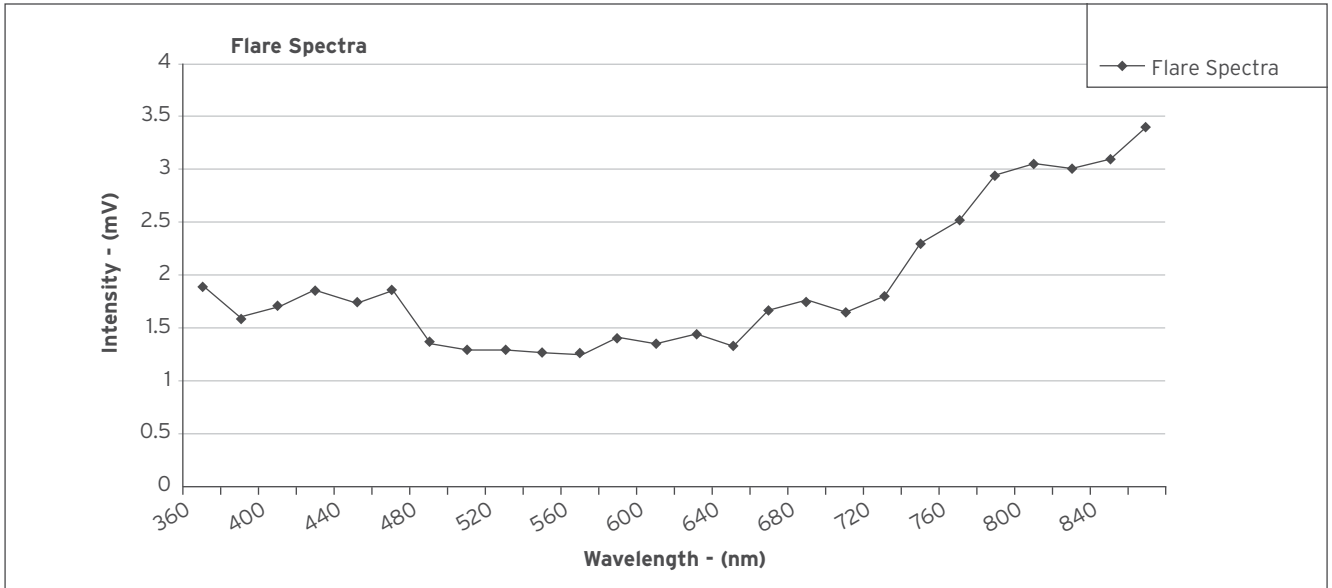


Figure 4.27: Flare Spectrum and Intensity

Source: Pendoley 1996

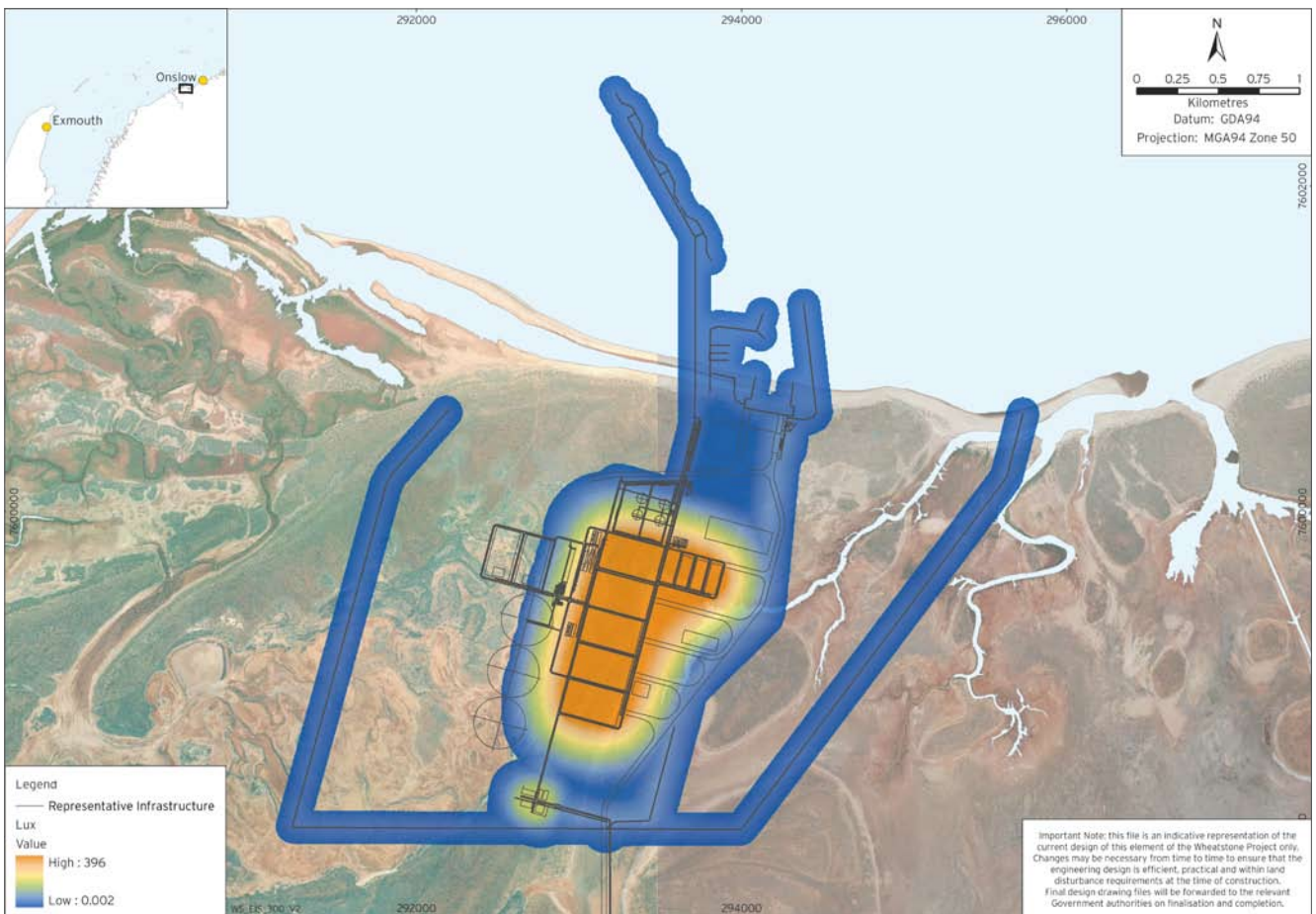


Figure 4.28: Light Intensity

4.5 Noise

4.5.1 Overview

The Pilbara region is characterised by mining and industrial centres separated by large distances. Regional towns are sparsely scattered throughout the Pilbara and tend to be hundreds of kilometres apart. There are also many pastoral stations scattered throughout the region. These properties are large and the homesteads are usually isolated from anthropogenic noise sources. Given the vast distances between receptors and noise sources in the Pilbara region, background noise is often very low.

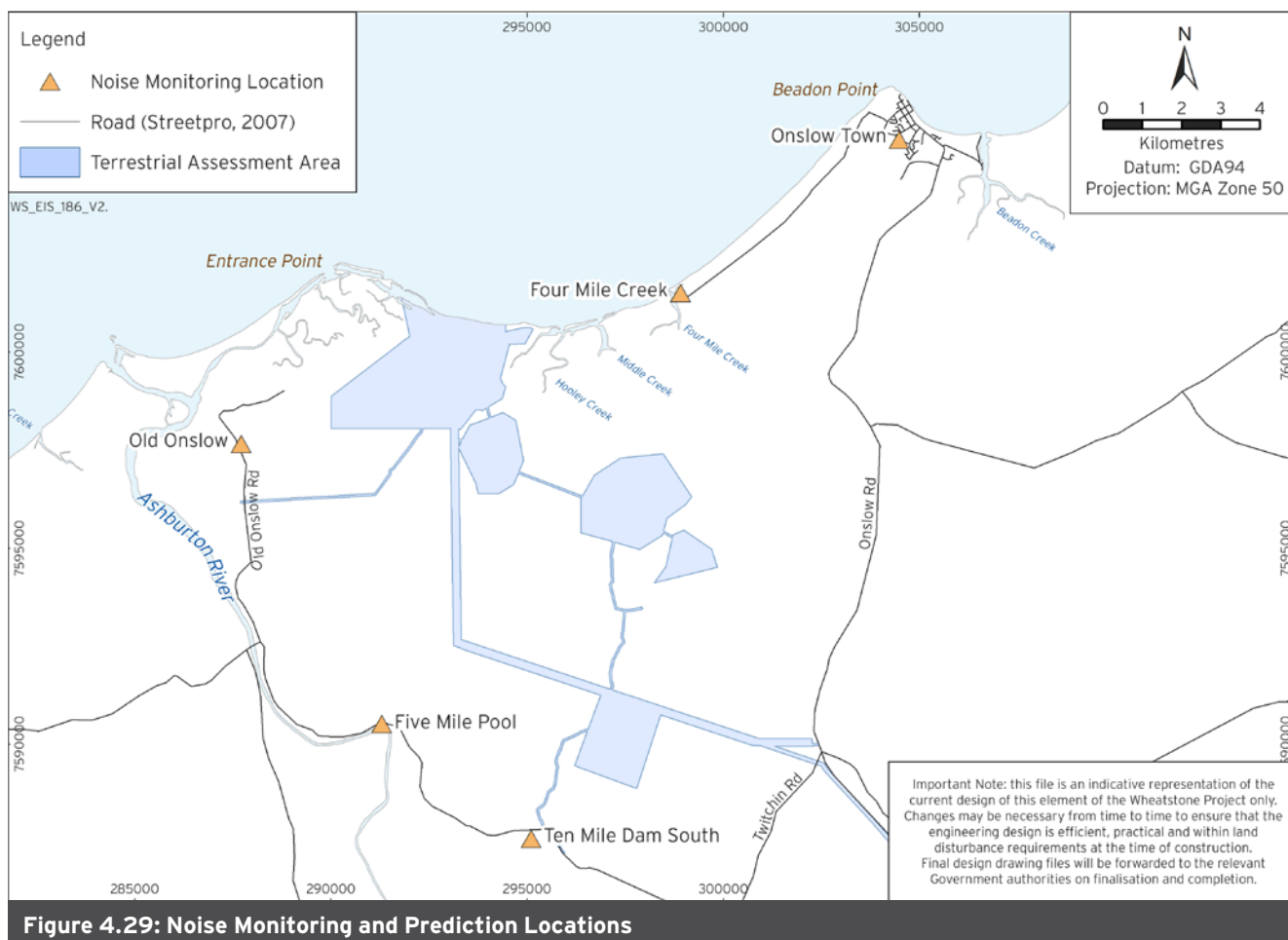
Background noise levels in the coastal areas around Onslow are influenced primarily by ocean noise. Onslow is a regional town with a permanent population of approximately 500 people and a small light-industrial zone.

Recreational areas such as Five Mile Pool (used for camping) and the Old Onslow Town Site heritage area are more remote, located approximately 20 km south-west of Onslow. These areas attract tourists and campers who contribute to noise in the area.

Onslow Salt is the main industrial activity close to Onslow, located approximately mid-way between the town and the Ashburton North SIA. The operation contributes noise sources such as vehicle traffic and process equipment to the background noise levels.

4.5.2 Existing Environment

Continuous onshore noise monitoring was conducted by SVT over a two-week period between 3 June and 17 June 2009 (Appendix E1), at five sites considered by the Onslow community to be sensitive receptors. The selected monitoring sites included the Onslow town site, Ten Mile



Dam, Four Mile Creek, Five Mile Pool and the Old Onslow Town Site heritage area. The Ashburton North SIA and the sensitive receptors to noise are shown in Figure 4.29.

The noise monitoring equipment recorded L_{A1} , L_{A10} and L_{A90} noise levels at 15-minute intervals. Noise level measurements are defined as follows:

- L_{A1} is the noise level exceeded for one per cent of the time
- L_{A10} is the noise level exceeded for ten per cent of the time

- L_{A90} is the noise level exceeded for 90 per cent of the time.

The L_{A90} noise level is applicable for representing background noise levels. Noise measurements are provided in decibels (dB) and have been weighted to approximate human hearing - denoted by "(A)". The monitoring results for the sensitive receptor sites are shown in Table 4.17.

Table 4.18 provides context for understanding noise levels generated from various industrial and urban sources.

Table 4.17: Background Noise Monitoring Levels at Sensitive Receptor Sites

Sensitive Receptor Sites		Underlying Background Noise Level (Average L_{A90}) dB(A)		
		Daytime	Evening	Night-time
Onslow town site		38	41	34
Four Mile Creek (camping area)		38	40	36
Five Mile Pool (camping area)		34	28	25
Old Onslow Town Site (heritage area)		36	34	25
Ten Mile Dam (representative of accommodation village)		38	30	24
	Assigned Night-time Levels	Underlying Background Noise Level (Average L_{A10}) dB(A)		
	L_{A10} dB(A)	Daytime	Evening	Night-time
Onslow town site	35 @ > 450 m from industrial zoning	45	45	39
Four Mile Creek (camping area)	NA	46	45	41
Five Mile Pool (camping area)	NA	44	35	30
Old Onslow Town Site (heritage area)	NA	45	39	28
Ten Mile Dam (representative of accommodation village)	35	52	39	32

Source: SVT 2009

Table 4.18: Typical Comparative Sounds and Their Loudness

Noise Level dB(A)	Typical Sources of these Levels of Noise
55-60	Highway traffic, lawnmower or electric drill operating next door, light aircraft in the distance
45-50	Busy local traffic, strong wind in the trees, noisy air conditioner next door
35-40	Distant suburban traffic, light wind in the trees, quiet air conditioner next door
25-30	Rural area at night, light wind in the grass, far distant traffic

Source: EPA (2007)

WA legislation requires that the maximum L_{A10} noise level for residential areas greater than 450 m from land zoned for industrial use, is 35 dB(A). For industrial sites, the L_{A10} noise level is 65 dB (A).

The existing offshore noise relating to marine mammals is discussed in Chapter 8, *Marine Risk Assessment and Management*.

4.5.3 Offshore Noise

Underwater acoustic emissions during construction and installation, commissioning, operations and decommissioning activities will be influenced by water depth, characteristics of the seabed, characteristics of the noise source (pressure, frequency and duration), background noise levels and thermoclines in the water column. The potential impacts are discussed in more detail in Chapter 8, *Marine Risk Assessment and Management*.

4.5.3.1 Offshore Construction

This phase is likely to result in the most significant noise generation in the Project. Each activity has multiple installation and operation permutations with associated acoustic emissions. It is not possible to determine, at this stage, which of the possible technologies will be utilised for installation and operation of infrastructure during each of the phases. Table 4.19 summarises the potential acoustic sources.

The following provides a general description of potential noise generating activities. Further details are shown in Chapter 8, *Marine Risk Assessment and Management*.

Drilling

Drill rig noise levels are typically between 85 and 135 dB re 1 μ Pa when not drilling and between 100 and 160 dB re 1 μ Pa in intensity when drilling, depending on whether a drill ship, semi-submersible or jack up is used.

Construction Piling

Piling operations may use either piston-type or rotary-type percussive hydraulic hammers using turbocharged diesel engines (above water level) or underwater power-packs, or vibratory head units.

Studies have indicated that percussive pile driving generated source sound-pressure levels peaking at 220 dB at 300 Hz with sound-pressure levels at 500 m away, in 45 m of cold seawater, ranging between 142 to 176 dB (re 1 μ Pa @ 1 m), with sound-exposure levels of 133 to 154 dB (re 1 μ Pa²-s). Acoustic emissions consisted of a low frequency pre-pulse followed by the main pulse. Energy

generated extended up to 20 kHz with most of the energy below 2 kHz. The same studies indicated that vibro-piling generated sound-pressure levels peaking at 142 to 155 dB (re 1 μ Pa @ 1 m). Chapter 8, *Marine Risk Assessment and Management*, provides an assessment of the potential impact of this on the marine environment.

Dredging

Sound levels from some large trailer suction hopper dredges (TSHD) operating in rocky areas have been recorded in excess of 150 dB at 1 km, while large cutter suction dredges (CSD) can emit strong tones that are audible 20 to 30 km away (Richardson *et al.* 1995). Underwater noise levels from self-propelled hopper barges engaged in transferring dredge material can often be higher than the noises from the dredge itself, particularly during the loading and dumping operation of rocky material. Recorded noise levels for large cutter suction dredgers are higher than those associated with grab dredgers.

Trenching

Acoustic emissions produced by subsea trenching operations vary with the nature of the seabed sediments. A trenching noise spectrum reported by Richardson *et al.* (1995), indicated that, for mechanical dredging, generated source sound-pressure levels peaked at 178 dB (re 1 μ Pa @ 1 m) at 160 Hz. Mechanical dredging may have higher acoustic emissions than alternative trenching methods, such as surface sediment fluidisation.

4.5.3.2 Offshore Operations

Pipeline and Trunkline

Given there are no substantial restrictions in the flowlines or pipelines other than the subsea choke and safety and isolation valves (open during routine operations) sound levels from turbulent flow around obstructions will be low. External rock dump, trenching and concrete coatings will serve to insulate sound.

Wheatstone Platform and Wellheads

Given the platform is elevated above sea level, little above-surface noise is transmitted underwater during operations. The current structure will be gravity based so no installation piling is planned.

Wellhead operational noise is typically low (broadband noise around 110 to 115 dB re 1 μ Pa), falling to background levels within a few hundred metres of the wellheads.

Vessel and Helicopter Movements

Acoustic emissions from vessels arise mainly from propeller cavitations and the propulsion drives and is normally a combination of broadband interference and tonal acoustics at specific frequencies. In addition, emissions are generated from inboard dredge pumps, generators, bow thrusters, compressors and welders. This is discussed in more detail in Chapter 8, *Marine Risk Assessment and Management*.

Helicopter acoustic emissions have been determined to have source sound-pressure levels peaking at 122 to 162 dB (re 1µPa @ 1 m) for frequencies of 50 Hz to 7000 Hz. Penetration subsea depends on the angle of the helicopter, helicopter height above sea level and sea state.

Table 4.19: Typical Offshore Construction Acoustic Emissions

Phase	Acoustic Emission Source
Wellhead construction and commissioning	<ul style="list-style-type: none"> Anchor (tension leg) placement or vessel Dynamic Positioning System (DPS) Drilling of exploration/production wells - low frequency acoustics from drill but higher frequency acoustics from drilling vessels, helicopter service vehicles, and flaring Installation of support infrastructure Supply vessels Remotely operated vehicles Heavy-lift vessels Installation support vessels Support vessels and helicopters Power generators
Pipeline and flowline installation and commissioning	<ul style="list-style-type: none"> Surveying the seabed (echo-sounder, side-scan sonar, sub-bottom profiler) Pre-cut trenching by dredgers (backhoe, trailing suction hopper, bucket ladder or grab) Post-laying trenching by ploughing (towed by mother ship) or powered mechanical trencher Pipeline stress reduction by use of rock placement (by fall-pipe vessel) to eliminate free-span sag, as gravel cover, as gravel basement under tie-ins, counter-fill under rock berms in certain seabed conditions, support for cable crossings or as rock armouring Pipelaying vessel, moored or dynamically positioned Heavy-lift vessels Pipe transport vessels
Platform Installation and commissioning	<ul style="list-style-type: none"> Flare Installation and supply vessels Support vessels and helicopters
Near-shore infrastructure development and maintenance	<ul style="list-style-type: none"> Piling operations, including driven-pile foundations, suction piles or spread-concrete foundations Navigation channel, ship turning basin, MOF and pipeline approach corridor dredging Dredge vessels Rock placement during construction and maintenance of MOF and jetty

4.5.4 Onshore Noise

4.5.4.1 Potential Onshore Noise Emissions during Construction

Noise emissions will be generated during site preparation, civil works, mechanical installation of infrastructure and commissioning.

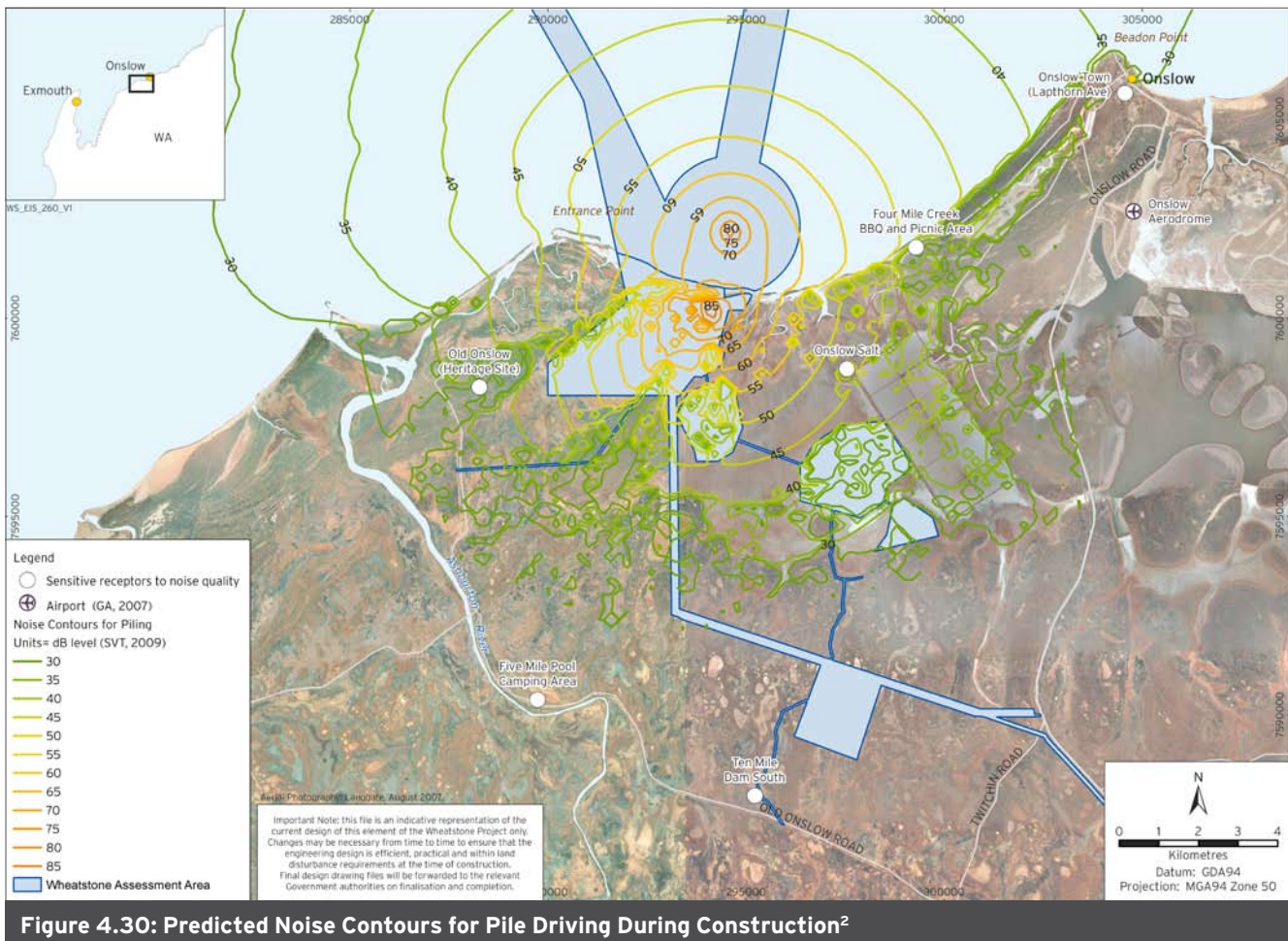
Equipment for site preparation and civil works will include excavators, loaders, compactors, water tankers, pile drivers, dredges, dump trucks and air compressors. It is possible that this equipment will be operating 24 hours per day for seven days per week for the duration of the required work, although it is unlikely that they will be operating at maximum mode simultaneously. However, in order to present worst-case conditions it has been considered that 24-hour operations will occur.

Sound pressure levels for construction equipment range between 60 and 130 dB(A) at 15 m. Typical noise point sources will include dredges for:

- MOF development: 80 to 110 dB(A)
- Compactors: 87 dB(A)
- Dump trucks: 82 dB(A).

The noise emissions from these activities have been modelled and are predicted to fall below guideline values (see Appendix E1).

Onshore and nearshore foundation works may include the use of pile drivers, which may present the most significant potential noise source for Onslow. It is possible that up to ten pile drivers will be operating at the processing facility site for up to 18 months, while pile driving for construction of the export jetty and the MOF may involve two pile drivers for up to 14 months. Modelled noise emissions for the onshore processing facility predict that pile driving, under worst case conditions, may generate sound pressure levels in Onslow of 31 dB(A) – adjusted to 41 dB(A) if pile driving noise is impulsive –



2. SVT Engineering Consultants. *Environmental Noise Impact Assessment - Chevron Wheatstone LNG Plant*, 2009

and 22 dB(A) – adjusted to 32 dB(A) if pile driving noise is impulsive – at the proposed accommodation village site. Modelled predicted noise contours for piling activities are shown in Figure 4.30.

The construction incinerator for treatment of wastes may be located within 1500 m of the accommodation village. Sound emissions from the construction incinerator, including pre-treatment of waste will range between 70 and 100 dB (A) at 1 m. Pre-treatment will include shredding and baling.

A noise management plan will be developed as part of the CEMP.

4.5.4.2 Noise Emissions during Routine Operations

During the operations phase sound pressure levels will be dominated by:

- Gas turbines: 80 to 90 dB(A) at 1 m
- Liquefaction compressors: 80 to 92 dB(A) at 1 m

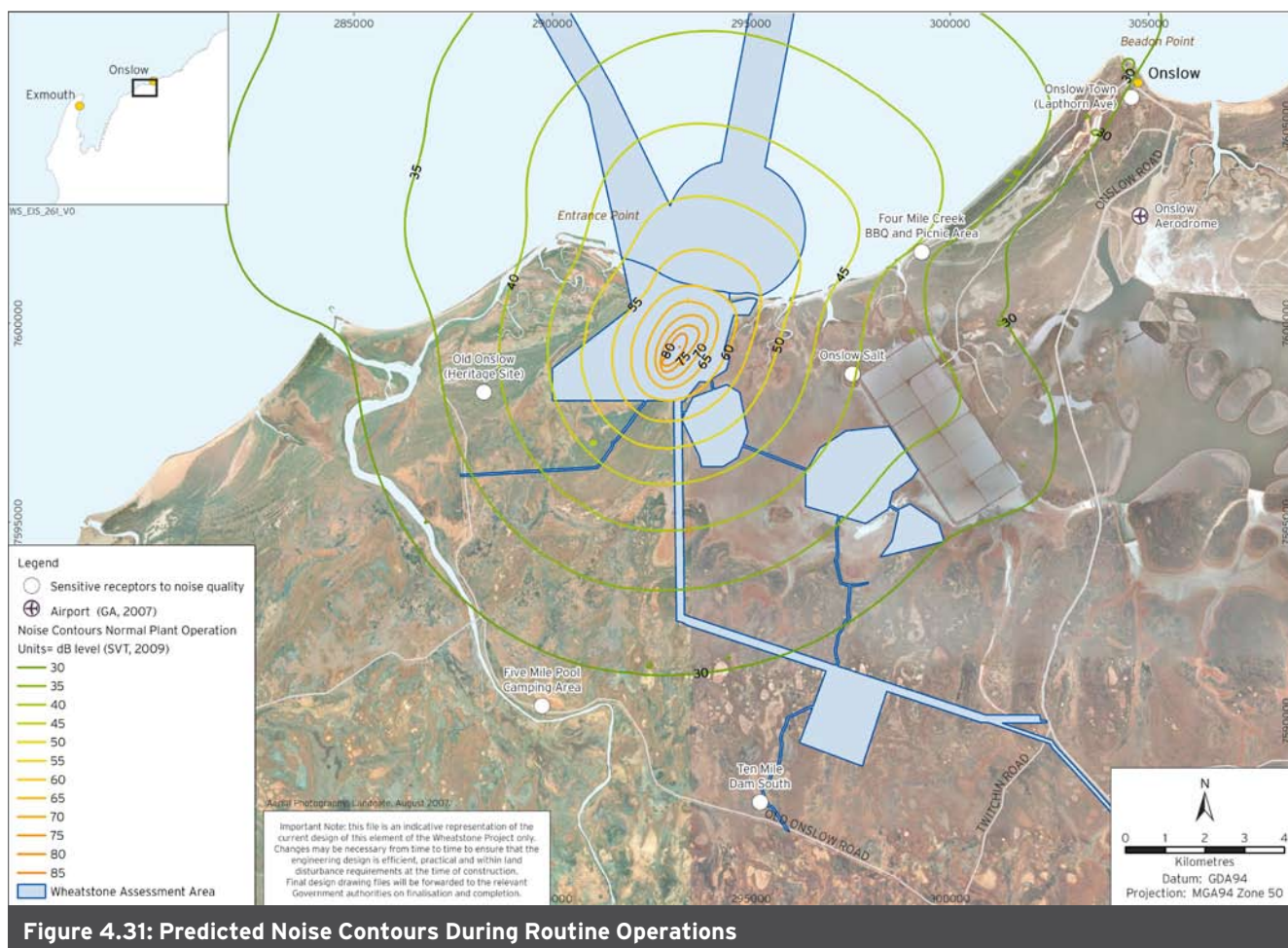
- Elevated flares: 60 to 85 dB(A) at up to 175 m from the flare base³.

The sound pressure levels indicated incorporate the use of the following acoustic dampening techniques:

- Compressor suction, discharge and recycle piping lagged with 100 mm acoustic insulation
- Use of acoustic enclosures for the gas turbines
- Use of silencers on the gas turbine exhausts.

Predicted noise contours for routine operations are shown in Figure 4.31. Chapters 8 and 10 provide more detail of the potential impacts of noise emissions during routine operations.

3. Non-routine noise emissions were modelled based upon flare heights some 50 m lower than current design. This change has been assessed by SVT and is considered immaterial to the final noise contours.



4.5.4.3 Non-Routine Operations

Non-routine operations represent approximately six per cent of plant availability. During upset conditions the flares may operate to maintain the facility within safe operational guidelines. Wet and dry flares (85 dB(A) at 150 m from the base), represent significant point source emissions. Predicted noise contours for non-routine operations are shown in Figure 4.32. Chapter 10, *Social Risk Assessment and Management* provides more detail of the potential impacts of noise emissions to the community during non-routine operations.

4.6 Marine Discharges

4.6.1 Overview

This section discusses the possible discharges and wastes from the offshore facilities and the discharges from the onshore facilities into the nearshore environment.

The possible discharges and wastes from the offshore facilities will be treated wastewater, including PW, sewage water, cooling water (CW), hydrostatic test water, hydrocarbon contaminated water, drill cuttings and fluids.

Potential onshore placement of dredged material will generate large volumes of decant water containing elevated levels of total suspended solids that will be gravity released into the nearshore environment. This topic is discussed in Chapters 8 and 9.

Discharges to the marine environment during each phase of the Project are summarised in Table 4.20.

No controlled waste (as defined by the Environmental Protection [Controlled Waste] Regulations 2004) will be discharged to the marine environment. Controlled wastes and all other non-biodegradable solid wastes will be sent for onshore treatment and disposal or recycling and reuse as appropriate.

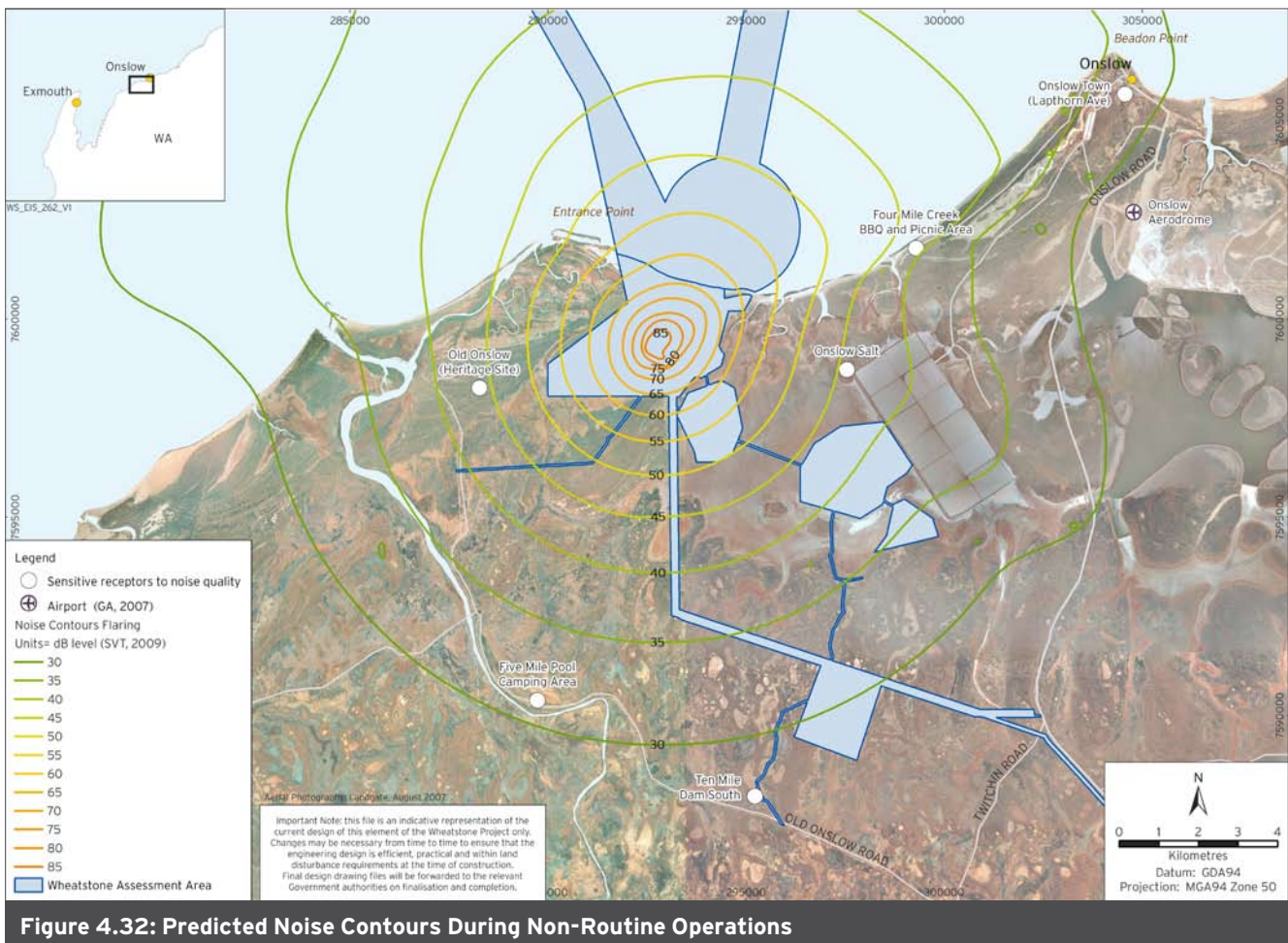


Table 4.20: Summary of Marine and Nearshore Discharges

Discharge	Drilling	Construct	Commission	Operations	Decommission
Offshore Facilities					
Drill cuttings	●				
Drill fluids	●				
Sludges/sand	●			●	
Completion fluids	●				
Deck drainage	●		●	●	●
Sewage	●	●	●	●	●
Galley wastes	●	●	●	●	●
Reverse osmosis rejects	●	●	●	●	●
Ballast water		●	●	●	●
Cooling water	●		●	●	
Process water				●	
Storm water				●	
Hydrate inhibitor			●	●	
Produced water			●	●	
Control fluids		●	●	●	
Process chemicals		●	●	●	
Hydrostatic test			●		
Onshore Facilities					
Sewage		●	●	●	●
Produced water			●	●	
Reverse osmosis rejects		●	●	●	●
Treated process water			●	●	●
Ballast water		●	●	●	●
Decant water		●			
Stormwater		●	●	●	●
Hydrostatic test		●			

4.6.2 Offshore

4.6.2.1 General Wastes

Food scraps from the offshore accommodation facilities will be macerated to less than 25 mm in size, where practicable, to enhance ease of dispersion and discharged overboard with other treated waste waters in compliance with MARPOL 73/78, Annex V and the Protection of the Sea (Prevention of Pollution from Ships) Act 1983.

General solid waste, including scrap metal, plastics, glass, other inert wastes, hydrocarbon-contaminated materials, spent process chemicals and containers, will be transported to the onshore facilities for appropriate treatment and disposal.

4.6.2.2 Ballast and Bilge Water

Vessels and structures arriving from overseas locations are required to exchange 95 per cent of their ballast water in depths greater than 200 m outside Australian territorial waters in line with an approved Ballast Water Management Plan. Compliance with this regulation is administered by the Australian Quarantine and Inspection Service (AQIS).

The control and management of bilge and ballast water is described in greater detail in Chapter 8 *Marine Risk Assessment and Management*.

4.6.2.3 Chemical Use

The potential for impacts upon the marine environment from discharges and wastes will depend upon the volumes and the ecotoxicity of the materials discharged. The choice of chemicals used during drilling, commissioning, routine production, non-routine production and decommissioning will be guided by the Oslo and Paris Commissions (OSPAR) Recommendation 2000/4 on Harmonised Pre-screening Scheme for Offshore Chemicals. This scheme requires that chemicals for use in the offshore petroleum industry consider toxicity, biodegradation, bioaccumulation and bioconcentration in selection of chemicals.

4.6.2.4 Chemical Transfers

Drilling rigs and the offshore facilities are likely to be supplied with chemical reagents and diesel fuel on a regular basis. Chemicals may include drilling muds, biocides, lubricants, compressor oils, disinfectants, MEG, TEG, heating oils, detergents, various acids and alkalis, chemicals for reverse osmosis treatment and conditioning, and a multitude of other chemicals.

Transfer of reagent and waste chemicals between the drilling rigs, WP and service vessels will be managed in line with appropriate legislation and guidelines.

Spill response procedures will be developed, containment and recovery equipment will be on hand and personnel will be trained in the use of the equipment.

The risk associated with transfer of chemicals and wastes in the offshore environment is discussed further in Chapter 8, *Marine Risk Assessment and Management*.

4.6.2.5 Drilling Discharges and Wastes

Drilling Fluids

Drilling fluids ("muds") will be used during the drilling of production well bores for:

- Cooling the cutting tip of the drill bit
- Lifting the drill cuttings to the surface
- Providing buoyancy to the drill string
- Sealing permeable formations
- Providing a balance to pressure from the formation to reduce the potential for well kicks and well blow-outs.

Drilling fluids are composed of a variety of different components, each with its own specific function. Drilling fluids used for the development of well boreholes may be either water-based muds (WBMs) or synthetic based muds (SBMs). For WBMs, the continuous phase is normally over 75 per cent water with over 50 per cent of the balance attributable to barite (barium sulfate), bentonite clay and salt. For SBMs, the continuous phase is an organic chemical compound, such as esters, olefins, paraffins and polyols, synthesised specifically for formulation of the mud product.

WBMs have limitations for some applications, particularly where water sensitive formations can result in hole enlargement or collapse. SBMs are beneficial in drilling situations with high downhole temperature, hydratable shales or salt, and for high-angle directional, horizontal and extended-reach wells.

During drilling, the drill fluids are re-circulated. Mud and cuttings are brought to the surface and passed through separation equipment (shale shaker) where the cuttings and mud are separated (see Chapter 2, *Project Description*). As drilling proceeds, sand and silt not removed by the shale shaker accumulate in the mud. The sand and silt are periodically separated in desilters and desanders.

At the end of the drilling operation, or occasionally during a drilling campaign, a large portion of the mud is discharged or disposed. WBMs may be discharged overboard whereas SBMs will be pumped to a vessel's storage tanks and transported to shore for reconditioning and re-use on other wells or disposal (typically incinerated) in an approved manner.

Drill Cuttings, Sand and Silt

Drill cuttings are particles of crushed rock, sand and silt, produced by the grinding action of the drill bit as it penetrates the ocean floor, that are carried to the surface during subsea well construction.

Cuttings discharged at the completion of or during drilling campaigns using WBMs usually contain five to 25 per cent drilling fluids, whereas cleaned SBM cuttings normally contain less than 10 per cent synthetic chemical. Cuttings may also contain small amounts of hydrocarbons from the geologic strata under penetration.

Drill cuttings discharged overboard from the MODU may result in an increase in the turbidity of the water column below the MODU during well development campaigns. Cutting piles may develop on the ocean floor as a result of drill cutting disposal, water depth and dispersion due to current and wave action. The impact of cutting piles on bottom living biological communities is related mainly to smothering and low sediment oxygen concentrations caused by organic enrichment and toxicity of the drill chemicals and hydrocarbons.

Sludges and sand that are separated from the drilling muds may contain residual contamination from the drilling mud. Sand and silt recovered from the desanders and desilters may contain hydrocarbons and, potentially, minor quantities of naturally occurring radioactive materials (NORMs) and heavy metals.

Each drilling campaign will be subject to an approved Environment Plan under the Offshore petroleum and Greenhouse Gas Storage (Environment) Regulations 2009.

4.6.2.6 Commissioning

Modules and equipment will be pre-commissioned, wherever possible, to reduce the requirement for commissioning in the field.

Hydrostatic Test Fluids

Pressure vessels on the production platform and infield and export pipelines will be pressure tested to ensure that they are capable of maintaining operational pressures without failure. Some vessels may be pneumatically tested while large vessels and the pipelines will be hydrostatically tested. Hydrostatic testing requires that pressure vessels or pipelines are filled with water. A selection of inhibitors—such as low toxicity biocides, oxygen scavengers and corrosion inhibitors—and a tracer dye are added, and then pressure in the system is increased to highlight defects.

The nearshore and offshore portions of the Trunkline are likely to be installed by different pipelay vessels due to the

limited water depth along the nearshore section. The schedule for the two pipelay spreads is such that the offshore portion of the Trunkline may be installed prior to the nearshore section or visa versa depending on vessel availability. This may require flooding of the nearshore and/or offshore portions of the Trunkline separately, both temporarily during installation and on completion of pipelay. This could be for the purposes of ensuring stability in a cyclone prior to secondary stabilisation being installed and to confirm the integrity of the Trunkline. In addition to the planned flooding and dewatering operations, it may also be necessary to perform a contingency flood and dewater in the unlikely event of dry or wet buckle during installation.

Flooding of the Trunkline could be from onshore to offshore or conversely from offshore to onshore depending on the available vessel spreads and practicalities of obtaining water from the shore crossing location during certain seasons of the year (namely cyclone season).

If flooding is to be performed from onshore to offshore then the water will be obtained from the sea in the vicinity of the shorecrossing location, and will be taken from a suitable depth so as to avoid the ingress of excessive amounts of siltation. In all cases, when flooding from onshore to offshore, it is anticipated that a temporary lagoon will be required at the shore crossing site to hold a contingency volume of uninhibited seawater to mitigate against the flooding operations being affected by tidal or mechanical delays.

Alternative options are also under investigation to obtain water from the jetty location or to utilise water from the temporary lagoon used for onshore pressure vessel testing; both these options would require the installation of a temporary onshore pipeline within the site boundary.

The Trunkline and carbon steel infield lines will be flooded with filtered seawater containing chemicals to control oxygen levels and biological growth. The corrosion resistant alloy clad infield lines will be flooded with filtered seawater, or fresh water depending on corrosion assessment, containing chemicals to control oxygen levels and biological growth. If flooding of the nearshore Trunkline is required, in an emergency, then discharge during the flooding and subsequent dewatering operations of the nearshore portion of the line may be at any location in the nearshore area. Dewatering of the offshore portion of the Trunkline, if required temporarily and on completion of Trunkline installation, will be such that the hydrotest water is discharged at the platform location.

The infield lines may be flooded from the drill centres or the platform location depending on installation contractors and

equipment selected. The discharge point for the infield lines flooding and hydrotest water is likely to be at the platform location, although this could also be at the drill centres for certain lines depending on the selected precommissioning philosophy.

The approximate volume of hydrotest water for the Trunkline and infield lines, to cover the range of contingency flooding, dewatering and final hydrotest requirements, is 956 000 m³

Choice of chemicals will be guided, where practicable, by OCNS. The export pipeline and infield production lines may require swabbing with MEG to remove residual water prior to commissioning.

Discussion of the impacts and management of hydrostatic test water discharges is included in Chapter 8, *Marine Risk Assessment and Management*

4.6.2.7 Production Discharges

Subsea Control Fluids

Subsea hydraulic control systems are used for operation of valves and chokes on valve trees, manifolds and pipelines. These systems require the use of hydraulic fluids that can operate at required speeds and at challenging temperatures and pressure. In such “open-loop” systems, a small volume of hydraulic fluid is released into the environment each time the valves actuate. To reduce the potential impact of these releases, the hydraulic fluid selection will be guided by OCNS as described above.

The volume of control fluids required will depend upon a number of factors including; number of wells and manifolds, size and types of control valves, number of platform shutdowns, trips and emergency shutdowns and the well testing strategy assumed. It is estimated approximately 70m³ per year will be used for routine operations.

Produced Water

Offshore Facilities Wastewater Discharges

Up to approximately 6 600 m³ of PW (excluding MEG), 114 m³ RO brine, and 182,000 m³ CW may be discharged from the offshore facilities each day. Discharge volumes may increase during shutdowns.

Up to 29 m³ per day of sewage and putrescible organic matter, treated in compliance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78, Annex IV), may be discharged overboard from the WP. Detergents used in grey water will be low nutrient types, where practicable.

Treated wastewater, discharged overboard, will undergo a range of degradation and dispersion processes. Direct dilution will occur in two phases: rapid near-field and slower far-field. The first phase is impacted by the discharge velocity / momentum and density differences between the discharge and surrounding water body. The second phase is far-field mixing which relies on natural processes of winds and waves inducing dilution. Plume distribution is determined by tidal flows, wind velocity and regional circulation patterns.

Dispersion modelling of offshore facility discharges is discussed in Chapter 8, *Marine Risk Assessment and Management*.

Hydrate Inhibitors

Hydrates are crystals consisting of water and certain hydrocarbons. Hydrate formation can cause blockages in flow lines and subsea wellheads. These blockages can be potentially hazardous.

Under normal operations hydrates are not expected to occur. However, after maintenance or emergency shutdowns, hydrate inhibitors may be required to ensure that blockages do not occur in the flowlines and risers.

It is anticipated that either kinetic and/or thermodynamic hydrate inhibitors, such as MEG, will be used to inhibit hydrate formation during commissioning and start-up of operations. MEG would be injected through dedicated delivery lines and then returned with the production fluids to the offshore facility. Chapter 2, *Project Description* provides an overview of the MEG system and includes estimated volumes.

Discharge of MEG would be intermittent in varying volumes and durations. The duration and volume of the MEG used depends on a number of factors, including the water cut and the degree of flowline cooldown. Work is progressing on minimising MEG volumes; however, the current conservative predictions are for a maximum MEG injection case (i.e. when PW volumes are high and seabed temperatures are low) of 150 m³/hr for 18 hours. Assuming more typical operating conditions the MEG injection rates are expected to be between 20 and 50 m³/hr, with total MEG injection volumes around 1000 m³.

The discharge will form part of the PW stream. Disposal during each event is estimated to last for less than 24 hours with the MEG dispersion expected within 24 hours of cessation of discharge. MEG toxicity is assessed as very low (ANZECC and ARM CANZ 2000). MEG is also readily biodegradable in water with degradation likely to occur through aerobic bacterial activity.

Discussion of the impacts of MEG discharges is included in Chapter 8, *Marine Risk Assessment and Management*.

Other Production Chemicals

A number of chemicals may be discharged to the marine environment with the PW. These chemicals include antifoams, scale inhibitors, kinetic hydrate inhibitors, corrosion inhibitors, biocides, oxygen scavengers, pH adjusters, emulsifiers and demulsifiers. The chemicals may be added either continuously or intermittently and will partition between the hydrocarbon phase and the water phase to varying degrees.

Small volumes of methanol may be required primarily for hydrate remediation purposes. In this case methanol would return to the WP and the bulk would be discharged overboard via the PW System while minor volumes may continue to onshore.

Naturally Occurring Radioactive Material

NORMs are a result of naturally occurring radiation in shales and silts. Fluid property reports for both the Wheatstone and Iago fields indicate that Pb-210 is marginally high, while all other NORMs are below average or minimal. As the production of NORMs is anticipated to be minimal, there is no expected impact to the marine environment as a result of offshore discharges.

Should the levels of NORMs increase or be found in levels presenting a risk, proposed management shall be in line with the legislation and industry guidelines.

Cooling Water

CW will be required at the offshore facility for a number of purposes. CW will be sourced from the ocean and treated with an appropriate biocide additive before being circulated through the closed-loop, tempered water system. As seawater is not directly circulated against heat exchangers containing hydrocarbons but will be circulated against the closed loop system there is no likelihood of CW being contaminated by hydrocarbons prior to discharge. Environmental impacts from the discharge of CW will be managed through the consideration of discharge rates and temperature, and discharge caisson design (such as depth and diameter).

Further discussion of the impacts and management of water temperature increase resulting from the Project is included in Chapter 8, *Marine Risk Assessment and Management*.

Deck Drainage

Deck drainage may consist of wash-down water, routine fire drill water containing aqueous film-forming foams and first flush rainfall run-off (from plated areas), all of which may contain hydrocarbons and other process chemicals. The offshore platforms will be constructed so as to collect any potentially hydrocarbon-contaminated first-flush stormwater in the open drains system. The stormwater then passes to the slops tank and oily water separation system where it will be treated prior to discharge overboard through the open drains caisson. A proportion of deck drainage may discharge directly overboard.

Further discussion of hydrocarbon discharges and their impacts and management is included in Chapter 8, *Marine Risk Assessment and Management*.

4.6.3 Nearshore

4.6.3.1 Anti-fouling Compounds

Antifouling coatings and the potential impact on the environment are discussed in Chapter 8, *Marine Risk Assessment and Management*.

4.6.3.2 Construction

Marine discharges associated with nearshore construction activities are discussed in Chapter 2, *Project Description*.

4.6.3.3 Pre-commissioning and Commissioning Hydrostatic Test Fluids

Pressure vessels, including pipelines, at the onshore LNG production facility will be pressure tested prior to commissioning to ensure that they are capable of maintaining operational pressures without failure. Some vessels may be pneumatically tested while large vessels and pipelines may be hydrostatically tested. Hydrostatic testing requires that pressure vessels or pipelines be filled with water and then the pressure is increased in the system to highlight fatigue cracks, weld imperfections and leaks through the monitoring of the water pressure over a period of time. If the integrity is compromised, a pressure drop will be observed. Sometimes there is the addition of inhibitors, such as low toxicity biocides, oxygen scavengers, corrosion inhibitors and a tracer dye, added to the hydrotest water, if necessary depending on water source and residence time in the tanks/pipes.

The chemicals chosen will be guided, where practicable, by OCNS. Hydrostatic test water may be treated and discharged through one of the nearshore ocean outfalls and is estimated to amount to over 180 000 kL.

Table 4.21: Summary of Waste Generation Source

Discharge	Construction	Commission	Operation	Decommission
Examples of Offshore wastes brought onshore				
Sludges		●	●	●
Personal protection	●	●	●	●
Electronics		●	●	●
Pallets	●	●	●	●
Containers	●	●	●	●
Plastics	●	●	●	●
Paper/cardboard	●	●	●	●
Controlled wastes*	●	●	●	●
Filters		●	●	●
SBMs		●	●	●
LNG facility/Export jetty wastes				
Putrescible	●	●	●	●
Paper/cardboard	●	●	●	●
Radioactive loggers		●	●	
Personal protection	●	●	●	●
Electronics	●	●	●	●
Pallets	●	●	●	●
Containers	●	●	●	●
Plastics	●	●	●	●
Controlled wastes*	●	●	●	●
Molecular sieves		●	●	●
Ash	●	●	●	●
Quarantine waste	●	●	●	●
Biosolids	●	●	●	●
Cellulose		●	●	●
Filters	●	●	●	●
Activated carbon		●	●	●
aMDEA		●	●	●
Accommodation village wastes				
Putrescible	●	●	●	●
Paper/cardboard	●	●	●	●
Electronics		●	●	●
Pallets	●	●	●	●

Discharge	Construction	Commission	Operation	Decommission
Containers	●	●	●	●
Plastics	●	●	●	●
Grease and oil	●	●	●	●
MOF wastes				
Controlled wastes*	●	●	●	●
General wastes	●	●	●	●

* Controlled Wastes include aerosols, light globes, paint, solvents, clinical wastes, batteries (NiCad, lithium, lead-acid), coolants, oils, grease, absorbents contaminated with hydrocarbons, tyres.

Hydrotesting is discussed in Chapter 2 *Project Description*. Discussion of the impacts and management of hydrostatic test water discharge is included in Chapter 8 *Marine Risk Assessment and Management*.

4.6.3.4 Operations Discharges

Ballast and Bilge Water

Ballast water will be discharged into nearshore waters during LNG loading activities to maintain vessel stability in line with Australian and international (MARPOL) regulations. This water will be clean seawater, isolated from bilge water and is not expected to have an adverse environmental impact upon discharge.

Bilge water from dedicated service vessels will be handled by third-party service providers for treatment and disposal. The facility will not receive bilge water or grey water from third party vessels arriving at the PLF or MOF.

Chemical Transfers

Transfer of reagents and waste chemicals between dedicated service vessels and onshore storage vessels at the MOF may occur. This will be managed in accordance with appropriate legislation and guidelines.

Diesel refuelling of dedicated operation support vessels will be carried out using transfer hoses fitted with “dry break” couplings. Spill response procedures will be developed, containment and recovery equipment will be on hand and personnel will be trained in the use of the equipment.

Risks to the environment associated with transfer of chemicals and wastes are discussed in Chapter 8, *Marine Risk Assessment and Management* and Chapter 9, *Terrestrial Risk Assessment and Management*.

Sewage and Domestic Discharges

Treated sewage and domestic grey water generated during the operations phase may be discharged through one of the nearshore ocean outfall pipelines. Volumes for discharge may range up to 435 kL per day. Treated domestic effluent may achieve a quality suitable to be recycled for dust suppression and vehicle wash water.

Process Water Discharges

During operations, process waters will include reverse osmosis brines and filter backwash water, stormwater contaminated with hydrocarbons, clean stormwater, hydrostatic test water, and PW from offshore facilities. This water will be treated through different parts of the plant, depending upon the source and the level of contamination.

Treatment methods may include:

- Reverse osmosis brines and filter backwash - discharged without treatment through an ocean outfall. Anticipated volumes range up to 5600 kL per day
- Stormwater - after a first flush of around 25 mm of water it is anticipated that clean (non-contact) stormwater will be discharged through the sedimentation ponds. Stormwater volumes will vary but may be up to 9,600 kL per day. Contact stormwater and process water volumes are anticipated to range up to 3100 kL per day, although anticipated volumes are variable due to the erratic rainfall patterns of the region. The proposed collection system for this first flush is shown in Chapter 2 *Project Description*
- PW - passes through the MEG recovery and oily water separation system prior to discharge through an ocean outfall. Anticipated volumes are up to 13 200 kL per day.

Further discussion of discharge water quality, the potential impacts to the environment and planned management measures are included in Chapter 8 *Marine Risk Assessment and Outcomes*.

Marine Outfalls

There is likely to be several marine outfalls for the 25MTPA project. These are likely to be in two main locations; beneath the jetty at the 5m contour, and running adjacent to the trunkline to the 20m contour. The discharges from these outfalls is discussed further in Chapter 8, *Marine Risk Assessment and Management*.

4.7 Waste Management

4.7.1 Overview

This section discusses the onshore reuse, recycle or disposal of wastes into the terrestrial environment.

Waste recycling, treatment or disposal will be required for wastes from the onshore facilities and for waste generated offshore for management onshore, such as inert solids and controlled wastes, including dangerous goods. Waste generated during each phase of the Project are summarised in Table 4.21.

Wastes can be segregated into recyclable and dispose only materials.

- Recyclable materials include:
 - Economically recyclable - materials that provide a positive economic return, accounting for transport costs to the recycling markets in Perth, the Eastern States or overseas. In broad terms, recyclables will include ferrous and non-ferrous scrap metal, heavy casing filters, some plastics and certain electronic goods. These materials may be crushed to provide maximum transport densities
 - Uneconomically recyclable - materials may include inert solids, such as concrete batch plant residue, glass, decontaminated ceramics, and compostable materials such as paper, green waste, biosolids, putrescibles and timber (not treated with methyl bromide or copper/chrome/arsenate)
 - Controlled recyclable - materials that are controlled wastes requiring initial pre-treatment to allow recovery of all or most of the waste. Such wastes may be economic, such as aerosol cans or uneconomic such as activated carbon.
- Dispose only - Controlled wastes are materials that are defined by legislation to be too hazardous to be disposed to Class I, II or III landfills without treatment

or encapsulation, or to be disposed to a sewer as a trade waste. Controlled wastes, above a minimal threshold volume, must be packaged appropriately and then transported and treated by DEC licensed service providers. Controlled wastes for onsite treatment or disposal to third-party service providers may include both prescribed and quarantine wastes.

4.7.2 Existing Waste Disposal Options

Waste management in the Pilbara region is currently limited to:

- Shire operated Class II landfill disposal. Shire operated Class II landfills are generally unlined landfills that can accept inert wastes, putrescible wastes, compostable organics, biosolids and certain special wastes, such as clinical waste. Class II landfills cannot accept controlled waste. Chevron is not intending to use these sites. Controlled wastes, including quarantine wastes, can be either transported to Perth for treatment and disposal or disposed to appropriate, local, third-party waste service providers
- Transport of waste to Perth for recycling, treatment and/or disposal
- Disposal of waste to private, third-party, waste management service providers (i.e. Port Hedland hazardous waste incinerator).

4.7.3 Offshore

During construction and installation, there may be a requirement for additional offshore accommodation in the form of a floatel or similar. This may be near the proposed platform location.

All solid wastes generated offshore during construction and operations will be transported to shore for onshore disposal. The only exception to this would be putrescibles organic matter and sewage. This would be treated in line with MARPOL requirements.

4.7.4 Onshore

4.7.4.1 Construction Wastes

During the construction phase a waste management area is proposed. This waste management area would be constructed to handle appropriately segregated wastes. These wastes will be segregated by type and toxicity. The wastes will be stored in accordance with Australian standards and will be covered and banded, where appropriate.

Table 4.22: Estimated Peak Construction Waste Tonnage

Recyclable Wastes (t/yr)		Controlled Wastes (t/yr)	
Accommodation Village Rubbish		Waste Oil	30
		Batteries	250
Food	2 300	Biosolids	200
Paper	1 500	Engine oil filters	15
Cardboard	300	Electrical Fibre optic scrap	80
Glass	500	Welding rod tips	70
Plastics	900	Used tyres	500
Total Accommodation Village Rubbish	5 500	Air filters	250
Dunnage	1 300	Aerosols	100
Scrap Metal	1 100	Fluorescent tubes (no mercury)	100
Steel and Aluminium	90	Sealant containers	3
General inert	1 500	Incinerator ash	700
Total	9 490	Total	2 298

* Totals from estimated maximum year of construction

Table 4.23: Estimated Peak Operations Waste Tonnage

Recyclable Wastes (t/yr)		Controlled Wastes (t/yr)	
Trash		Waste lubricant oil	30
Food	70	Spent oils	4
Paper	50	Biosolids	15
Cardboard	10	Oily sludge/float	23
Glass	20	Spent solvents	1
Plastics	25	AGC (amine)	567
Total Trash	175	AGC (mercury)	135
Molecular Sieve Waste	238	Cellulose	4
Dunnage	15*	aMDEA	250
		Incinerator ash	50*
		Quarantine	50*
Total	428	Total	1129

- All figures from Bechtel except those marked *. These have been sourced from similar industries in the Northwest of WA

Table 4.24: Onshore Waste Management

Waste Type	Waste Management (Average Tonnes per Year)			
	Construction		Operations	
	tonnes	% Contribution	tonnes	% Contribution
Economic recyclable	1820	15%	238	15%
Uneconomic recyclable	8300	70%	190	12%
Controlled	1668	14%	1129	73%
Total	11 788		1557	

Recyclable Material

Recyclable wastes will primarily be generated by onsite clearing and by construction of concrete footings, pads and plinths, and by wastes resulting from the installation of equipment, electrical and plumbing systems. Considerable quantities of dunnage and other packaging wastes, including steel strapping, will also be generated. Estimated annual waste generation during construction is presented in Table 4.22. Wastes may be source-segregated into economic and uneconomic for further waste management.

Controlled Wastes

Controlled wastes generated during construction may include batteries, lubricants, aerosol cans and tyres. Estimated annual controlled waste tonnages generated during the construction phase are shown in Table 4.22.

4.7.4.2 Operation Wastes

Wastes generated during the operations phase will be mainly related to spent process chemicals and consumables. Relatively minor quantities of “domestic” wastes will be generated after the completion of construction activities due to the significant reduction in onsite personnel. A waste management area is proposed for the operational phase. This waste management area would be constructed to handle appropriately segregated wastes. These wastes will be segregated by type and toxicity. The wastes will be stored in accordance with Australian standards and will be covered and banded, where appropriate.

Recyclable Materials

Recyclable materials generated during the operations phase consist mainly of ferrous and non-ferrous scrap metal. Decontaminated inert wastes, such as ceramic balls and molecular sieves form a significant portion of

wastes that are uneconomic to recycle. Estimated waste generation during operations are shown in Table 4.23.

Controlled Wastes

Controlled wastes estimated to be generated during the operations phase are shown in Table 4.23. Controlled wastes will include a range of process chemicals and column packing materials. The main materials are activated granular carbon (AGC) in the amine and mercury removal units (this may occur very infrequently), molecular sieves, and filters contaminated with hydrocarbons. The main spent reagent will be activated methyl diethanolamine (aMDEA) from the acid gas scrubber unit. Certain oily wastes, such as slops and knock-out drum bottoms will also form a significant waste stream.

Scale

Although flowlines and pipelines may be dosed with scale inhibitor, it is likely that small quantities of scale formation may occur during normal operations of the onshore and offshore facilities. Scale is likely to be collected at the slug catchers and inlet separators. Scale will normally consist of barium and strontium sulfates and calcium carbonate. It is possible that scale may also develop that contains double salts of radium sulfate (NORM). NORMs may occur from the reservoir; however, initial indications are that levels are considered low. Scale removed from the unit during maintenance will be disposed offsite by an appropriately licensed third-party service provider.

4.7.5 Waste Disposal Options

A landfill south of the main town of Onslow (See Chapter 5, *Stakeholder Consultation*) was described as “nearing the end of its operational life” in the 2003 Onslow Structure Plan. Since this time, the Shire of Ashburton has employed consultants to identify new sites for a potential landfill.

These sites are currently undergoing further investigation. Chevron will review the preferred location and construction of the planned landfill to determine if it is appropriate for use.

Economic recycling may be employed for a range of materials that can be processed and recycled as secondary resources, representing approximately 15 per cent (see Table 4.24) of waste tonnage. These materials include ferrous and non-ferrous scrap (including batteries and electronic waste). These materials will be consolidated and transported to waste markets for on-selling.

Uneconomic recycling accounts for between 12 and 70 per cent (see Table 4.24) of waste tonnage and can be employed for inert materials, such as concrete, glass, and materials that form mulch or compost, such as green waste, dunnage, paper and cardboard. During construction, uneconomic wastes will be managed by either in-house pre-treatment and/or incineration or by third-party waste disposal. During operations, consideration of environmental and economic outcomes will determine the preferred waste management outcome.

Controlled wastes form the balance of generated waste and account for between 14 and 73 per cent (see Table 4.24) of the waste tonnage, including quarantine wastes and hydrocarbon wastes. During both construction and operations, these wastes, excluding tyres and inorganic mercury absorbent, may be treated either in-house by incineration or by third-party waste disposal.

Due to the isolated location of the Project site, an incinerator has been considered as a potential waste management option. This is due to the lack of suitable nearby waste management alternatives.

The proposed incinerator would be in-line with Australian regulations for design, certification and emissions. It is anticipated that any incinerator would be completed with:

- Primary and secondary combustion chambers
- Dual fuel burners
- Liquid waste storage and injectors
- Combustion air blower(s)
- Liquid fuel atomising air blower(s)
- Electric motor drivers for the blowers
- Air manifolds
- Automatic and manual waste lifting/dumping system
- Interconnecting ducting and stack
- Combustion control system with control panel

- Instruments
- A system of ladders and platforms for safe access and operability.

The incinerator stack emissions will meet the emission requirements for New South Wales as listed under Group 6 standards. The criteria includes the following:

- Particulate matter - 50 mg/m³
- NO_x - 350 mg/m³
- VOC (inc benzene) - 20 mg/m³
- CO - 125 mg/m³
- Hydrocarbon - 5,000 mg/Nm³
- Dioxins or furans - 0.1 ng/m³.

The design will also consider flue gas scrubbing to meet the emissions criteria. The top of the incinerator stack will be a minimum of 15 m above grade.

The planned operation of the incinerator is 12 hours per day and seven days per week. The incinerator will be designed not to exceed the maximum noise level requirements.

Incineration would be effective in processing all Project-generated uneconomic recyclable and controlled wastes, with the exception of tyres and inorganic mercury absorbent, as they are not acceptable material for incineration. This represents over 83 per cent of generated wastes.

4.8 Accidental Releases (Spills and Leaks)

4.8.1 Overview

Spills and leaks are unplanned events where solids, liquids or gas flow from a containment vessel into a secondary containment (bund) compound or into the environment. A spill or leak into a bund would be an on-site incident, while a spill or leak into the environment may have serious risk implications. Spills and leaks are different to planned emissions of solid, liquid and gas to the environment under DEC operating licence conditions.

Spills are normally the result of failure of safe work practices. Spills may result from:

- Overfilling receiving storage vessels
- Failure to observe correct hose disconnection protocols
- Overturning of transport vehicles (tankers or flat-tops) during transport incidents
- Reagent containerisation design failure.

Leaks are normally the result of equipment failures, where the designed containment system is compromised. Leaks may result from:

- Transport tanker rupture
- Transport tanker valve failure
- Storage tank rupture
- Storage tank valve failure
- Transfer pipeline rupture
- Transfer pipeline valve failure.

The potential for leaks from pipeline and vessel failure is based on diameter, length (pipe sections), shape, wall thickness, corrosion protection, environmental conditions (such as vibration, movement, temperature, and chemicals being transported), material of construction and weld quality and influenced by the age (fatigue) of the equipment.

Spills and leaks may occur across the Project life cycle. The impact of any spill or leak is related to the volume of chemical released into the environment, the toxicity of the chemical released and the nature of the receiving environment.

Leaks from reagent storage and process plant compounds will be mitigated by construction of bunded compounds to the appropriate Australian Standard for storage of flammable (AS 1940:2004) materials. This is discussed further in Section 4.8.3.

Fire fighting equipment will be maintained in compliance with relevant Australian Standards.

4.8.2 Offshore

Chapter 8, *Marine Risk Assessment and Management* details the potential spill scenarios associated with offshore activities, the likelihood of occurrences and the possible impacts on the environment. Credible scenarios identified in risk assessments based on likelihood and consequence were modelled to determine the probability of hydrocarbons, if spilled, of reaching a particular location and impacting to a particular degree. This probability of impact is determined largely by the location of the spill relative to the sensitive receptors, characteristics of the hydrocarbons, spill mitigation and the range of possible environmental conditions such as currents, wind and temperature.

In the first instance, worst-case credible scenarios were defined to determine the envelope of potential scenarios.

Bunkering activities have historically had a higher likelihood of incidents; however, the Project bunkering and storage volumes are relatively small. Spills of diesel have been modelled but spills of chemicals such as MEG or corrosion inhibitor have benign environmental characteristics or comprise small volumes respectively, hence such scenarios are not considered to be defining the worst-case envelope. Chemicals used in the umbilicals and process chemicals will be selected in part based on their environmental characteristics and as such leaks or spills are expected to pose negligible biodegradation or bioaccumulation risk and have a localised impact.

Bunkering procedures include limits set on acceptable sea states, constant visual monitoring of couplings and hoses and of tank levels, constant radio contact between vessels and the platform and clear definitions of responsibilities and accountabilities.

Loss of well control has also been modelled in Chapter 8, *Marine Risk Assessment and Management*. The worst-case scenario was considered to be the potential loss of well control during drilling.

The following measures are being considered in the design and operation of the offshore facilities to manage the risk of accidental releases:

- Design
 - Flowline and pipeline design (including compliance with applicable standards and codes, construction materials, corrosion allowance, pipeline external concrete coating, external corrosion protection, armouring of flowline/pipeline in dropped object hazard zone, protection over pipeline crossings, welding procedures, stabilisation). Predicted stresses designed within allowable limits, fatigue checks for cyclic loading
 - Dehydration facilities to manage pipeline corrosion, splash zone corrosion protection.
- Operations
 - Integrity management including periodic ROV pipeline and flowline inspections and pipeline pigging as required (e.g. post cyclones or post excursions from key performance indicators etc.)
 - Pressure alarms on pipelines and flowlines to provide early warning of excursion

- Hydrotesting and non destructive testing inspections prior to start-up
- Location and design of laydown areas with respect to riser and pipeline/flowline location. Inspection and maintenance of lifting equipment
- Export pipeline corrosion inhibition
- Hydrate remediation procedures, continuous monitoring of moisture content of all streams to pipeline
- Oil spill contingency plans, ship based oil spill emergency plans (SOPEP), pipeline and platform emergency response plans
- No anchoring in exclusion area gazetted and shown on navigational charts.

4.8.3 Onshore

4.8.3.1 Construction Phase

Fuel

During the construction phase, diesel will be used on site each day. Storage of diesel fuel will be by a transportable, dual wall, tank system with integrated fuel bowser. The delivery tanker will unload within an appropriately constructed compound.

Diesel is a Class 3 dangerous goods (C1 - combustible) with significant potential for ecotoxic effects in water bodies (EC_{50} - *Daphnia magna* - 4 mg/L). Diesel can move quickly through the soil profile to groundwater, and attenuation is dependent upon soil organic matter and silt/clay content. Diesel can microbiologically biodegrade in soils; however, the rate of biodegradation is limited by availability of soil moisture and nutrients.

Fuel leaks are not anticipated during the construction phase due to the high level of maintenance required for the vehicle fleet.

Fuel spills will be managed by the use of dry disconnect couplings on fuel hoses, where practicable. Spills will be recovered by excavation of contaminated soil and remediation, where applicable.

Lubricants, fuel, and hydraulic oils will be stored on site. Waste oils and lubricants will be stored and either incinerated or removed off site by third party service providers. Any spills will be recovered by excavation of contaminated soil and remediation, where applicable.

Process Chemicals

During the construction phase, the main chemicals stored on site will be Portland cement, for the concrete batch plant, and sewage treatment chemicals, such as sodium hypochlorite and ferric chloride.

Portland cement is an irritant material (X_1) with minor potential for ecotoxic effects. Portland cement will be brought to site by road tankers and pneumatically discharged into silos fitted with appropriate dust abatement technology. Leaks of cement dust through the filter baghouse are likely to occur periodically during the construction phase. As these incidents will only occur during silo loading operations, the potential for environmental impacts is considered to be low. Spills will be recovered by excavation and disposal to an inert landfill.

Sanitary treatment chemicals will be stored on portable, self-bunded pallets. Chemicals will be received as packaged goods in packaging between 20 and 1000 litres.

Both sodium hypochlorite and ferric chloride are dangerous goods and are acutely ecotoxic in water bodies (ferric chloride - EC_{50} - *Daphnia magna* - 15 mg/L), (sodium hypochlorite - LC_{50} - *Daphnia magna* - 0.01 mg/L). Both chemicals degrade quickly in the soil to inert salts.

4.8.3.2 Operations Phase

Overview

Fuel and reagents stored on site, during the operations phase, will include dangerous goods, hazardous and non-hazardous chemicals. The toxicity of some of these chemicals is shown in Table 4.25.

Significant risks for negative environmental impacts exist from the transport, storage and use of concentrated corrosives.

Minimum separation distances will be maintained between incompatible classes of dangerous goods and goods of the same class that will react violently (such as sodium hydroxide and sulfuric acid). Each of the bulk storage tanks and ISOtainers will be maintained within bunded compounds. Bunds will comply with Australian Regulations.

Spills of fuel and reagents may occur as a result of transport accidents, bulk reagent loading and bulk product loading. It is not anticipated that tank spills will move outside bunded compounds. Spills that occur outside bunded compounds, including transport accidents and bulk reagent loading will be recovered. Clean up equipment and absorbent materials will be stored adjacent the storage tanks to allow rapid spill response.

Table 4.25: Toxicity and Ecotoxicity of Reagents

Chemical	DG Class	Oral LD ₅₀ - rat (mg/kg)	48h - EC ₅₀ -Daphnia magna (mg/L)
Fuel			
Diesel	3 - C1 combustible	5000	4
Reagents			
Sodium hydroxide (50%)	8 PG II	400	100
Sulfuric acid (98%)	8 PG II	2140	87
Ferric chloride (40%)	8 PG III	450	15
Cement	Non-DG/Hazardous	2000	> 3000

Leaks may occur, due to equipment failures, during transfers from delivery vessels to storage tanks; fuel transfers from storage tanks to mobile and stationary equipment; product transfers to transport vessels; failure of storage vessels; and failure of isolation valves and interlocks. Leaks may most likely occur due to the failure of pump glands, flexible hoses, transfer pipes, valves, flanges and couplings. The majority of leaks are likely to occur within banded and secondary banded compounds.

Leaks that do occur outside banded compounds will be recovered. Clean up equipment and absorbent materials will be stored in appropriate locations to allow rapid leak response.

The movement of process chemicals and hydrocarbon products due to the Project increases the risk of spills and leaks of materials into the environment.

LNG Storage Tank Rupture

An assessment of the risk of spills and leaks (including rupture of LNG processing facilities and the potential for storage tank failure) to different facets of the marine and terrestrial environment is provided in the Wheatstone Draft EIS/ERMP (see Chapters 8 and 9). On all occasions, the most conservative assessments determined a 'Low' risk potential. This assumed a consequence category of 'Medium' and likelihood of 'Unlikely'.

Since LNG is odourless, colourless, non-combustible, non-corrosive and non-toxic, it will not pollute land or water resources. If it is spilled, either on land or water, it will form a pool and vaporize rapidly, dissipating into the atmosphere with no residual trace.

There is however the potential for a flammable vapour cloud to form. If this vapour cloud comes in contact with an ignition source, it will burn back to the source and form a pool fire. If the vapour cloud is confined there is the potential for an explosion to occur, resulting in hazards to personnel and damage to equipment. Also in the event the cloud does not ignite there is the potential for asphyxiation. Due to the safety implications of such events there are multiple controls in place to ensure that the potential for a release of LNG is extremely remote. A detailed assessment of the potential risk of a failure will be undertaken as part of the Facility Safety Case, which will be completed prior to the commencement of operations. The proposed controls that will be incorporated into the design to mitigate against a release will be provided in the supplement to this EIS / ERMP.

Given the information presented above, Chevron does not expect a release of LNG to pose a significant risk to the nearshore marine environment. As such, we do not currently intend to update the Draft EIS/ERMP as we believe that the information provided above confirms our "Low" assessment for the risk of impact to the marine environment.

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5.0

Stakeholder Consultation



A man in a blue short-sleeved shirt and khaki pants stands at the front of the room, pointing towards the projector screen. He appears to be the presenter.

Concepts
Innovation History Diversity
Sustainability Safety Community Well-being
Resilience Planning Economic Access
Quality Empowerment Transit Health
Work-life balance Smart Design People
Infrastructure



5.0 Stakeholder Consultation

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5.0 Stakeholder Consultation

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5.0 Stakeholder Consultation

5.1 Stakeholder Consultation Strategy

Chevron Australia Pty Ltd. (Chevron) is undertaking a transparent stakeholder and community engagement process in the development of the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP). The program is consistent with the Interim Industry Guidelines to Community Involvement (Department of Environment 2003) and the International Association for Public Participation Guidelines for best practice in Social Impact Assessment (International Association for Public Participation Australasia 2004).

The stakeholder consultation strategy is aligned with Chevron's corporate values, which call for the company's business to be conducted in a socially responsible and ethical manner. Chevron respects the law, supports universal human rights, protects the environment and benefits the communities in which it operates (Chevron Australia 2009a).

5.2 Aims of Stakeholder Consultation

The aim of the consultation undertaken for the proposed Wheatstone Project (Project) and the associated impact assessment process has been to:

- Provide a forum for stakeholders to participate, deliberate and contribute in a meaningful way to discussion, to raise concerns, and to provide suggestions and advice on the Project
- Provide opportunities for stakeholder input and feedback throughout the impact assessment process to inform Project decision-making
- Broaden Chevron's knowledge of the issues, concerns and opportunities that may arise in relation to the Project to enable the development of effective mitigation and enhancement strategies
- Allow Chevron to interact with stakeholders to find the best ways to increase benefits from the Project and reduce potential adverse impacts
- Capture stakeholder issues and concerns during the development of the EIS/ERMP
- Consider stakeholder views in planning future consultation.

5.3 EIS/ERMP Stakeholder Consultation

The level of engagement on each key potential impact identified in the EIS/ERMP has varied according to the level of risk, public interest and regulator concern. In most instances this has involved public participation to a level of "Consult" (as defined by the Interim Industry Guidelines to

Community Involvement - DoE 2003 - and the International Association of Public Participation framework). This level of consultation means Chevron has:

- Sought broad-based input and feedback on the proposed Project
- Kept stakeholders informed
- Listened to and acknowledged stakeholder concerns
- Provided feedback on how stakeholder input has influenced Project decisions.

Consultation was undertaken with key identified stakeholders as part of the scoping and EIS/ERMP preparation processes. Workshops and meetings were held with government representatives across technical sections of agencies such as the Environmental Protection Authority (EPA), Department of Environment and Conservation (DEC), Department of the Environment, Water, Heritage and the Arts (DEWHA), Department of State Development (DSD), Department of Fisheries (DoF), Department of Health (DoH), Department of Water (DoW), Heritage Council of Western Australia (HCWA), and Pilbara Development Commission. The workshops and meetings focused on:

- Chevron's application of the risk-based approach to the Project
- Initial risk assessment results
- The scopes and methodologies associated with addressing the high and medium environmental, social and health factors for the Project
- Issues associated with dredging and dredge material disposal.

A list of the meetings and workshops is contained in Appendix B1, and the results of these workshops are briefly provided in Chapter 7, *Impact Assessment Methodology*.

5.3.1 Community Consultation

Comprehensive community consultation was also conducted throughout 2009, with the following objectives:

- Identify stakeholder and community issues, concerns and potential impacts in relation to the Project
- Validate community issues and provide further information on the Project through the preparation of appropriate communication materials and engagement forums
- Identify appropriate strategies to address potential adverse impacts and enhance positive impacts associated with the Project

- Incorporate social, economic and health issues raised by the community in Project design, planning and management commitments.

A key purpose of the community consultation was to collect and analyse information that would be incorporated into the social and health risk assessment for the EIS/ERMP.

Consultation involved local government, non-government organisations, Indigenous organisations, Onslow residents, tourists visiting Onslow and the private sector. These stakeholders were considered to be potentially affected parties under the Commonwealth Guidelines for the Content of a Draft Environmental Review and Management Programme/Environmental Impact Statement included as Appendix 5 of the Environmental Scoping Document (Scoping Document). Stakeholders identified and consulted as part of the Project to date are listed in Appendix B1.

Approximately 343 community stakeholders were consulted between March 2009 and March 2010. This was done to support the social and health impact component of the EIS/ERMP and a Social Impact Statement (SIS) which is required under the Shire of Ashburton’s Local Planning Policy - Social Impact Assessment. The social impact assessment will provide information that may

inform Project design and subsequent social programs. Stakeholders are summarised by sector group in Table 5.1.

5.4 Assessment, Consultation and Communication Methods

A range of methodologies were utilised to assess stakeholder issues and values. Table 5.2 summarises the consultation methods utilised for the EIS/ERMP.

Consultation with government officials and environmental stakeholders was primarily through workshops, presentations and meetings, while consultation with the Onslow community was through a number of interactive engagements such as personal interviews. A range of assessment and consultation mechanisms was utilised to ensure that a representative number of community stakeholders informed the EIS/ERMP.

It should be noted that a particular effort was made to engage the local Onslow Aboriginal community. This included monthly meetings with the Burrabalayji Thalanyji Association Incorporated (BTAI) completion of a heritage survey of the main Project area and its associated infrastructure area, presentations and involvement in the Wheatstone Project Aboriginal Social Impact Assessment

Table 5.1: Regional/Community Stakeholders Consulted for the SHIA Program

Sector Group	No. Consulted
Onslow Community Residents	Total = 95
Indigenous	31
Non-Indigenous	64
Visitors/Tourists	47
Health and emergency services	34
Tourism operators and accommodation providers	33
State Government agencies, including Pilbara Development Commission	27
Local business and business associations	23
Local government (Shire of Ashburton)	16
Commercial fishers and pearlers, and relevant associations	21
Students/Youth (Years 3, 4, 8, 9, 10)	16
Service providers (e.g. education, childcare, policing and recreation)	12
Public utilities and infrastructure providers	8
Major industry (e.g. mining)	7
Community organisations	4
Total	343

Table 5.2: Stakeholder Consultation Methods and Approaches

Methodology/ Approach	Description/Detail
Stakeholder workshops	<p>Workshops were held with government and non-government stakeholders to understand their key concerns in regard to the Project. These workshops were open to all stakeholders and representatives from several State Government departments, the Commonwealth, local community members and the Cape Conservation Group attended.</p> <p>They included:</p> <ul style="list-style-type: none"> • Workshops in November 2008 in Onslow and Karratha, and in December 2008 in Perth on the site-selection process for the onshore LNG plant and associated coastal infrastructure • Three workshops on the Draft Scoping Document in February and March 2009 • One workshop on terrestrial risks in September 2009 • One workshop on marine risks in September 2009.
Stakeholder presentations	<p>Presentations have been provided to Commonwealth Government agencies, State Government agencies, the Shire of Ashburton and key non-government organisations such as the Cape Conservation Group in Exmouth.</p> <p>A combined Wheatstone and Gorgon briefing was held for the WA Conservation Council and World Wildlife Fund (WWF) in January 2009. Participation by the Cape Conservation Group, Conservation Council and WWF was funded under a contract through APPEA and Strategen.</p>
Stakeholder meetings	<p>Meetings have been held with:</p> <ul style="list-style-type: none"> • Government agencies • BTAI • Environmental non-government organisations (ENGOS) • Pastoral lease owners/managers • Local fishing and pearling businesses • Key fishing, boat charter and pearling industry associations • Industry proponents such as BHP Billiton and Onslow Salt • Foreign consular representatives. <p>These included both broader meetings to discuss the Project and approaches to the EIS/ERMP, or focused on a specific issue.</p>
Senior government stakeholder consultation	<p>A range of local, State and Commonwealth government officials have been consulted about the Project to date as part of the Project stakeholder engagement process. These include:</p> <ul style="list-style-type: none"> • Ministers of the Crown • Ministerial chiefs of staff • Senior ministerial and political advisers • Government departmental and agency heads • Government departmental and agency senior reports • Local shire CEOs, presidents and councillors. <p>These consultations began in late 2007 and have continued since. Consultations have ranged from general-information briefings to discussions on specific issues.</p>
Public review of Scoping Document	<p>The Draft Scoping Document was released by the EPA for public review. Copies were also mailed to a number of stakeholders and placed on the Chevron website (Chevron 2010). A total of 14 submissions were received by the EPA. Chevron prepared and submitted to the EPA and DEWHA a response to the submissions.</p>

Methodology/ Approach	Description/Detail
<p>Survey research: Mail surveys Personal surveys Telephone surveys Intercept surveys</p>	<p>A range of survey methods has been utilised to obtain information of relevance to the SHIA. Surveys included mail, personal surveys and telephone surveys. In the current assessment, personal surveys were most commonly utilised; however, mail and telephone surveys were also undertaken as appropriate. The surveys were structured to collect information on community needs and aspirations, Project issues and impacts, and service capacity.</p> <p>Intercept surveys were also undertaken in areas perceived to be of “high value and/or use” to the community, as identified through the values assessment. Surveys were conducted across three time slots: 7 am to 10 am; 11 am to 2 pm; and 3 pm to 6 pm, to gain a cross section of the uses of the areas identified. Intercept surveys were undertaken at the following locations:</p> <ul style="list-style-type: none"> • Ashburton River • Four Mile Creek • Beadon Creek • Sunrise Beach (locally known as “Front Beach”, near the War Memorial) • Sunset Beach (locally known as “Back Beach”) • Hooley Creek. <p>Intercept interviews were also undertaken with visitors at the Ocean View and Beadon Bay caravan parks.</p> <p>A total of 24 intercept survey applications were undertaken (eight locations over three time slots) which sampled 92 people.</p>
<p>Aboriginal household survey</p>	<p>An Aboriginal household survey was undertaken to collect current information from Aboriginal households within the Onslow community. A total of 24 Aboriginal households were sampled, totalling 87 Aboriginal people resident within the Onslow and Bindi Bindi communities. The survey was structured to address socio-demographic questions included in the Australian Bureau of Statistics Census survey, and to collect additional information on community needs and aspirations regarding education, training and employment. The Onslow Aboriginal Household Survey thus provides a recent snapshot of the local indigenous community’s family and household structure, age distribution, education levels, and employment and training needs and aspirations.</p>
<p>Values mapping</p>	<p>The identification of values and uses of the locality were undertaken using a values mapping technique. Responses from all stakeholders were collated and spatially referenced to produce maps highlighting areas of community value/importance. Values mapping is a participatory technique applied through survey/consultation methods with community stakeholders to identify visually what they value about a place (i.e. what the place means to them, their attachment to it, their use of the place and their vision for what the place could be in the future). A key advantage of the technique is that it allows values to be identified without reliance on language and thus has wide application for a range of demographic groups.</p>
<p>TRC-Analysis</p>	<p>TRC (Town Resource Cluster)-Analysis was utilised to examine the link between resource use and social systems. TRC defines the meaningful spatial units on which to base the SHIA and engagement process.</p> <p>(Cont’d)</p>

Methodology/ Approach	Description/Detail
Photovoice	<p>Photovoice is an innovative method of needs assessment and community visioning that has been used in a range of settings to provide community members/key stakeholders with an opportunity to “paint a picture” of community life in their own terms. The method utilises photography to document participants’ lived reality, concerns, hopes and aspirations.</p> <p>A series of community workshops was held to outline the process, to collate and analyse photographs and stories and to develop community centrepiece ideas to summarise Project outcomes.</p> <p>The photographs generated in the process present an opportunity to record a baseline of community perception, experience and function, and to examine changes in community attitudes over time.</p>
Project information session/open day	<p>Poster and slide presentations about the environmental and social studies undertaken for the Project were on display at community open days held in Onslow in August and December 2009.</p> <p>This was an effective means of generating comment from the community.</p>

where five local Aboriginal people were trained to assist in conducting the research, a survey of Aboriginal households in the Onslow community, and developing community feedback specifically for the Aboriginal community. In total, representatives from approximately half of Onslow’s Aboriginal households were consulted.

Table 5.3 summarises the methods and approaches utilised across the stakeholder groups involved. Several approaches were used for each stakeholder group.

5.4.1 Communications

In addition to the consultation methods listed in Table 5.2, a range of communication tools were utilised to provide information on the Project and feedback on key assessment outcomes. The Community Reference Group (CRG) has been a constant and ongoing mechanism for this. Table 5.4 provides more detail on the communication mechanisms utilised.

5.5 Proposed Consultation

Chevron shall engage stakeholders throughout each phase of the Project to identify, monitor and manage key issues and relevant impacts. Meetings and Project briefings with government departments, environmental groups, the CRG and local stakeholders are planned to be held on a regular basis. Communication mechanisms such as media releases, community open days and community bulletins have been successful to date and shall continue through the planning, construction and commissioning phases of the Project.

Where it is entitled to do so, Chevron shall make the supporting data for the EIS/ERMP (including results of

environmental surveys, modelling studies and monitoring programs) available to government agencies, scientific organisations, academic institutions and the public to further the understanding of the local environment in the Project area.

Stakeholders shall have a formal opportunity to comment on the EIS/ERMP during the Commonwealth and Western Australian Government review of the draft EIS/ERMP and the ten-week public review period.

5.6 Project Issues and Impacts

As part of the consultation program, stakeholders were asked to identify the key issues and impacts of the Project. The key issues and themes identified by community stakeholders were somewhat different from those identified by regulatory stakeholders, and are therefore discussed separately. A summary of key potential impacts and stakeholder concerns is presented in Table 5.5.

5.6.1 Regulatory Stakeholders

Regulatory stakeholders raised a number of environmental issues at meetings, workshops or through the review of the Scoping Document. This feedback has been considered in the risk assessments presented in Chapters 8 to 10 of this EIS/ERMP. The following environmental issues/impacts were highlighted as the most important for this Project. Potential impacts from dredging was the most commonly raised concern, the remainder follow in no particular order of importance. Note that no agency advised that the proposal was in breach of any policy based on the information before them.

Table 5.3: Stakeholder Consultation by Method and Approach

	Workshops	Presentations	Meetings	Senior government consultation	Public review of Scoping Document	Mail surveys	Personal interviews	Telephone interviews/surveys	Intercept surveys	Aboriginal Household survey	Values mapping	TRC analysis	Photovoice	Project information session/open day
ENGOS	•	•	•		•									•
Indigenous Groups/ Native Title Bodies	•	•	•		•		•			•	•		•	•
Visitors/ Tourists									•		•			•
Non-Indigenous Onslow Community Residents	•						•	•	•		•		•	•
Community Organisations	•		•		•		•				•			•
Students/ Youth (Yrs 3, 4, 8, 9, 10)													•	•
Local Business and Business Associations	•	•	•			•	•	•			•			•
Commercial Fishers and Pearlery and Relevant Associations		•	•				•	•			•	•		•
Health and Emergency Services			•				•	•						•
Public Utility and Infrastructure Providers		•	•				•	•						•
Service Providers	•		•				•	•			•		•	•
State and Cth Govt Agencies	•	•	•	•	•		•	•			•			
Local Govt	•	•	•	•	•		•	•			•			•
Industry/ Mining/ Salt	•		•				•	•			•			•

Table 5.4: Communication Mechanisms

Method	Description
CRG	Chevron established Gorgon CRGs in Onslow and Karratha in 2005. The Onslow CRG, comprising 12 community, local government and regional body representatives, consented to become a Chevron Onslow CRG in February 2008. Three CRG meetings were held in 2008 and four in 2009 to discuss the Project, site selection, social impact management, the EIS/ERMP process and any community concerns.
Community newsletter	Chevron commenced production of a Wheatstone Community Bulletin for Onslow in early 2009. Distributed in March and July 2009, the bulletins contain articles about the Project, the EIS/ERMP and social impact processes, investigative works programs and also provide relevant Chevron contact details.
Community information sheets	Information sheets were developed and distributed to stakeholders as part of the SHIA program at key Project milestones to provide information on the proposal, validate issues and summarise assessment program outputs.
Community information day	Community information days were undertaken to provide feedback to the community regarding the outcomes of the social and environmental assessment studies, to provide an opportunity for stakeholders to discuss specific issues with company representatives and environmental experts, and to gain feedback on proposed mitigation and enhancement strategies. Information days were held in August and December 2009 with 84 and 17 people attending respectively. Posters displayed at the open days were also reproduced as a booklet and distributed to stakeholders.
Project briefings and presentations	A range of Project briefings and presentations have been initiated with key stakeholders. These include briefings to the Shire of Ashburton in April and November 2008, and in March and November 2009.
Media releases	Six Project media releases have been developed to provide information to the wider regional community and to Perth. These include announcements regarding the preferred Project site and the award of the Front End Engineering and Design contract.
Chevron website	Chevron has developed a website that includes information on the Project, economic and community benefits and environmental responsibility and approvals. It also contains copies of the Scoping Document and Environmental Impact Referral. The website is http://www.chevronaustralia.com/ourbusinesses/wheatstone.aspx

5.6.1.1 Dredging

There was considerable concern surrounding potential impacts of the large scale capital dredging program and material placement required to create the navigational channel, turning basin and port facilities. In particular, regulatory stakeholders are interested in potential impacts on BPPH and marine wildlife such as turtles and marine mammals. These issues have been the focus of a detailed assessment in Sections 8.3 and 8.4 of this EIS/ERMP.

5.6.1.2 Coastal Processes

In addition to dredging, regulatory stakeholders were interested in understanding the potential impact on marine coastal processes during construction and operation of the onshore and marine facilities (including jetties, offloading facilities and flood protection). As a consequence of

potential impacts on marine coastal processes, regulatory stakeholders were also interested in understanding potential impacts on the ecological communities and systems dependant on these natural processes. Potential risks on physical marine processes are assessed in Section 8.5.

5.6.1.3 Mangroves and Corals

Potential impacts on the Ashburton River delta mangrove system were a concern expressed by the EPA Board and other government officials at a meeting in Onslow in October 2009. In addition, participants at the risk ranking workshops in September 2009 considered corals to be sensitive receptors. Potential risks to the Ashburton North and Hooley Creek mangrove communities are assessed in Section 8.3. Potential risks from the Project on corals are also assessed in Section 8.3.

Table 5.5: Key Potential Impacts and Stakeholder Concerns

Potential Impact	Stakeholder Concern	Raised By	Response
Dredging	Impact of large-scale dredging on benthic primary producer habitat (BPPH) and marine fauna; timing in relation to cyclone season	Regulatory stakeholders during stakeholder consultation; DEC Marine Ecosystems Branch during public submissions to the Scoping Document	Addressed in Sections 8.3 and 8.4
Coastal processes	Impact on natural processes from onshore and marine facilities; impact on ecological communities dependent on these processes	Regulatory stakeholders during stakeholder consultation; Cape Conservation Group during public submissions to the Scoping Document	Addressed in Section 8.5
Mangroves and corals	Impacts on mangrove and coral systems, corals as sensitive receptors	Regulatory stakeholders during stakeholder consultation and public submissions to Scoping Document; EPA Board during stakeholder consultation	Addressed in Section 8.3
Turtle nesting areas	Impacts on nesting areas on mainland and nearby areas, including effects from lighting	Regulatory stakeholders during stakeholder consultation and public submissions to the Scoping Document	Addressed in Section 8.4
Island nature reserves	Impact on islands close to offshore facilities, including damage to corals and disturbance to fauna	Regulatory stakeholders during stakeholder workshops; DEC Environmental Management Branch during public submissions to the Scoping Document	Addressed in Section 8.4.4.5
Greenhouse gas emissions	Options for the management of greenhouse gas emissions generated by the Project.	Regulatory stakeholders during stakeholder consultation	Discussed in Sections 3.7 and 4.2
Surface water drainage	Potential effects on surface water flow due to barriers such as roads and plant facilities; impacts on nutrient flows to mangrove systems	Regulatory stakeholders during stakeholder workshops; EPA Board during stakeholder consultation	Addressed in Section 9.4
Introduction of pests and weeds	Introduction of pests and weeds, both on land and in the marine environment by vessels from international ports of origin	Regulatory stakeholders during stakeholder consultation	Addressed in Sections 8.4.4.4, 9.5 and 9.6
Fish and fish stocks	Impact on fish and fish stocks from dredge material and changes to coastal processes, particularly prawns	Regulatory stakeholders during stakeholder consultation	Addressed in Sections 8.4 and 10.4
Mitigation	Proposed management measures for mitigating adverse environmental effects; use of best practice; need to articulate risk-ranking assumptions	Regulatory stakeholders during stakeholder workshops; DEC Environmental Management Branch during public submissions to the Scoping Document (Cont'd)	Addressed in Chapters 8, 9, 10, 11 and 12

Potential Impact	Stakeholder Concern	Raised By	Response
Mosquito-borne disease	Potential increase of mosquito-borne disease due to mosquito population increase	DoH during stakeholder consultation and public submissions to the Scoping Document	Addressed in Section 10.7.4.1 (Cont'd)
Population change	Management of workforce influx, especially housing, behaviour and pressures on the local recreational fishery	Community stakeholders during stakeholder consultation	Addressed in Sections 8.4.4.5, 10.4 and 10.5; continued community consultation, assessed in SIS
Economics and employment	Potential for Project to bring economic and employment benefits to the region, need for skills	Community stakeholders during stakeholder consultation; Shire of Ashburton/Department of Indigenous Affairs during public submissions to the Scoping Document	Continued community consultation to discuss local benefits, to be addressed in SIS
Service provision	Impact on already strained services, especially health and emergency services and housing	Community stakeholders during stakeholder consultation	Continued community consultation and discussions with Shire
Social issues	Exacerbated antisocial behaviour due to increased alcohol consumption by workers allowed in town	Community stakeholders during stakeholder consultation	Continued community consultation, addressed in SIS
Recreation	Impact on commercial and recreational fishing, such as exclusion zones and depleted stocks, loss of access to recreational areas	Community stakeholders during stakeholder consultation	Addressed in Sections 8.4.4.5, 10.4 and 10.5; continued community consultation
Sense of community	Impact of workforce on sense of community, Aboriginal residents' sense of safety	Community residents and Aboriginal stakeholders during stakeholder consultation	Continued community consultation, key principle in SIS
Environment	Impact on air quality and local environment due to traffic and emissions	Community stakeholders during stakeholder consultation	Addressed in Sections 4.3, 9.8 and 10.6.7; continued community consultation
Trust and engagement	Praise for community engagement process and individual consultation	Community stakeholders during stakeholder consultation	Continued community consultation and transparency
Health and wellbeing	Increased alcohol consumption, illegal drug use and further strain on health resources, impact on water and air quality as a result of the Project	Community stakeholders during stakeholder consultation	Partly addressed in Sections 4.3 and 10.6.7; continued consultation with Department of Health and community

5.6.1.4 Turtle Nesting Areas

Turtles were raised as an issue by a number of participants attending the risk ranking workshops in March and September 2009. Of particular interest were potential impacts on nesting areas both on the mainland and on the nearby islands. Potential adverse impacts on turtles due to light generated from the Project were also raised at the September workshops. Potential risks to turtles and turtle nesting areas are assessed in Section 8.4.

5.6.1.5 Island Nature Reserves

Concern was expressed regarding excessive recreational use of the offshore islands close to Onslow by large numbers of construction and operational workers. Concerns included habitat degradation, disturbance to fauna, and the introduction of non-native species and damage to coral. Potential risks are assessed in Section 8.4.4.5.

5.6.1.6 Greenhouse Gas Emissions

Through discussions at various workshops and meetings, regulatory stakeholders enquired about potential greenhouse gas emissions from the Project. They were interested to know how Chevron planned to manage these emissions. Greenhouse gas emissions from the Project are discussed in Sections 3.7 and 4.2.

5.6.1.7 Surface Water Drainage

Potential effects on surface water flows from physical barriers such as access roads and the plant area were raised during the September 2009 workshops, particularly in relation to cyclones and heavy rainfall events. This was re-iterated by the EPA Board in terms of how these potential barriers could affect nutrient flows to the Ashburton delta mangrove system. Risks to surface water drainage are assessed in Section 9.4.

5.6.1.8 Introduction of Pests and Weeds

The introduction of weeds and other non-native species has been expressed as a concern by several government departments during individual meetings and at the risk ranking workshops. The spread of weeds at Ashburton North and the introduction of non-native marine species by vessels arriving from international ports of origin were identified as requiring study and mitigation. These assessments are presented in Sections 8.4.4.4, 9.5 and 9.6.

5.6.1.9 Fish and Fish Stocks

Fish and fish stocks were identified as potential receptors which could be adversely affected by the disposal of dredge material and changes to coastal processes. Prawns in particular were identified as sensitive receptors and as

a result have been included in the risk rankings for the dredging program. Potential risks to fish and fish stocks are assessed in Sections 8.4 and 10.4.

5.6.1.10 Mitigation

During the workshops held in September 2009, participants were particularly interested in what management measures were being proposed to mitigate potential adverse environmental effects. Questions were asked on the use of best practice, and specific Project details. Chevron was also asked to clearly articulate the assumptions behind the various risk rankings. This information is provided in Chapters 8 to 12.

5.6.1.11 Mosquito Borne Disease

The DoH raised concern about the potential increase in mosquitoes in the area and hence an associated increase in mosquito-borne diseases. An assessment of the risk of mosquito-borne disease from the Project is presented in Section 10.7.4.1.

5.6.2 Community Stakeholders

During consultation undertaken for the EIS/ERMP and SHIA, a range of social, economic, health and environmental issues/impacts were raised and have been categorised according to issue/impact themes. A short description of the main themes is provided as background context and Figure 5.1 provides a summary of the potential impacts raised. The responses are listed in descending order of Multiple Response Frequency whereby participants can provide more than one perceived community issue.

5.6.2.1 Population Change

This theme related to the potential influx of Project construction and operational workforces. Stakeholders were interested in understanding how the company intended to manage workforce influx, particularly the housing of workers and how behaviour would be effectively managed to reduce impacts on the local community. This stemmed from a general perception that increased population may exacerbate existing issues within the community related to alcohol and drug use and sexual behaviour. In addition, concern was expressed on a growing population's potential impacts on the recreational fishery. On a more positive note, there was a feeling that an increase in population would result in improved access to services within the Onslow community. Potential risks to the recreational fishery are assessed in Sections 8.4.4.5 and 10.4.

Population change has been the focus of internal presentations to Project design teams and Chevron

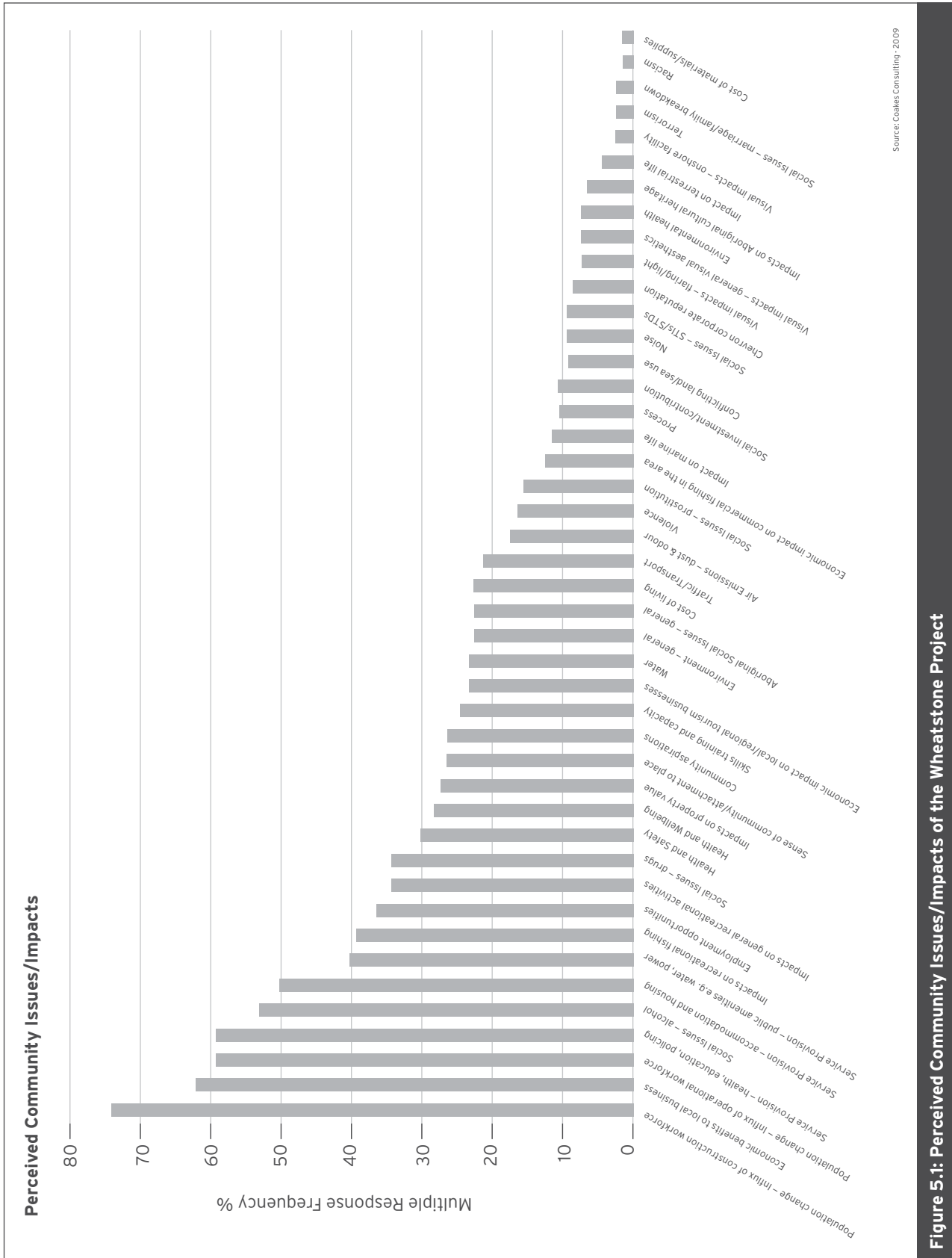


Figure 5.1: Perceived Community Issues/Impacts of the Wheatstone Project

employees and contractors. These potential issues have been validated through community open days in Onslow on August 7 and 8, 2009. Feedback from the community has also been presented to the Shire of Ashburton Council.

5.6.2.2 Economics and Employment

There was a strong belief among many stakeholders that the Project would bring significant economic benefits to the community and the region. Procurement opportunities for local business, employment of local residents, and greater company and employee expenditure in the community were frequently cited. However, stakeholders also said that the community would need to develop skills/training and business practices so benefits could be enhanced at the local level. There were also genuine fears that the Project would significantly increase the cost of living. Consultation shall continue on this issue with the community and the Shire of Ashburton.

5.6.2.3 Service Provision

Although service provision is acknowledged as an existing problem in Onslow and within the broader region, the community raised concerns about the impact of population change on service provision, particularly health and emergency services, accommodation and housing. There was a concern that health and emergency services were already at capacity and were struggling to service the existing population. There was also a perception that existing public utilities such as power and water would not cope with additional population growth and required an infrastructure overhaul. Consultation shall continue on Project related issues with the community, the Shire of Ashburton, service providers and DoH.

5.6.2.4 Social Issues

A number of social issues were identified, particularly those associated with the prevalence of alcohol and, to a lesser extent, illicit drugs. There was a sense that the lack of activities in town resulted in local licensed premises being the focus of the majority of social events. Excessive drinking was considered to be responsible for much of the antisocial behaviour in the community such as disorderly behaviour, domestic violence and sexual misconduct. Community members expressed concern that antisocial behaviour would be exacerbated if construction workers were allowed to drink in town. Project related social issues shall be identified through ongoing consultation with the community and Shire. In addition, feedback from the community has been compiled and discussed with Project teams and presented to more than 450 Chevron staff.

5.6.2.5 Recreation

Fishing appears to define the Onslow community and is considered a favourite pastime for locals and visitors. Consequently, there were significant concerns about the Project's potential effects on fishing - particularly recreational fishing, but also commercial fishing. Such concerns included restricted access to fishing locations, exclusion zones around the proposed Product Loading Facility and potential impacts on marine health and habitat such as fish nurseries and stocks. Community members were also concerned that an influx in population may lead to overfishing in the area, further depleting local fish stocks.

Overall, based on community feedback, recreational values in these areas clearly outweigh the other identified values of commercial, historic/heritage and physical/infrastructure. Interestingly, only a small number of people identified environmental values associated with the surrounding environs. But in discussion on recreational values, many community stakeholders referred to the beauty of the natural environment and the freedom to enjoy it without disruption or disturbance. Furthermore, some community stakeholders access recreational areas such as Hooley Creek via the designated Project area. Risks to recreation and other marine users are assessed in Sections 10.4 and 10.5.

5.6.2.6 Sense of Community

Many community residents mentioned the safe and friendly nature of Onslow. Some people reported that everybody got along well in town, while others spoke of individual and group divisions. Some Aboriginal stakeholders were concerned that a large workforce influx could alter what is currently a good relationship between the Aboriginal and non-Aboriginal communities or that it could impact on the Aboriginal community's sense of security and safety. There was a desire to see any future operational workforce in town integrated with the local community in a physical and social sense to help preserve Onslow's strong sense of community. Consultation shall continue with the community and the Shire of Ashburton on potential Project-related social issues.

5.6.2.7 Environment

Onslow was described by community stakeholders as a very clean and pollution-free place in which to live. As a result, Project issues regarding increased traffic, air emissions and visual impacts were raised by some community members. However, many of the comments obtained from local residents were more general, reflecting the natural

capital of the area and the relatively untouched nature of particular local places. Air emissions from the Project are assessed in Sections 4.3 and 9.8. Amenity is assessed in Section 10.6.7.

5.6.2.8 Trust and Engagement

Generally, stakeholders were complimentary of Chevron's community engagement process, in which residents received Project information via pamphlets, local media releases, public meetings and the CRG. There was also positive feedback about Chevron's individual consultation on the Project, with many residents experiencing individual engagement of this nature for the first time. Chevron shall utilise engagement mechanisms such as those identified in Table 5.4.

5.6.2.9 Health and Wellbeing

Community stakeholders were asked to identify potential health issues/impacts associated with the Project. The top three perceived health impacts were increased alcohol consumption, increased illegal drug use, and additional stress on health and emergency services. However, it was noted that the Project may assist in further developing community health and emergency services.

There was concern about an increase in prostitution (including informal sexual bartering) and in the prevalence of sexually transmitted diseases and illnesses. Such issues were thought to occur as a result of the presence of a predominantly male fly-in, fly-out workforce.

Other health issues identified were more environmentally focused and included the perceived impact of the Project on air quality and water as a result of plant emissions. Air emissions from the Project are assessed in Sections 4.3, 9.8 and 10.6.7.

Concerns were also raised in relation to potential plant explosions and the introduction of foreign viruses and disease. The Aboriginal community in particular was concerned about a potential increase in communicable diseases such as influenza and gastroenteritis. Chevron shall consult with DoH on Project related health and wellbeing issues.

5.7 EIS/ERMP Consultation with Native Title Claimants

An estimated 53 per cent of the Onslow population is Indigenous (approximately 300 people) with 11 language groups identified, including the Thalanyji, Yindjibarndi and Banyjima. The Thalanyji people are the determined native title holders of the land in the Onslow area, including the Ashburton North Strategic Industrial Area site.

Chevron is committed to working with the Thalanyji and signed a Heritage Agreement with the Burrabalayji Thalanyji Association Incorporated (BTAI) in December 2008. This agreement was amended in August 2009 to facilitate the appointment by BTAI of a dedicated heritage liaison officer and heritage field representative to assist with Aboriginal heritage issues on site, in support of Chevron's ongoing investigative works program. Chevron and the Thalanyji are also discussing opportunities for BTAI to provide Aboriginal cultural awareness training to Chevron's Wheatstone team and the Project contractors' field personnel.

In February 2009, Chevron signed a Negotiation Protocol with the Thalanyji setting out the procedures for negotiation of a Native Title Agreement for the Project. Chevron and the Thalanyji continue to hold monthly negotiation meetings with a view to reaching a Native Title Agreement.

Chevron has also engaged the Thalanyji to undertake a number of heritage surveys over the proposed Project land area and is developing a Cultural Heritage Management Plan with the Thalanyji for the Project.

Consultation with the Thalanyji has included:

- Monthly meetings in Onslow or Karratha
- Completion of a heritage survey of the main Project area and its associated infrastructure area
- Ongoing heritage surveys
- A visit to the North West Shelf Venture Karratha Gas Plant Visitors' Centre
- Presentations and involvement in the Wheatstone Project Aboriginal Social Impact Assessment - developing research questions and recruiting local research assistants for the assessment.

The Thalanyji and wider Aboriginal community will have a formal opportunity to comment on the EIS/ERMP during the statutory public review periods.

5.8 Native Title Claimants' Project Issues and Impacts

As part of the native title negotiations and the social impact consultation program, stakeholders were asked to identify what they perceived to be the key issues and impacts of the Project. The key issues raised can be categorised according to the following issue/impact themes. A short description of each is provided as background context.

- Protection of Cultural Heritage - relates to protecting all aspects of cultural heritage, including protection of physical sites and improving understanding of cultural heritage through appropriate staff training
- Opportunities for Socio-economic Development - relates to creating opportunities to improve education, employment, and health, and business development for Aboriginal people
- Social Impact Issues - Aboriginal people consulted as part of the Aboriginal Social Impact Assessment identified the same themes as the broader Onslow community. There was some additional concern that an increase in population may have a more significant impact on the Aboriginal community due to its higher vulnerability on particular social indicators such as health status. There was also more concern among the Aboriginal community that an influx of people would change the safe nature of Onslow and reduce children's free movement around the town.

6.0

Overview of Existing Environment



6.0 Overview of Existing Environment

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6.0 Overview of Existing Environment

6.1 Introduction

This chapter describes the key physical and biological features of the existing natural environment in the Ashburton Shire of the Pilbara region and, in particular, the proposed Wheatstone Project (Project) area. The Project area comprises offshore Petroleum Titles WA-253-P, WA-16-R, WA-17-R and WA-356-P, and an onshore gas processing facility at the Ashburton North Strategic Industrial Area (SIA), south-west of Onslow. The Project area also includes associated pipelines and infrastructure linking the gas fields to the processing plant, and the processing plant to existing onshore infrastructure, such as the Dampier-to-Bunbury Natural Gas Pipeline (DBNGP). Chapter 2, *Project Description* details the Project and its components.

To assess the existing marine and terrestrial environments of the Project area, a variety of detailed scientific surveys and studies have been undertaken. These provide a description of the environment in, and surrounding, the Project area. Information collected from the surveys and studies has provided baseline information used to

inform the assessment of potential impacts resulting from development of the Project. Discussion of the potential impacts and proposed management measures for the marine and terrestrial environments is included in Chapter 8, *Marine Risk Assessment and Management*, and Chapter 9, *Terrestrial Risk Assessment and Management*.

6.2 Regional Overview

6.2.1 The Pilbara Region

The onshore components of the Project are located within the Ashburton Shire, in the south-west Pilbara region of Western Australia (WA). The Pilbara is located between the Tropic of Capricorn and latitude of approximately 19°48'. It extends from the coast to the WA border and occupies an area of 502 000 km². The region incorporates the shires of Roebourne, Ashburton and East Pilbara, and the township of Port Hedland.

Figure 6.1 shows the boundary of the Pilbara and the location of the onshore and offshore components of the Project.



6.2.2 Climate

The Pilbara region experiences an arid to tropical climate and is influenced by two air masses—the Indian Tropical Maritime air moving in from the west or north-west during summer, and the tropical continental air from inland during winter. A pronounced dry period is typically experienced from August to November (ANRA 2009).

6.2.2.1 Temperature

Meteorological data is recorded at a Bureau of Meteorology (BoM) weather station at the Onslow Airport, located approximately 12 km north-east of the Project site. This data has been collected since 1940. The daily temperatures in the Project area can be expected to follow the pattern illustrated by Figure 6.2. The figure shows that Onslow Airport experiences mean daily summer temperatures ranging from 19 °C to 36 °C with the maximum reaching 49 °C. During winter, mean daily temperatures range between 13 °C and 27 °C with the minimum occasionally dropping to 3 °C.

6.2.2.2 Rainfall

Average yearly evaporation for the Pilbara region is approximately 3300 mm (BoM 2009). Tropical cyclones contribute 40 to 60 per cent of the rainfall in the north, but less than 30 per cent in the southern and eastern parts of the region (ANRA 2009). The average annual rainfall recorded at the BoM weather station at Onslow is 328 mm. The mean monthly rainfall is presented in Figure 6.3. The Project area is expected to follow this pattern due to its proximity to Onslow. The figure shows that the majority of rain falls between January and June. Rainfall in the region varies significantly from year to year and is dependent on rain-bearing low-pressure systems, thunderstorm activity and passage of tropical cyclones. Cyclonic events range from storms delivering up to 300 mm of rainfall to milder 30 mm events. Wet years typically receive a large proportion of rainfall from tropical cyclones (SKM 2009).

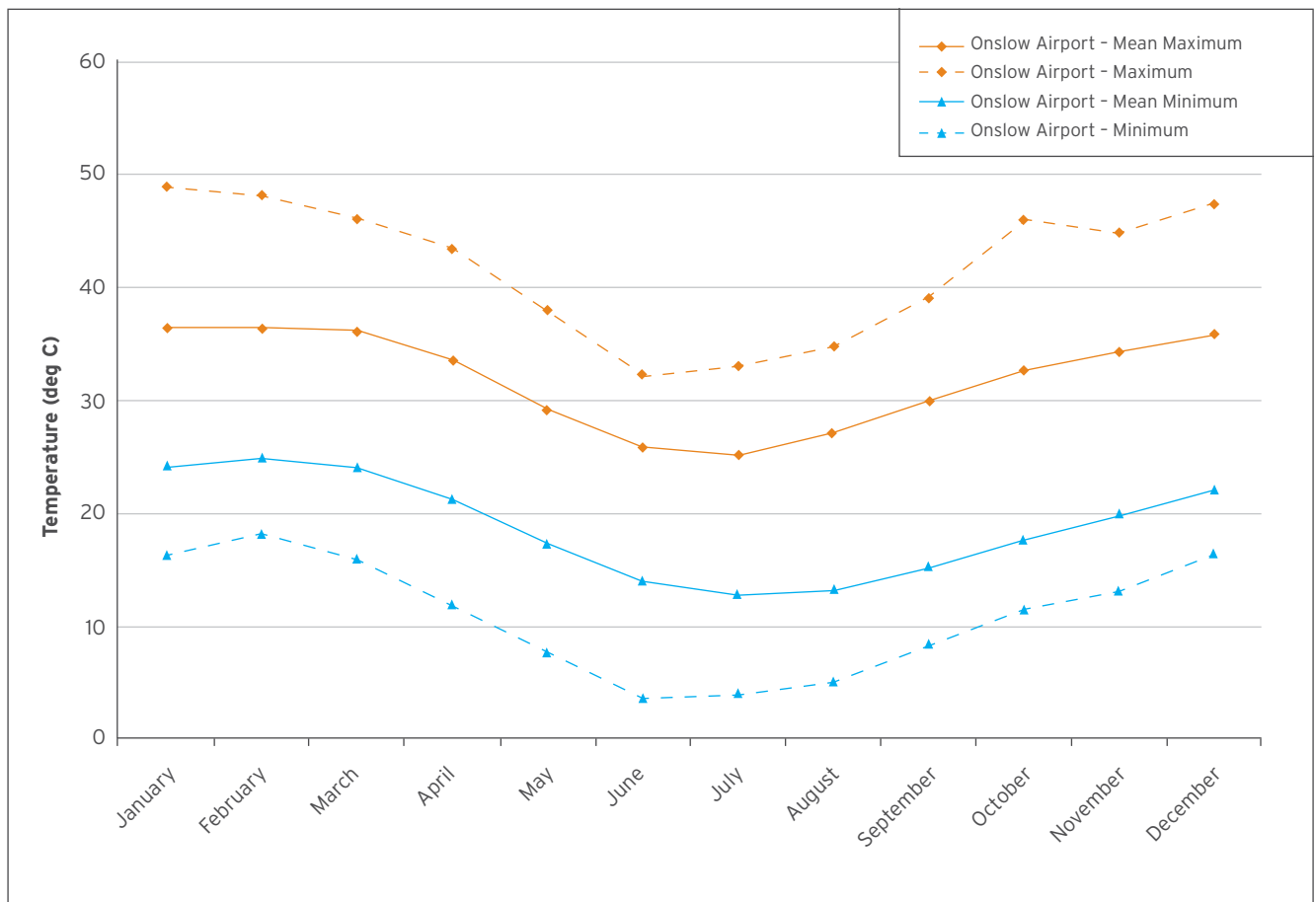


Figure 6.2: Monthly Temperatures at Onslow Airport (1940 - 2009)

Source: BoM 2009

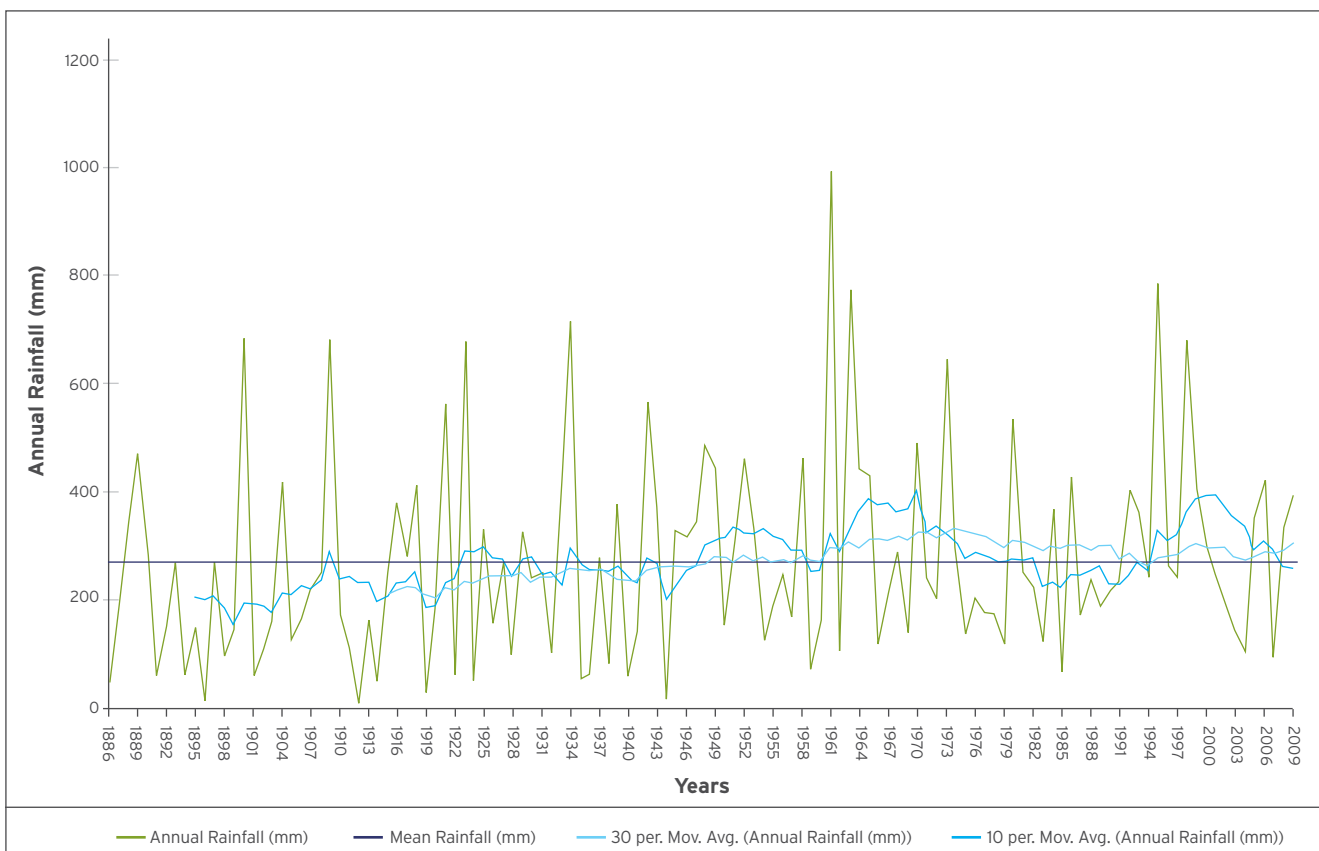


Figure 6.3: Annual and Mean Rainfall at Onslow (BoM Station 00516; 1886 - 2009)

Source: BoM 2009

6.2.2.3 Wind

Differential heating between the land and ocean commonly causes formation of a local thermal cell structure, which modulates the direction and strength of coastal winds (Damara 2009). Three dominant wind patterns occur in the western Pilbara region. These include an easterly pattern with winds varying from north-east to south-east over the diurnal period, a westerly pattern with winds varying from north-west to south-west, and a rotation pattern with winds rotating in an anti-clockwise direction through 360 degrees over 24 hours (Physick 2001). The seasonal wind roses are presented in Figure 6.4 to Figure 6.7. The figures demonstrate that the dominant southerly to westerly winds occur primarily during the spring and summer periods. The land-sea breeze cycle is less defined during winter months. Although a change in wind direction typically occurs during late morning or early afternoon, southerly winds occasionally remain persistent throughout the day.

Analysis of the directions associated with strong winds (8.8 to 11 m per second) at Onslow Airport suggests that they most frequently occur from the north-east quadrant. However, this bias is not reflected in the distribution of

winds stronger than 75 km per hour, which have occurred from a wider range of directions. A relative absence of strong and extreme winds occurs from the south-east to south, which is likely to be caused by overland frictional loss (Damara 2009).

6.2.2.4 Cyclonic Activity

An average of five tropical cyclones passes through WA each year, although this may be highly variable from year to year. Cyclones are typically generated offshore from the Kimberley coast, which receives the highest frequency of cyclone events. Although the Pilbara is to the south-west of this zone, the region still experiences significant winds—above 90 km per hour (Beaufort Force 10)—approximately once every two years (Damara 2009). Cyclones that affect Onslow typically take a southerly or south-easterly track as they move from offshore Kimberley waters (BoM 2009a). Tropical cyclones passing to the north-west of Onslow are more frequent, including systems that track parallel to the North West Shelf (NWS) (Damara 2009). Figure 6.8 shows the tracks of cyclones that have affected Onslow since 1953.

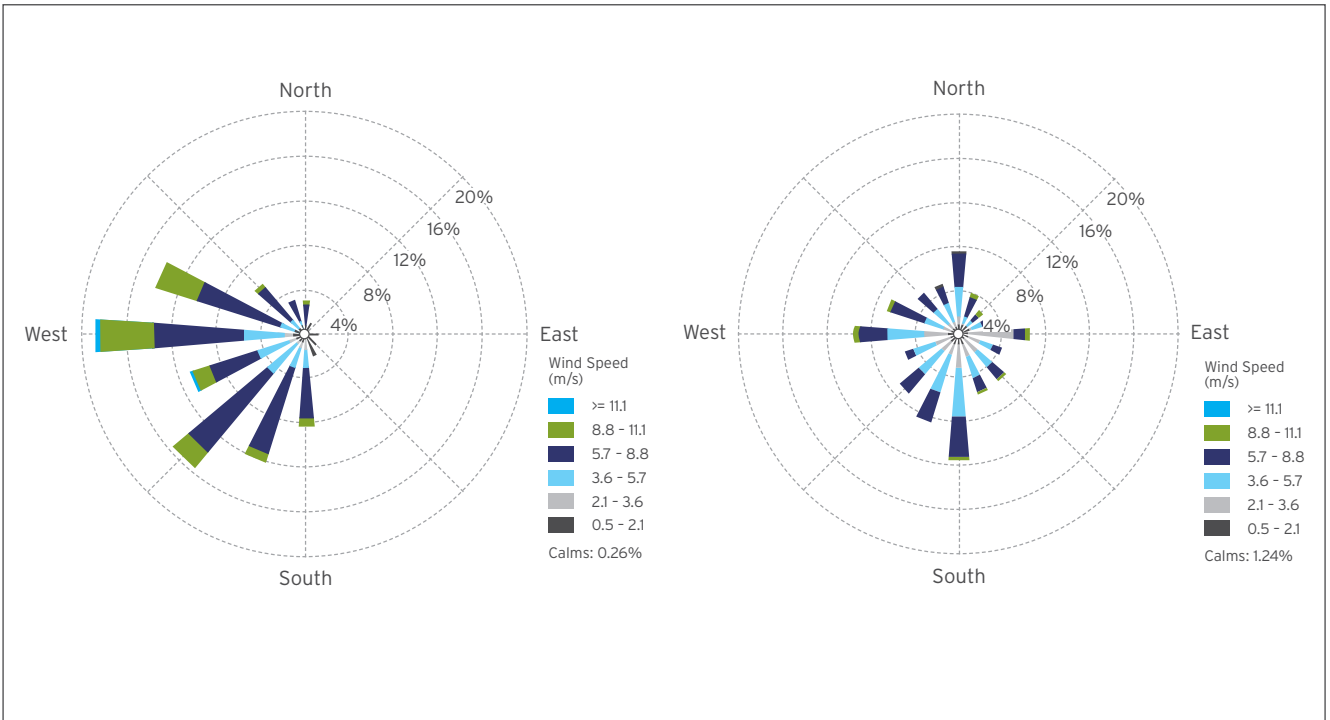


Figure 6.4: Summer Wind Rose for Onslow Airport (1998 - 2008) **Figure 6.5: Autumn Wind Rose for Onslow Airport (1998 - 2008)**

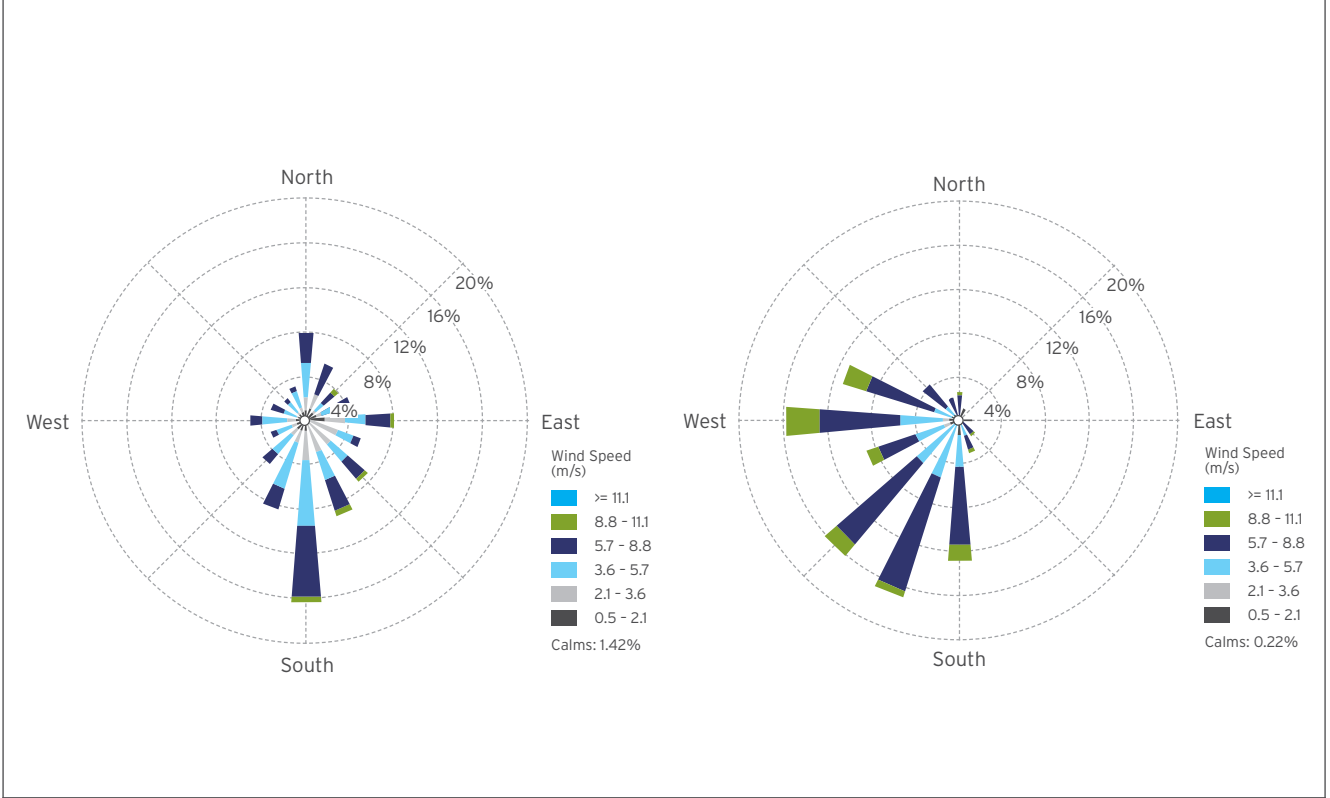


Figure 6.6: Winter Wind Rose for Onslow Airport (1998 - 2008) **Figure 6.7: Spring Wind Rose for Onslow Airport (1998 - 2008)**

Source: SKM 2009

The original Onslow settlement located near the mouth of the Ashburton River—now a registered heritage site—was relocated in 1925 due to significant changes to the river channel believed to be caused by cyclone-related flooding. Further information on the Old Onslow Town Site heritage area is included in Section 6.5.

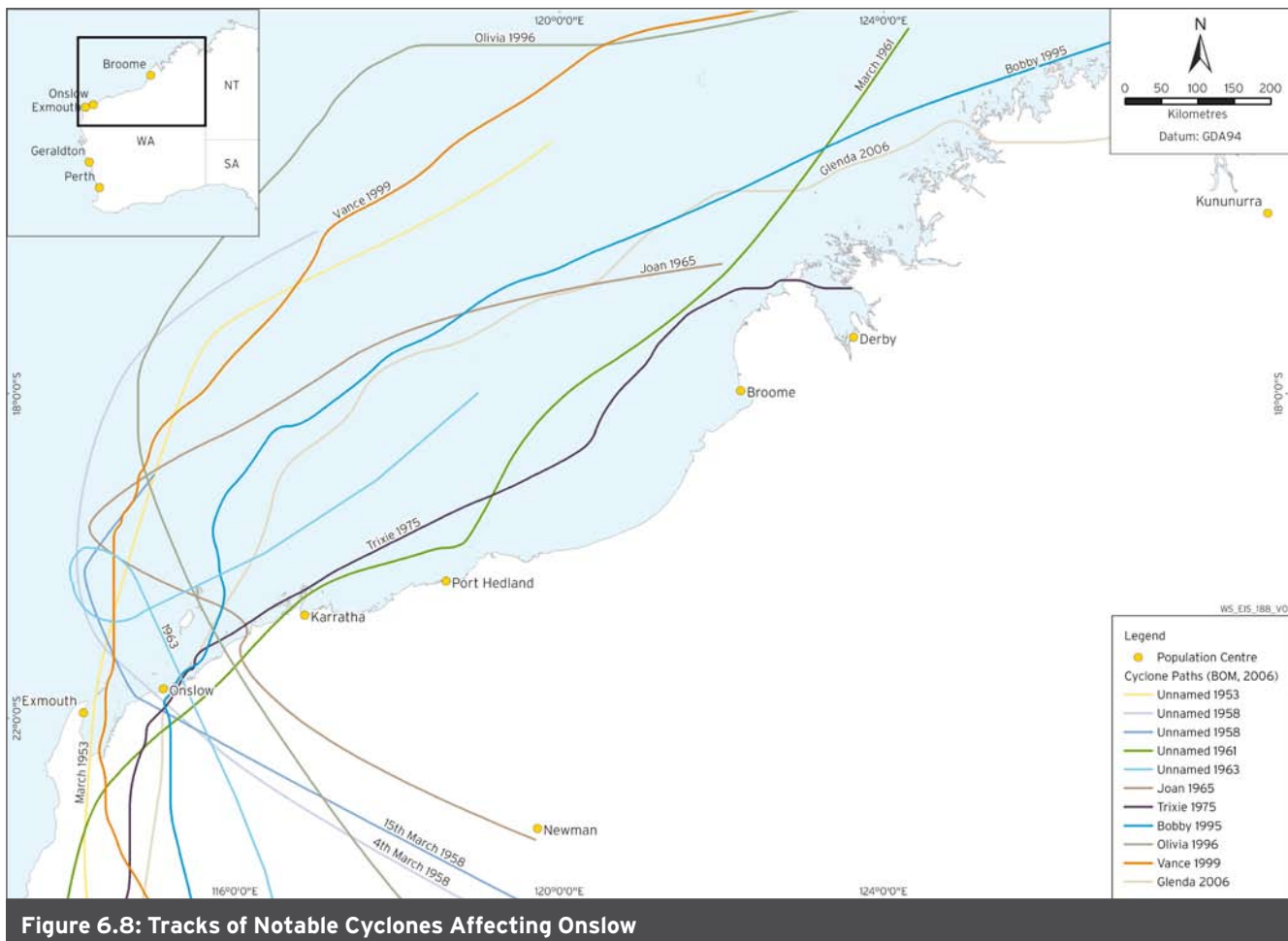
6.2.3 Ambient Air Quality

A Pilbara regional air quality study was conducted by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) in 2001. This included surface and upper air meteorology, and surface air quality at various locations in the Pilbara. The CSIRO study did not extend as far as Onslow in the west and therefore this section only addresses Pilbara regional air quality and its relationship to emissions sources. Ambient air quality at a scale local to the Project area is discussed in Section 6.3.

The air-quality data for the regional study were recorded at the regional industrial centres of Dampier/Karratha

(approximately 300 km north-east of Onslow) and Boodarie (approximately 500 km north-east of Onslow). Surface air-quality data measured at Dampier/Karratha included ten-minute averages of ozone (O₃), nitric oxide (NO), nitrogen dioxide (NO₂), carbon monoxide (CO), particulate matter of 10 microns or less and 2.5 microns or less (PM₁₀ and PM_{2.5} respectively). Surface air-quality data measured at Boodarie included O₃, NO, NO₂, sulfur dioxide (SO₂), hydrogen sulfide (H₂S) and PM_{2.5} (Physick 2001). Data from Dampier/Karratha would be expected to be slightly more representative of the environment at Ashburton North than Boodarie, but needs to be compensated for industrial sources local to the area.

The CSIRO study revealed that ambient atmospheric concentrations for CO, O₃, SO₂, PM_{2.5} and NO₂ in these locations are very low and well below the National Environment Protection Measure (NEPM) for Ambient Air Quality standards (Physick 2001).



Source: Bureau of Meteorology 2009a

Data from Dampier indicated eight-hourly concentrations of CO typically below 0.3 parts per million (ppm) compared with a NEPM of 9.0 ppm. These values are typical of rural background sites and may be even lower at Ashburton North.

The study found that Karratha O₃ concentrations peaked at 60 ppb for an hourly concentration. This is indicative of some photochemical activity, since background levels in the Southern Hemisphere are typically around 27 ppb. Given the lack of industrial activity around Ashburton North, these background values would typically be encountered under most circumstances.

Data from Karratha indicated that hourly concentrations of SO₂ were typically less than 1 ppb compared with a NEPM of 200 ppb. A similar background level of SO₂ would be expected at Ashburton North.

Local sources of NO₂ at Karratha reached maximum hourly concentrations as high as 60 ppb, compared with a NEPM of 120 ppb. Fiftieth percentile concentrations for the years 1999 and 2000 were approximately 5 ppb and 8 ppb respectively. These latter concentrations are considered most likely to be representative of those encountered at Ashburton North.

Daily PM₁₀ values were measured between 1998 and 2001 at Dampier. These results show a strong seasonal cycle with the lowest values being in April and May. A similar cycle can be seen for the PM_{2.5} values measured at Boodarie. A review of seasonal wind directions indicates a reversal in dominant wind direction between winter and summer, with strong easterly winds blowing during summer and strong westerlies blowing during winter. This suggests that this is a Pilbara-wide phenomena indicating that the summer maxima for particulate matter—which exceed the NEPM—are from natural causes (e.g. wind-blown dust from the central desert regions) and would therefore also be encountered at Ashburton North.

6.2.4 Terrestrial Biogeographical Setting

The Interim Biogeographic Regionalisation for Australia (IBRA) categorises the Australian continent into regions of like geology, landform, vegetation, fauna and climate, referred to as bioregions (DEWHA 2009b). There are 80 such regions throughout Australia, with 26 in WA. The boundaries of the IBRA regions in WA are broadly compatible with Beard's phytogeographic regions (Beard 1975), a hierarchical system of provinces comprised of botanical districts and subdistricts.

The proposed onshore facilities are located close to the boundary of the Carnarvon (CAR) and Pilbara (PIL) bioregions, with the majority of the Project infrastructure

located within the north-eastern corner of the Carnarvon bioregion. Figure 6.9 shows these bioregions and their sub-regions. Important features of each bioregion are presented in the following sections.

6.2.4.1 Carnarvon Bioregion

The CAR bioregion comprises 83 800 km² of land from Onslow to south of Denham in WA. It includes the chain of islands from Exmouth to Karratha, islands of the Exmouth Gulf and islands within Shark Bay, including Dirk Hartog Island. The Shark Bay World Heritage area is also within the bioregion. The bioregion consists of a gently undulating landscape with open drainage. The main land use is pastoralism. Salt production also occurs in the bioregion, particularly at the Lake MacLeod salt lake and at the Onslow Salt operations directly adjacent the Project. The major population centres are Carnarvon and Exmouth (ANRA 2009a).

The Carnarvon bioregion consists of two sub regions, described as:

- CAR 1 - Cape Range: rugged tertiary limestone ranges and extensive areas of red aeolian dunefield, Quaternary coastal beach dunes and mud flats. *Acacia* shrublands (*Acacia stuartii* or *Acacia bivenosa*) over *Triodia* on limestone and red dunefields, *Triodia* hummock grasslands with sparse *Eucalyptus* trees and shrubs on the Cape Range. Extensive *Triodia* hummock grasslands on the Cape Range and eastern dune-fields. Tidal mud flats of sheltered embayments of Exmouth Gulf support extensive mangroves. Beach dunes with spinifex communities. An extensive mosaic of saline alluvial plains with samphire and saltbush low shrublands along the eastern hinterland of Exmouth Gulf. Islands of the Muiron, Barrow, Lowendal and Montebello groups are limestone-based (Kendrick and Mau 2002).
- CAR 2 - Wooramel: Alluvial plains associated with downstream sections and deltas of the Gascoyne, Minilya and Wooramel Rivers. Includes Lake MacLeod and Kennedy Range. Tree to shrub steppe over hummock grasslands on and between aeolian red sand dunefields are extensive in the north and east as well as on top of Kennedy Range. Permian sediments are common in northern parts. Southern areas comprise limestone plateaux overlain by red sand plains. *Acacia* shrublands (mulga, bowgada and *Acacia coriacea*) over bunch grasses on red sandy ridges and plains. Mangroves confined to small areas around Lake MacLeod and near Carnarvon. Saline alluvial plains with samphire and saltbush low shrublands in near-coastal areas (Desmond and Chant 2001).

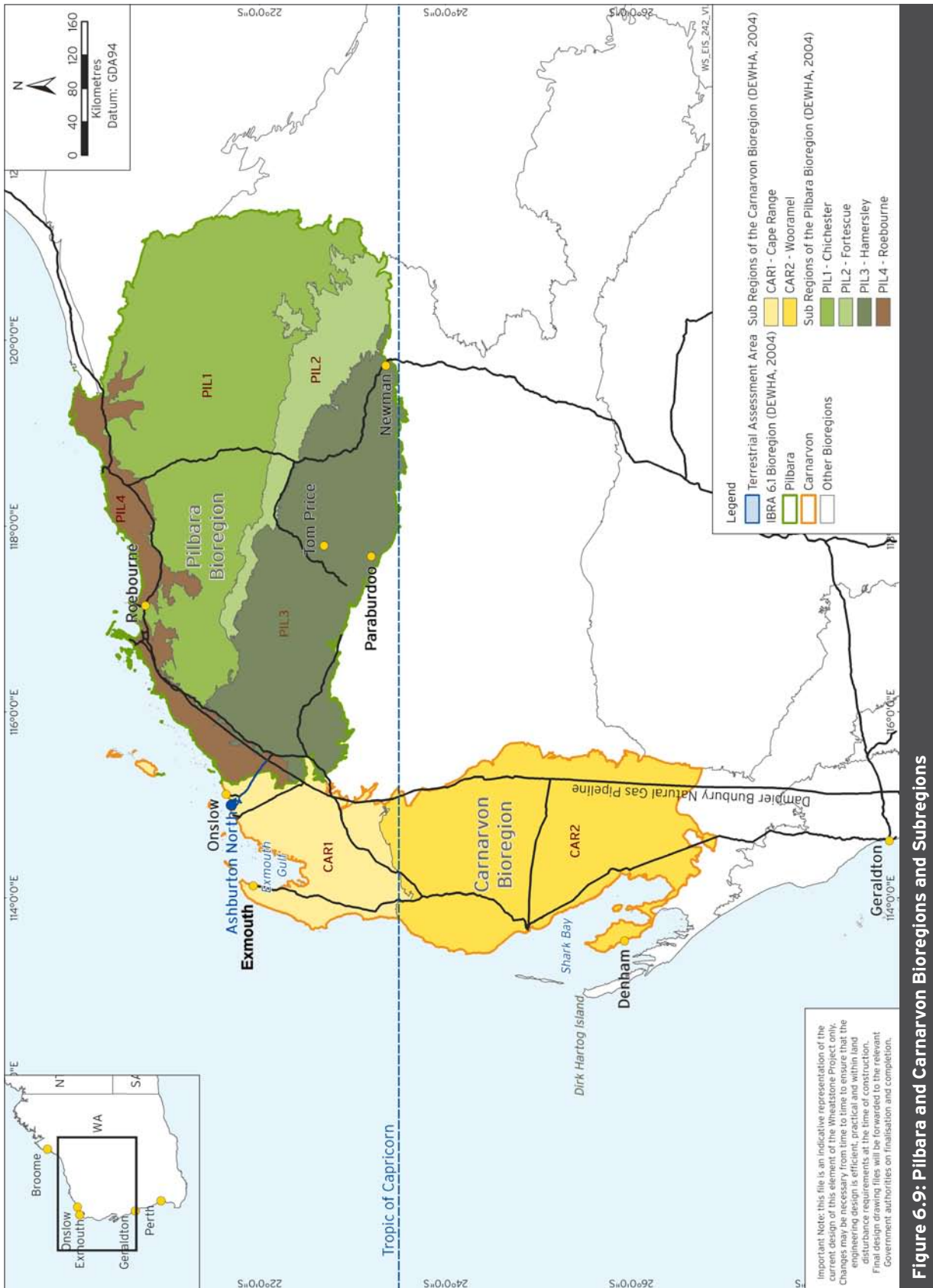


Figure 6.9: Pilbara and Carnarvon Bioregions and Subregions

6.2.4.2 Pilbara Bioregion

The PIL bioregion occupies 178 500 km². The bioregion adjoins the coast in north-western WA from Onslow to near Pardoo (520 km east of Onslow). The bioregion comprises Aboriginal land, leasehold land, conservation reserves and provides the majority of the State's exports in petroleum, natural gas and iron ore (ANRA 2009).

The Pilbara bioregion is divided into four sub-regions, described by the DEC as:

- PIL 1 - Chichester: Archaean granite and basalt plains supporting shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasses. Snappy gum tree steppes occur on ranges
- PIL 2 - The Fortescue Plains: Alluvial plains and river frontages. Salt marsh, mulga-bunch grass, and short grass communities on alluvial plains. River gum woodlands fringe the drainage lines. Northern limit of Mulga
- PIL 3 - Hamersley: mountainous area of Proterozoic sedimentary ranges and plateaux with Mulga low woodland over bunch grasses on fine textured soils and Snappy gum over *Triodia brizoides* on skeletal sandy soils
- PIL 4 - Roebourne: Quaternary alluvial plains with grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia translucens* over *Triodia pungens*. Samphire, Sporobolus and Mangal occur on marine alluvial flats. Arid tropical with summer rain (DEC 2005).

6.2.5 Seismicity

According to earthquake risk mapping for the Australian continent by Gaull *et al.* (1990), the Pilbara region is located in a zone with approximately an 11 per cent chance of a significant earthquake occurring in the next 50 years. This risk level is considered low but is higher than the earthquake likelihood in most of central Australia and the eastern seaboard.

The most significant concentration of seismic activity in Australia has been recorded off the north-west coast of WA. The onshore region of the north-west also has elevated seismicity. One of the largest earthquakes known in the Australian region occurred off the north-west coast on 19 November 1906. It had a magnitude of 7.75 and was felt over the entire western half of WA. In recent times, a magnitude 6.3 event occurred at Collier Bay, approximately 200 km north-east of Broome in August 1997, and a magnitude 5.1 event occurred north-west of Exmouth in October 2000. The last recorded earthquake near Onslow

occurred west of Exmouth in 2006, registering a magnitude of 3.4 (UWA 2009).

6.2.6 Soils and Landforms

6.2.6.1 Soil-Landscape Regions and Provinces

The Project area is part of the Western Region soil-landscape region covering just under half of the total area of WA (47.6 per cent or 1 201 400 km²). The boundaries of the Western Region extend from the Indian Ocean to the edge of the Sandy Desert and Central Southern Regions. The Western Region is divided into ten soil-landscape provinces. The Project area is located within the Exmouth and Ashburton soil-landscape provinces. Figure 6.10 shows the soil-landscape regions and provinces in WA.

The Exmouth Province occupies approximately 25 100 km² (1 per cent of WA) and generally comprises alluvial plains or sand plains with coastal flats and dunes, and some ranges and stony plains, on sedimentary rocks of the Carnarvon Basin. The Ashburton Province is located to the south-east of the Exmouth Province and occupies approximately 188 375 km² (7.5 per cent of WA). The Ashburton Province comprises a mosaic of hilly terrain and stony plains with rugged ranges, hills, ridges and plateaux found on the sedimentary rocks of the Ashburton, Edmund and Collier Basins.

Soils vary over the Western Region as a result of a wide range of parent materials and climatic conditions encountered. Soils of the Exmouth Province generally comprise:

- Sand plains and dunes dominated by deep red sands and deep sandy duplexes
- Red/brown non cracking clays, hard cracking clays and deep red sandy duplexes on the alluvial plains and floodplains, along with some red loamy earths
- Tidal soils on the coastal flats
- Coastal dunes of calcareous deep sands and deep red sands
- Calcareous shallow loams, red loamy earths and stony soils on the Cape Range and other limestone hills
- Red deep sands on the undulating sandy plains to the south.

Soils of the Ashburton Province generally comprise:

- Stony soils in the hilly terrain
- Red shallow loams, red/brown non-cracking clays, loamy earths and deep sandy duplexes on the stony plains

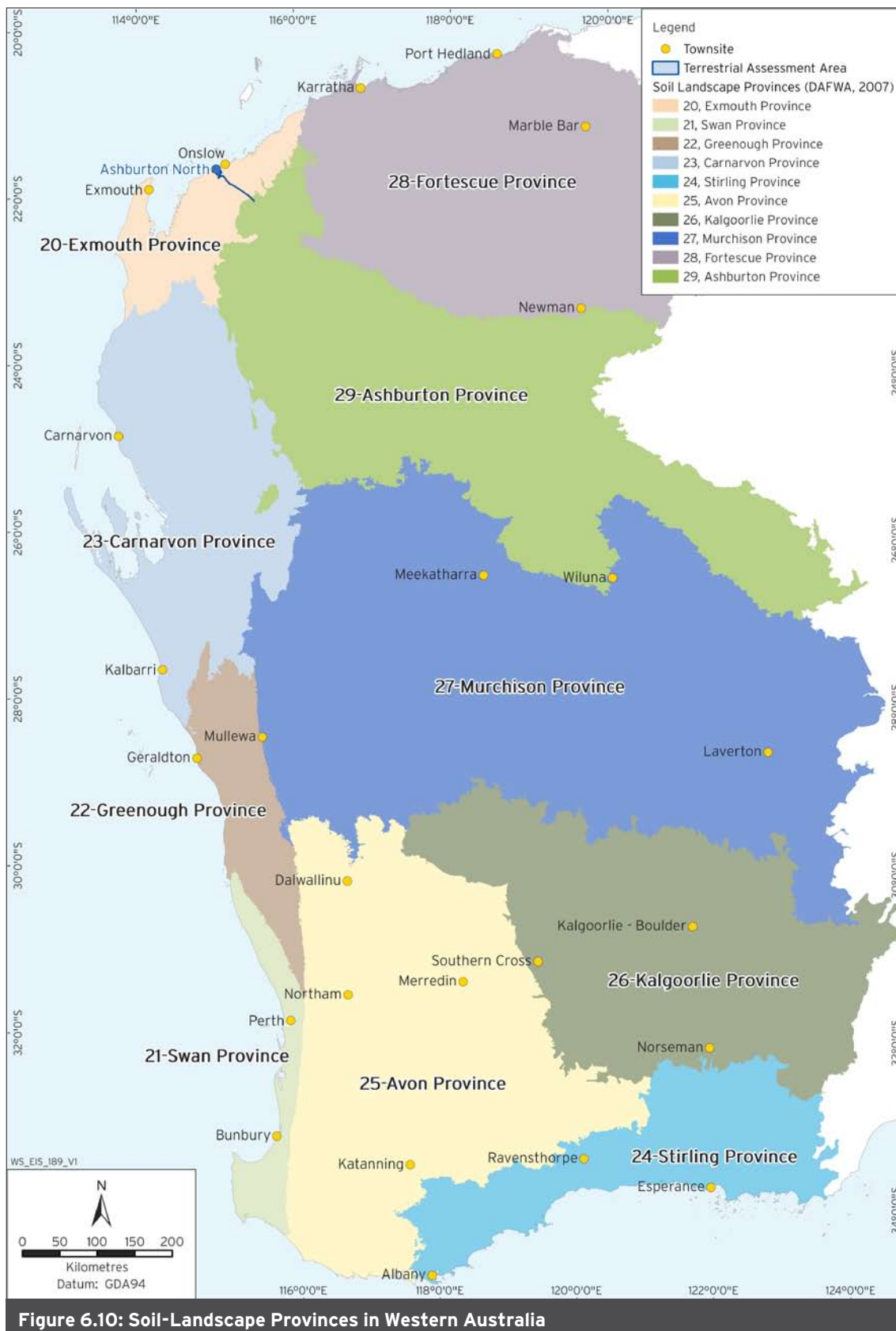


Figure 6.10: Soil-Landscape Provinces in Western Australia

- Red loamy earths and red/brown hardpan shallow loams, deep red sands and shallow sandy duplexes along the hardpan wash plains
- Deep red sands, sandy duplexes on the sand plains
- Red loamy earths, calcareous loamy earths and deep red sands on alluvial plains
- Calcareous shallow loams on the calcrete plains.

Discussion of the soils and landforms found in the Project area is included in Section 6.4.4. A more detailed description is included in Appendix H1.

6.2.6.2 Acid Sulfate Soils

The probability of encountering acid-generating material in the Western Region ranges from “extremely low” to “high”, according to acid sulfate soils risk mapping completed by the CSIRO (2009). The high probability areas are generally located in low-lying areas of 0 to 3 m above Australian Height Datum (AHD) including intertidal flats, supra-tidal salt flats and mangrove swamps along the coast. Areas of low risk are generally associated with red earths typically encountered throughout most of the Exmouth and Ashburton provinces.

Further discussion of acid sulfate soils is included in Section 6.4.4.

6.2.7 Hydrogeology

The predominant known shallow aquifer resources of the Pilbara coast occur in unconfined valley floor alluvial and calcrete channel deposit aquifers beneath downstream reaches of the De Grey, Yule, Fortescue, Robe and Ashburton rivers. These aquifers are formed by relict fluvial sand and gravel deposits in ancient riverbeds that occur beneath and/or adjacent to the current watercourses. It is expected that similar deposits beneath the watercourses of the George, Maitland, Yannarie and Cane rivers might also host groundwater resources, although the catchments—and hence yield potentials—are smaller (URS 2004). Groundwater recharge to these resources occurs mostly from infiltration of stream flow and, less significantly, by direct infiltration as a result of rainfall (DoW 2008).

Regionally, groundwater flow is to the north-west, towards the coast, with groundwater levels typically less than 10 m below ground level in inland areas and within a few metres of (or at) ground surface near the coast. Shallow groundwater is generally brackish with total dissolved solids (TDS) of around 6000 mg/L, increasing to become saline towards the coast (>10 000 mg/L TDS). Fresh groundwater resources may occur locally near major river systems (URS 2004).

Typically, the alluvial successions of the superficial formations are less than 30 m in thickness and are at greatest thickness beneath the river systems. Groundwater yields from the superficial formations are moderate to small. Pastoral supplies of brackish to saline groundwater are drawn from low-yielding bores and wells. Low-salinity groundwater from alluvial palaeochannel aquifers beneath the Cane, Yule and De Grey rivers is currently used for town water supply (URS 2009a).

Groundwater is also hosted in confined aquifers in the deeper Carnarvon Basin successions. Confined aquifers underlying Ashburton North are formed by the Windalia Radiolarite, Birdrong Sandstone (confined by the Muderong Shale) and Mungaroo Formation (URS 2009a).

Most of the aquifer systems are untested locally except for the superficial formations. However, the Birdrong Sandstone is a major regional aquifer and is used to supply industrial quality groundwater. Near Onslow, the Birdrong Sandstone occurs approximately 500 m below ground level and dips to the north-west. The Birdrong Sandstone is predominantly glauconitic sandstone with minor siltstone and conglomerate, and typically yields to production bores from 500 to 4500 kL per day across the Carnarvon Basin. The groundwater in the Birdrong Sandstone beneath Onslow is saline with TDS of 12 000 mg/L, increasing to 30 000 mg/L TDS offshore (URS 2004). There are no known major groundwater resources near the coast in the rocks of the Pilbara Craton.

6.2.8 Surface Water

The surface water environment is characterised by three main components: local rainfall, run-off from upstream catchments and tidal variation.

The Project area is located in the Ashburton River Catchment and several small coastal sub-catchments. The Ashburton River Catchment area is approximately 78 777 km² and is depicted in Figure 6.11. The Ashburton River is one of the major rivers of the Pilbara and is typically ephemeral, flowing only in response to significant rainfall.

The Ashburton River is characterised by:

- A large catchment area
- Long dry periods and high intensity rainfall events, which generate significant stream flows. The magnitude of stream flow is predominantly determined by the Average Rainfall Interval (ARI) of the rainfall events.

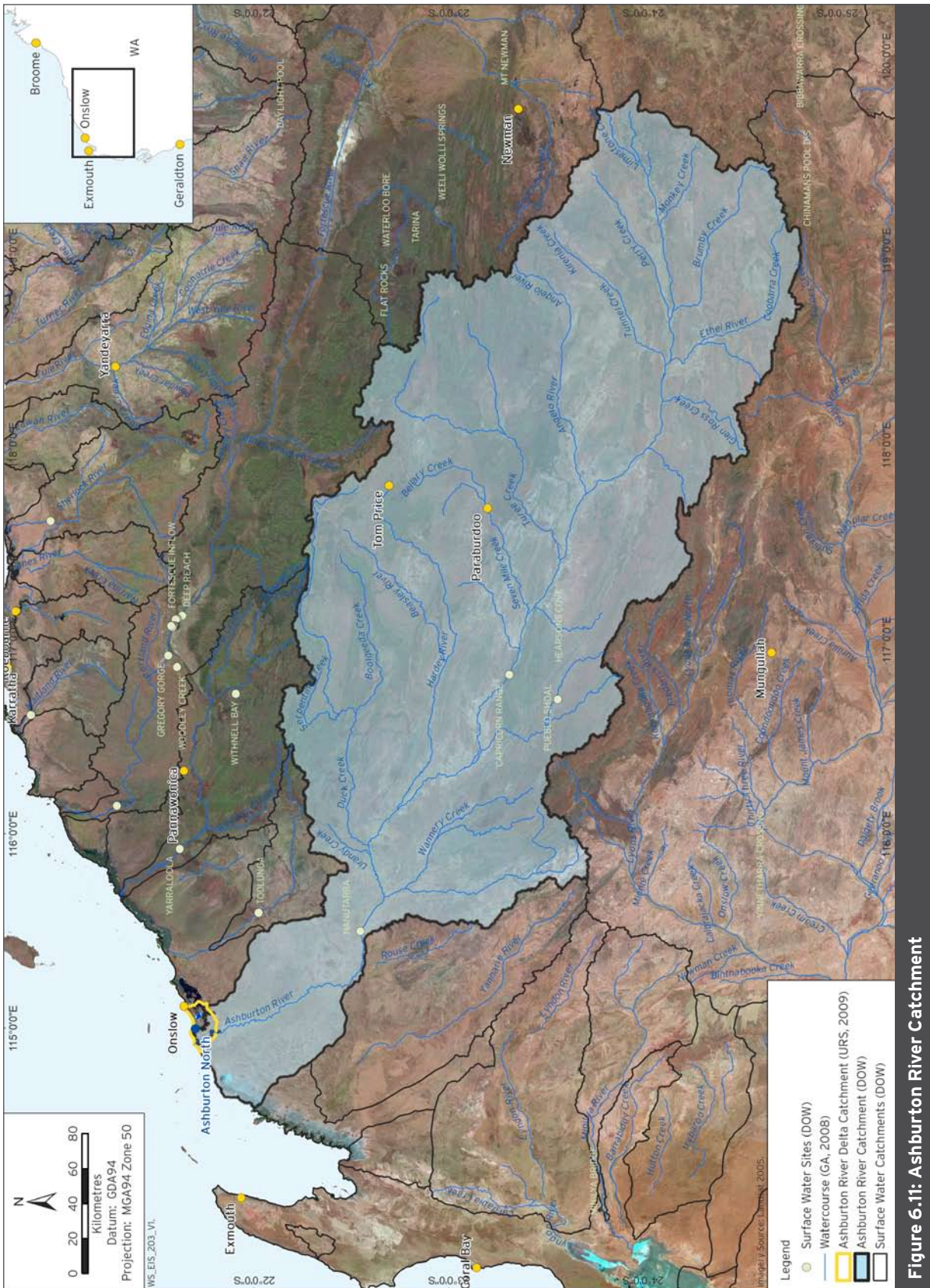


Figure 6.11: Ashburton River Catchment

The WA Department of Water (DoW) operates several stream flow gauges throughout the Ashburton River Catchment. The lowest elevation gauge is at Nanutarra, about 100 km upstream of Ashburton North, with stream flow recorded since 1972. The recorded annual flow volumes at this gauge are widely variable, ranging from 3 gegalitres (GL) in 2007 to 4500 GL in 1997.

The largest flood event on record occurred in January 1997 when 477 mm of rain was recorded in 24 hours, of which 415 mm fell within five hours (Mitchell and Leighton 1997). The associated peak flow rate recorded at Nanutarra was 12 600 m³ per second, which is estimated to be about a once-in-60-years ARI flood event.

A flood frequency assessment of the Ashburton River was performed to obtain the magnitude and frequency of stream flow on the Ashburton River (URS 2009). Peak flow rates for selected ARI events are shown in Table 6.1. Major flows occur in the Ashburton River every one to three years. River flows predominantly occur during the cyclone season and are typically short-lived.

Run-off is channelled in the upper reaches of the catchment due to greater topographic relief. Downstream on the Coastal Plain, the Ashburton River fans into a deltaic system (Ashburton River Delta) that hosts wide and braided flow paths (Ruprecht and Ivanescu 2000). The delta hosts tidal creeks and pools, the lower reaches of which are subject to tidal inundation.

Landforms on the coast within the Ashburton River Delta are influenced by tides. The highest recorded sea level at the tidal gauging station at Onslow (Beadon Creek) is +1.68 m AHD, recorded on 8 March 2000 (DPI 2004). Daily tidal fluctuations affect expressions of inundation in the lower reaches of the Ashburton River Delta.

Storm surges pose a threat to coastal areas in the Pilbara. Storm surges are a complex function of cyclone intensity and motion, extent of maximum winds, bathymetry and coastline shape. The associated seawater level, called the storm tide, is a combination of the storm surge and tidal variation. The worst-case scenario is to have a severe cyclone pass near the coast during high tide. This may cause seawater levels to rise above the highest astronomical tide. Significant historical storm surges have flooded parts of Onslow, particularly during the cyclones of 1934, 1958, 1961, and 1999 (BoM 2009a).

6.2.9 Terrestrial Biodiversity

The onshore Project area is located at the junction between two of the IBRA bioregions, Carnarvon and the Pilbara. The Carnarvon bioregion has a low and gently undulating landscape, with major land tenure being pastoral leasehold. The Pilbara bioregion is characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges.

6.2.9.1 Flora and Vegetation

The onshore Project area lies across portions of both the Carnarvon Botanical District and the Fortescue Botanical District of the Eremaean Botanical Province, as defined by Beard (1975). The vegetation of this province is typically open and frequently dominated by spinifex, wattles and occasional eucalypts. The majority of the Project's onshore area (that area within the Carnarvon bioregion) is located within the Carnarvon Botanical District and falls within the Cape Yannarie Coastal Plain. The remainder of the Project area (the eastern-most third of the domestic gas pipeline corridor, that area within the Pilbara bioregion) is located in the Fortescue Botanical District and falls within the Onslow Coastal Plain (Beard 1975).

Table 6.1: Ashburton River Flood Frequency

Average Recurrence Interval (years)	Peak Flow Rate (m ³ /s)
1	5
2	870
5	2 170
10	3 730
25	7 500
50	11 500
100	18 200
200	28 700
500	52 000
1000	81 700

Flora species of the highest conservation concern in WA are listed as Declared Rare Flora (DRF) as defined by the DEC under the *Western Australian Wildlife Conservation Act 1950* (WC Act). There are two DRF known from the Pilbara bioregion (*Thryptomene wittweri* and *Lepidium catapycnon*) and a single DRF species listed in the Carnarvon bioregion (*Eucalyptus beardiana*). These species are also listed as Threatened species under the EPBC Act (Cth). The DEC also defines four categories for species that are considered Priority flora. Definitions of threatened species listed under Western Australian and Commonwealth legislation are listed in Table 6.22 and Table 6.23.

Based on DEC database searches, four Priority flora species have previously been recorded near the Project area (Onshore Environmental Consultants 2009). These are:

- *Abutilon uncinatum* (Priority 1)
- *Helichrysum oligochaetum* (Priority 1)
- *Carpobrotus* sp. Thevenard Island (Priority 2)
- *Triumfetta echinata* (Priority 3).

6.2.9.2 Threatened Ecological Communities

An ecological community is defined as “a naturally occurring biological assemblage that occurs in a particular type of habitat” (DEC 2007). A community is classified as a threatened ecological community (TEC) if it has been defined as “presumed totally destroyed”, “critically endangered”, “endangered” or “vulnerable” by the Western Australian Threatened Ecological Communities Scientific Advisory Committee (English and Blyth 1997), the EPBC Act (Cth) or by the DEC. A number of TECs have been defined by the DEC for the Pilbara and Carnarvon bioregions; however, these do not coincide with the Project area.

A Priority Ecological Community (PEC) is defined as a possible TEC that does not meet the survey criteria for TECs. The DEC lists a number of PECs for the Pilbara and Carnarvon bioregions, none of which coincides with the Project area.

6.2.9.3 Vertebrate Fauna

Mammals

There are 57 mammal species known to occur within the Pilbara bioregion and 61 within the Carnarvon bioregion. Twelve introduced mammal species have been recorded within the Pilbara bioregion and nine have been recorded in the Carnarvon bioregion. These include the red fox, cat, rabbit, donkey, camel and sheep (National Heritage Trust 2002).

Birds

Important areas for waterbirds in the Pilbara and Carnarvon bioregions include the Dampier salt works, Barrow Island and the eastern and southern coastlines of Exmouth Gulf. These areas support many thousands of waterbirds, with Barrow Island supporting almost 20 000 individuals regularly. Town Beach in Onslow is also considered to support locally significant numbers of waterbirds (Bamford 2008).

Reptiles

The DEC Pilbara Biological Survey conducted between 2002 and 2009 recorded 140 reptile species in the Pilbara region, including the discovery of several new cryptic gecko species, two prevalent pebble mimicking dragons and several species of sand-swimming skinks (DEC 2008). A suite of species endemic to the Pilbara occur in the Hamersley and Chichester Ranges and three species are endemic to individual islands off the Pilbara coast (DEWHA 2009c). The DEC's NatureMap (2009) currently has records for 184 reptile species and subspecies for the Carnarvon bioregion.

Amphibians

At least 12 species of frog are known from the Pilbara region (Amphibian Research Centre 2009). The DEC's NatureMap (2009) currently records 15 amphibian species for the Carnarvon bioregion.

6.2.9.4 Claypan Ephemeral Invertebrate Fauna

The floodplains surrounding the Project area contain many aquatic systems that include a large number of ephemeral and often interconnected pools and claypans. Claypans are a type of ephemeral wetland formed from an impervious clay layer that makes up the base of the pan, naturally restricting run-off and seepage (Timms 2002). Claypans are often found in arid or semi-arid regions of the world, which are seasonally flooded during rain events and dry up due to evaporation (Hancock and Timms 2002). As claypans are naturally filled from rainwater, they are predominantly freshwater systems and often highly turbid.

The invertebrate fauna of claypans depends on the stage of the filling/drying cycle, and is generally dominated initially by phyllopod crustaceans and then by opportunistic insects (Hancock and Timms 2002). Both suites of invertebrates have adapted specialised methods to survive within these unique ephemeral habitats. Common claypan crustaceans, such as fairy, clam and shield shrimp have adapted evolutionary traits such as eggs that are

desiccation resistant and require for hatching a temporary dormant state following submersion. Insects use flight to increase the range of dispersal in search of other suitable habitat. Due to these adaptations, many claypans will only harbor one generation of most crustacean groups before succeeding to an insect dominated environment (Biota and Timms 2009).

The claypans surrounding the Project area can fill at other times of the year; however, they most commonly fill during cyclonic events between December and March. A review of the literature by Biota and Timms (2009) suggests that there has been very little previous work done on the claypans surrounding Onslow. The only other sampling of claypan ephemeral fauna in the Onslow locality has been completed by the DEC. This sampling was very limited in the Onslow area and was undertaken as part of the DEC Pilbara Biological Survey.

6.2.9.5 Subterranean Fauna

Subterranean fauna is a term used to describe a variety of fauna species inhabiting a range of underground niches. Stygofauna is a general term for aquatic fauna that inhabit groundwater systems. They are known to be present in a variety of rock types including karst, fissured rock and porous rock. Troglifauna is a general term for terrestrial fauna that inhabit air chambers in underground caves or small humid air-filled voids (Marmonier *et al.* 1993). Subterranean fauna in WA can exhibit high levels of endemism and many appear to have restricted ranges (EPA 2003).

Extensive subterranean fauna habitats (karstic, fractured rock, vuggy [small cavities] Channel Iron Deposits and porous aquifers, parafluvial and hyporheic environments) are known to exist in the Pilbara region; however, at present there are limited scientific data on distribution and diversity.

Stygofauna known to occur in the Pilbara region include a range of crustacean taxa, worms (platyhelminthes and oligochaetes), water mites and beetles (Humphreys 1999; Watts and Humphreys 1999; Biota unpublished data).

Troglobitic fauna within Australia are predominantly represented from groups including the Schizomida, (centipedes), Polydesmida (millipedes), Diplura (bristletails), Thysanura (silverfish), Coleoptera (beetles) and Blattodea (cockroaches) (Humphreys 2001; Biota 2006).

Five stygofaunal species recorded in the Pilbara region have been declared as Specially Protected (Threatened) fauna under the WC Act (WA).

6.2.9.6 Groundwater Dependent Ecosystems

A groundwater dependent ecosystem (GDE) is a natural ecosystem requiring access to groundwater to meet some, or all, of its water requirements so as to maintain its communities of plants and animals, ecological processes and ecosystem services (Resource and Environmental Management Pty Ltd 2007). Australia has a diverse set of GDEs that can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps (Connected Water 2009). Cave and aquifer ecosystems, particularly, are very specialised and characterised by high levels of endemism.

Two ecosystems in the Pilbara region are recognised as GDEs (SKM 2001):

- Pilbara spring systems - these ecosystems are entirely dependent on groundwater where only slight changes in key groundwater attributes below or above a threshold would result in their demise. These have a high conservation value.
- Pilbara river pool ecosystems - these ecosystems are communities where moderate changes in groundwater discharge or water tables would result in a substantial change in their distribution, composition and/or health. These are highly dependent on groundwater and have a moderate conservation value.

6.2.10 Coastal Geomorphology

A complex geologic framework determines the coastal geomorphology of the western Pilbara region. The sub-region lies north of the Gascoyne Sub-basin and on the Peedamullah Shelf (GSWA 1982). Partially lithified and unconsolidated alluvial sediments dominate the terrestrial landscape near Onslow and the Ashburton North site. Close to shore, these are overlain in places by sediments of marine origin, including shelly sands and reworked alluvial sands. Some of the sands are of recent Holocene origin and overlie older Pleistocene sedimentary structures (Semeniuk 1993).

Rivers in the Pilbara region play an important role in structuring the coast. Flows are highly variable and typically carry a high sediment load, which is discharged to the ocean and deposited along the coast. This sediment deposition and subsequent movement results in a constantly changing coastline. Further discussion of sediment loads and the effects on the Project area are included in Section 6.2.11.

Further seaward, the inner continental shelf landward of the 20 m isobath supports two major structural features:

- Mary Anne reefs and Great Sandy and Barrow shoals form an extensive ridge trending approximately north-north-east off the mouth of the Cane River to water over 20 m deep. This ridge and North West Cape provide topographic controls in shaping the curved shore between Tubridgi Point and Cape Preston.
- Chains of islands and shoals form lines approximately parallel to the shore between the mouth of Exmouth Gulf and Barrow Island. One line occurs in shallow waters, close to the 5 m isobath. The other is located closer to the 20 m isobath and includes more substantial islands such as the Muiron, Serrurier, Bessieres and Thevenard islands. These islands formed the coastline during the Holocene and earlier periods, and were left exposed as the sea level rose.

Bathymetry and coastal morphology in the region surrounding the Project area is presented in Figure 6.12. At a regional scale, three distinct coastal compartments can be identified along the reach of coast between Tubridgi Point (at the mouth of Exmouth Gulf) and Cape Preston. These are related to the regional geology, and secondarily related to coastal aspect and large coastal landforms such as deltas. Each compartment is comprised of a complex array of physical landforms and coastal processes in which the state of the environment is highly dynamic, varying over space and time.

The coastal compartments comprise a number of sediment cells. A sediment cell is an area, including the nearshore terrestrial and marine environments, within which the movement of sediment is readily identifiable, if not largely self-contained (Komar 1996). The Ashburton coastal compartment, which extends from Tubridgi Point to Coolgra Point (and encompasses the coast around the Project area), is a single sediment cell, extending over 70 km. It contains the active delta of the Ashburton River, long sandy beaches and dunes, and the island chains running approximately parallel to the shore.

The function of the Ashburton compartment as a single sediment cell is especially relevant to marine and coastal management, because disruption of one part of the cell is highly likely to affect the stability of the coast downstream. The Ashburton sediment cell has two sectors, the western shore between Tubridgi Point and the mouth of the Ashburton River, and the eastern shore from the river mouth to Coolgra Point. The net sediment movement within the cell is easterly, although reversible from time

to time due to onshore winds. As a result, sediment in the western sector is largely sediment reworked by erosion processes and littoral drift along the shore. In contrast to this, sediment in the eastern sector is of fluvial origin and littorally reworked, as Chenier spits migrating eastwards from the mouth of the Ashburton River.

6.2.11 Coastal Processes

6.2.11.1 Background

The Ashburton River catchment, within which the Project area is located, lies in the arid Pilbara region, which is on the fringe of both tropical and extra-tropical rainfall influences (Gentilli 1971; Semeniuk 1996; BoM 1998). As a result, rainfall may occur during either summer or winter months, but there are extended periods of sustained drought. Consequently, the Ashburton River is subject to highly variable flow conditions, with extended periods of low flow and short periods of intense flow, generally associated with extreme rainfall due to tropical cyclones.

The Pilbara coast has been identified as a significant floodplain system, subject to highly variable flows, which may contribute large quantities of fluvial sediments to the coastal region for relatively brief periods of time (Semeniuk 1996). This material is transported along the coast through the combined effect of waves and tidal currents. Despite highly variable sediment supply, the Pilbara coast changes slowly due to the extensive presence of coastal rock features acting as strong controls upon coastal structure.

Tidal creek networks commonly occur where breaches occur through the coastal barriers. Over the longer term, these systems generally provide a pathway for the import of sediment to the floodplain because of ongoing sea level rise (Ryan *et al.* 2003). However, over shorter time scales, this behaviour may be reversed, particularly if the tidal creek networks act as a run-off pathway.

Net alongshore sediment transport from Tubridgi Point to Dampier is generally considered to be from west to east, based upon offshore wave climate, prevailing winds, the orientation of tidal creek entrances, accretive features on the west side of rocky headlands and the drift paths of modelled circulation across the NWS (Pearce *et al.* 2003). Transport reversal during winter, or under cyclonic action, is expected and the quantum of potential transport may vary significantly due to inter-annual variability of the trade winds and land-sea breezes. It is noted that offshore suspended sediment transport is generally in the opposite direction to alongshore transport, moving from east to west (Margvelashvili *et al.* 2006).

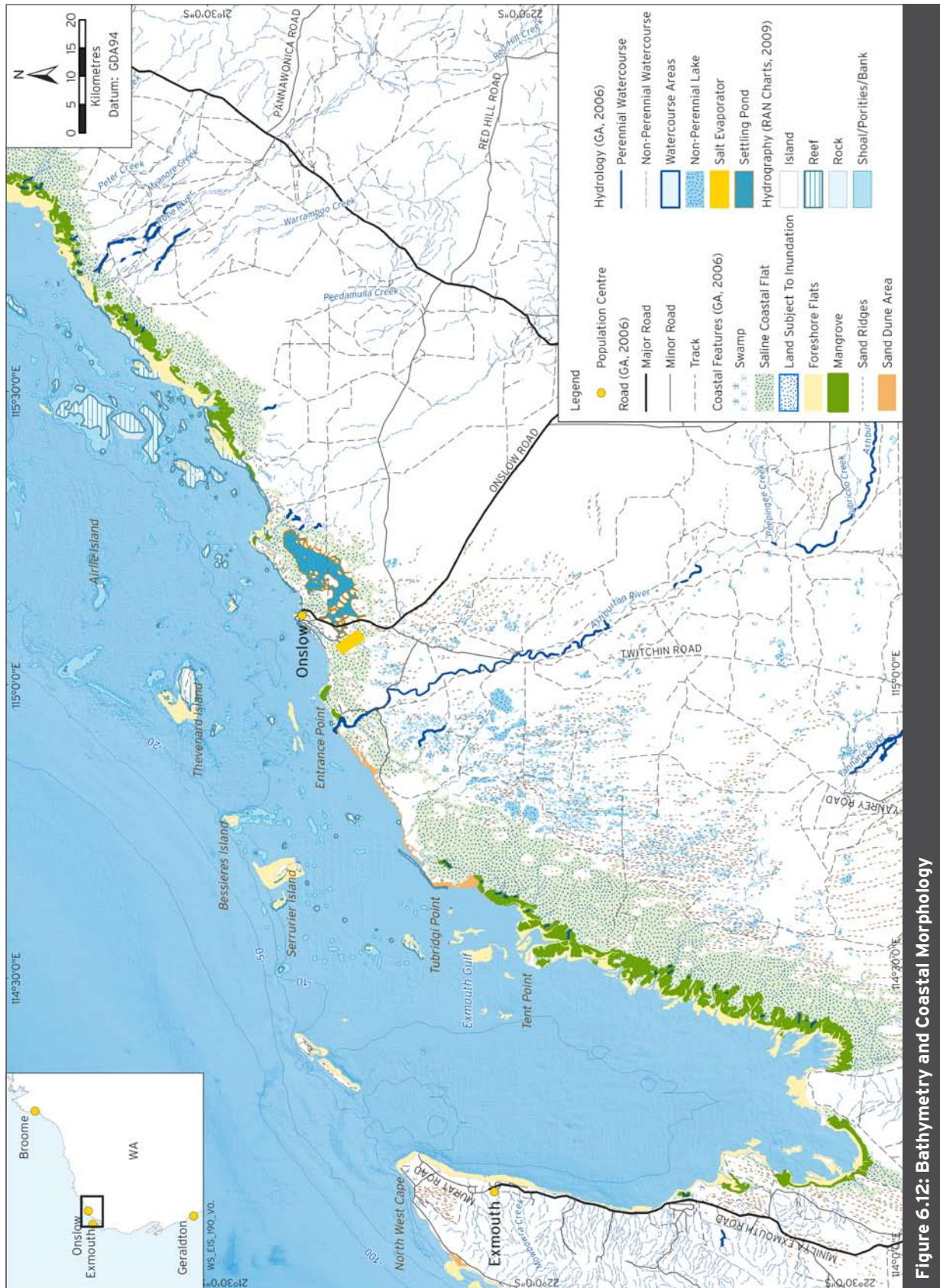


Figure 6.12: Bathymetry and Coastal Morphology

The impacts of cyclonic storm surge along the coast are noticeably localised, with washover fans apparent on north-west facing shore as well as on low-lying spits and foredunes in the immediate vicinity of tidal creeks and the river mouth.

6.2.11.2 Ashburton Delta

The Ashburton River can make a significant contribution to sediment deposition along the coast, particularly when it is in flood. Its delta comprises an extended area of generally low-lying land with an array of channels and ridges. Some of the channels actively transport river flows, others are only active during flood events. Some of the channels are characteristic in structure of tidal inlets and apparently, bear little flood run-off. Historic movements of the Ashburton River delta include internal channel movements and external coastal evolution (Figure 6.13).

Over a long geological period, the Ashburton River has delivered a substantial amount of sandy sediment to the coast from the Precambrian hinterland (Semeniuk 1993, 1996). The sediment has accumulated to form a riverine plain with up to approximately 25 m of unconsolidated red sand and muddy sand overlying an early Pleistocene or older limestone pavement. A more recently formed pavement of marine origin commonly sits above the deep red sand and outcrops at the surface. The pavement has a variety of lithified geomorphic features associated with fluvio-deltaic and near-shore marine processes. Preliminary radiometric dates for pavement sediments indicate some development in the previous interglacial period, approximately 120 000 years ago. The geomorphic features include landforms of mid-delta environments, including channel gorges, topographic rises and basins. Delta front features such as beach rock, beach ramps and low bluffs are also present as small islets with fringing



Figure 6.13: Chenier Spit Migration

coral reefs and are apparent close to the modern shore. In places, the limestone features are overlain by recently deposited, unconsolidated dune and beach sands as well as sediments characteristic of supra-tidal and intertidal flats. Whether any of the unconsolidated sediments are likely to be mobilised by metocean processes or destabilised by engineering works is open to question.

Throughout the Quaternary at least, the shifting Ashburton River has built a suite of coalescing deltas with the deltaic plain consisting of overlapping and inter-fingering delta lobes against a north-west trending rocky shore. The switching pattern has commonly resulted from channel avulsion with one of the few distributaries present at any time carrying the majority of water and sediment discharge. Judging by the formation of recorded changes to Entrance Point, the active channel rapidly progrades seaward while secondary channels are clearly less active and may be blocked by deposition from the main channel. In several places, particularly where the channel has been driven parallel to shore, presumably under the influence of winds and waves from the west and flowing in a north-easterly direction, the delta is asymmetrical with the river feeding Chenier spits on the eastern side of its mouth.

The main flow path of the Ashburton River across the delta has historically switched between channels, as the river previously exited near Entrance Point (British Admiralty 1923) in the eastern part of the delta. The old channel silted up, and switching of the main channel entrance to its present position in the western part of the delta occurred recently. Channel switching is typically associated with river systems bearing a high sediment load, under relatively low wave and tide conditions (Coleman & Wright 1975). A local salient and shoal structure commonly occurs at the site of the active channel, which may subsequently be rapidly destabilised if the river flow switches to an alternate channel. This feature is locally apparent at the existing Ashburton Channel entrance, with only residual shoals remaining at Entrance Point.

The northwest-facing coastline between the Ashburton River entrance and Entrance Point appears to have receded by 50 m between 1973 and 2004. Imagery from 1993 and 2001 shows a reasonably consistent trend of shoreline erosion in the order of 1.5 m per year. Concurrent accretion of a barrier spit occurred on the coast eastwards of Entrance Point, which gradually elongated, before eventually welding to the coast in 2005. This behaviour is consistent with an eastwards migration of the delta sediments.

The 2009 site inspection identified two creek entrances east of the main Ashburton River entrance. Historic

imagery shows there are three historic creek entrance sites that intermittently migrate, close up and break open.

The following features of the creek entrance and bars are noted:

- Ashburton east entrance closed between 2001 and 2004. There were no significant flow events during this period and it is assumed the littoral drift overwhelmed the tidal flow
- The entrance point western spit, evident in 2009, has historically been the site of a reasonably complex entrance bar complex, with the bar configuration suggesting eastwards littoral drift. This spit migrated eastward by about 700 m since 2004
- The Entrance Point western spit was located 300 m offshore of the 2004 coastline in 1973
- The Entrance Point eastern spit migrated eastwards by about 2.2 km between 1973 and 2009.

The rate of eastward migration since 1993 has been in the order of 100 m per year. This spit welded to the coastline after 2004, about the time when the current entrance to the west appears to have opened. The entrance spit is welded to the shore about 500 m west of the Project area. A coastal formation (salient) of beach material comprising a bulge in the coastline has developed by wave refraction and diffraction and longshore drift towards an offshore rock formation located further west (refer to Figure 6.13).

6.2.11.3 Hooley Creek and other Tidal Creeks

The entrance bar at Hooley Creek was estimated to be about 1.2 km long during the 2009 field inspection. In 1973, the entrance was located further west towards the centre of the three tidal creeks. There were two spits in the order of 1 km length on both sides of the entrance with the western spit further offshore.

The entrance bar configuration in 1993 was similar to 2009 but had deflated and progressively rebuilt during this period, most likely as a result of Tropical Cyclone Vance in 1999. The 2001 photography shows deflation of the entrance bar with isolated, disconnected sub-aerial bars evident in the entrance. The western spit of Hooley Creek had re-established in 2004 and elongated by about 700 m between 2004 and 2009. The eastward migration of sand is expected under typical conditions.

The historic photography of Hooley Creek suggests the entrance spit is highly dynamic having been rebuilt a number of times during the past 30 years, influencing tidal exchange to the creek systems.

The headwaters of tidal creeks between the western arm of Hooley Creek and Four Mile Creek display morphologies ranging from erosional to depositional. Regardless of the causes, which remain to be established for individual creeks, the changes are from headwater gullying and erosion in the west to headwater fans and deposition in the east. If the variation is long lasting rather than a response to seasonal or inter-annual fluctuation in metocean processes, it has ramifications for potential impacts on the Project site, particularly for harbour development. A further constraint on floodwater discharge, particularly its restriction to a single discharge outlet adjacent to the development area, may result in channel entrenchment and enhanced erosion of the floodplain landward of the existing salt-flats. This could be intensified by an abrupt change in the course of the main channel of Ashburton River in extreme flooding conditions. While these are matters for consideration in site design and environmental management, flood discharge from a reduced number of tidal creeks will also affect littoral sediment transport processes.

6.2.11.4 Dredged Channels

Dredged navigation channels are present at the Onslow Salt Jetty and the entrance of Beadon Creek, which is trained with a rock wall on its western side. Due to the distance from the proposed Materials Offloading Facility (MOF) and differences in scale and coastal structure, sedimentation of the proposed navigation channel is likely to differ markedly from these channels. In this context, the behaviour observed at each channel is indicative of sediment transport processes rather than expected rates of sedimentation.

The Onslow Salt channel (9.5 km in length) is approximately 10 m sounding depth, extending from a 6 m deep natural surface at the jetty to 10 km offshore. Anecdotally, the channel has not required maintenance dredging since its initial excavation, although subsequent capital dredging may have accounted for some accretion. Preliminary difference plots suggest that limited accretion has occurred over the period from 2000 to 2008, except for a narrow section, approximately coincident with the 10 m contour on the natural seabed surface. This position corresponds to a local rise in seabed gradient, which acts as a minor pathway for shore-parallel sediment transport. The channel does not extend to shore, and is considered unlikely to influence the majority of alongshore sediment transport. A shallow coastal convexity to the west of the jetty and a concavity to the east suggest that shelter from the jetty acts to trap a small quantity of sand.

The Beadon Creek navigation channel is maintained regularly by the Department for Transport, with approximately 5000 m³ per annum of sediment dredged since excavation of the navigation channel in 1968 (Crawford 1995). The channel is trained with a rock wall on its western side and a tidal spit on the eastern side acting to provide “natural training”. The navigation channel is connected to a tidal creek network, which links to a large area of inundated mud flats during extreme tides, high storm surges or high run-off drainage. Following the approach of Bruun (1978) for an inter-tidal area of 33.8 ha, the channel is estimated to have a capacity to naturally bypass 5000 to 10 000 m³ of alongshore drift. Considerable sedimentation has also been observed at either side of the navigation channel.

Accumulation to the west of the training wall is estimated to be in the order of 15 000 to 30 000 m³ per annum. Sedimentation within the tidal creek network is estimated at 10 000 to 40 000 m³ per annum, based on a rise of 0.1 to 0.5 m, which is related to inflow during extreme spring tides and cyclonic flooding. Combined with the observed rate of sedimentation and natural bypassing, a net eastwards littoral transport rate of 35 000 to 85 000 m³ per annum is estimated.

6.2.11.5 Onslow

Key water level processes affecting Onslow include tide, cyclonic surge, seasonal ranging and inter-annual mean sea level variations (National Tidal Facility 2000). The tidal forcing contains a range of cycles, including the semi-diurnal ranging, the monthly spring-neap cycle, a bi-annual cycle due to movement of the solar equator and a 4.4-year cycle developed from lunar elliptic motion (Damara 2008).

The seasonal variations of tides, surges and mean sea level are generally not in phase for several reasons. Tidal peaks occur near the equinoxes in March and September, while surge peaks mainly occur in January to March due to tropical cyclones, and from June to August due to mid-latitude systems. The seasonal mean sea level peaks during April.

This relative timing means that there is opportunity for high water level events—>2.8 m Chart Datum (CD)—over most of the year. The relative timing of the tidal and mean sea level peaks provides increased potential for extreme water level events to occur as a result of late season tropical cyclones in March or April.

Modelling of extreme cyclonic water levels for the Onslow townsite and Onslow Salt (GEMS 2000; Nott & Hubbert 2005) has estimated the 100-year average recurrence interval (ARI) water level as 4.7 m AHD (6.2 m CD), including allowance for wave setup.

6.3 Local Marine Environment

6.3.1 Location

The offshore Project area is located approximately 60 km north-north-west of the Montebello Islands, 145 km from mainland WA, in Commonwealth waters (Figure 6.14). The offshore facilities will be developed within Petroleum Titles WA-253-P, WA-17-R, WA-356-P and possibly WA-16-R. The Petroleum Titles are located on the edge of the continental shelf. The majority of the seabed at the field dips gently down towards the north-west, with an average gradient of less than one degree. Towards the northern end of the Petroleum Titles, the seabed descends more steeply from approximately 250 m to greater than 500 m water depth, with gradients of up to 45° (Fugro 2006).

The trunkline route, connecting the offshore facilities with the LNG plant, extends along the outer continental shelf west of Barrow Island, at approximately the 110 m isobath.

The nearshore Project area is located in WA waters, on the coastal side of the 20 m isobath, approximately 10 km west of Onslow and 8 km east of the Ashburton River mouth (Figure 6.15). The proposed shipping channel extends approximately 16 km from the mainland, across the inner continental shelf, passing Saladin Shoal, Hastings Shoal, Gorgon Patch and Weeks Shoal, and ending around 5 km east of Thevenard Island. Nearshore waters are shallow in this area, generally between 5 and 15 m water depth.

The nearshore portion of the trunkline route approaches the coast between Bessieres Island and Thevenard Island, curving north of Ashburton Island before coming ashore about 6 km east of the Ashburton River mouth.

6.3.2 Oceanography and Hydrodynamics

6.3.2.1 Regional Scale Circulation Patterns

The NWS is at the eastern boundary of a major oceanic frontal system, sitting within the Indo-Australian Basin, surrounded by the ocean region between the north-west coast of Australia and the Indonesian islands of Java and Sumatra. The region is influenced by a number of regional circulation currents including the Indonesian Throughflow to the north—a dominant current flowing through Indonesia into the North-west Region—the Holloway Current, the South Equatorial Current, the Eastern Gyral Current and the Leeuwin Current (Figure 6.16). The Holloway Current is driven by the Indonesian Throughflow along the outer NWS. Further south, the narrow and meandering Leeuwin Current flows near the continental shelf break and typically flows southwards off the west coast of Australia with varying strength throughout the year.

The current is strongest (0.25 m/s) during autumn and winter, from April to July, when opposing winds are weakest (Holloway & Nye 1985). It is weakest during the summer months, from November to March, when winds are predominantly blowing strongly from the south-west. Generally, the Leeuwin Current flows most strongly along the continental shelf at the 200 m isobath.

6.3.2.2 Offshore Oceanography

Waves

Offshore wave conditions are dominated by swell waves from the Southern Ocean (Table 6.2). Significant wave height peaks in winter (July, 50 per cent exceedence of 2.4 m) and is lowest in summer (December through to April, 50 per cent exceedence of 1.6 to 1.7 m).

6.3.2.3 Nearshore Oceanography

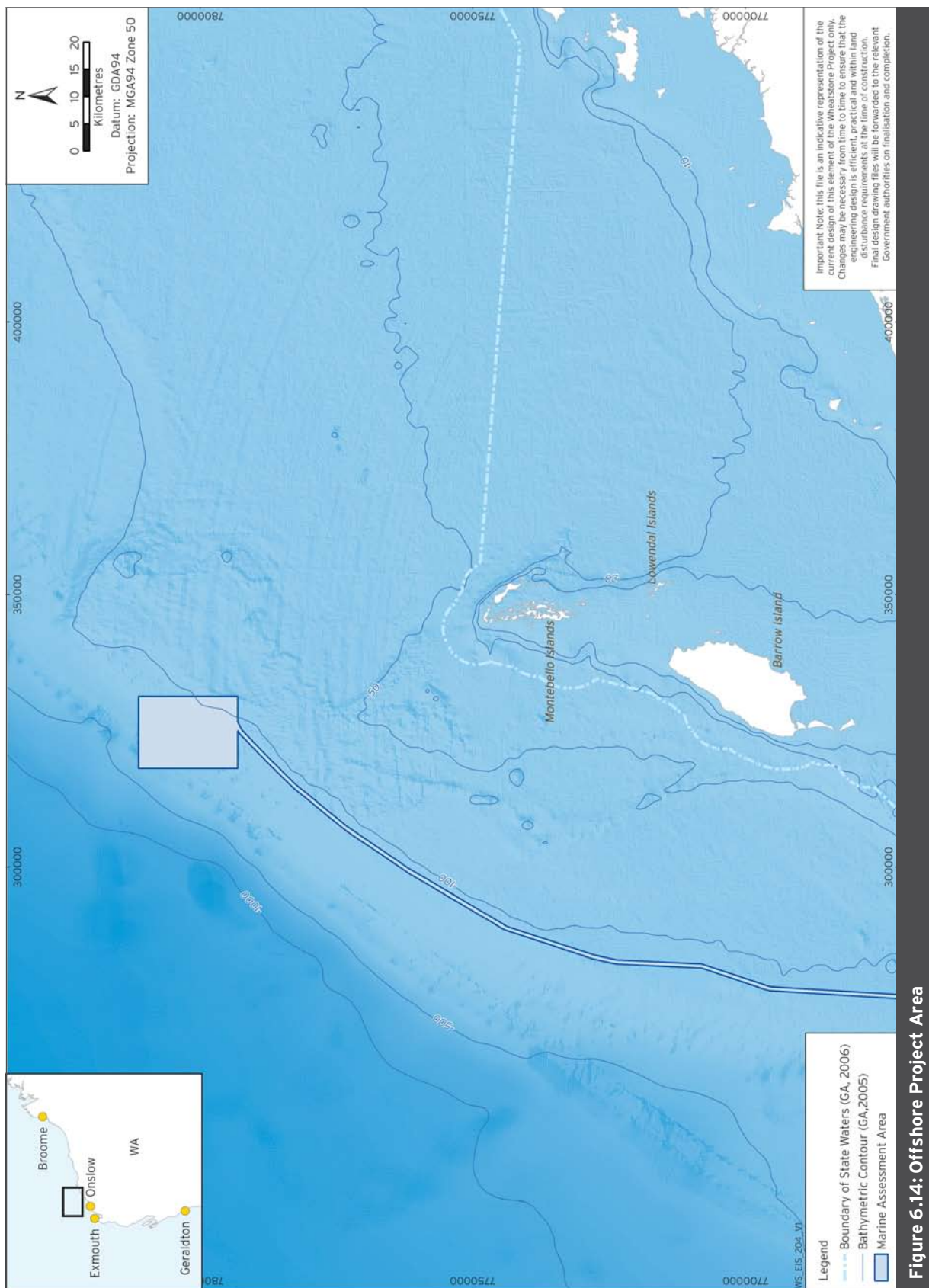
Waves

There are four broad sources of waves along the west Pilbara coast:

- Southern Ocean and Indian Ocean swells, propagating past North West Cape
- Winter easterly swells generated across the Timor Sea
- Locally-generated wind waves
- Wind waves generated by tropical cyclones.

The coast around Onslow is sheltered from prevailing south-west swells (i.e. from the Indian Ocean) by the continental landmass of North West Cape. Similarly, Barrow Island and the shoals of the Lowendal and Montebello islands provide shelter from Timor Sea swells. Consequently, the nearshore wave climate is mainly influenced by locally generated wind waves and occasional tropical cyclones (Damara WA 2010).

Wave conditions measured from January 2006 to March 2007 were mild with the significant wave height rarely peaking above 1 m. Typically waves are notably higher during summer with a median significant wave height in the order of 0.5 m compared to a winter median wave height in the order of 0.25 m. The mean direction is westerly during summer and north-north-westerly during winter. Mean wave periods are short, at three to four second intervals during summer when the climate is dominated by locally generated wind waves. During winter, the wind is predominately blowing in the offshore direction and the wave period is dominated by a very small swell wave penetrating to the nearshore area.



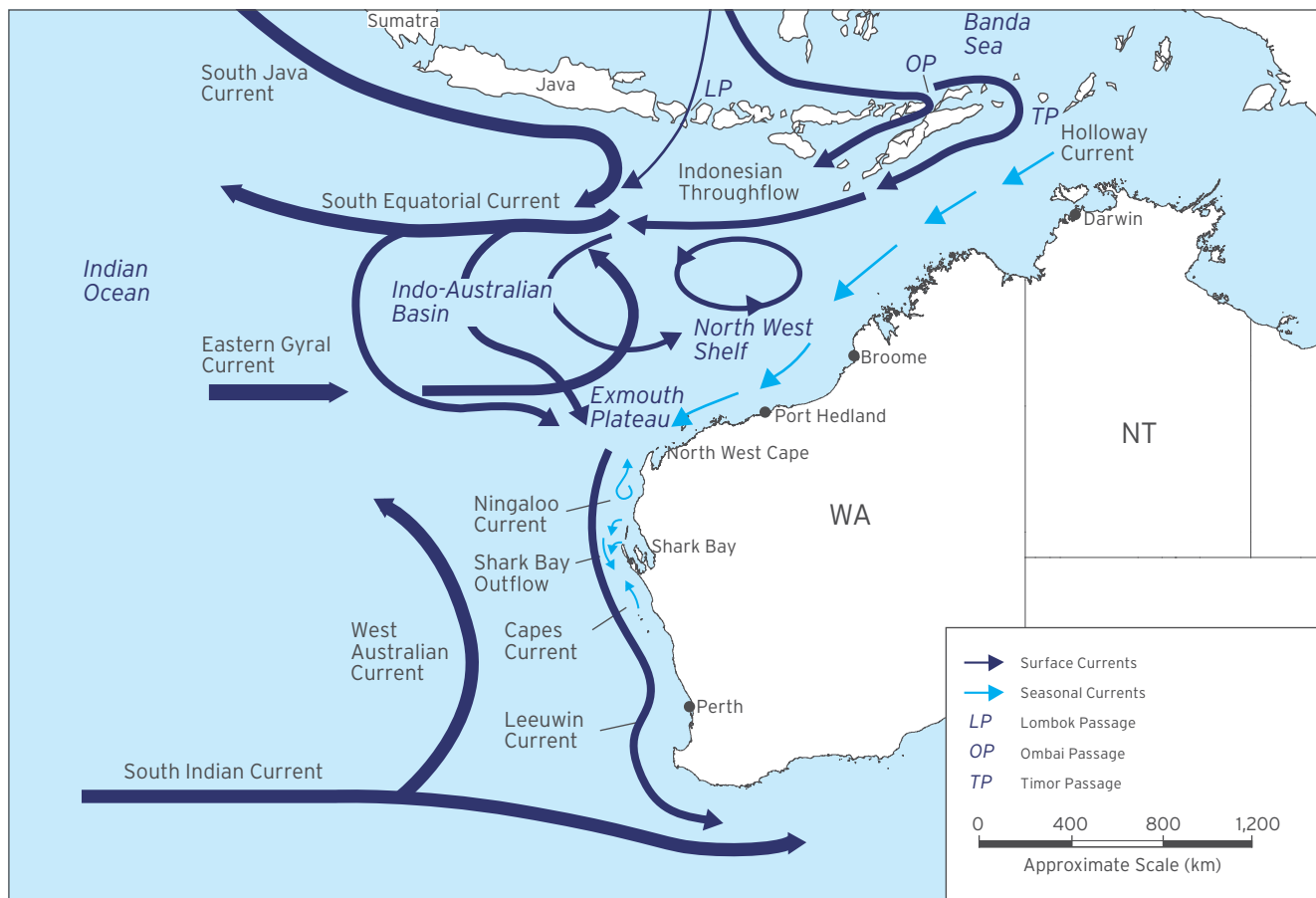


Figure 6.16: Surface Currents Affecting Western Australia

Source: DEWHA 2007

Table 6.2: Significant Wave Height Statistics for the Offshore Area

Month	Hs (m) statistics		Mean Direction
	50%	1%	
January	1.7	3.2	SW
February	1.7	3.1	SW
March	1.6	3.8	SW
April	1.6	3.0	SW
May	1.9	3.5	SW
June	2.3	3.6	SW
July	2.4	3.6	SW
August	2.2	3.7	SW
September	2.2	3.5	SW
October	2.0	3.4	SW
November	1.8	2.9	SW
December	1.7	2.7	SW

Wave conditions were also recorded using acoustic Doppler current profilers (ADCPs) and a directional wave rider deployed in the nearshore Project area (Figure 6.17) (RPS Metocean Engineers 2009). Wave conditions from January to April 2009 were again generally mild, with a median wave height of 0.2 m and wave period of 4.0 seconds. Tropical cyclones Dominic and Freddy passed through the region during the 2009 sampling period, and generated northerly winds and elevated wave conditions. Other energetic conditions similarly occurred due to low-pressure systems located to the west of Onslow, producing onshore winds.

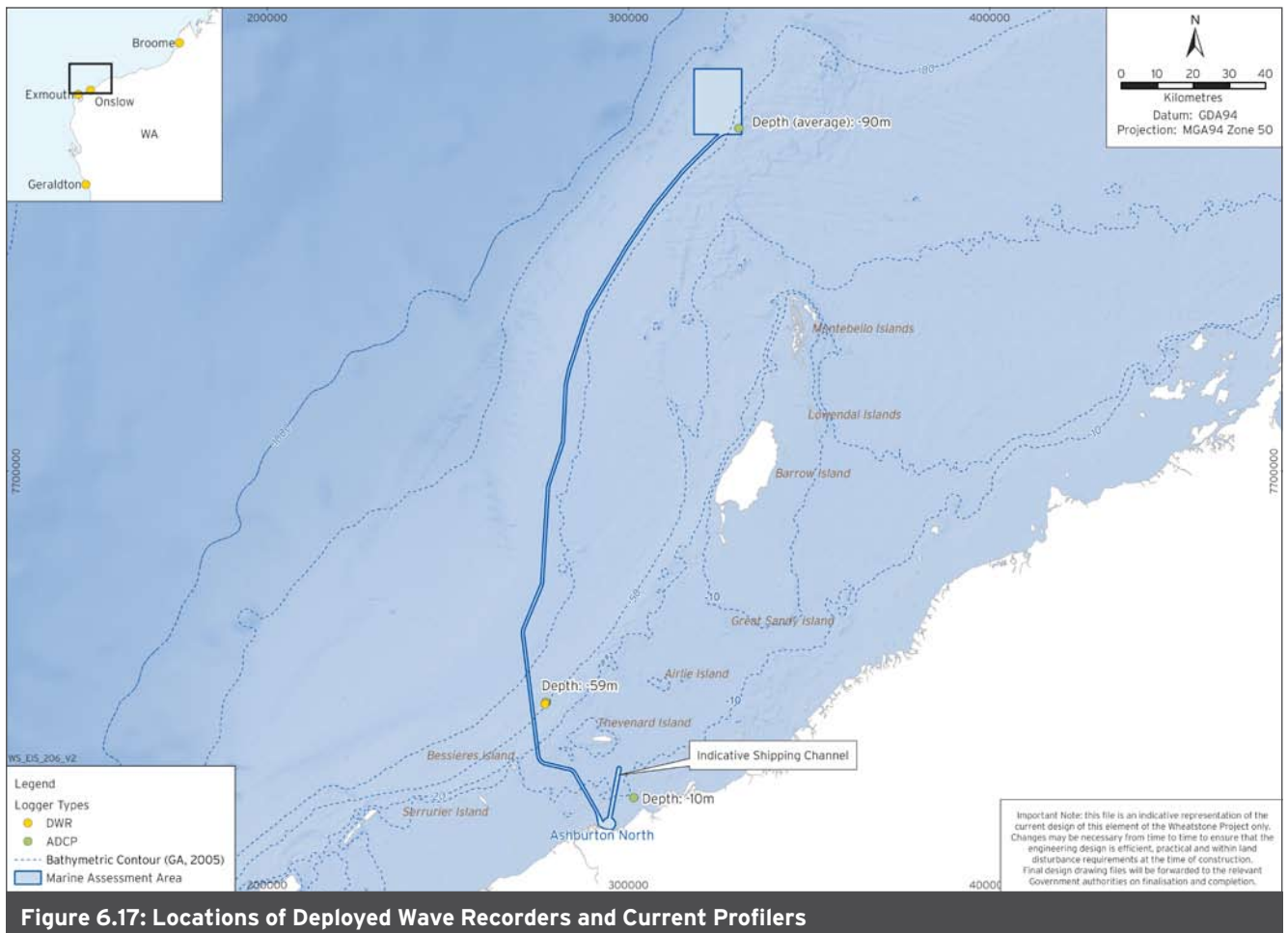
Tides and Currents

Tides in the nearshore Project area are semi diurnal with a spring tidal range of 1.9 m (mean high and low water spring tides of 2.5 m and 0.6 m respectively). Tidal peaks occur near the equinoxes in March and

September. The highest astronomical tide is 2.9 m. The tidal signal changes progressively along the NWS coastline with increasing tidal ranges from Exmouth to Broome (Figure 6.18).

Modelling of extreme cyclonic water levels for the Onslow town site and Onslow Salt (GEMS 2000; Nott & Hubbert 2005) has estimated the 100-year ARI water level as 4.7 m AHD (6.2 m CD), including allowance for wave setup.

The moderate tidal range leads to moderate tidal currents at the site. Ocean currents are predominantly found on or seaward of the continental shelf, deeper than the 200 m contour. Nearshore current measurements do not show patterns attributable to large-scale ocean currents and it is likely that they do not play a significant role in the nearshore current environment.



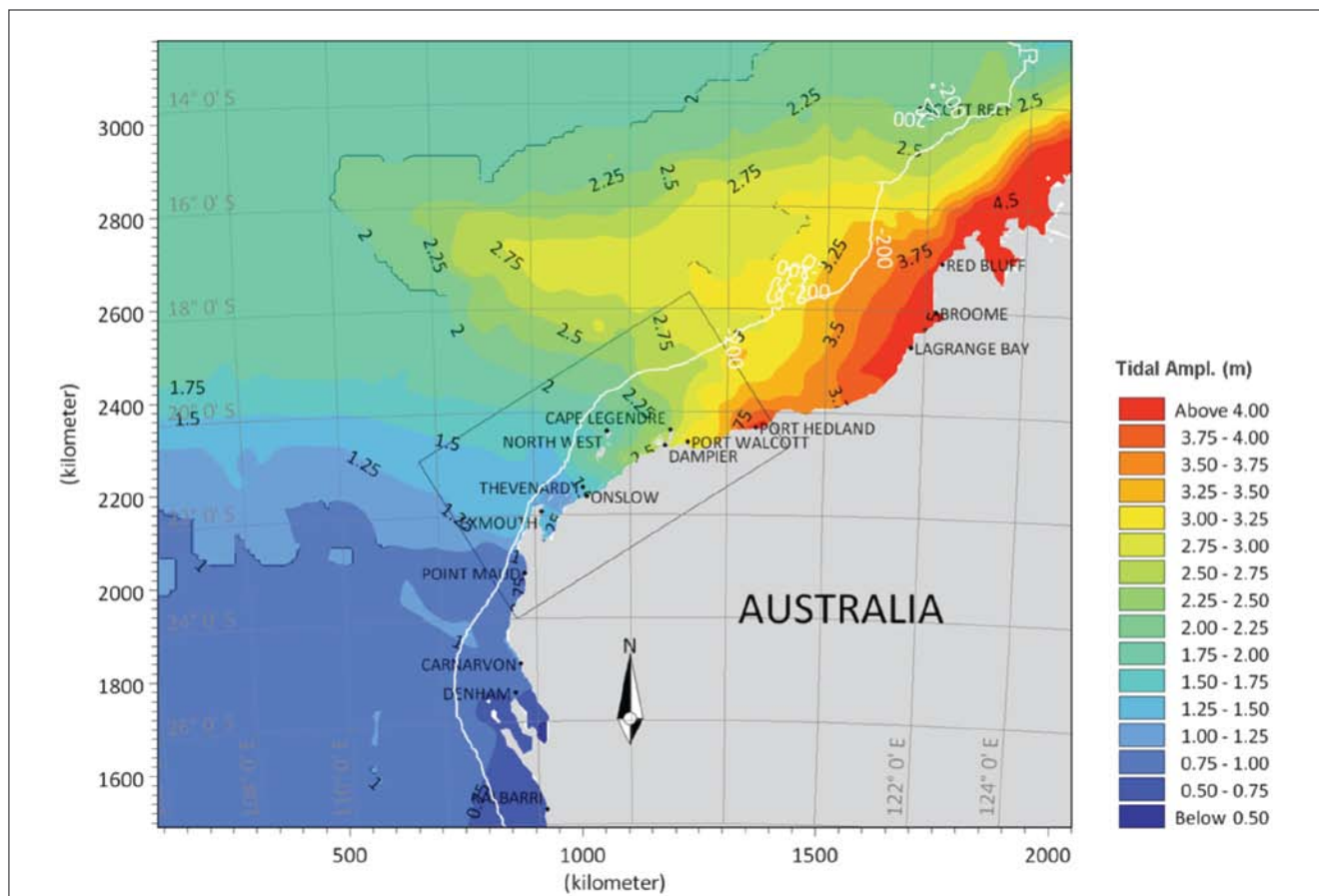


Figure 6.18: Difference between Chart Datum and Mean Sea Level (approximately equal to maximum tidal amplitude) along the NWS

The locally generated circulation patterns due to tides and winds are best illustrated through 2D modelling (Appendix P2). Typical spring flood and ebb tide currents during summer are illustrated in Figure 6.19. These illustrate that tidal currents are weak in deep water. The tidal currents increase in strength toward the east due to the higher tidal amplitude. Locally, the tidal currents are strongest over areas where shoals limit the water depths such as between the Mangrove Islands and out over Barrow Island to the Montebello Islands.

In the nearshore Project area, the local topography directs the tidal currents along the coastline with easterly flow on flood tide and westerly flow on ebb tide, although this pattern can be interrupted by wind driven currents, in particular during neap tides when tidal currents are weakest. West of the Ashburton delta, the tidal current directions are controlled by the flow in and out of Exmouth Gulf with southerly flow into the gulf on flood tide and northerly flow out of the gulf on ebb tide.

Induced by wind stress and, to a lesser extent, gradients in pressure, net currents generally propagate along the coastline and can generate significant alongshore flow, particularly in shallower water. The net currents in shallower water are primarily driven by local winds. Samples of simulated net current patterns for summer and winter conditions are illustrated in Figure 6.20. The effects of the seabed topography can be clearly seen, with a strong increase in local net current speeds through the passage between the shoals of the Mangrove Islands and Barrow Island. Magnitudes of simulated net currents are in the order of half the spring tidal current speeds in many areas, including the Project area. Field measurements (RPS Metocean Engineers 2009) confirm the simulations, including the wind driven net currents dominating over tidal currents during both neap and spring tidal conditions.

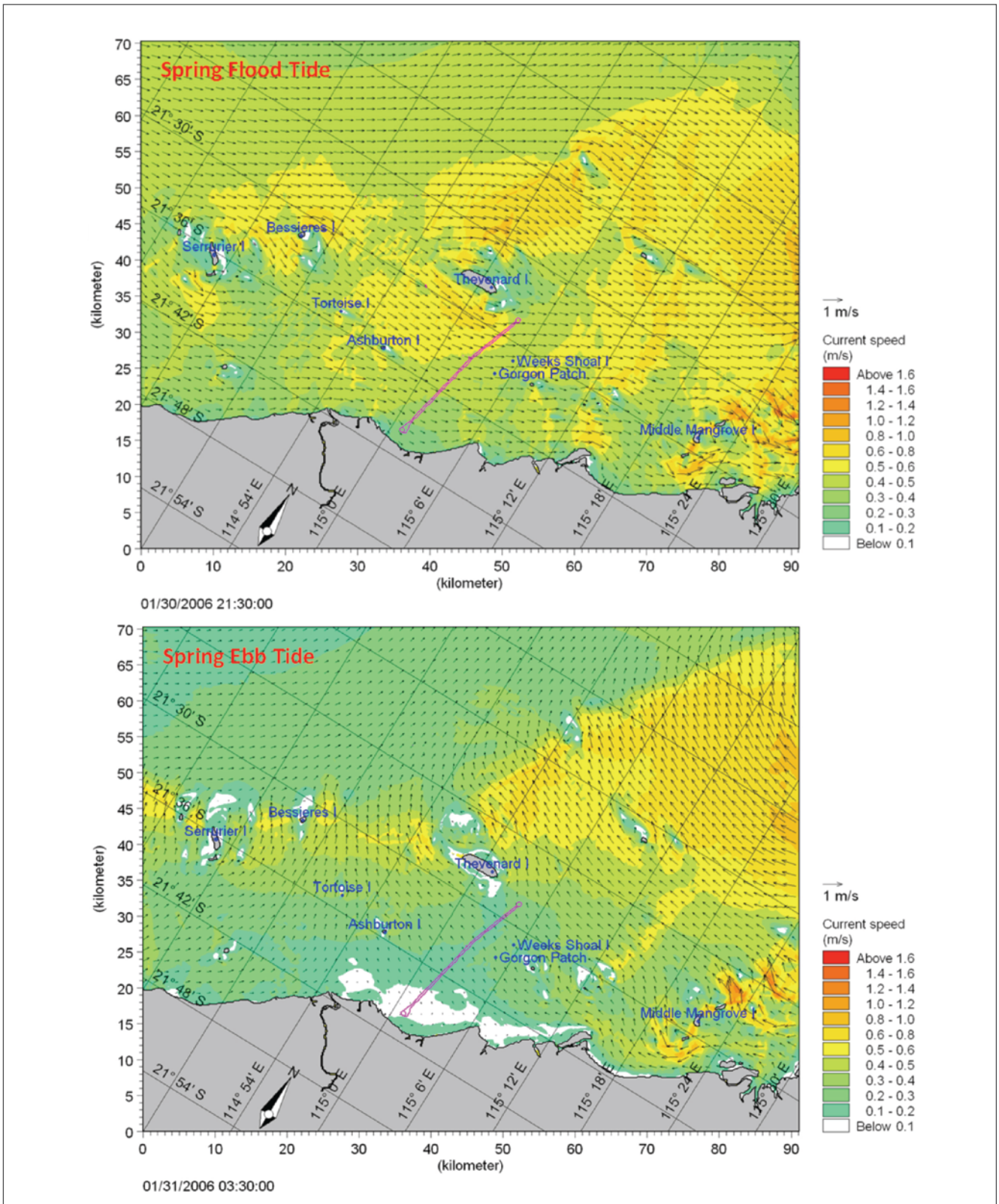


Figure 6.19: Nearshore Simulated Spring Flood (Top) and Ebb (Bottom) Tide Currents during Summer Conditions with a Wind Driven Net Easterly Flow

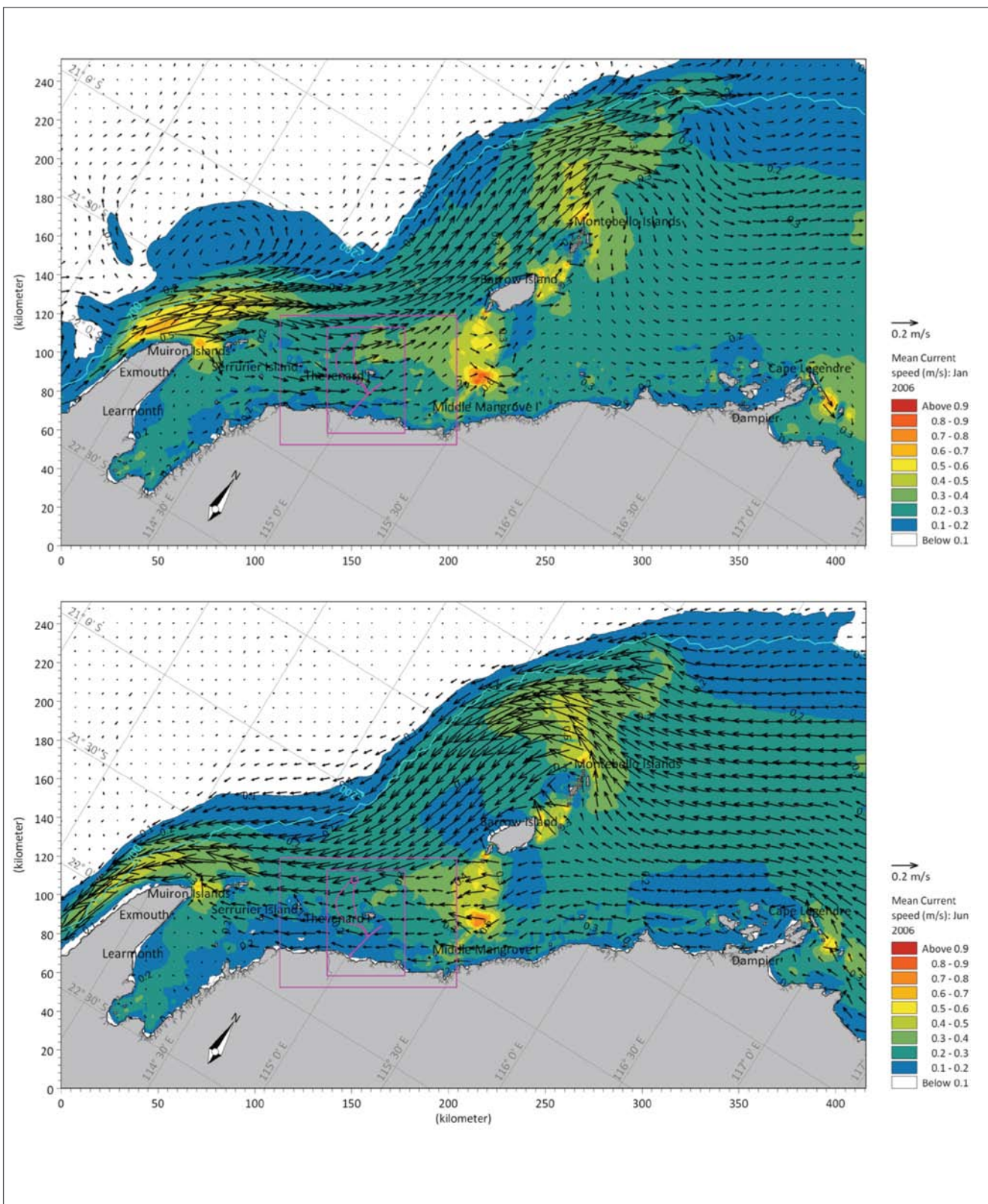


Figure 6.20: Simulated Average Net Currents over a Summer Month (top, January 2006) and a Winter Month (bottom, June 2006)

6.3.3 Water Quality

6.3.3.1 Levels of Ecological Protection

The majority of the marine area adjacent to Onslow, according to the Environmental Quality Management Framework set out by the Department of Environment (DoE) (2006a), is afforded a high Level of Ecological Protection (LEP). Areas around the existing dredge material placement areas, the Onslow Salt jetty and berths have been allocated a moderate LEP. Areas around the Onslow Salt discharge are allocated low to moderate LEP.

6.3.3.2 Turbidity and Total Suspended Solids

Turbidity is a measure of the amount of light scattering through water caused by suspended material in the water column. Suspended material varies according to water movement and sediment type. Total suspended solids (TSS) are a measurement of the mass of suspended solids per litre of water. TSS and turbidity are sometimes highly correlated (Stoddart & Anstee 2005), and may be influenced by sediment characteristics, prevailing wind and swell and by metocean characteristics (tide, wind swell, wave period). Turbidity and TSS are considered important indicators of the amount of light available for photosynthetic activity for corals, seagrasses and other BPP.

The NWS is characterised by a relatively clear water column, however these waters sometimes have a naturally higher levels of turbidity as a result of local current-induced

re-suspension of fine sediments. A review of studies in the Onslow region (MScience 2009; Appendix Q7) indicated the regional median turbidity was usually less than one nephelometric turbidity units (NTU) and the 80th percentile less than three NTU during non-cyclonic periods. Corresponding TSS values ranged from 3 to 5 mg/l. However, on a finer small scale, there is high temporal and spatial variation in water quality. Across 30 sites, median turbidity ranged from less than one NTU during winter up to six NTU during some non-cyclonic periods in summer. Turbidity approached or exceeded 12 NTU at 20 per cent of the sites assessed during some weeks of summer. During spring and summer there are persistent westerly winds and increased run-off from rainfall as well as periodic cyclones. Also sites in shallow water (<10 m) that were closer to shore (<10 km) were more turbid than deeper offshore waters. Examples of site and seasonal variation in turbidity can be seen from calibrated Moderate-Resolution Imaging Spectroradiometer (MODIS) images of the region (Figure 6.21).

Turbidity and TSS are elevated by cyclonic activity. During the passage of Tropical Cyclone (TC) Dominic in January 2009, daily median turbidity increased to approximately 80 NTU and remained above 20 NTU for at least 10 days. Cyclonic conditions increase turbidity through seabed stress but, for the Onslow region, high levels of sediment are also discharged from the Ashburton River. The highly turbid waters of the Ashburton River after a rainfall event in February 2009 are shown in Photograph 6.1.



Photograph 6.1: Ashburton River Turbid Water following a Rainfall Event in February 2009

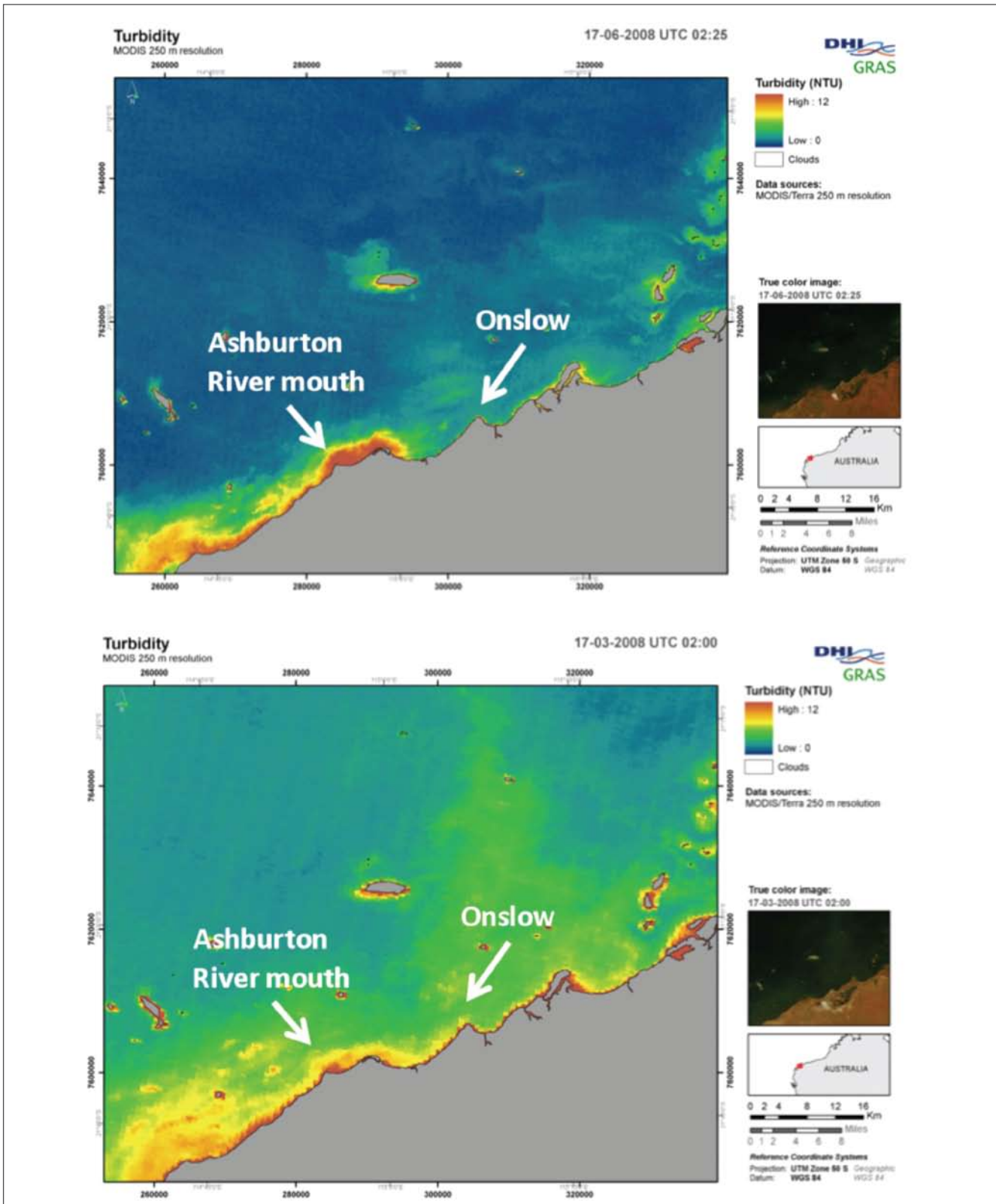


Figure 6.21: Examples of Turbidity during Winter (top image, 17/06/08) and Summer (bottom image, 17/03/08) in the Onslow Region as Predicted from Calibrated MODIS Images

Source: DHI

Water quality information is also available from other locations on the NWS. Mermaid Sound is one example; the study area is located approximately 200 km north-east of Onslow and adjacent to the town and port of Dampier. At nine reference sites in and around Mermaid Sound in 2004, mean turbidity among sites ranged from 0.3 to 2.0 (NTU) at the surface and 0.5 and 2.44 NTU at the bottom over eight months. Mean TSS at the same sites ranged from 3.5 mg/L to 4.3 mg/L at the surface and 4.0 to 5.4 mg/L at the bottom. In this study, no measurements were taken during rough weather and cyclones so these numbers are likely to underestimate both turbidity and TSS. Even with this limited sampling protocol, turbidity ranged from zero to 13 NTU and TSS from four to 20 mg/L within individual sites (Stoddart & Anstee 2005). These values are similar to those reported for Onslow, but much lower than recently reported at Cape Lambert where monthly median turbidity ranged from less than one NTU in winter to 19.8 NTU in summer, and 9.5 in August to 34.0 in November. Near the ocean floor, the monthly median TSS was higher, ranging from a low of nine mg/L in July to 74 mg/L in November (SKM 2009). In both studies, turbidity and TSS were highest in spring and summer.

6.3.3.3 Light and Light Attenuation

The light requirement of marine communities on the NWS is not well defined. In other parts of Australia, it has been suggested that, where suitable substrata exist, the minimum light required for a coral reef to persist is six to eight per cent of surface irradiance (Cooper *et al.* 2007). This is based on a limited sampling protocol. A minimum light requirement relative to surface irradiance means that light attenuation, rather than light, may be an appropriate means of defining the change in light as a result of natural or anthropogenic disturbance.

Intensive boat based measurements of light attenuation around Onslow have shown a very strong relationship between turbidity, TSS and light attenuation (E) under natural conditions. Using this relationship, together with direct measurements of light across three separate studies, median light attenuation across sites and/or time was $<0.2 \text{ m}^{-1}$ nearshore and $<0.1 \text{ m}^{-1}$ offshore. As with turbidity and TSS, light attenuation was higher in summer. Median attenuation (across sites) measured a few days after the passage of TC Dominic approached 0.3 m^{-1} with the 80th percentile exceeding 0.4 m^{-1} (MScience 2009; Appendix Q7).

Light attenuation of 2 m^{-1} is consistent with a loss of 99 per cent of the light at a depth of one metre. After the passage of TC Dominic, light attenuation of 0.3 m^{-1} was associated

with a turbidity of approximately 18 NTU and is consistent with a loss of 50 per cent of light at a depth of 1 m. In clear water where turbidity was less than one NTU, light attenuation is $<0.1 \text{ m}^{-1}$.

Limited light attenuation data exist for the NWS. Pearce *et al.* (2003) cites the report of Rochford (1980) which noted that offshore light attenuation was always below 0.05 m^{-1} outside the Dampier Archipelago but sometimes exceeded 0.3 m^{-1} near the coast. These data were collected over four discrete sampling periods between October 1980 and September 1981.

Because attenuation of light through the water column occurs through a combination of absorption and scattering, suspended material in the water will attenuate light. Under such circumstances measurement of TSS as an indicator of light attenuation has been advocated. However, the relationship between light attenuation and measured TSS is not always strong. Turbidity, a water quality parameter measured through optical backscatter, may be a more appropriate surrogate.

6.3.3.4 Temperature and Salinity

Waters of the NWS show temporal and spatial variation in water temperature, with mean sea surface temperatures (SST) in open shelf waters being $29.3 \text{ }^\circ\text{C}$ in March and dropping to $24 \text{ }^\circ\text{C}$ in August. Nearshore temperatures in semi-enclosed waters fluctuate through a higher range ($22.3 \text{ }^\circ\text{C}$ to $30.4 \text{ }^\circ\text{C}$) (Pearce *et al.* 2003). A similar temporal pattern has been reported in the waters around Onslow (MScience 2009; Appendix Q7). The cross-shelf temperature gradient reverses in winter when strong heat loss to the atmosphere and differential cooling occur, resulting in coastal waters becoming cooler than those offshore. While the mean monthly temperatures peak at around $30 \text{ }^\circ\text{C}$, maximum monthly water temperatures from January to March exceeded $32 \text{ }^\circ\text{C}$. Such increases in SST ($>33 \text{ }^\circ\text{C}$) during 1994 and 1998 in the Dampier Archipelago have been correlated with coral mortality attributed to bleaching (loss of symbiotic algae) (Blakeway 2005).

The degree of variability both between and within years depends on a range of forcing factors such as tides, local winds, non-tidal long period waves, the occurrence of tropical cyclones and the Leeuwin Current causing an influx of warm water during the cooler months (June to August). Various studies have indicated that temperature is only weakly depth stratified in the winter months (April to October) but the difference between bottom and surface may be up to $3 \text{ }^\circ\text{C}$ between November and March (Pearce *et al.* 2003; Stoddart & Anstee 2005; Wenziker *et al.* 2006).

Water salinity varies between 34.5 and 36.3 g/L around the NWS (Pearce *et al.* 2003; Wenziker *et al.* 2006). Surface salinity tends to be slightly elevated during summer.

Cyclones and heavy rainfall events can result in dilution of salinity within the Dampier Archipelago as a result of run-off. Similar effects are likely to occur around Onslow at times when the Ashburton River is flowing, in flood, or during cyclonic events. During the passage of TC Monty in March 2004, Dampier and surrounding areas experienced very heavy rainfall and run-off (over 300 mm in 24 hrs). Surface water salinity in Mermaid Sound dropped to approximately 20 g/L and remained low for several days. This resulted in high coral mortality around the shoreline of several inshore islands (Blakeway 2005).

6.3.3.5 Trace Metals and Organics

A study by the former Department of Environment (now Department of Environment and Conservation - DEC) indicated that the coastal waters of the NWS generally have very low levels of anthropogenic contamination (Wenziker *et al.* 2006). The study measured dissolved concentrations of cadmium, chromium, copper, lead and zinc, total mercury, polycyclic aromatic hydrocarbons, phenols, benzene, toluene, ethyl-benzene, xylene and petroleum hydrocarbons. The survey was conducted at one sampling time in winter and while it provides a "snapshot picture" of water quality of the NWS, it should be noted that factors such as tidal currents, wind and swell conditions can significantly influence water quality. Also in this study, the background concentrations for the NWS were derived from sampling around the Dampier Archipelago, in Nickol Bay and off Port Hedland, but not in the immediate vicinity of Onslow.

Overall, NWS water quality was classified as a "very high" LEP (99 per cent species protection) based on the recommended guidelines and approaches in Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000). At the time of sampling, specific sites adjacent to industrial centres in Dampier and Port Hedland had elevated concentrations of some metals relative to natural background. However, with the exception of copper at Port Hedland, these sites still achieved the national guidelines for 99 per cent species protection. Offshore waters on the NWS are expected to be of high quality given the distance from shore and lack of terrigenous inputs.

A preliminary study of Onslow waters has indicated that the concentrations of most of the trace metals in marine waters met the environmental quality guidelines for a high LEP.

Zinc and aluminium were the exceptions (MScience 2009; Appendix Q7).

The Wenziker *et al.* (2006) study found no detectable levels of organics in the waters of the Dampier Archipelago. However, natural oil seeps are known to occur on the NWS, with the amount of hydrocarbons from such seeps entering NWS waters estimated to be 3300 t annually (Fandry *et al.* 2006). The ecological impacts of these seeps remain largely unknown.

6.3.3.6 Nutrients

The waters of the NWS region are oligotrophic, with limiting rates of primary production. However, blooms of nitrogen-fixing microbes such as *Trichodesmium* or mangrove tidal mud-flat cyanobacteria may contribute significant amounts of nutrients into the marine environment. Around Onslow, nitrogen and phosphorus concentrations in the marine waters are not always low and may exceed the default trigger values of 100 µg/l (total nitrogen) and 15 µg/l (total phosphorus) specified by ANZECC/ARMCANZ (2000). Nitrogen concentrations approaching 350 µg/l have been measured and phosphorus may exceed 18 µg/l (MScience 2009; Appendix Q7).

Onslow is also subject to sporadic but variable discharge of nutrients when the Ashburton River flows. The high nutrient levels at some times of the year are consistent with the discharge of nitrogen and phosphorus from the Ashburton River. D.A. Lord and Associates (2002) reported that 172 tonnes of nitrogen and 26 tonnes of phosphorus are discharged from the Ashburton River to the offshore environment annually. Estimates may be an order of magnitude higher or lower, depending on the annual river flow. More recent estimates of nutrient loads since 1973 indicate average nitrogen discharge from the Ashburton River of 403 t/year and phosphorus of 134 t/year (URS 2009, Appendix Q6).

High spatial and seasonal variability are evident in nutrient and chlorophyll-a concentrations within parts of the Dampier Archipelago (Pearce *et al.* 2003). Phosphorus (as orthophosphate) is generally between 0.7 and 8 µg/l; however, a peak was recorded in June 1981 of more than 12 µg/l (Rochford (1980) cited by Pearce *et al.* (2003)). Nitrogen, as ammonium or nitrate ions, also varied over a five-fold range, depending on year and distance from shore. Where nitrogen is the primary limiting nutrient, an increase in bioavailability of this element can cause significant ecological changes such as seagrass or coral loss, and "blooms" of species of phytoplankton.

6.3.3.7 Sedimentation

Under conditions undisturbed by cyclones or dredging, sedimentation levels of between one and 12 mg/cm².d and two to 20 mg/cm².d have been reported for Onslow and Mermaid Sound (Simpson 1988; MScience 2009; Appendix Q7). However, natural rates of sedimentation as high as 240 mg/cm².d, averaged over five consecutive days (highest single value was 330 mg/cm².d), have been observed in Mermaid Sound without any corresponding coral impact (Woodside Petroleum Ltd 2006). Higher sedimentation rates have been reported at shallow nearshore sites, particularly in the summer months when turbidity increases.

These reported sedimentation rates are gross sedimentation, measured using tubular sedimentation traps. Under natural conditions, much of this sediment would be re-suspended from flat or exposed seabed surfaces by tidal currents and wave energy resulting in net sedimentation that may be much lower.

6.3.4 Marine Sediments

6.3.4.1 Offshore Sediments

Sediment types in the offshore Project area were characterised through sediment coring and interpretation of side scan sonar surveys, conducted by Fugro Surveys Pty Ltd. (Fugro) in 2006. Sediments in the east of the offshore field area are uniformly clayey, silty, medium sand with shell and coral fragments. Two areas of irregular sandwaves or sand ribbons were recorded on the western edge of the area. In the north, west and south-west of the offshore field area, sediments are slightly finer in texture (Fugro 2006).

A varying number of seabed depressions, typically five to 10 m in diameter and less than 0.3 m deep, are found in the centre and south-west of the Project area. In the north-west of the Project area, there are occasional, small areas of rock or reef outcrops with relief generally greater than 0.5 m (Fugro 2006).

6.3.4.2 Nearshore Sediments

The physical and chemical characteristics of nearshore sediments have been assessed extensively as a result of the following investigations:

- Pilot Marine Sediment Quality Report (URS 2009b)
- Draft Sediment Quality Assessment (URS 2009c, Appendix Q5)
- Draft Interpretative Report - Nearshore Geotechnical Investigation (Coffey 2009).

Additional information is available from work conducted by DEC in 2005 (DEC 2006).

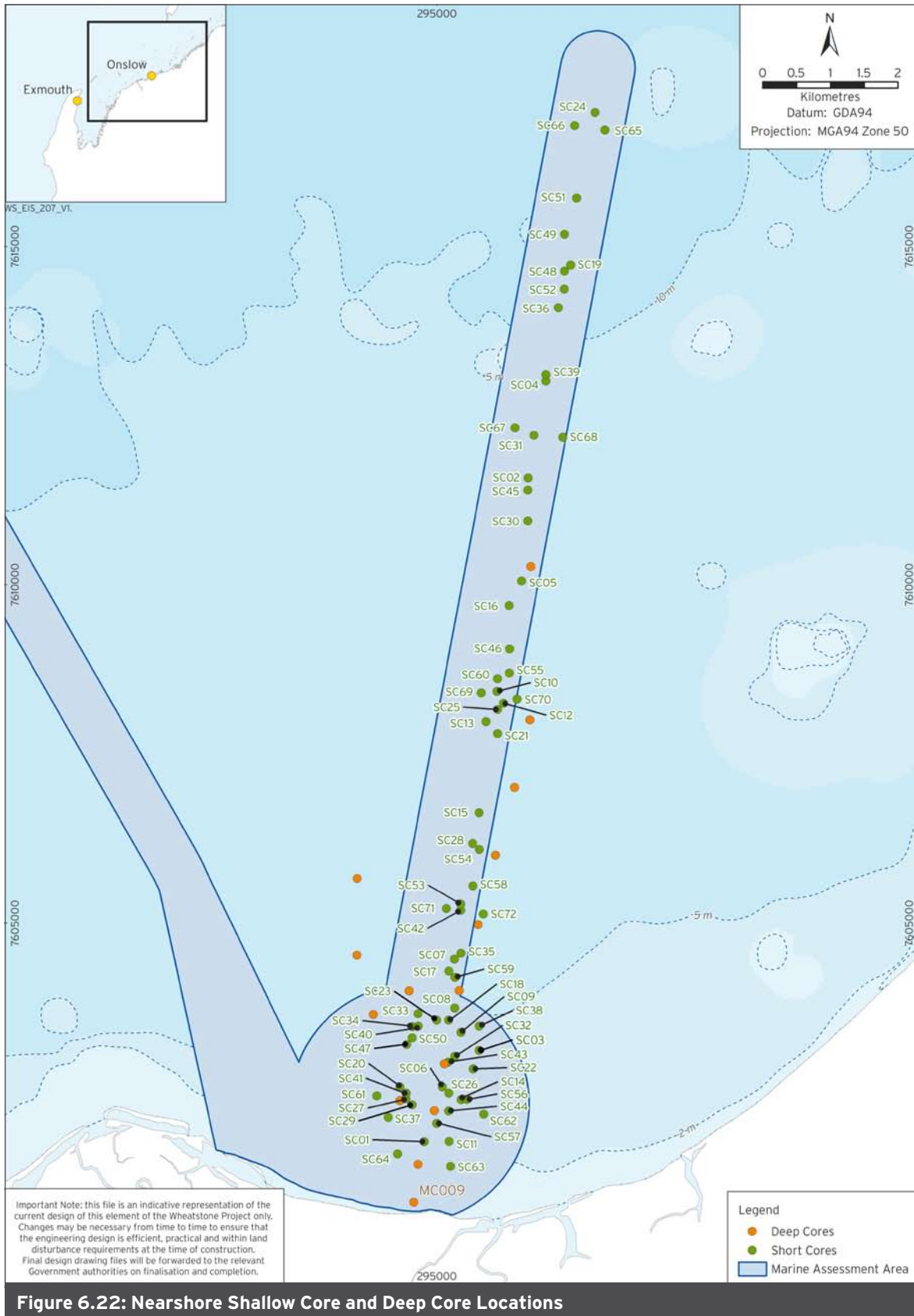
Physical Characteristics

The nearshore area is broadly characterised by silt and sand sheets of varying thickness overlying Pleistocene limestone. Surface sediments are generally dark red to red-brown clayey gravelly sands with abundant carbonate shells and shell fragments, with varying mud (silt and clay fraction) contents of between 20 to 40 per cent and gravel contents ranging from less than five to 34 per cent. Shallow sediment coring (Figure 6.22 and Figure 6.23) (URS 2009c) encountered hard, armoured surfaces at numerous sample locations in the nearshore Project area, where shell and pavement beds made penetration of the percussion corer difficult. Clay contents (<2 micron fraction) of between 10 and 33 per cent were present within the area and refusal of the percussion corer in stiff clay or pavement and shell beds at a depth of less than 0.40 m was observed at all sample locations. Organic carbon contents are generally less than 0.2 per cent (URS 2009c, Appendix Q5).

Surface sediments, discharged from the Ashburton River, tend to comprise a higher proportion of silts and clays with high silica content. There is a tendency for increasingly coarse-grained sediments, and an increase in calcium carbonate content, with distance offshore due to the decreasing input of terrigenous silts and clays from river run-off and coastal erosion (Figure 6.24).

Coarse and medium-grained calcareous sandy sediments predominate to the 100 m depth contour, with a transition to continental slope silts around 100 to 150 m water depth (Black *et al.* 1994). Elsewhere sand and pavement dominate the inner shelf although finer sediments are found in patches due to oceanographic conditions around islands and shoals (URS 2009b). Finer sands and silts dominate the less energetic parts of the outer shelf. Considerable areas of exposed and sand veneered pavement are found on the upper section (20 to 40 m isobath) of the shelf break (UWA 2009a; Appendix N8).

The location of deep cores obtained by Coffey (2009) along the channel alignment and in the vicinity of the turning basin for the PLF is shown in Figure 6.25. In summary, two types of sediments occur to 15 m CD (the depth of the navigation channel). These are sands intermixed with variable fractions of clays, silts and or gravels; and rock (siltstone, claystone and sandstone) that is generally weathered and weak.



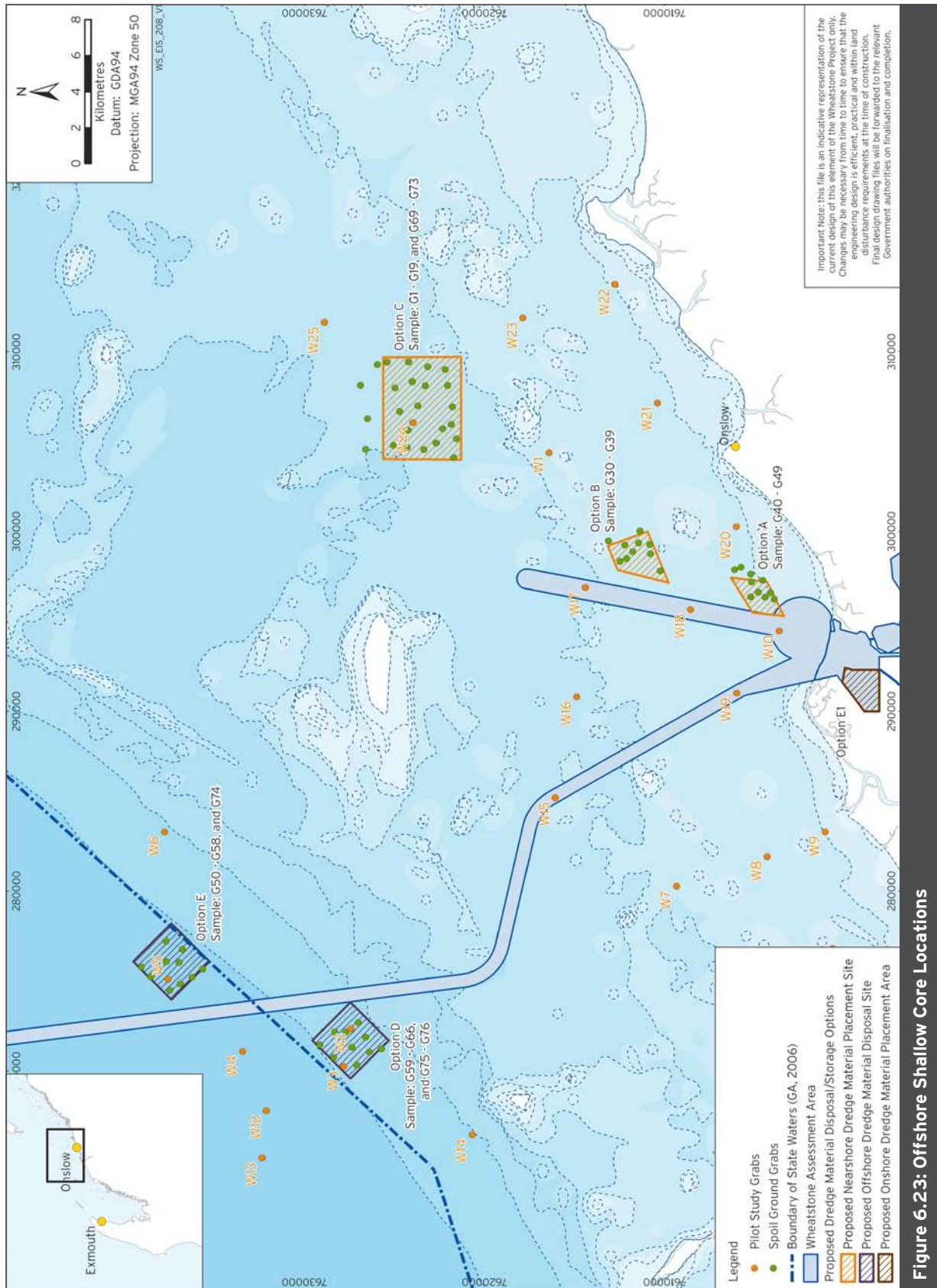


Figure 6.23: Offshore Shallow Core Locations

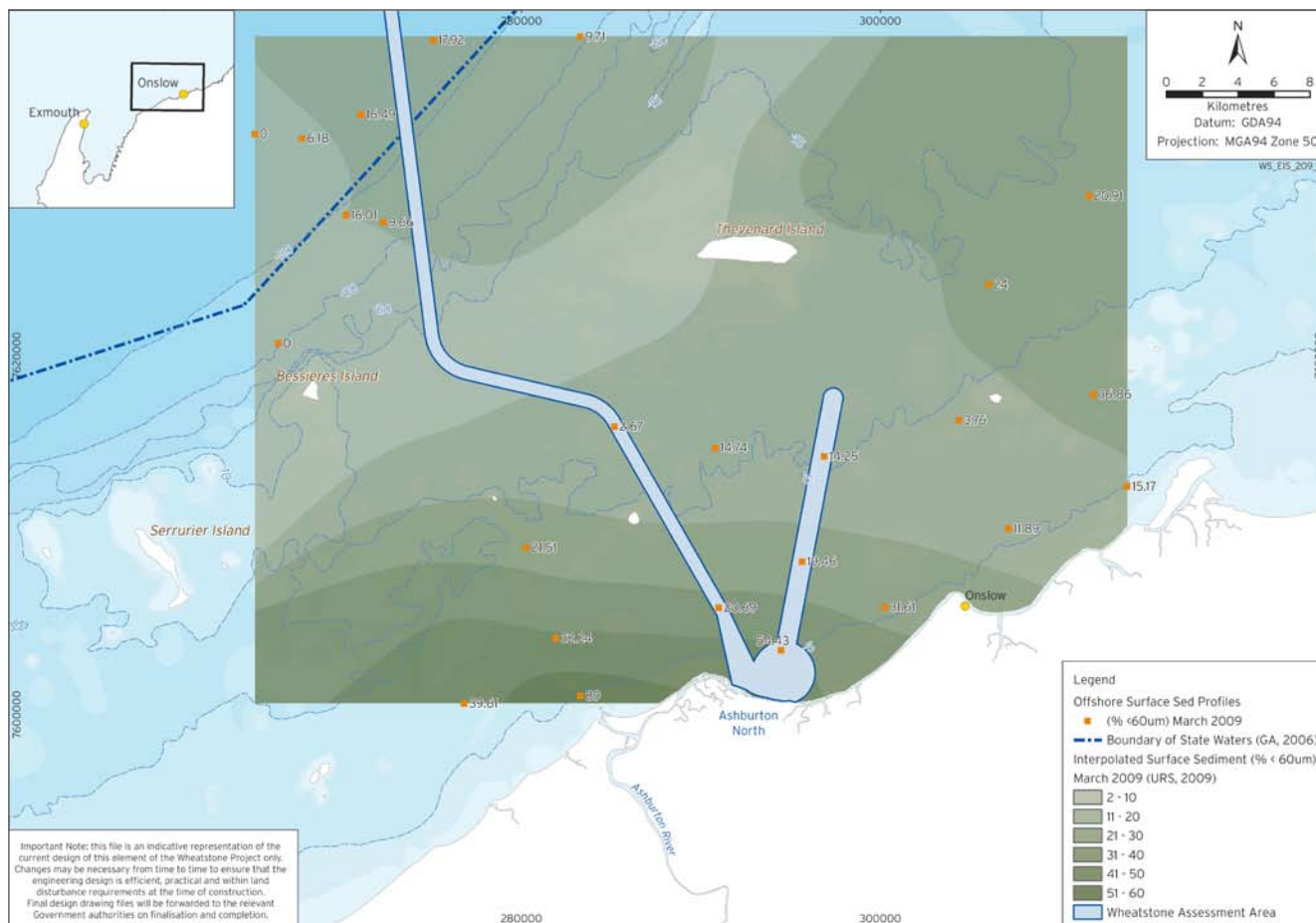


Figure 6.24: Sediment Grainsize Distribution in the Marine Environment off Onslow and the Ashburton River Mouth

Table 6.3 provides a description of the geological stratigraphy of the sediments in the vicinity of the proposed navigation channel. It shows that surface sediments are mainly comprised of marine sands and recent alluvial soils. These are underlain by the soils of the Ashburton Red Beds, which comprise stiff and dense sandy clay and silty sands. This unit is subsequently underlain by weak rocks of the Ashburton Red Beds which comprise claystone, sandstone and siltstone and a conglomerate of low to medium strength. Carbonate rocks underlay the above, but occur at depths greater than 15 m CD. Most of the soil units above 15 m CD are low in calcium carbonate content (approximately 20 per cent). The conglomerate which occurs near the base of the channel has a moderate calcium carbonate content of 42 per cent (Table 6.4).

Chemical Characteristics

Previous chemical testing conducted in the area (DEC 2006) reported no discernible anthropogenic enrichment of contaminants (e.g. organotins, hydrocarbons, organochlorine pesticides and polychlorinated biphenyls) in sediments offshore of the Ashburton River mouth. Natural background concentrations of all trace metals were also below the relevant ANZECC/ARMCANZ (2000) screening levels, with the exception of arsenic (DEC 2006).

Further investigations were made to assess contaminant concentrations against the National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia 2009) Screening Levels. Concentrations of Contaminants of Potential Concern in sediments in shallow and deep cores from within and near the proposed dredging area and in grab samples from the proposed nearshore dredge material placement sites were generally below the NAGD sediment quality guideline values, except for arsenic and nickel. The NAGD guideline values for these analytes were exceeded in several samples.

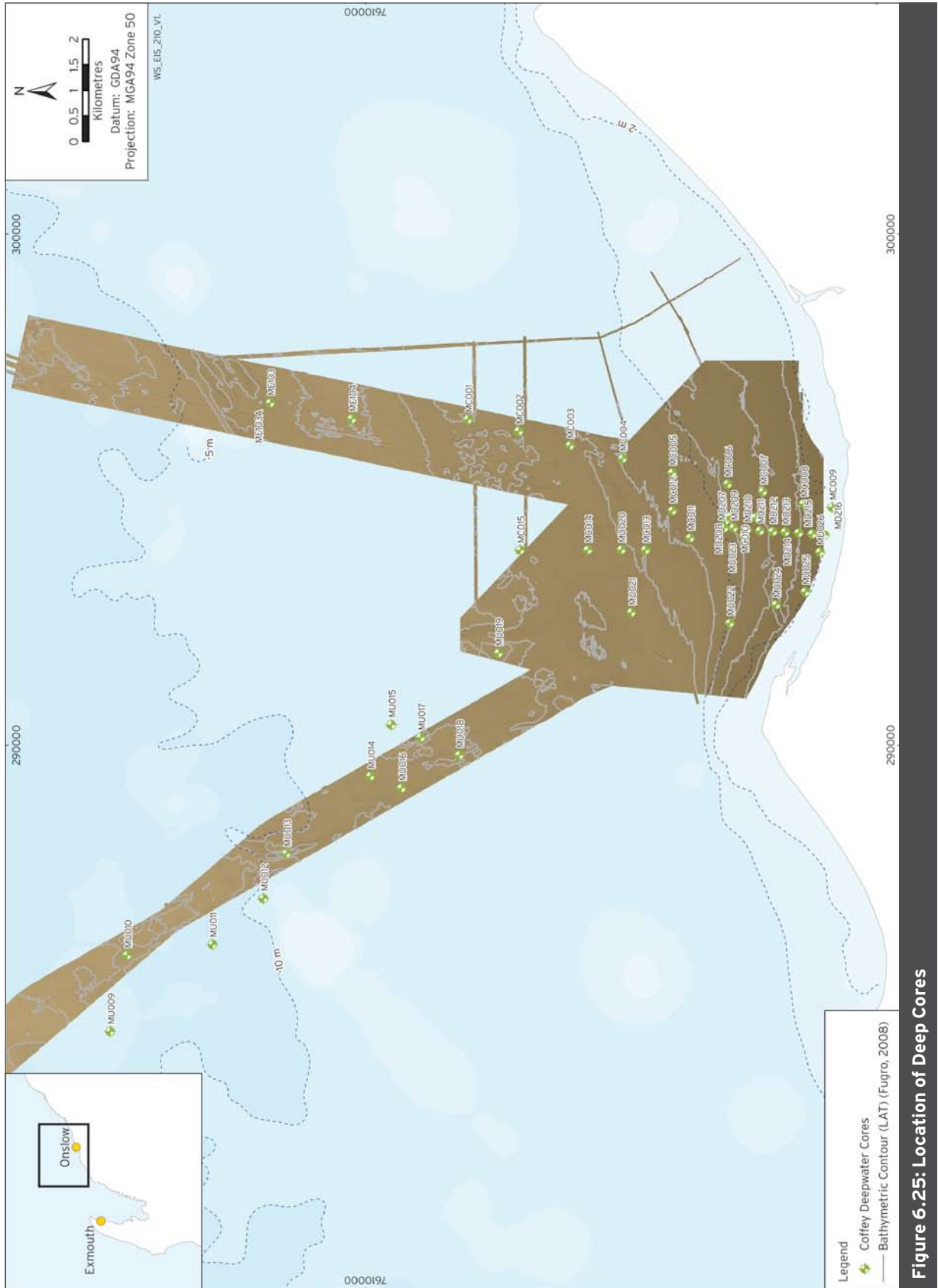


Table 6.3: Description of the Geological Stratigraphy of the Sediments in the Vicinity of the Proposed Navigation Channel

Approx Geological Age*	Geological Unit		Engineering Sub Units and Descriptions	Stratigraphical Relationships and Depositional Environments	
	Unit Number	Unit Name			
Recent Holocene to Present (0.011 million years ago (MA) - Present)	1	Dune Sand and Sandplain	Sand, quartzose, partly of aeolian origin medium grained, loose to medium dense	Units 1 and 2 conformably overlie older deposits of Quaternary age. Units are morphostratigraphic and dependant on depositional environments*. Depositional environments include Alluvial, Colluvial, Intratidal complexes, Supratidal complexes, Dune complexes and Beach complexes with minor Aeolian distortion between units.	
	2	Marine Sediments and Recent Alluvial Soils (including intratidal and supratidal sediments)	Clay and Silt, very soft to soft, Sand, Gravelly Sand, Sandy Gravel and Gravel, loose to dense		
Tertiary -Quaternary Pliocene to Holocene (5.33 MA - 0.011 MA)	3a	Ashburton Red Beds (Soils)	3ai	Unit 3a conformably underlies recent surficial deposits. Unit is believed to have been deposited in Supratidal to Intertidal flat environments.	
			3aii		Sandy Clay, very stiff Sand and Silty Sand, dense to very dense
	3b	Ashburton Red Beds (Weak Rocks)	3bi	Unit 3b conformably underlies Red Bed Soil deposits and is deposited in similar environments. The unit is believed to derive low rock strengths from a combination of localised in situ cementation and pseudo-consolidation from overlying stratum. Minor in situ alteration within the rock mass is noted.	
			3bii		Claystone / Sandstone / Siltstone very low to medium strength Conglomerate very low to medium strength
Tertiary Low to Mid Miocene (23.03 MA - 7.24 MA)	4	Carbonate Rocks	4a	Unit 4 is unconformably overlain by Units 3a and 3b. The unit is believed to have been deposited in shallow water marine clastic environments. The unit shows notable similarities to both the Tulki Limestone member and Trealla Limestone member of the Cape Range Formation*.	
			4b		Conglomeratic limestone, Calcilutite, Calcisiltite, Calcarenite, Calcirudite, Limestone, medium to high strength
			4c		Limestone low to medium strength
Cretaceous Campanian (83.5 MA)	5	Glauconitic Rocks	Claystone, Siltstone, Sandstone, very low to low strength, locally highly Glauconitic	Unit 5 is unconformably overlain by Units 4a and 4b. The unit is believed to have been deposited in low energy shallow marine environments with later formation of authigenic Glauconite within the rock mass. The unit shows notable similarities to the Toolonga Calcilutite member*.	

Note: *The Western Australia Geological Survey (1982) 1:250,000 Geological Series - Explanatory Notes for Onslow (Sheet No. SF50-5).

Table 6.4: Calcium Carbonate Content Test Results

Geological Unit	Calcium Carbonate Content (%)	
	Range	Average
2	9 to 49	24
3ai	9 to 34	18
3aii	7 to 52	20
3bi	5 to 79	23
3bii	14 to 75	42
4a	18 to 99	75
4c	58 to 98	88

Natural enrichments of arsenic and nickel above NAGD sediment quality guideline values have been shown to occur regionally and are therefore not limited to the proposed dredge area. The concentrations of nickel in sediments in the dredge area follow a strong grain-size-related trend, which confirms the natural origin of nickel in these sediments.

6.3.5 Ambient Underwater Noise

Ambient noise in the ocean has both natural and anthropogenic sources. Natural sources are generated physically or biologically. Natural physical sources include tectonic activity, lightning strikes, thermal noise, wind waves, surf, rainfall and tidal turbulence. Natural biological noise is generated by a variety of animals, including whales, dolphins, fish, snapping shrimp and sea urchins.

The main anthropogenic sources of noise in the marine environment include:

- Trade, working and recreational vessels
- Dredging activities
- Drilling and pile-driving
- The use of explosives
- Sonar (including depth sounders, fish finders and acoustic deterrents)
- Geophysical sonar
- Noise from low flying aircraft and helicopters.

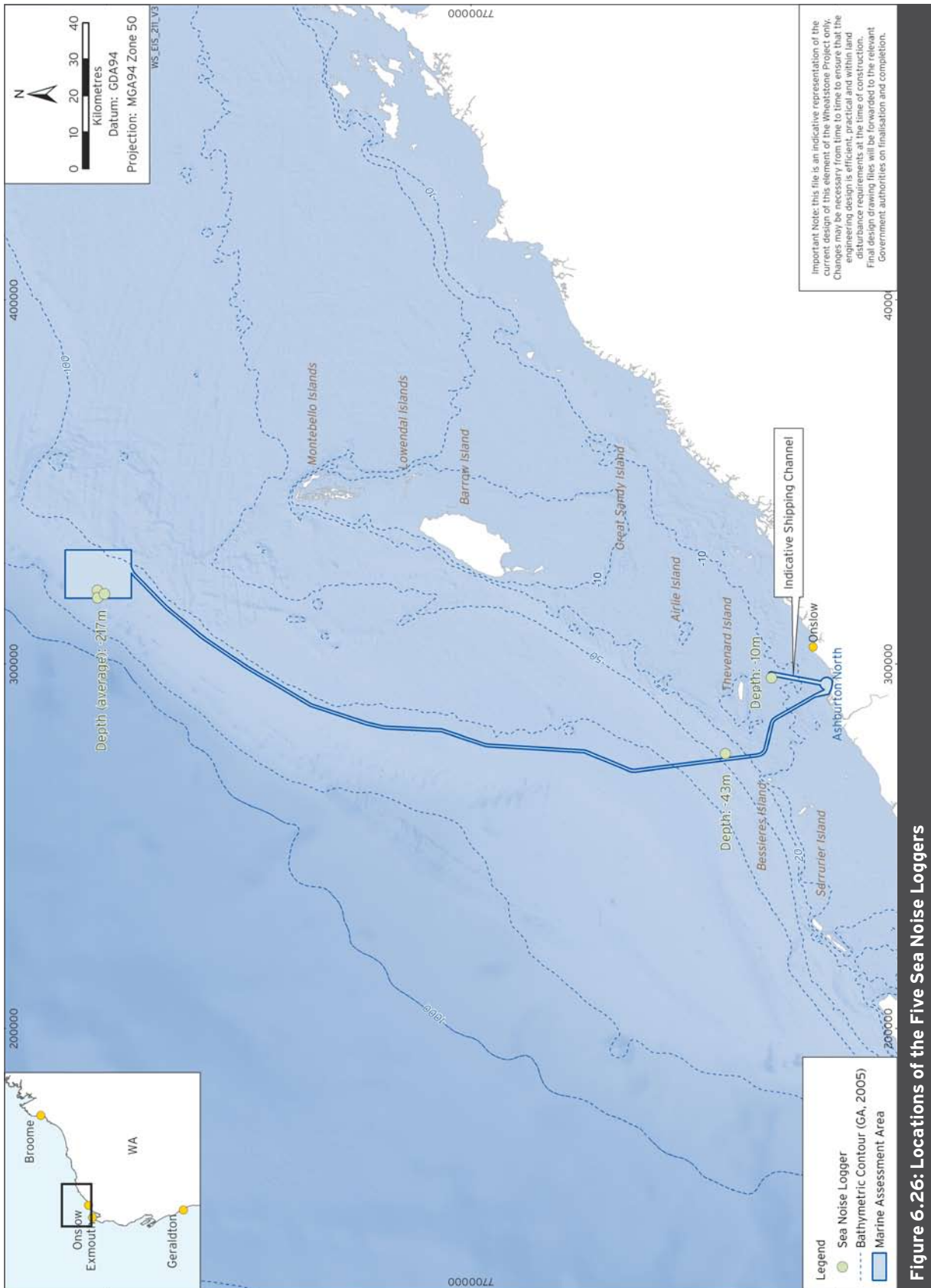
Broadband ambient noise spectrum levels range from 45 to 60 decibel (dB) in quiet regions (light shipping and calm seas) to 80 to 100 dB for more typical conditions and over 120 dB (re 1 μ Pa) during periods of high winds, rain or

biological choruses (Urlick 1983). In the 100-to-500 Hertz (Hz) range, (Urlick 1983) estimated average deep water ambient noise spectra of 73 to 80 dB for areas of heavy shipping traffic and relatively high sea states and 46 to 58 dB for areas with light shipping and calms.

Background levels in the 20 to 500 Hz range are frequently dominated by distant shipping, particularly in heavy traffic regions. Vocalisations of whales also contribute to this low frequency band, with the duration and frequency of these choruses increasing in breeding, migrating and feeding areas (Croll *et al.* 2001, McCauley and Cato 2003). Above 300 to 400 Hz, the level of weather-related sounds exceeds shipping noise, with wind wave conditions and nearby rainfall dominating the 500 to 50 000 Hz range (Urlick 1983).

Information is available from five sea noise loggers deployed in the Project area (Figure 6.26). Although the primary aim of the study was to explore the presence and movements of great whales, the data give an insight into the baseline acoustic environment. Two were deployed nearshore, west of Onslow at 10 m and 43 m water depth (April to July 2009) (Appendix O2). Three were deployed in a triangle configuration offshore, north of the Montebello Islands and near the Petroleum Titles, in approximately 200 m water depth (May to July 2009).

Figure 6.27 provides an example of the data developed by the 43 m logger, which shows noise records made by three different types of sources: vessels, seismic studies and humpback whales. The calls of various whale species were detected at both offshore and nearshore sites including Pygmy Blue, Dwarf Minke, Bryde's and Humpback Whales. Regular evening fish choruses were also heard at the nearshore location.



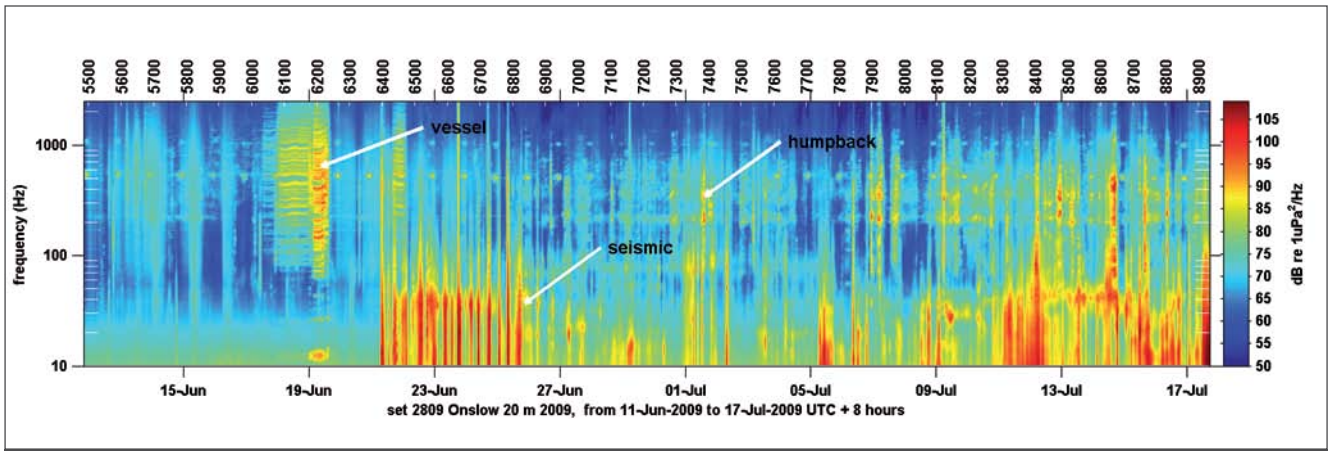


Figure 6.27: Stacked Sea Noise Spectra (36 Day Period) for the 43 m Logger (Frequency Scale is Logarithmic Form 10-2500 Hz) with Examples of Three Noise Sources

The entire recording period of the offshore loggers was dominated by seismic survey noise. At times three seismic survey sources could be detected. These are believed to have been associated with two seismic surveys running in deep waters adjacent to the continental shelf to the south.

Vessel noise was prominent at the offshore location as well, probably from vessels involved in site works at nearby gas fields. This was seen either as periods of sustained noise across a broad frequency band or continual tonal type signals for a vessel holding station nearby.

The nearshore waters around Onslow and the surrounding islands are relatively popular for recreational purposes and are also the site of oil and gas operations and other industry such as salt export. It is likely, therefore, that a moderate level of vessel noise is a routine component of the existing baseline acoustic environment in this area.

6.3.6 Marine Biogeographical Setting and Biodiversity

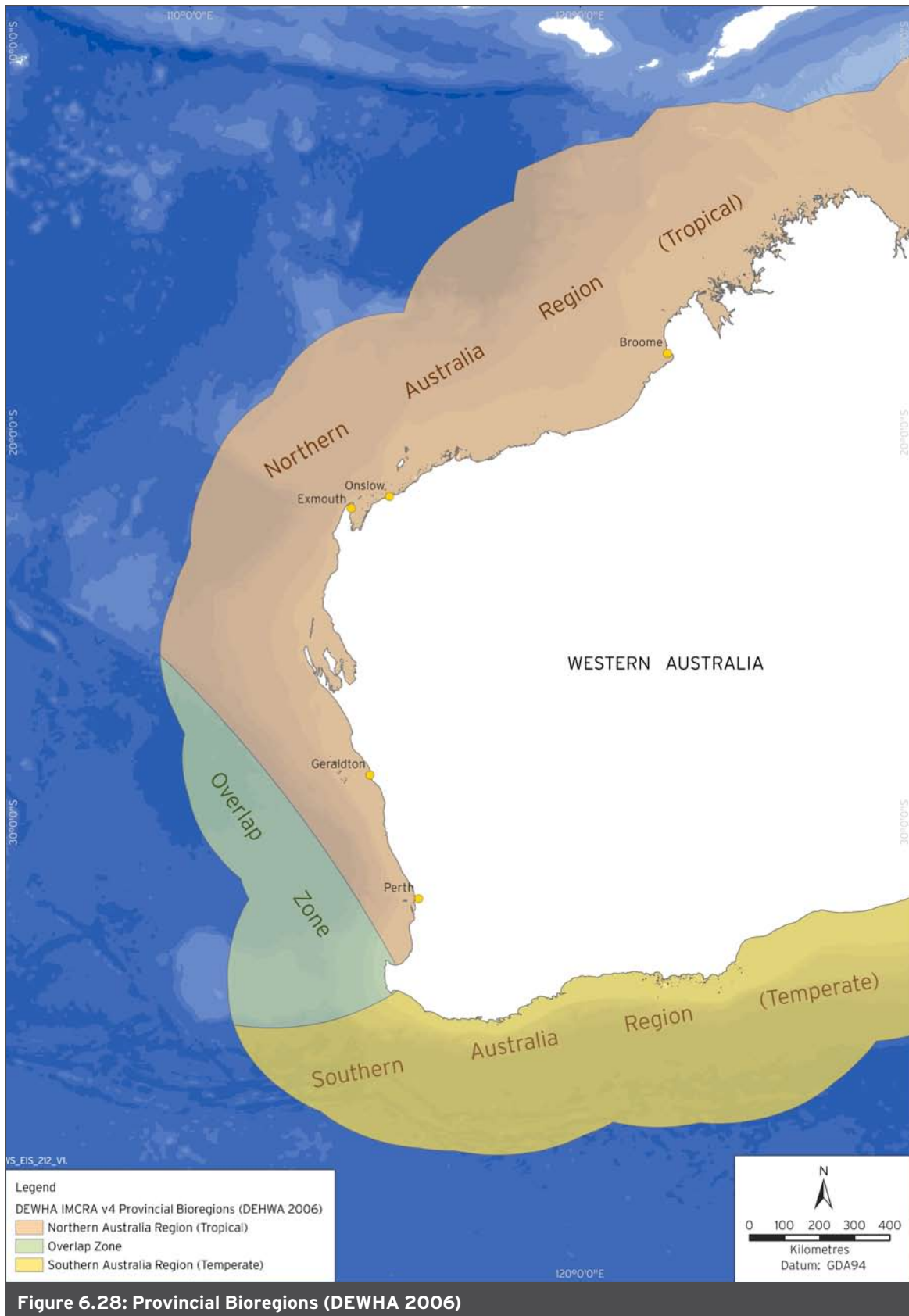
Figure 6.28 shows the distribution of marine biogeographic zones in WA. The key feature of WA marine distributions is that shallow water marine species are widespread. There are no species known to be restricted to the Project area, which is in the tropical Northern Australia Region that extends north-east from North West Cape across the north coast of the continent to the southern extent of the Great Barrier Reef (Wells 1980; Wilson & Allen 1987). The Northern Australia Region is part of the vast Indo-West Pacific Region that reaches from the east coast of Africa through the tropical parts of the Indian and Pacific oceans as far east as Hawaii, and well north and south of the equator. There are no major distributional barriers along the north coast of WA. Essentially, if suitable marine

habitat for a species occurs, it will be found across the entire north coast (Wells 1980). A small proportion (around 10 per cent) of the shallow water marine biota of WA is endemic to the state.

The west coast Overlap Zone occurs between Cape Leeuwin and Shark Bay or North West Cape and scientific opinion differs on the northern limit. This is an area of biogeographic overlap, where the tropical and temperate biotas mix. Of the marine species endemic to WA, most tend to have at least part of their range in the west coast Overlap Zone (Wells 1980; Wilson & Allen 1987).

The Interim Marine and Coastal Regionalisation for Australia (IMCRA 2006) provides a more detailed classification of the Australian marine environment into 60 meso-scale bioregions, of hundreds to thousands of square km from the coast to the edge of the continental shelf (defined as the 200 m isobath). The meso-scale bioregions are defined using biological and physical information, including the distribution of demersal fishes, marine plants, invertebrates, sea floor geomorphology and sediments, and oceanographic data. The IMCRA bioregions provide more detailed information on the Project area within the Tropical Australia Province.

The marine components of the Project cross three IMCRA meso-scale marine bioregions. The nearshore Project area is in the Pilbara Nearshore bioregion, while the subsea pipeline route traverses the Pilbara Offshore bioregion. The gas field and offshore facilities extend into the far south-west corner of the NWS bioregion. Figure 6.29 shows the location of these bioregions. The bioregions are summarised in the following sections, based upon descriptions provided by IMCRA (2006).



Importantly, State or Commonwealth marine protected areas are not located within the Project area. The Project area is, however, located on the boarder of the Gascoyne and Kimberley/Pilbara recreational fisheries bioregions.

6.3.6.1 Pilbara Nearshore Bioregion

The Pilbara Nearshore bioregion includes coastal waters to 10 m depth (generally between one and two nautical miles from shore), from Cape Keraurdren at the southern end of Eighty Mile Beach to North West Cape near Exmouth. The marine environment is characterised by a large tidal range, resulting in highly turbid water, and low wave energy except during storm conditions. Several large estuaries are associated with major seasonal rivers in this region (IMCRA 2006).

Along the mainland, barrier islands and associated protected lagoons, embayments and deltas predominate and the coast is either open or partly protected by chains and clusters of small, limestone islands. Structurally complex mangals are a feature of the mainland shore, with lesser systems around the islands. Wide supra-tidal flats occur behind most of the mainland mangals, with extensive intertidal mud flats and sand flat habitats seaward of the mangals that feature a high diversity of fauna. In many areas, there are extensive rock pavements in the shallow subtidal zone, usually covered with a thin sediment sheet.

The benthic fauna of this bioregion is typical of the coastal habitats across northern Australia and contains a suite of endemic coastal species. The mangal systems are structurally complex but are of limited diversity. The low number of mangrove species probably resulting from the semi-arid climate. These mangals are likely to contribute significantly to the nutrient resources of the Pilbara coastal waters.

The burrowing invertebrate fauna of the intertidal mud and sand flats are important as a food source for migratory birds. A feature of the bioregion is the presence of diverse benthic invertebrate faunal communities on rock pavement habitats in the shallow sublittoral zone, consisting principally of sponges and scleractinian (hard) and soft corals. Seagrasses are present in the shallows, and although not considered extensive they are, along with algal beds, important elements of the region's ecosystem that are probably utilised by herbivorous fishes, turtles and Dugong.

Scleractinian corals are common even in these turbid inshore waters but, with a few exceptions, coral reefs are developed mainly around the seaward margins of islands in the outer part of the bioregion.

6.3.6.2 Pilbara Offshore Bioregion

The Pilbara Offshore bioregion covers waters seaward of the 10 m depth contour, between North West Cape and the Montebello islands. The marine environment is characterised by a large tidal range, moderate wave energy and generally clear waters, with some turbidity during spring tides.

The north-west continental shelf is wide in this bioregion, with a change of slope at about the 20 m bathymetric contour. A series of limestone islands occurs landward of this contour, including the South and North Muiron, Serrurier, Bessieres, Thevenard, Rosily, Barrow and Montebello islands. Fringing coral reefs are well developed on the seaward sides of most of these islands. The seaward sides of the Muirons and Barrow Island feature intertidal rock platforms, a habitat not well represented in the Pilbara Nearshore area. Wide intertidal sand flats occur on the leeward sides of most of the islands, often over rock pavements, and mangals are not well developed. The sandflats are listed on the register of the National Estate (DEWHA 2009a). Smaller intertidal rock platforms occur on some of the islands in the Project area.

The fringing coral reefs of this bioregion are extensive and species-rich, particularly around the outer islands of the Dampier Archipelago (around 200 km north-east of the Project area). Key species of the Indo-West Pacific oceanic coral reef invertebrate assemblages occur here, and the burrowing invertebrate fauna of the island sand flat habitats are also diverse and abundant. Many of the Pilbara islands are important nesting sites for turtles and seabirds (IMCRA 2006).

6.3.6.3 NWS Bioregion

The NWS bioregion covers offshore waters in the outer portion of the north-west continental shelf, lying between about the 30 m bathymetric contour and the shelf edge. These waters are generally clear, with moderate wave energy that increases to extreme during cyclones. Current speeds are generally high, particularly in deep waters, and the area is influenced by the poleward flowing Leeuwin Current. Sediments are predominantly calcareous, with little sediment currently being supplied to this bioregion. The benthic invertebrate communities in the bioregion are considered diverse, and these waters support a rich pelagic and demersal fish fauna (IMCRA 2006).

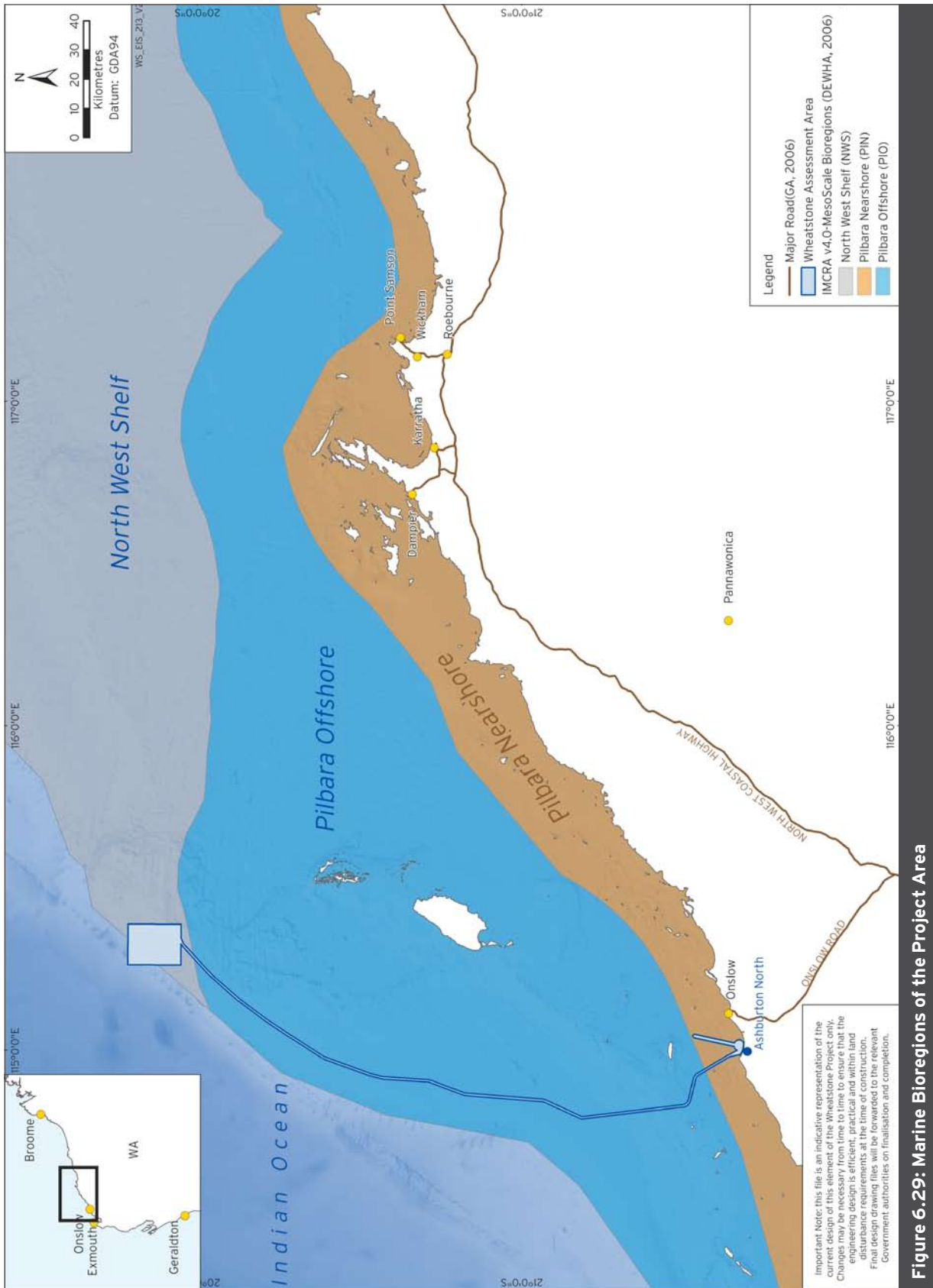


Figure 6.29: Marine Bioregions of the Project Area

6.3.7 Deepwater (Offshore) Benthic Habitats

Field investigation of benthic habitat in the offshore Project area (70 to 250 m water depth) was carried out in August 2009 (URS 2009d). The survey collected video footage along 42 transects to provide a description of substrate and benthic assemblages at sites surveyed along the trunkline route and at the proposed site of the offshore facilities. The information has been used to ground truth data available from hydroacoustic surveys and to produce a broad-scale habitat classification map of the surveyed areas.

No ecologically isolated, sensitive, unique or significant habitats were found in the study area. Areas of soft substrate made up the majority of the survey area with typically low coverage of benthic sessile invertebrates. Hard substrate areas supported sparse (1 to 2 per cent) to occasional (2 to 10 per cent) epibenthic coverage. The vast majority of the sites surveyed can be classified into the following categories:

- Flat to micro rippled (<0.5 m) relief
- Silt/sand substrate
- Sparse (1-10 /m²) to abundant (50-100 /m²) bioturbation (evidence of infauna such as burrows and mounds)
- Trace to very sparse (<1 per cent) benthic sessile and motile invertebrates including soft corals, sea pens, sponges, sea whips, ascidians, urchins and hydroids.

The proposed location of the Wheatstone Platform (WP) is on a large ridgeline (approximately 11 km long) over an area of hard substrate with occasional (2 to 10 per cent) coverage of benthic sessile invertebrates (the highest observed in the study area) (Figure 6.30). This level of coverage is likely to be found along the length of the ridgeline and on most hard substrates at this depth in the region.

Hard substrate areas (limestone/sandstone) and isolated bommies (rock outcrops) found along the trunkline route generally hosted sparse (one to two per cent) to occasional (2 to 10 per cent) coverage of a diverse array of benthic sessile invertebrates, dominated by gorgonians (sea fans and whips), sponges and soft corals. These areas also had fish aggregations, with species such as Gold-band Snapper, batfish, Red Emperor, Spangled Emperor and Rankin Cod present.

6.3.8 Nearshore Benthic Habitats (Intertidal and Subtidal)

6.3.8.1 Studies Undertaken

A number of surveys have been undertaken in order to describe the range of marine habitats that occur within

the study area and to map their distribution. Surveys conducted to date include:

- Three Remotely Operated Vehicle (ROV) video surveys of the subtidal habitats on the seafloor in the Project study area undertaken in December 2008, May 2009 and August 2009 (URS 2009e, Appendix N12). The summer survey, conducted in December 2008, inspected 150 sites and focussed on the navigation channel, trunkline and dredge material placement sites and contiguous potential impact areas. The May 2009 survey inspected 46 sites and was focussed on hard substrate areas in the vicinity of the channel (reef, bommies, shoals, islands) with the aim of identifying suitable areas to establish coral dive transects for future impact monitoring. The winter survey (August 2009) inspected 155 sites and was focussed on:
 - “Ground-truthing” gaps in potential hard substratum areas (reef, bommies and shoals) derived from Admiralty charts and URS interpolated nearshore bathymetry surface map
 - Revisiting soft sediment areas identified in the summer ROV survey as supporting algae and seagrass, to look for seasonal trends
 - Surveying far field areas and proposed dredge material placement sites.
- Surveys of intertidal habitats in the vicinity of the Project area and along the adjacent coastline between the Ashburton River and Coolgra Point were undertaken between November 2008 and May 2009. Focus was primarily on beach, sand flat and rocky shore habitats, mangroves and adjoining high tidal mud flats in the Ashburton delta, Hooley Creek area and a selection of regional sites using a combination of land access, vessel and aerial survey techniques (URS 2009f, Appendix N13).
- Survey of representative inter-tidal habitats on eight islands within the Project area conducted in February 2009 with a focus on rocky shore communities (URS 2009g, Appendix N10).
- Tow and drop camera survey of the continental shelf break, defined in this region as the area between the 20 m and 70 m isobath, conducted in August 2009. Towed video footage covering five transects on the shelf break was analysed according to substrate and biotic composition of benthic assemblages (UWA 2009a, Appendix N8).

The main findings of these investigations are summarised in the following sections. The complete technical reports are provided in Appendix N8.

6.3.8.2 Subtidal Mapping Methodology

The total of 351 subtidal sites surveyed by ROV from December 2008 to August 2009 were analysed following the development of a biota classification matrix that included per cent cover for the major biotopes of macroalgae, seagrass, hard coral and filter feeders. A geostatistical interpolation mapping method, based on kriging (ESRI 2009), was used to develop per cent cover prediction surfaces for the dominant substratum, which were soft sediments in subtidal areas < 20 m CD. A transect method was adopted for the deeper (20 to ~70 m CD) offshore shelf-break region. Boundaries for hard substratum areas including islands and hard substrate benthic areas (e.g. corals, bommies, reefs and shoals) were digitised from Royal Australian Navy Admiralty Charts and ground truthing during ROV surveys. A full description of the subtidal habitat mapping methodology is given in URS (2009h, Appendix N5).

6.3.8.3 Habitat Types and Distribution

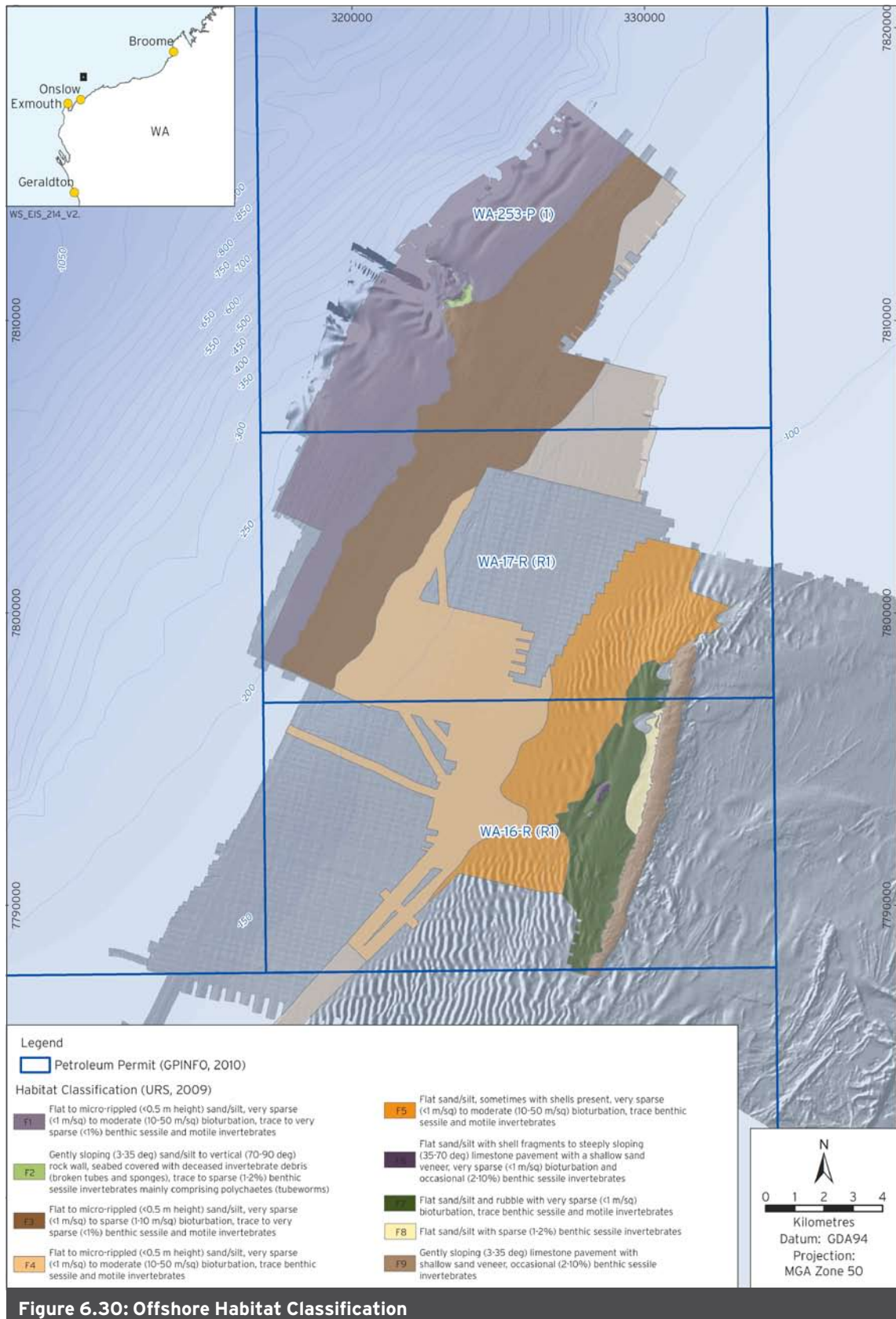
Information obtained by the above surveys has been collated and the distribution of the various benthic habitats has been mapped. Figure 6.31 and Figure 6.32 present the subtidal and intertidal benthic habitat maps for the nearshore Project area. Habitat classification was derived from several sources, following the systematic methodology outlined in Bancroft (2003) and Lyne *et al.* (2006).

At the highest level, the habitat is divided into intertidal and subtidal. Both areas are then further subdivided into hard and soft substrate, and subtidal habitats separated again to show the location of sand veneered pavement. Bottom sediments in the Project area show evidence of zonation with nearshore sediments having predominantly high silt content due to terrigenous sediment loading from the Ashburton River. Elsewhere, sand and pavement dominates the inner shelf although finer sediments are found in patches due to localised oceanographic conditions around islands and shoals. Finer sands and silts dominate the less energetic parts of the outer shelf. Considerable areas of pavement are found on the upper section (between 10 and 40 m) of the shelf break (UWA 2009a, Appendix N8).

For the purpose of the impact assessment (see Chapter 8, *Marine Risk Assessment and Management*) specific habitat types are grouped into "Level 4 biotopes", which sit within wider biogeomorphic units (URS 2009h). The biotope consists of the physical habitat and its biological community. Biotopes identified within the biogeomorphic units of the Project area are summarised in Table 6.5.

Particular emphasis in assessments of this type is placed on benthic primary producers (BPP) and the habitats that can or do support them. BPP includes "marine plants" such as mangroves, salt marsh, intertidal algal mats, seagrasses and algae—including benthic macroalgae (seaweeds), turf algae and sand algae. BPP also includes invertebrates such as scleractinian (hard) corals and some other filter feeding invertebrates such as some sponges and soft corals, which obtain a proportion of their energy requirements from photosynthetic symbiotic microalgae that live in their tissues (EPA 2009). Also of importance are the benthic secondary producers (BSP) and the habitats that support them. In the Project area, benthic habitats vary widely in extent, form and function and all include primary and secondary producers. The following benthic primary producer habitat (BPPH) and benthic secondary producer habitat (BSPH) types have been recognised in this study area and are distributed from mean high water springs level down to approximately 70 m depth:

- Upper intertidal mud flats supporting cyanobacterial algal mats
- Upper intertidal saltmarsh/burrowing crab communities
- Mixed species low density mangrove communities
- Mixed-species dense mangal
- Mixed species macroalgal communities on lower intertidal and shallow subtidal pavements
- Subtidal coral communities on rocks fringing islands or on shoals
- Scattered seagrass patches generally at low cover on most of the soft substrates of the study area, but with some more protected areas exhibiting denser cover (approximately 10 per cent)
- Scattered foliose brown algae occurred on most of the soft substrates of the region, but in greater density on areas of sand veneered pavement
- Sessile benthic filter feeder communities (sponge/whip gardens) primarily located in deeper offshore waters (10 to 40 m CD) on sand veneered limestone pavement. Such communities are also found generally in low abundance on some of the nearshore shoals where corals are dominant
- A red microalgal mat occurs on sandy substrate in deeper waters of the shelf break (40 to 70 m CD).



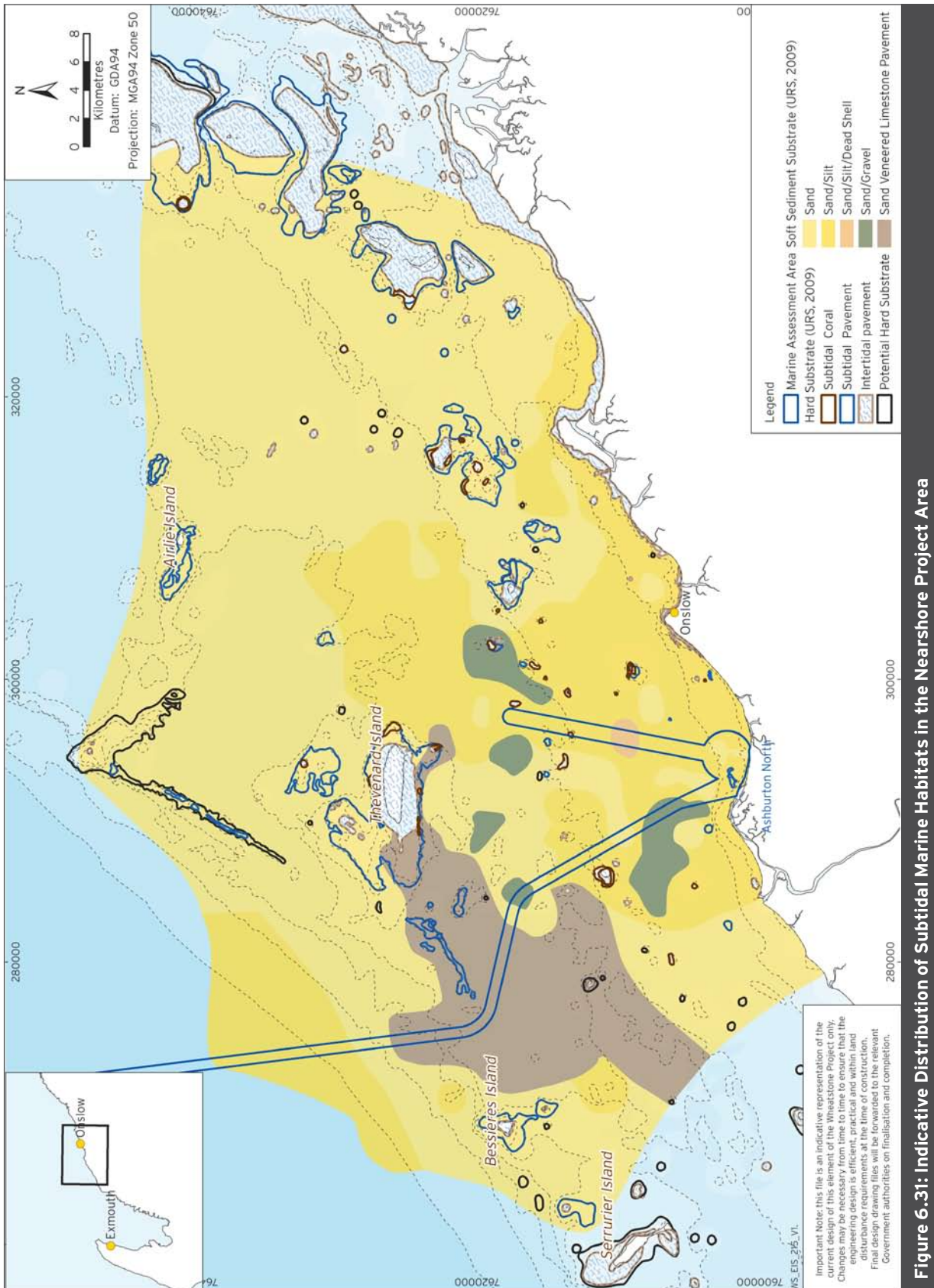


Figure 6.31: Indicative Distribution of Subtidal Marine Habitats in the Nearshore Project Area

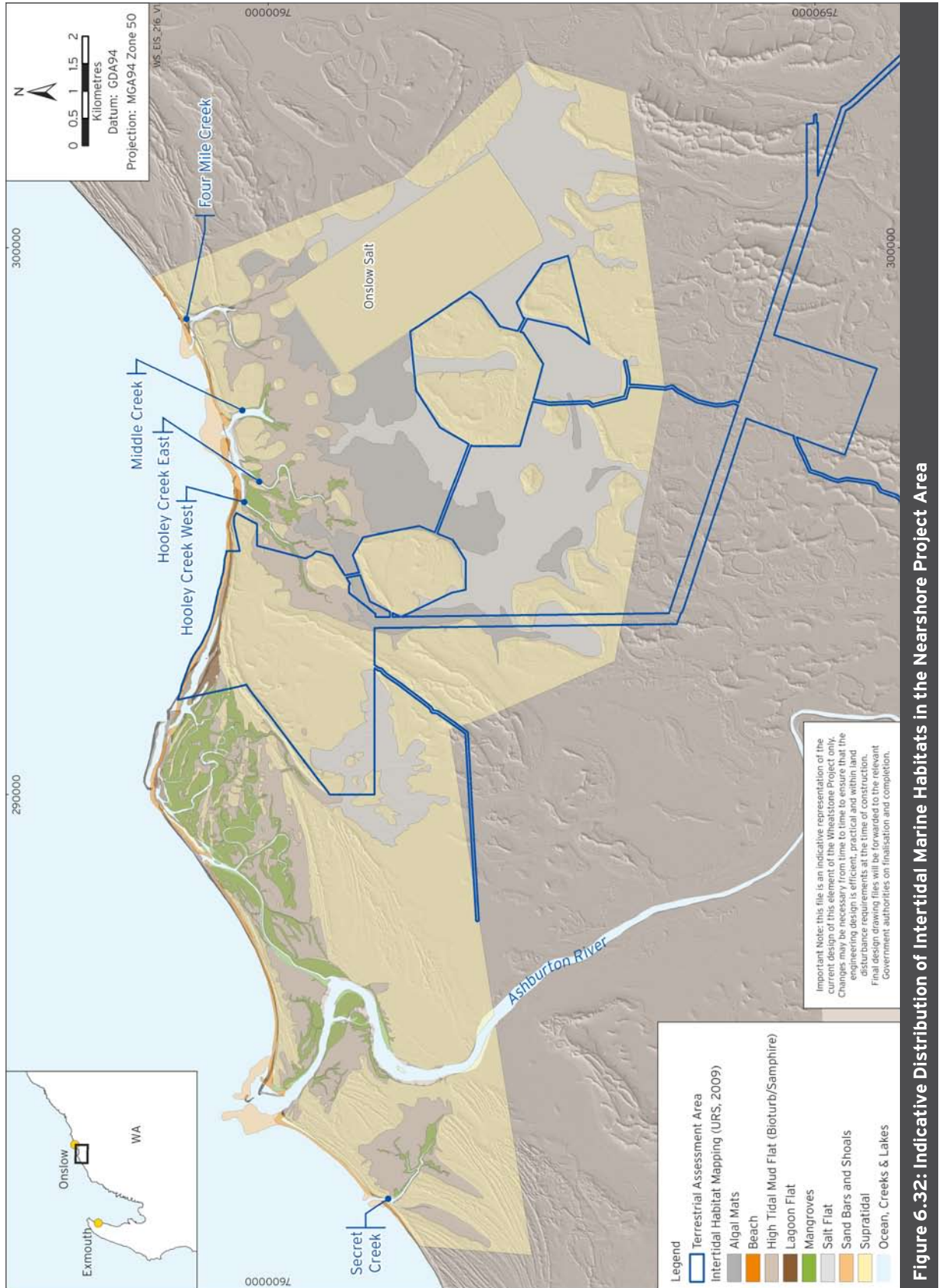


Table 6.5: Biotopes Identified in the Nearshore Project Area

Biogeomorphic Unit	Biotopes
Onslow	Intertidal biotopes (highest astronomical tide - HAT- to LAT) comprise: <ul style="list-style-type: none"> • Sandy beaches • Sand bars and shoals at the mouth of tidal creeks • Mangroves • Bioturbated high tidal mud flats with samphire communities • Cyanobacteria algal mats • Supra-tidal salt flats • Nearshore limestone platforms (at Coolgra Point and Beadon Point) • Offshore intertidal limestone platforms (around the smaller islands). Subtidal biotopes (0 to 10 m CD) comprise: <ul style="list-style-type: none"> • Nearshore soft substrates (silt/sand/gravel beds) supporting low abundance ephemeral seagrasses and algae and burrowing infauna) • Scattered patch reefs and shoals where limestone pavement is exposed and colonised by algae, corals, sponges and other invertebrates • Emergent reefs and small islands supporting fringing coral bommies (Ward Reef, Ashburton, Tortoise and Direction Islands) and macroalgae.
Barrow - Murion	Intertidal biotopes (HAT to LAT) comprise: <ul style="list-style-type: none"> • Sandy beaches • Intertidal limestone platforms Subtidal biotopes (0-10 m CD) comprise: <ul style="list-style-type: none"> • Shallow subtidal limestone pavement supporting dense macroalgae • Biogenic coral reef fringing islands • Coral communities on hard shoals/rock • Sponge/ascidian filter feeders on sand veneered pavement • Sand/gravel plains and shoals supporting sparse foliose macroalgae.
Shelf break between 20-70 m depth	<ul style="list-style-type: none"> • Filter feeders on sand veneered pavement • Sand plain supporting burrowing infauna and microalgal mat.

The BPPH types that are most widespread and cover the greatest area are the low cover foliose algae and seagrasses, which occur on soft substrates and sandy pavement in the region. The next largest single unit is that of the sessile filter feeders, which occur on sand veneered pavement. All other BPPH types are restricted in distribution to either intertidal flats, or hard bottom reefs and shoals, both intertidal and subtidal. They also occupy relatively small areas in comparison to those occupied by the soft substrates. Coral communities are not abundant in the immediate vicinity of the Project area, and are restricted to a small number of individual shoals that occur along the 10 m isobath, and along the edges of the intertidal pavements, which fringe many of the islands in the region. Onshore, mangroves, samphires and algal mat communities

are relatively widespread, but occur within discrete creek or river systems. Most of the shoreline in the study area is comprised of sandy beach.

6.3.8.4 Detailed Description of the Key Benthic Habitats Seagrasses

The seafloor of the Pilbara Nearshore bioregion is sparsely vegetated, with patchily distributed seagrass occurring to depths of approximately 30 m (LEC & Astron 1993). The seagrasses occurring along the Pilbara coastline comprise part of the suite of widely distributed tropical and subtropical Indo-Pacific seagrass species, such as *Syringodium isoetifolium* and *Halophila* spp. A small number of persistent, meadow-forming (perennial) species such as *Thalassia hemprichii*, *Enhalus acoroides*

and *Thalassodendron ciliatum* also occur in the bioregion. Seagrasses are important primary producers, but their sparse distribution in the Pilbara Nearshore bioregion (URS 2009d, Appendix N15) means that they are likely to make only a small contribution to benthic primary production when compared to mangroves, macroalgae and corals.

The abundance and distribution of tropical seagrass species can vary greatly due to seasonal changes in water quality (turbidity, light penetration) and conditions (wave action, temperature), with biomass tending to peak in summer (Lanyon & Marsh 1995). Extreme natural events such as tropical cyclones and freshwater run-off will greatly influence seagrass abundance and play a vital role in structuring species compositions. For example, in exposed environments frequently disturbed by tropical cyclones, seagrass assemblages tend to be dominated by pioneer species, such as *Halophila* spp. (Lanyon & Marsh 1995). In the Project area *Halophila* are the most widespread of the seagrasses. Biomass of this genus tends to be highest late in the year (November-December) when seeding occurs and lowest during April to May (Lanyon & Marsh 1995). *Halophila* spp. are recognised as pioneering species (Lanyon & Marsh 1995), attributed to the rapid rate of germination of their prolific seed (Birch & Birch 1984).

Surveys conducted in the Project area in both summer and winter found that seagrasses were generally sparsely distributed (<10 per cent cover), occurring in small patches within larger areas of suitable substrate. Small areas of higher (>50 per cent) seagrass cover occur in shallow clear water areas, but are not common (URS 2009e, Appendix N12). For example, low cover (<10 per cent) areas of seagrass were found south-west of Thevenard Island and northeast of Onslow. Figure 6.33 shows the location of these areas. Areas of seagrass mapped in Figure 6.33 do not represent contiguous cover of seagrass; rather they indicate where patches of seagrass are more common.

Species present include members of the genus *Halophila* (Photograph 6.2), such as *Halophila spinulosa*, *H. decipiens* and *H. ovalis* (Appendix N15). *Halodule* spp. and *Syringodium isoetifolium* are also present. *Thalassodendron* occurs only sparsely distributed in the shallow macroalgal meadows that occur to the west of Thevenard Island (Figure 6.33) (Appendix N15). Observations are generally consistent with a survey of subtidal areas off Onslow in November 1989 (reported in Paling 1990), which found that seagrass was absent from most sites with only very sparse patches of *H. decipiens*.



Photograph 6.2: *Halophila* spp. (likely *H. decipiens*), near Coolgra Point

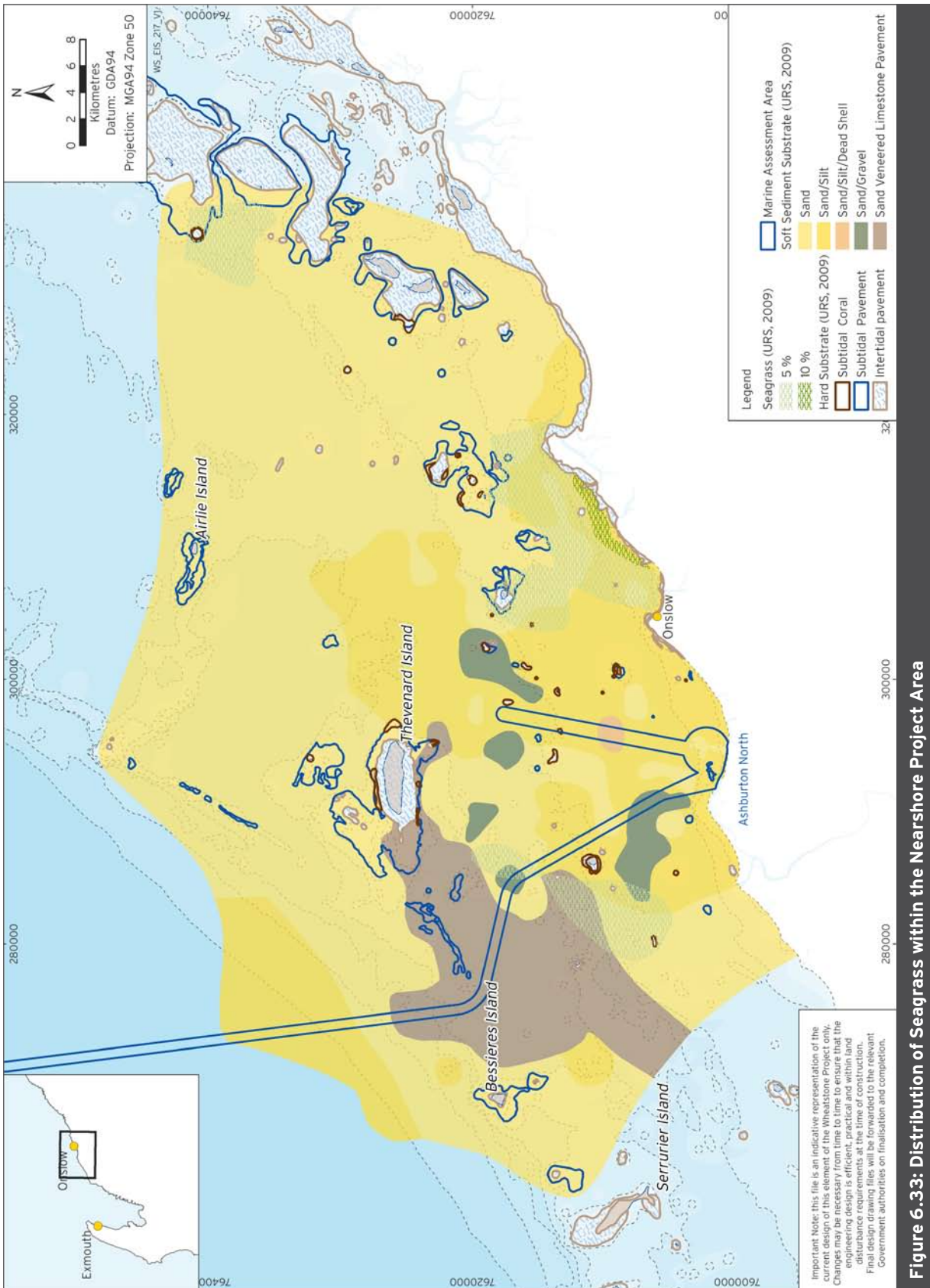


Figure 6.33: Distribution of Seagrass within the Nearshore Project Area

Macroalgae

Macroalgae, like scleractinian corals, are generally restricted to hard substratum in subtidal and lower intertidal areas. Macroalgae occur in tidal pools in occasional outcrops of beach rock along the mainland shoreline, and more extensively on shallow subtidal platforms and flats surrounding the offshore islands. Limestone reefs and platforms provide habitat for more extensive development of mixed algal and seagrass beds. In the Pilbara Nearshore bioregion, these are generally dominated by brown macroalgae (typically *Sargassum* spp.) and large red algae, with green algae (*Halimeda* spp. and *Caulerpa* spp.) forming a smaller component, often in shallower (lower intertidal and shallow subtidal) water. However, Paling (1990) reported small macroalgae attached to shell fragments on very fine bioturbated mud east of Ward Reef, and occasionally species of the green alga *Caulerpa* in soft sediment, often in the presence of the seagrasses *Halophila* and *Syringodium*.

In the nearshore Project area (URS 2009e), macroalgae were present at low densities at a number of sites, and at higher densities at the reef and shoal survey sites. These included large brown algae of the genera *Sargassum*, *Padina* and *Dictyopteris*, and red algae of the genera *Gracilaria* and *Laurencia*. Less common were green algae of the genera *Halimeda* and *Caulerpa*. Extensive macroalgal habitats occur on the shallow platform at the western end of Thevenard Island, and on the pavement surrounding the Twin Islands (Figure 6.34) (URS 2009e, Appendix N12). In the slightly deeper areas of the shelf break (20 m to 40 m isobath) macroalgal beds have an average cover, based on survey points, of 14 per cent (UWA 2009a, Appendix N8).

Plankton

Phytoplankton are the primary producers of the pelagic (mid-water and surface water) zone and form a critical component of the marine food web, particularly for filter feeders including corals and early life stages of marine fish and shellfish. They include cyanobacteria, diatoms, and flagellates. Phytoplankton abundance varies temporally as well as spatially and dynamics are particularly variable within the estuarine components of the creeks and rivers in the region, particularly during periods of catchment run-off. Natural processes such as tides, nutrient upwelling and changes in temperature can alter nutrient and light availability, which ultimately control phytoplankton productivity. In addition, inputs from terrestrial nutrient run-off during monsoonal activity may influence nitrogen availability and therefore phytoplankton abundance. Peaks in chlorophyll associated with phytoplankton blooms are common in nearshore water waters following such events.

Surface slicks may result from blooms of phytoplankton concentrated by wind and tide-induced convergence in coastal embayment areas and around offshore islands and reefs. Episodic large-scale blooms of the pelagic cyanobacteria *Trichodesmium* spp. are a natural feature of tropical waters including the NWS (Hallegraeff & Jeffrey 1984). Benthic sediments can often contain high nutrient levels; therefore, disturbance of sediments may influence nutrient availability, while physical shading by suspended sediments may limit light availability. Phytoplankton is the food source for zooplankton, which are prey for many higher order consumers such as fishes and crustaceans.

Corals and Coral Reefs

Corals exist both as solitary individuals and, more commonly, as colonies of many identical individuals. Hermatypic (reef-building) corals (and some other marine invertebrates) contain zooxanthellae (a type of single-celled algae) within their tissues. It is a symbiotic relationship that has enabled the success of corals as reef-building organisms in tropical waters. A coral reef is a community comprised of corals and calcareous algae actively building a physical structure, and thereby creating habitat for a suite of other animals.

A coral reef is considered BPPH due to the primary production undertaken by the zooxanthellae and other associated photosynthetic organisms. Beyond their importance as BPPH, coral reefs also support a great variety of other animal and plant life (e.g. soft corals, sponges, ascidians, fan worms, octopus, snails, bivalves, crabs, rock lobsters, urchins, sea stars and macroalgae) and are used by humans for fishing and recreational purposes.

The coral reefs off the west Pilbara coast near Onslow form part of the Passage Islands, described by Veron and Marsh (1988). This extensive chain of low sandy islands is situated between two other important coral localities: the Ningaloo Reef to the south-west and the Dampier Archipelago to the north-east. Veron and Marsh (1988) noted that the coral assemblages in the Passage Islands resembled the inshore assemblages at the Dampier Archipelago. From limited collecting in the Passage Islands, 39 species of 23 genera were recorded.

All coral species recorded in the Passage Islands, and in WA waters, are found throughout tropical Australia and, in many cases, more widely throughout the Indo-Pacific region. The wide distribution of most WA scleractinian corals suggests that dispersal mechanisms, such as currents, have major influences on coral species composition and distribution along the WA coastline.

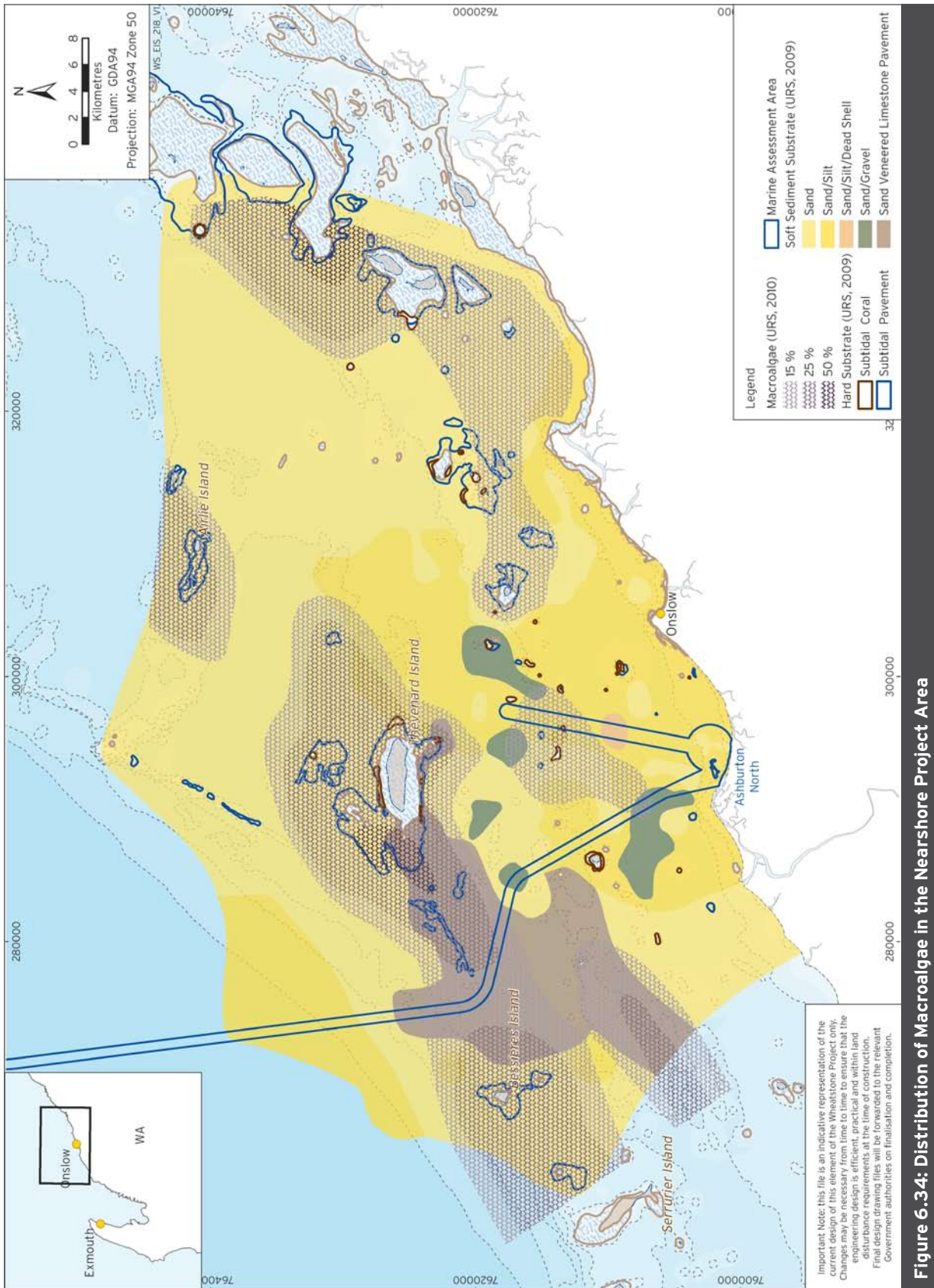


Figure 6.34: Distribution of Macroalgae in the Nearshore Project Area

In the immediate vicinity of the Project area, coral communities are not abundant, being restricted to a small number of individual shoals that occur along the 10 m isobath and along the edges of the intertidal pavements that fringe many of the islands in the region (Figure 6.31). Historical knowledge of the abundance and distribution of scleractinian corals in the Onslow area is drawn from baseline surveys and monitoring studies undertaken on behalf of oil exploration and production companies operating in the region from the 1980s to the late 1990s. General patterns to emerge from these studies have included:

- Coral abundance is extremely low on the mainland coast, mainly due to a lack of suitable substratum and high turbidity
- Coral abundance varies considerably among the islands and reefs offshore from the onslow area
- There are no extensive coral reefs in the area (such as those that occur at Ningaloo, Rowley Shoals, Barrow Island and the Montebello Islands)
- There are relatively well-developed fringing reefs at the western side of Thevenard Island and Serrurier Island
- Less well-developed fringing reefs occur on the shores of most of the smaller islands in the nearshore zone
- There are a number of reefs and shoals along the 10 m isobath supporting coral communities
- Despite the high turbidity in the area and relatively low abundance, scleractinian coral diversity is high
- Cyclone activity plays a significant role in rapidly reducing the abundance of living coral, particularly the more fragile species such as tabulate and staghorn *Acropora*. Coral community structure is likely to be highly temporally variable as a result
- Other pressures on corals in the area include bleaching events and predation by the coral-eating mollusc, *Drupella*, and the Crown of Thorns starfish (*Acanthaster planci*) (Hilliard & Chalmer 1992).

Within the nearshore Project area, the coral communities that are present are found on biogenic reefs and rocks fringing islands. These form two of the ten types of BPPH defined by Environmental Assessment Guideline 3 (EPA 2009d). Biogenic reefs in the area are primarily associated with the ecosystem unit between 10 and 20 m, which includes many of the offshore islands, such as Thevenard. The other coral communities do not form reefs but are found on areas of exposed hard substrate and are typically in the shallower nearshore waters to 10 m depth, an area that is characterised by a ridge of scattered patch shoals.

Targeted surveys have been conducted to provide a more detailed description of the corals and coral reefs within the Project area. Firstly, ROV-deployed video surveys have been used to ground-truth gaps in potential hard substrate areas (reef, bommies, shoals and islands) derived from Admiralty charting and existing literature. The information has been used both to confirm the presence or absence of coral communities and to provide (within the limitation of the survey technique) a description of coral per cent cover, coral type (including growth form) and general condition (Appendix N7).

Secondly, 10 m fixed belt transects have been surveyed in areas identified by the ROV as having high per cent coral cover. Although the primary aim of this work was to establish suitable coral monitoring sites within potential impact areas, the transects provide the basis of a baseline coral community description (Appendix N7), focussed on estimates of coral cover and an evaluation of the community diversity and gross taxonomic structure. While this latter survey does not provide estimates of the abundance of corals beyond areas of high per cent cover, it does provide an indication of where the high cover areas are located and of patterns in spatial distribution.

Coral Cover and Condition

Areas of high per cent coral cover, where present, exist as healthy communities with little bleaching, virtually no areas of freshly dead coral and with low levels of macroalgal growth, typical of the region for the time of the survey (MScience 2009a). Maximum living coral cover was 86 per cent; although, within sites, cover was highly variable, varying by up to five fold (MScience 2009a).

The reefs fringing the nearshore islands (e.g. Tortoise, Ashburton, Thevenard, Direction and Twin islands) support a low to moderate, but variable, per cent coral cover. One exception is the east side of Direction Island, which has areas of very high per cent coral cover. Surveys reported some visual evidence of cyclone related damage on these fringing reefs, including fragmentation of vase and branching corals and overturning of some submassive and massive colonies. In general, coral cover at the island sites visited was low to moderate (URS 2009e). Hastings Shoal, Weeks Shoal and Gorgon Patch appear to support a diverse and healthy coral community, with up to 100 per cent coverage in places. Elsewhere along the 10 m isobath, reefs and shoals generally have a lower coral cover of 10 to 20 per cent (e.g. Australind Shoal and Miles Shoal), or moderate cover of 50 per cent (at Saladin Shoal). Hydroids, gorgonians, sponges and macroalgae are also present in these locations (URS 2009e).

Closer to shore, the shoals and exposed pavements have a low coral cover, typically less than 10 per cent. However, Ward Reef, which lies between the nearshore reefs and the chain of shoals along the 10 m isobath, has a very high cover of corals over an extensive area (Photograph 6.3). Roller Shoal and the most eastern shoal of Glennie Patches support moderate coral cover of 50 per cent. Shoals located a similar distance offshore to the west (the remainder of the shoals comprising Glennie Patches) and east of Ward Reef support much lower coral cover (URS 2009e).

Types of Coral and Community Diversity

There is a marked cross-shelf zonation of coral species, with an inshore zone dominated by *Montipora* spp. (Photograph 6.3), a transition zone where *Montipora* are abundant but where other corals (including *Acropora* spp.) may become dominant, and an offshore zone where *Acropora* is the dominant coral (MScience 2009a). Much of the higher coral cover areas are associated with spreading corals such as tabulate *Acropora* or plating *Montipora* (MScience 2009).

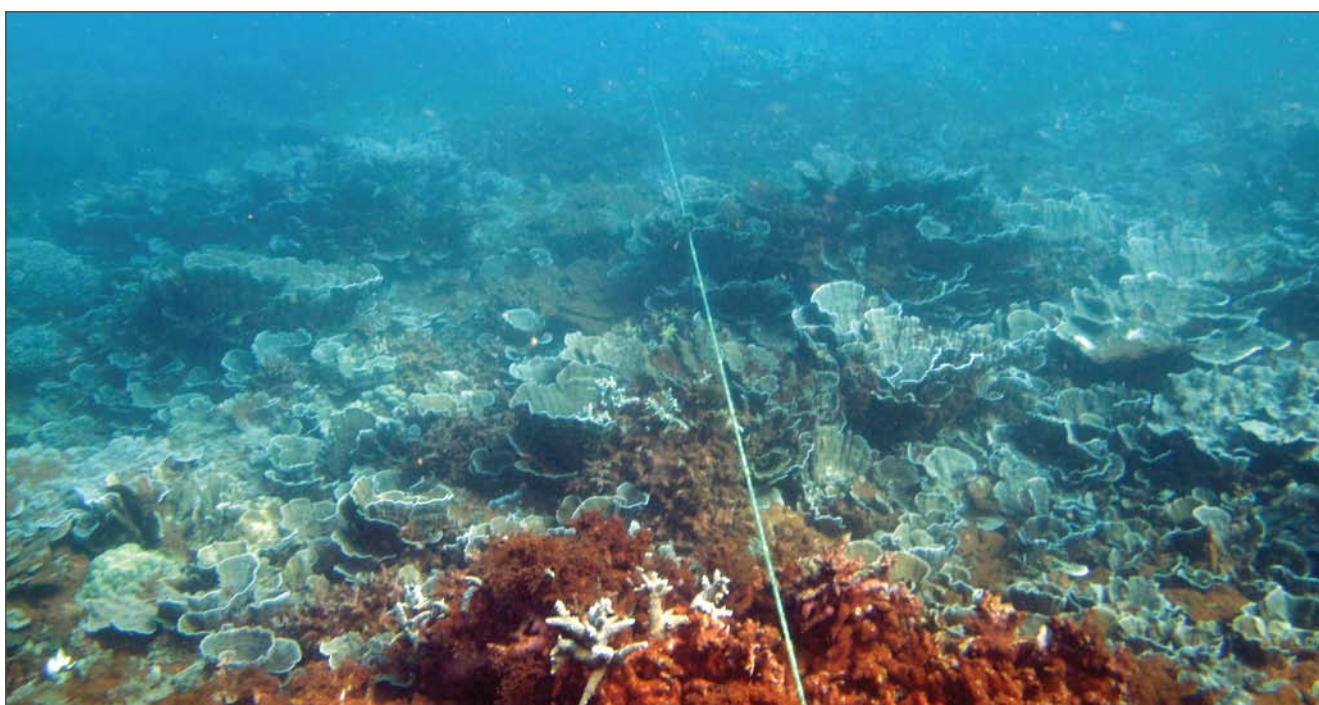
Community diversity varies from monospecific stands of *Montipora* spp. (e.g. Ward Reef, Photograph 6.3) to highly diverse sites with some *Montipora* but also representatives of the Acroporidae, Agariciidae, Faviidae, Mussidae, Pectiniidae, Pocilloporidae, Poritidae and Dendrophylliidae (*Turbinaria* spp.) (e.g. Direction and Twin islands). The

high-cover, low-diversity nature of sites such as Ward Reef is indicative of stable environments with low levels of environmental disturbance (Connell 1978).

Coral growth form (which determines, to an extent, the susceptibility of a colony to sedimentation) is linked to community type:

- *Montipora* are almost invariably foliaceous (plate or encrusting) forms
- *Acropora* are predominantly tabulate, with some corymbose and digitate forms also present
- *Porites* spp., faviids and mussids are predominantly massive.

The overall picture is supported by the results available from one of the few other, publicly available, detailed studies of coral communities in the local area - quantitative coral monitoring conducted at Thevenard Island as part of an ongoing long-term monitoring program (Chevron Australia 2007). Monitoring between 1998 and 2006 revealed an increasing trend in coral cover (up to approximately 40 per cent at some sites) during periods with the absence of cyclonic activity (2002 to 2005). Substantial damage to coral communities was recorded following the 2006 cyclone season, although signs of coral recovery were present at many sites. The work at Thevenard also confirms the existence of



Photograph 6.3: *Montipora* Dominated Community at Ward Reef (June 4, 2009)

healthy reefs in close proximity to existing oil and gas installations and areas of high activity (including pipeline replacement works).

Further details are presented in Appendix N7 (MScience 2009a).

Coral Spawning

The majority of coral species are broadcast spawners, meaning that they release eggs and sperm into the water column for fertilisation to take place. Many of these corals tend to spawn in unison; a phenomenon termed “mass spawning”. The term may be misleading, in that neither 100 per cent of species, nor 100 per cent of colonies spawn simultaneously. Therefore, in defining a mass spawning event, it is necessary to identify a threshold that is ecologically meaningful. Expert opinion recommends that simultaneous spawning by either 40 per cent of species or 40 per cent of colonies be defined as a mass spawning (Baird 2009).

In north-western Australia mass coral spawning has occurred between March and April (and possibly February) in almost all years that studies have occurred (Baird *et al.* in review). The vast majority of reproductive effort in the broadcast spawning coral assemblage occurs in autumn. Colonies will either spawn at this time (with the exception of the few that may spawn in spring), or not at all. The historical data is sufficient to support this proposition (Simpson 1985; Simpson *et al.* 1991; Rosser & Gilmour 2008; Gilmour *et al.* 2009; Rosser & Baird 2009; Baird *et al.* in review). Mass spawning generally takes place six to ten nights after the full moon.

It is also clear from the available historical data that the autumn spawning will be split between March and April (and possibly even February) in almost all years (Gilmour *et al.* 2009; Baird *et al.* in review) just like on the Great Barrier Reef where split spawning occurs in two out of every three years (Baird *et al.* 2009). The spring spawning is far less predictable because the historical data is sparse and sampling will be required for a few more years until the spatial and temporal variation in the magnitude of the spring spawn is established.

Other Subtidal Habitats

Sessile filter feeders (including soft corals, sponges and ascidians) are common on the sand veneered pavement that dominates the inner shelf and are consequently one of the largest BPPH units present, second only to the ephemeral low cover foliose algae and seagrasses (URS 2009e) (Figure 6.35). Silty sand habitat was generally found to support a lower density of sessile invertebrates

than the sandy gravel areas (URS 2009e; Appendix N12). It is possible that prawn trawling, which occurs over a significant part of the survey area (refer to Section 6.5), impacts on sessile invertebrate abundance in those areas close to shore (URS 2009e; Appendix N12).

On the upper parts of the shelf break (20 to 40 m isobath) sessile filter feeding communities (predominantly sponges) have an average cover, based on survey points, of 4.7 per cent (UWA 2009e; Appendix N12).

Mangroves

Mangrove vegetation communities are a key component of coastal systems in the Pilbara region, although they are not as species rich or extensive as the mangrove communities further north in the Kimberley region. Seven species of mangroves occur in the west Pilbara, the most common being *Avicennia marina* and *Rhizophora stylosa* (Semenuk & Wurm 1987).

Tidal exchange and flows are the dominant and prevailing processes that maintain the Pilbara mangroves as they regulate many of the physical, chemical and biological functions. Groundwater salinity gradients are established across the tidal flats in response to decreasing frequencies of seawater (tidal) recharge with increasing tidal flat elevation, and these gradients have produced recognisable structural and physiognomic zones within the mangroves (Semenuk & Wurm 1987).

Mangrove communities support a variety of other organisms, including algae and invertebrate fauna such as oysters, barnacles, snails and crabs. At high tide, fish, sea snakes and other marine animals enter the mangroves to feed, while at low tide, birds and mammals enter the system from adjacent land areas. Together, these combine to form a complex ecological system. Mangroves can also provide an important nutrient source in open coastal areas through the export of leaves, branches and detritus into the marine environment as the tides recede (Semenuk & Wurm 1987).

The EPA places particular conservation significance on the arid-zone mangroves of the Pilbara coast due to their geographical distribution, biodiversity, productivity and ecological function. A guidance statement issued by the EPA (2001) lists mangrove habitats at both the Ashburton River delta and Coolgra Point as “regionally significant”, with very high conservation value. Other studies have also recognised the high conservation value of the mangrove community at the Ashburton River delta on the basis of its diversity and extent, when placed in a regional context (LEC 1991; Pedretti & Paling 2001; MPRSWG 1994; Appendix N14). Unlike the Ashburton River area, the mangroves at Hooley Creek are not considered as regionally significant.

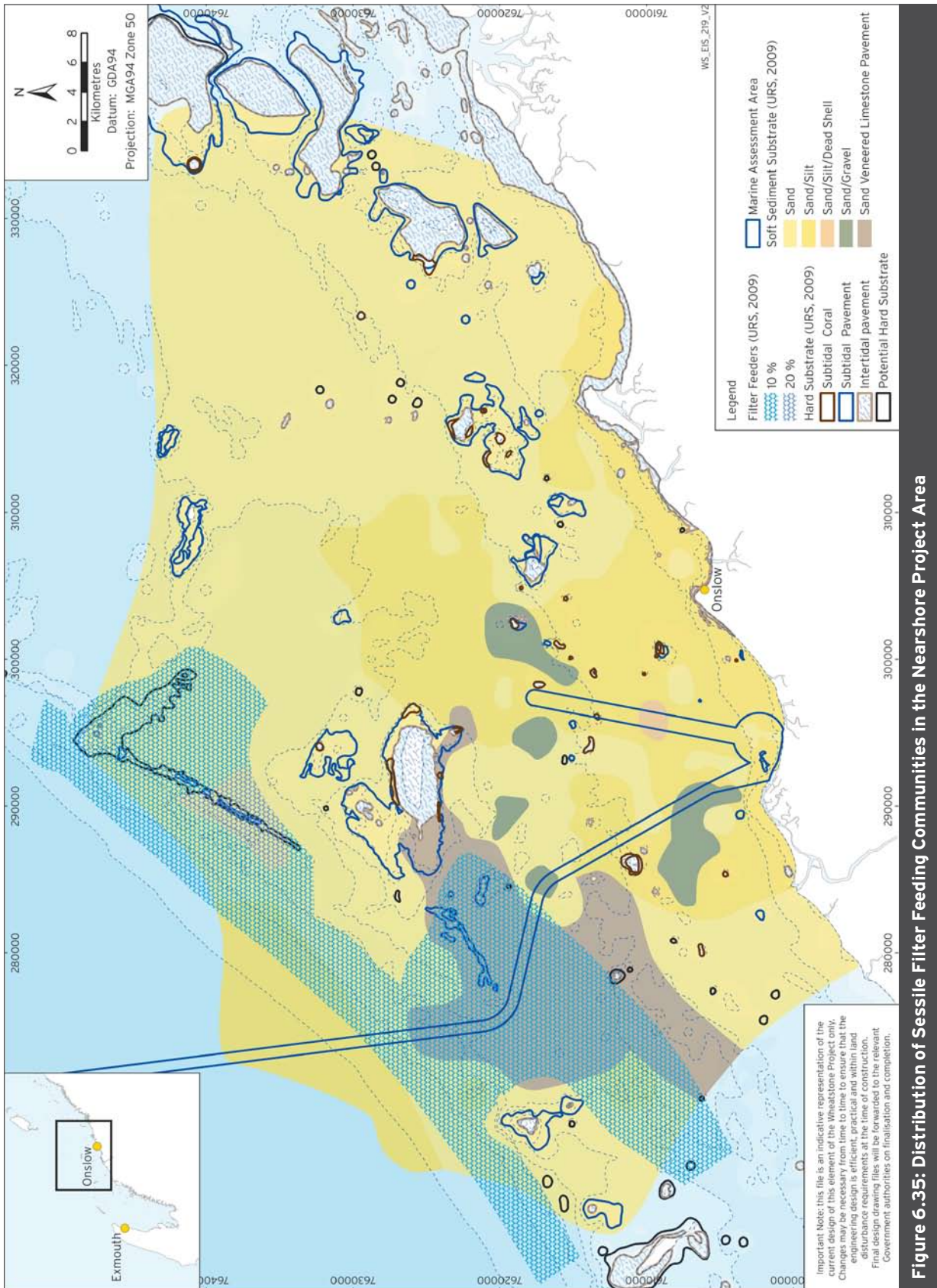


Figure 6.35: Distribution of Sessile Filter Feeding Communities in the Nearshore Project Area

Within the nearshore Project area, mangroves occupy the mainland intertidal zone between mean sea level (MSL) of 1.6 m CD and an elevation of approximately 2.2 m CD, which is between the high neap and spring-tide levels. Mangroves in the area occur mostly within river mouth and tidal creek systems, where they form nearly continuous ribbons of vegetation, fringing the channels. These mangroves are protected and partially isolated from the sea by barrier dune systems. Areas of mangroves also occur along the outer, coastal shoreline on the western and northern sides of Coolgra Point (URS 2009f; Appendix N11).

At Hooley Creek, Middle Creek, Four Mile Creek, Beadon Creek, and Second and Third creeks, mangroves are confined to a narrow fringe adjacent to the creek channel up to 20 m wide. More expansive mangrove areas are found at the Ashburton River delta (Photograph 6.4, taken 2009) and Coolgra Point, where there is far greater area and diversity of habitats suitable for mangrove colonisation (URS 2009f; Appendix N11). No intertidal mangrove areas occur on the islands of the nearshore Project area (URS 2009g; Appendix N10).

Six of the seven mangrove species recorded in the Pilbara region occur within the Onslow area (LEC 1991; Paling 1990) and these species were all recorded during surveys of the Project area—*Avicennia marina*, *Rhizophora stylosa*, *Ceriops tagal*, *Aegialitis annulata*, *Aegiceras corniculatum* and *Bruguiera exaristata*. *Avicennia marina* (grey mangrove) is widespread and occurs throughout the range of mangrove assemblages present. Five mangrove zones or associations were defined during the surveys as follows:

- Tall dense *Avicennia marina* thickets or low forests fringing the major creek systems and seaward margins
- Low, dense *Avicennia marina* shrubland
- Low, open to very open *Avicennia marina* scrub, typically occurring on the landward margin of the mangrove zone (and often integrating with high tidal mud flat habitat)
- Mixed, tall *Avicennia marina*/*Rhizophora stylosa* thickets/low forest/woodland
- Tall dense *Rhizophora stylosa* thickets or low forests.



Photograph 6.4: Mangrove in the Eastern Section of the Ashburton Delta

High Tidal Mud Flats

Landward of the mangroves, large areas of high tidal mud flats commonly extend to the hinterland margin, or merge with supra-tidal salt flats. These mud flat areas are not inundated by daily tides. There are two habitat types on the high tidal mud flats:

- Bioturbated mud flats, devoid of macro-vegetation but heavily worked over by burrowing crabs (Photograph 6.5)
- Samphire flats, dominated by halophytic shrubs but with some crab burrows.

Boundaries between these mud flat types are not always discrete and are not easily mapped. Typically an area of bioturbated mud flat occurs immediately behind (landward of) the mangrove zone, while samphire flats extend landward from the bioturbated mud flat to the hinterland margin. In many areas, patches of samphire plants also occur amongst the low open mangrove scrubs. Fiddler crabs (*Uca* spp.) and sesarmid crabs dominate this zone (URS 2009f; Appendix N11).

Vegetation communities on the samphire flats are dominated by two samphire species, *Tecticornia halocnemoides* and *T. pruinosa*. Other species commonly found in areas where the samphire flats about the hinterland or low islands located amongst the high tidal flats were *Muellerolimon salicorniaceum*, *Frankenia ambita*, *Neobassia astrocarpa*, *Hemichroa diandra* and the perennial grass *Sporobolus virginicus* (marine couch).

The samphire plants and algal mats, like mangrove trees, are primary producers while the bioturbated mud flats are areas of high secondary production essential in the trophic relay mechanisms of the ecosystem food web in these estuarine regions (e.g. Kneib 2000). Mangroves and associated mud flats have a high organic content; the benthos supports high microbial activity and large densities of invertebrate fauna. These organisms perform the critical “secondary production” role of breaking down organic material into forms that become available to the mangrove ecosystem and beyond. Within the upper intertidal zone, much of the mud flat areas are heavily burrowed by crabs, generally in vast numbers. The burrowers have very important functions in maintaining favourable geochemical conditions for nutrient cycling including augmentation of sulfate reduction rates in the substrate (Kostka *et al.* 2002).



Photograph 6.5: Bioturbated Mud Flat

Algal Mats

At locations where expansive mud flats extend further landward of the high tidal mud flat habitats described above, areas of algal mats (also referred to as cyanobacterial mats) frequently occur (Figure 6.32). During field surveys, these areas were devoid of macro-vegetation and crab burrows but covered with a layer of microalgae (cyanobacteria). Expansive areas of algal mats were observed on mud flats at Tubridgi Point, the Hooley Creek-Four Mile Creek system and the Second Creek-Coolgra Point system. Algal mat areas are only rarely inundated by the larger of the spring tides; a spring high tide of 2.6 m CD is pictured inundating the algal mat areas in Photograph 6.6 (taken May 9, 2009).

The algal mats vary from a sheet form to a pustular or crinkled form. In the most commonly observed sheet form, the mat is typically 5 to 10 mm thick and could be easily rolled and peeled back from the mud flat surface. Where the algal mats retain moisture, they take on a dark colouring and texture that makes them readily identifiable from a distance. These mats consist of dense micrometer scale communities in which the full plethora of microbial metabolism can be present (Stal 2000). The dense mass of cyanobacteria in the upper photic zone of the microbial mats results in high rates of photosynthesis (Stal 2000, Bauld *et al.* 1979) and, on a surface basis, the productivity

has been reported to exceed tropical rainforests (Malhi *et al.* 1998), thus considered to be the most productive ecosystems on Earth. Cyanobacteria use a variety of nitrogen sources including ammonia, several amino acids, nitrite and nitrate. They can also use nitrogen directly. All steps of the nitrogen cycle may be present in the microbial mat in which cyanobacteria play a particularly important role. Stal (2000) reports that saline cyanobacteria mats typically demonstrate a temporal separation of nitrogen fixation and photosynthesis activity over night and day respectively.

Rocky Shores

Rocky shores, with their characteristic epifaunal assemblages, are common around the islands of the nearshore Project area but not along the mainland shores, which are predominantly sandy. Some rocky shore habitat occurs near the Hooley Creek delta and at Beadon Point, but these sites contain poorly developed habitats, with very low to moderate biodiversity (URS 2009f; Appendix N11).

Invertebrate fauna species recorded in the upper littoral zone at Beadon Point included the moon snail (*Polinices conicus*) and two species of dog whelks: *Nassarius dorsatus* and *N. cf. clarus*. The outer mid littoral and lower littoral rock platform comprises a moderately diverse invertebrate fauna and moderate growth of leafy algae and low seagrasses.



Photograph 6.6: Algal Mats (dark colour) at Tubridgi Point

The herbivorous gastropods *Trochus hanleyanus* and *Angaria delphinus* were common, and the barnacle *Balanus* spp. and rock oyster *Saccostrea cucullata* were present on higher rocks, along with the gastropod predators *Morula margaritcola* and *Cronia crassulnata* (URS 2009f).

The zonation pattern found on rocky shores of the islands close to the nearshore Project area (URS 2009g) was similar to that recorded at the Dampier Archipelago by Wells and Walker (2003) and Jones (2004). The only species found in the upper intertidal was the littorinid snail *Nodilittorina trochoides*. The middle intertidal area was dominated by a variety of molluscs, including oysters (*Saccostrea cucullata*), chitons (*Acanthopleura gemmata*, *A. spinosa*) and gastropods. Barnacles, particularly *Tetraclita squamosa*, and crabs such as *Leptograpsus* spp. were abundant in this region. As in other areas, the lowest part of the intertidal zone has the greatest frequency and duration of immersion, so a larger number of species is able to survive in this area. While diversity was higher in these areas, the number of individuals of most species recorded during field surveys was still low (URS 2009g; Appendix N10).

In general, the low number of species of molluscs and other invertebrate groups encountered during the survey of the nearshore islands was indicative of only moderate biodiversity, which may be attributed to low habitat diversity. The number of species recorded by Jones (2004) in rocky shores at the Burrup Peninsula suggests greater species diversity than that recorded at the nearshore islands of the Project area (URS 2009g).

Corals were uncommon on the rocky shores surveyed on the nearshore islands off Onslow. Some shallow lower intertidal pools on the islands have small numbers of corals, including species of the genera *Goniastrea*, *Favites*, *Favia*, *Pleisiastrea*, *Porites* and *Turbinaria*. Other invertebrates found included polychaete worms, crustaceans and echinoderms.

Sand Beaches

Sand beaches dominate the upper intertidal zone along the coastal shorelines in the Project area and occur widely on the nearshore islands. The sands are highly mobile, moved about rapidly by winds and waves. Flora and fauna in this zone can be exposed by one set of conditions and then be rapidly buried in sand when conditions change. The habitat is therefore unsuitable for plants and most animals as they are unable to move at all, or rapidly enough, to survive the changing sand conditions.

Of the invertebrate fauna that do occur in this zone, the most conspicuous are ghost crabs (*Ocyropode* spp.) which burrow in the sand and forage along the beach for detrital food. There are also several species of bivalve (families Donacidae and Hemidonacidae) that burrow at the bottom of the beach profile. Detrital wrack in the strand line of beaches commonly supports a fauna of small crustaceans (notably amphipods) and a distinctive micro-fauna (meiofauna) (URS 2009f).

6.3.9 Marine Fauna

6.3.9.1 Threatened Marine Species

According to the Protected Matters database, 14 threatened marine fauna species are known to occur in the nearshore or offshore Project area. The threatened species include one bird, four marine mammals, six reptiles and three sharks/rays (Table 6.6).

In addition to these species, a number of migratory marine mammals and birds are protected under the EPBC Act (Cth), including all cetacean species (whales and dolphins), the Dugong, migratory seabirds and wetland birds. Many of these are protected under Commonwealth law because they are listed on international treaties to which Australia is a signatory. These include the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Table 6.7 lists the studies undertaken in the Project area to supplement previously available information on key marine fauna species in the region.

The abundances and distributions of these and other marine animals are described in more detail in the following sections.

6.3.9.2 Marine Birds

The Pilbara region supports important seabird breeding sites such as the Montebello and Barrow Island group (DEWHA 2008). The nearshore islands in the Pilbara Nearshore bioregion are also known to support seabird nesting, and a number of the islands are protected as Nature Reserves for this reason (DEWHA 2008). Species recorded on nearshore islands in the vicinity of Onslow include Caspian Terns, White-bellied Sea Eagles, Ospreys, Eastern Reef Egrets, Fairy Terns, Pied Oystercatchers and Wedge-tailed Shearwaters.

Table 6.6: Threatened Marine Fauna Potentially Inhabiting the Project Area

Scientific name	Common name	EPBC Act Conservation Status	Wildlife Conservation Act Status
Birds			
<i>Macronectes giganteus</i>	Southern Giant Petrel	Endangered	Rare
Mammals			
<i>Balaenoptera musculus</i>	Blue Whale	Endangered	Rare
<i>Balaenoptera musculus brevicauda</i>	Pygmy Blue Whale	Endangered	
<i>Eubalaena australis</i>	Southern Right Whale	Endangered	Rare
<i>Megaptera novaeangliae</i>	Humpback Whale	Vulnerable	Rare
Reptiles			
<i>Crocodylus porosus</i>	Saltwater Crocodile	Protected	
<i>Caretta caretta</i>	Loggerhead Turtle	Endangered	
<i>Chelonia mydas</i>	Green Turtle	Vulnerable	Rare
<i>Dermochelys coriacea</i>	Leatherback Turtle	Vulnerable	Rare
<i>Eretmochelys imbricata</i>	Hawksbill Turtle	Vulnerable	Rare
<i>Natator depressus</i>	Flatback Turtle	Vulnerable	Rare
Shark			
<i>Pristis zijsron</i>	Green Sawfish	Vulnerable	Rare
<i>Pristis clavata</i>	Dwarf Sawfish	Vulnerable	Rare
<i>Rhincodon typus</i>	Whale Shark	Vulnerable	

Source: (DEWHA 2009)

Table 6.7: Studies of Marine Fauna

Study	Report
Protected marine species desktop	URS 2009i (Appendix O7)
Marine mammal desktop review	RPS 2010 (Appendix O12)
Marine turtle desktop review	RPS 2010 (Appendix O11)
Turtle nesting 2008/09 season (mainland beaches and islands): Field survey	Pendoley Environmental 2009 (Appendix O8)
Turtle nesting 2009/10 season (mainland beaches and Ashburton Island): Field survey	RPS 2010 (Appendix O11)
Turtle foraging: Field survey	RPS 2010 (Appendix O11)
Turtle satellite telemetry: Field survey	RPS 2010 (Appendix O11)
Migratory birds: Field survey	Bamford 2009
Aerial survey program to provide description of megafauna distribution and abundance in the south-west Pilbara over a 12: Field survey-month period	Centre for Whale Research (CWR) 2009 and 2010 (Appendix O3 and O4)
Acoustic survey targeting presence of cetacean species: Field survey	CWR 2009 and 2010 (Appendix O3 and O4)

The Southern Giant Petrel was identified in a search of Protected Matters and is protected under the EPBC Act (Cth) and WC Act (WA). This species is highly mobile, but favour temperate waters in the Southern Ocean where they are widespread. They are known to breed on Macquarie Island, Heard Island and McDonald Island in Australia, and Giganteus Island, Hawker Island, and Frazier Island in the Australian Antarctic Territories (Environment Australia 2001; Patterson *et al.* 2008; Woehler *et al.* 2001; Woehler *et al.* 2003). The Project area is towards the northern limit of their distribution in Australia; therefore, this species would rarely be encountered. Since there are no major breeding or feeding areas for the Southern Giant Petrel in the vicinity of the Project, this species is not a key factor and has not been considered further in the impact assessment.

The EPBC Protected Matters Search identified the following five migratory seabird species that nest on the nearshore islands in this region:

- Fork-tailed Swift (*Apus pacificus*)
- White / great Egret (*Ardea alba*)
- Cattle Egret (*Ardea ibis*)
- Bridled Tern (*Sterna anaethetus*)
- Caspian Tern (*Sterna caspia*).

Shorebirds and waterbirds are discussed in Section 6.4 due to their terrestrial affinities.

6.3.9.3 Baleen Whales

Humpback Whales

Humpback Whales (*Megaptera novaeangliae*) migrate annually from Antarctic feeding grounds to tropical waters. Six separate populations have been identified in the southern hemisphere, with the Group IV population being associated with Australia's NWS bioregion. This WA population is thought to have been recovering at an annual rate of between 7 and 12 per cent, since the cessation of whaling in 1963 (Bannister and Hedley 2001, in CWR 2009, Appendix O3; CWR 2010, Appendix O4; RPS 2010, Appendix O12). Extrapolating this recovery rate forward to 2010, the population could reach 20 000 to 30 000 individuals (CWR 2010), up from an estimated 800 in 1963 (Chittleborough 1965, in CWR 2010).

The Group IV population utilises nearshore waters of the Kimberley coast for calving during the winter. A portion of the population during the migration also comes close to shore in the Pilbara Offshore bioregion. The exact timing of the Group IV migration is variable, attributed to annual variations in food availability in the Antarctic (Jenner *et al.*

2001). Generally, northbound migration takes place in May to July on the continental slope at an average depth of 300 m. A transitional phase takes place in late August, in which whale distribution varies in areas with water depths ranging from 50 to 1200 m. During the migration south, from September to November, high densities of cow-calf pairs have been observed resting in Exmouth Gulf for periods of up to two weeks. During the southern migration, most of the whales are in waters shallower than 75 m (Jenner 2008).

To understand the distribution and abundance of whales within the Project area, the Centre for Whale Research (CWR) undertook a 12-month program of fortnightly aerial surveys over the Project area. These surveys used fixed-wing aircraft to conduct a standardised survey design of strip transects. In addition, sea noise loggers were deployed at nearshore and offshore locations in the Project area (CWR 2010, Appendix O12). Information is available from the first 17 of the aerial surveys (mid May to late December 2009) and from the first three months of the recording period for the sea noise loggers. The aerial survey program, between May and December, included the complete northern and southern migratory cycle of Humpback Whales in this area. The start of the aerial survey program was timed to coincide with the bulk of the northbound Humpback migration. During 17 surveys, 801 pods containing 1221 individual whales were recorded, by far the most common species of whale sighted. A total of 95 cows with calves were sighted, predominantly from August to October.

Consistent with previous work conducted in the NWS region (e.g. Jenner *et al.* 2001), northbound Humpback Whales first appeared in the study area from early to mid June. At this time, the whales tended to be concentrated seaward of Thevenard Island and over the continental slope (Figure 6.36). During the northern migration period (prior to 20 August 2009), whales were sighted an average of 49 km offshore (CWR 2010).

As would be expected, migratory direction changed from being predominantly northbound to predominantly southbound in mid August, between flights on August 5 and 20, 2009. Higher proportions of resting/milling pods were sighted during the southern migratory phase than during the northern phase. During the southern migration period (after 20 August 2009), whales were sighted an average of 36 km offshore (Figure 6.37). Cows and calves predominantly rest when inshore of the 50 m isobath (Jenner & Jenner 2009), with some whales, including cows and calves, recorded in water less than 10 m deep during the latter part of the migration. The data do not indicate

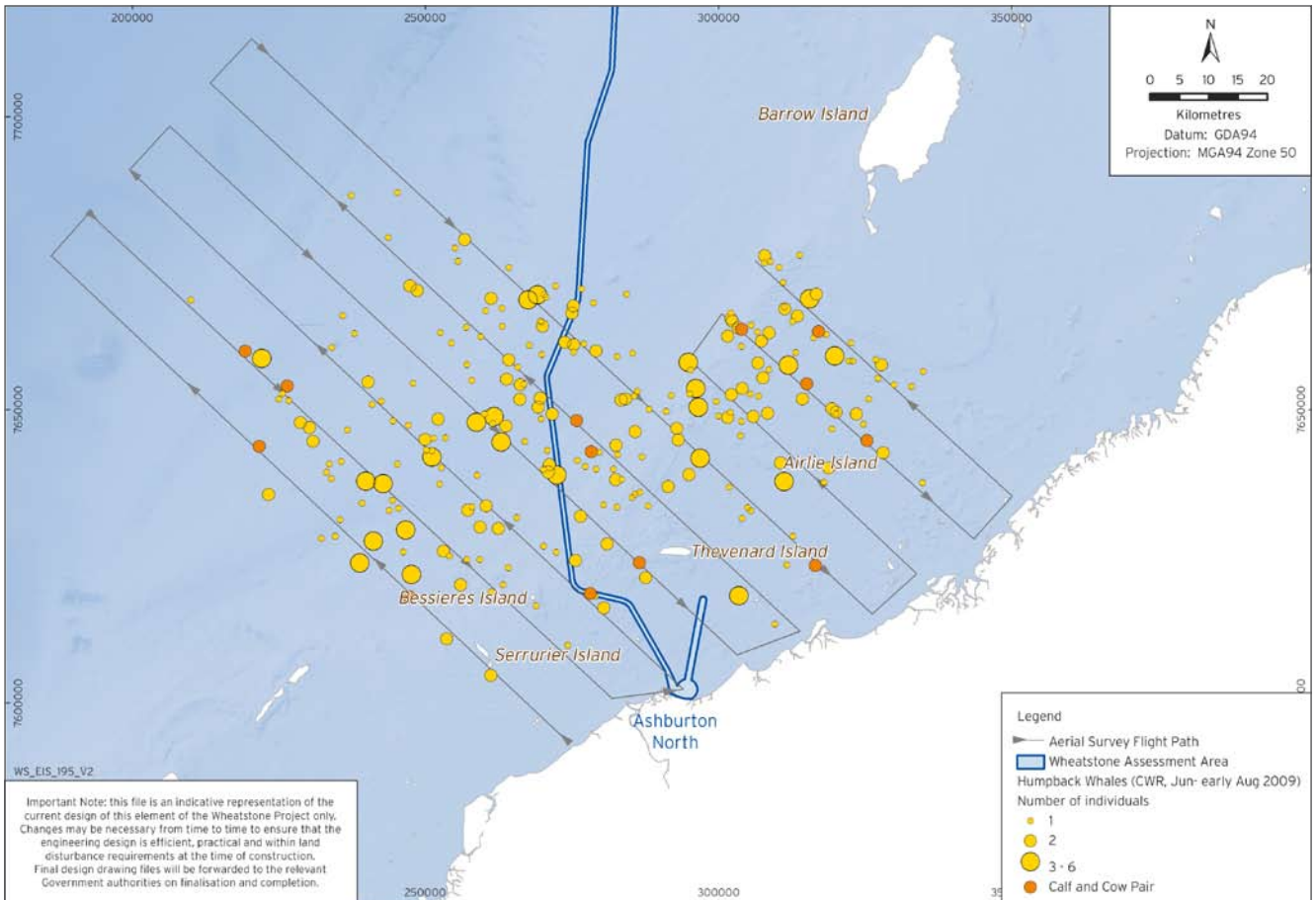


Figure 6.36: Humpback Whale Distribution during the Peak of the Northern Migration (June to early August 2009)

that the area has the same importance for resting or calving as Exmouth Gulf or Camden Sound, respectively.

Migratory direction was not as clearly defined during the northern migratory period as would be expected. In July, 22 per cent (during the first survey of this month) and 48 per cent of sightings (second survey) were reported to be resting and without migratory direction. Data from 2000 to 2005 from the North West Cape area (immediately to the south-west of the study area) indicate that 80 to 100 per cent of sightings are typically northbound at this time of year (Jenner et al., in prep). Causes may be environmental (such as abnormal oceanographic conditions) or anthropogenic (such as disturbance from seismic vessels). However, other aspects of Humpback Whale migration appeared closer to the anticipated patterns (e.g. Jenner et al. 2001, Prince 2001), such as the cross-shelf distribution of the migratory population in the Pilbara region.

Other Baleen Whales

In addition to Humpback Whales, the aerial surveys also sighted small numbers of Minke Whales and Pygmy Blue Whales. Thirteen additional whales were sighted but not identified to species level. However, acoustic surveys (CWR 2010, Appendix O4) indicated the presence of a greater range of species: Pygmy Blue Whales, Bryde’s Whales and Dwarf Minke Whales.

A summary of the acoustic survey results relating to these species is as follows:

- **Pygmy Blue Whales:** Pygmy Blue Whales only transit through deep waters of the Project Area in low numbers from October to January when southbound, and from May to August when northbound.
- **Dwarf Minke Whales:** The acoustic data suggested that Minke Whales transit through oceanic waters in low numbers. This species may be present in deep waters of the Project area throughout the year.

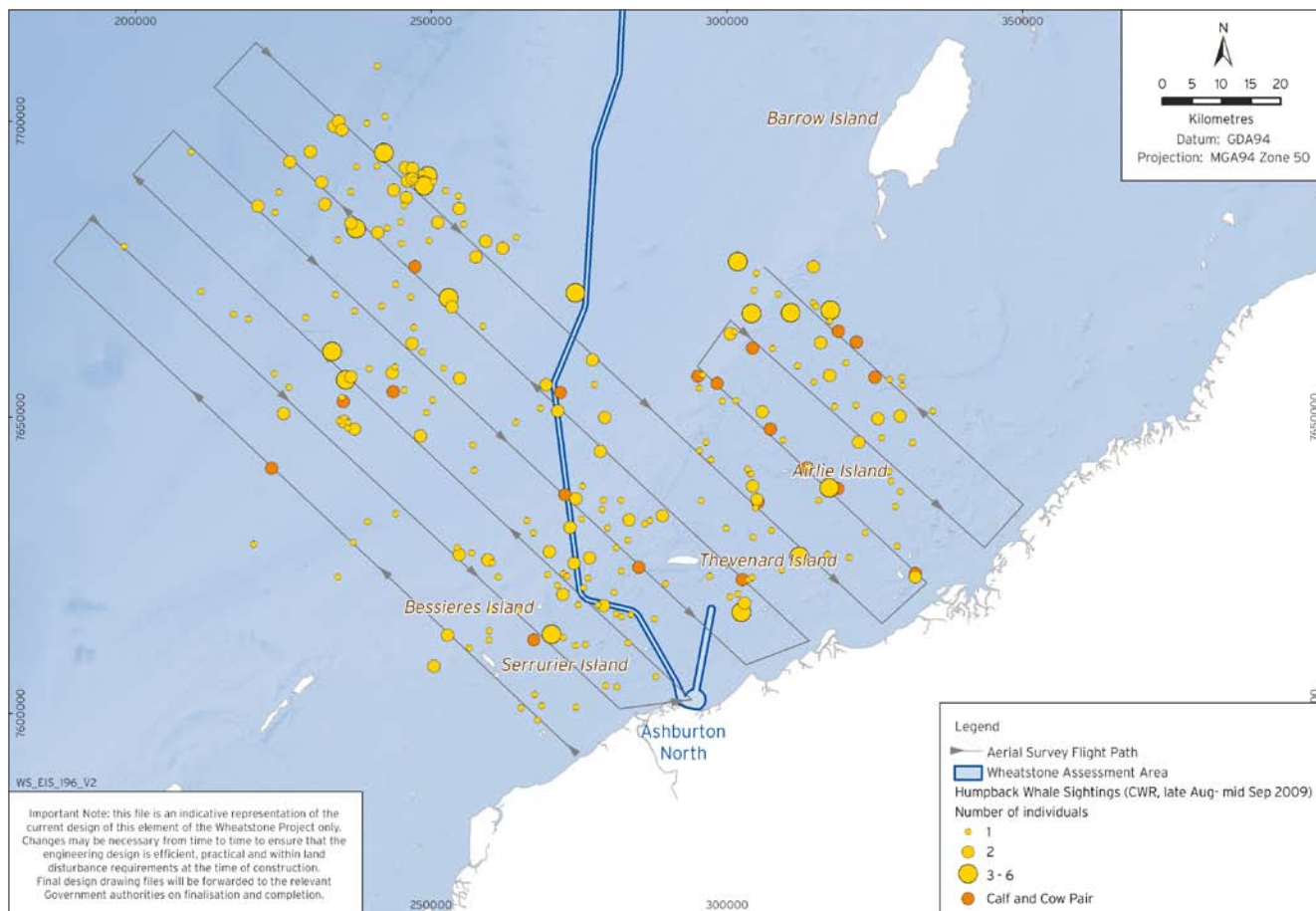


Figure 6.37: Humpback Whale Distribution during the Peak of the Southern Migration (late August to mid September 2009)

- Bryde’s Whales: Bryde’s Whales were detected infrequently in the Project area (McCauley 2009). Data suggested that Bryde’s Whales transit the continental shelf in low numbers.
- Antarctic Minke Whales, the Blue Whales and Southern Right Whales: These species were not recorded during the field surveys and are unlikely to be present within the Project area due to their preference for colder waters.

None of the above whale species were recorded in the shallow waters near the Project area at Ashburton North (CWR 2010, Appendix O12).

6.3.9.4 Dolphins and Toothed Whales

Toothed whales relate to true dolphins and moderately sized whales such as the Sperm Whale.

“True” Dolphins (Coastal)

Coastal dolphin species that could occur in the Project area include the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) and Bottlenose Dolphins (*Tursiops* spp.). Little is known of the population structure, movement patterns or ecology of these species within the Pilbara. The most recent surveys within the Project area suggested that the Indo-Pacific Humpback and Bottlenose dolphins are the most abundant species and occur mostly inside the 50 m isobath (CWR 2010, Appendix O4). These dolphin species

are likely to be present in shallow and nearshore waters of the Project area at any time. According to Prince (1991) and CWR (2010) coastal species occur in low numbers in the Pilbara, but are widely dispersed. Indo-Pacific Humpback Dolphins are known to move between different shallow water estuaries and inlets along the coast (RPS 2010, Appendix O12).

“True” Dolphins (Offshore)

Several species of delphinids are likely to be present in deep-water areas over the continental shelf. A pod of 25 Pilot Whales (a large species of dolphin) was recorded on the 450 m isobath on the continental slope (CWR 2010, Appendix O4). This species may be attracted to the upper and middle parts of the continental slope that have important demersal fish and squid communities (DEWHA 2008). A pod of up to 12 dolphins (unidentified species) was recorded by the aerial survey in waters of approximately 550 m depth on the upper slopes of the North West Province.

There was one sighting of Killer Whales (another large dolphin species) recorded during the aerial surveys. A pod of five Killer Whales was recorded in waters 400 m deep in November 2009, close to a Humpback Whale pair, presumed to be travelling southwards. As suggested by Corkeron and Connor (1999), Killer Whale movements are largely linked to those of smaller marine mammals, which they prey upon. It is likely that Killer Whales move into this area at certain times of the year in predatory pursuit of Humpback Whale calves (C Jenner [CWR] 2010, pers. comm.).

Sperm Whales

A pod of ten Sperm Whales was recorded on the 830 m isobath during the aerial survey. Sperm Whales sometimes occur in the deep oceanic waters in the Project area, possibly when foraging or transiting between foraging areas.

Beaked whales

It is possible that beaked whales are present in the deep oceanic waters, but in small numbers only.

6.3.9.5 Dugongs

Previous estimates of the abundance of Dugongs (*Dugong dugon*) have reported densities of up to 9.1 individuals per 100 km of coastline in the Onslow to Dampier onshore sector (Prince 1986). In addition, Shark Bay (approximately 500 km south of the Project area) contains an internationally significant population of an estimated 10 000 to 14 000 Dugongs, with a density of

0.7 ($\pm 0.12SE$) Dugong per km² (see summary in Gales *et al.* 2004). Exmouth Gulf (approximately 100 km southwest of Onslow) and Ningaloo Reef are also important Dugong habitats, each with about 1000 individuals (Marsh *et al.* 1994; Preen *et al.* 1997). Recent evidence suggests that some populations have strong patterns of migration, which are thought to be driven by variations in food availability (Gales *et al.* 2004) and possibly by water temperature at the higher end of their latitudinal distribution (Sheppard *et al.* 2006).

Dugongs tend to occur in wide shallow bays, mangrove channels and in the lee of large inshore islands. Shallow waters such as tidal banks and estuaries have also been reported as sites for calving (Oceanwise Environmental Scientists 2005). They are herbivorous and consume mainly seagrass species, with the genera *Halodule* and *Halophila* known to be particularly important.

While Dugongs are found in the Project area, it is not considered critical habitat due to the lack of extensive seagrass habitat. The first 17 CWR aerial surveys, completed between mid May and late December 2009 recorded 148 Dugongs (CWR 2009, 2010, Appendix O4). Individuals were sighted during all but three of the 17 flights in this period. The number of sightings tended to be highest in surveys during June to September, peaking at 31 in the late-June survey. From the available data, it is expected that at least some Dugongs are resident in the area year round but with seasonal variation in densities (CWR 2010). Because the CWR aerial surveys were designed to estimate Humpback Whales densities, Dugong abundances cannot reliably be compared with other studies.

Herds containing cow/calf pairs accounted for 10 per cent, or nine of the 86 herds sighted. They were predominantly sighted in the south-western portion of the study area (i.e. towards Exmouth Gulf) and in water depths less than 10 m (Figure 6.38). This distribution is suggestive of a link to populations in Exmouth Gulf and possibly to food sources in that area (CWR 2010). Dugongs were often sighted near areas where seagrass is common (Figure 6.38), as identified during subtidal surveys of the area (URS 2009e).

In conclusion, the Project area does not appear to have the same importance for Dugongs as Exmouth Gulf or Shark Bay, but Dugongs are likely to be present in the nearshore area throughout the year. It remains unclear whether they are resident or migratory, or a mixture of the two. The habitat surveys show that potential food sources (seagrasses) are present in the nearshore area. Data also show that calves are present (CWR 2010), albeit in small numbers. It remains unclear whether all key life processes of feeding, mating, calving and weaning occur in this area.

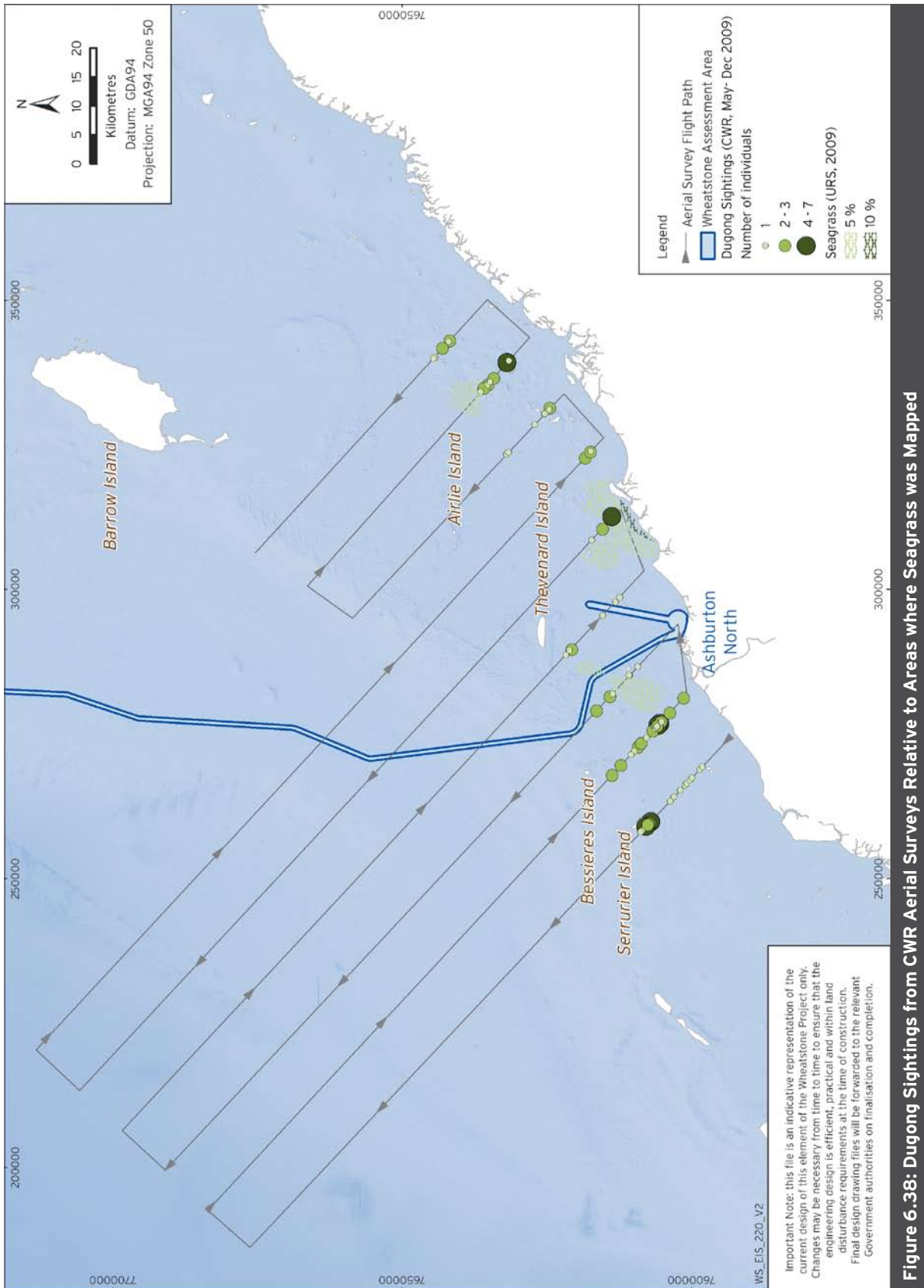


Figure 6.38: Dugong Sightings from CWR Aerial Surveys Relative to Areas where Seagrass was Mapped

6.3.9.6 Turtles

Green (*Chelonia mydas*) and Flatback turtles (*Natator depressus*) are known to occur in the Project area during all sensitive life-history phases (mating, nesting and inter-nesting), and may be present in the area year-round (RPS 2010a, Appendix O11). Loggerhead (*Caretta caretta*) and Hawksbill turtles (*Eretmochelys imbricata*) are less abundant and their distribution in the area is unclear. Leatherback Turtles (*Dermochelys coriacea*) have not been recorded in the Project area, nor are they known to nest in the Pilbara. A detailed description of the abundance and distribution of turtle activity is given in RPS (2010a, Appendix O11).

Turtle Nesting Habitat

The Project area is known to be used for nesting by four species of turtles. Turtle nesting activity is generally higher on islands than on the mainland and the Flatback, Green, Hawksbill and Loggerhead turtle rookeries located in these bioregions are considered significant to the populations of

these species throughout north-western Australia. Peak nesting periods vary slightly between species, as do preferred nesting and foraging habitats (RPS 2010a, Appendix O11).

A nesting beach survey conducted along the mainland coast at the Ashburton North site in early 2009 found no evidence of nesting marine turtles (Pendoley Environmental 2009, Appendix O8). High-tide waters overtopped the sand bar on sections of the beach along the Ashburton North Project site, making it unlikely that marine turtles utilise the area. However, low-density Flatback Turtle nesting was observed on a beach approximately 4 km to the west of Ashburton North (Figure 6.39). Preliminary surveys of this beach suggest that approximately 20 to 35 Flatback Turtles attempt to nest on this beach each night in the peak of the Flatback Turtle nesting season, and that five to nine of these turtles were successful (RPS 2010a; Appendix O11). Most of the turtles nest towards the eastern end of the beach.

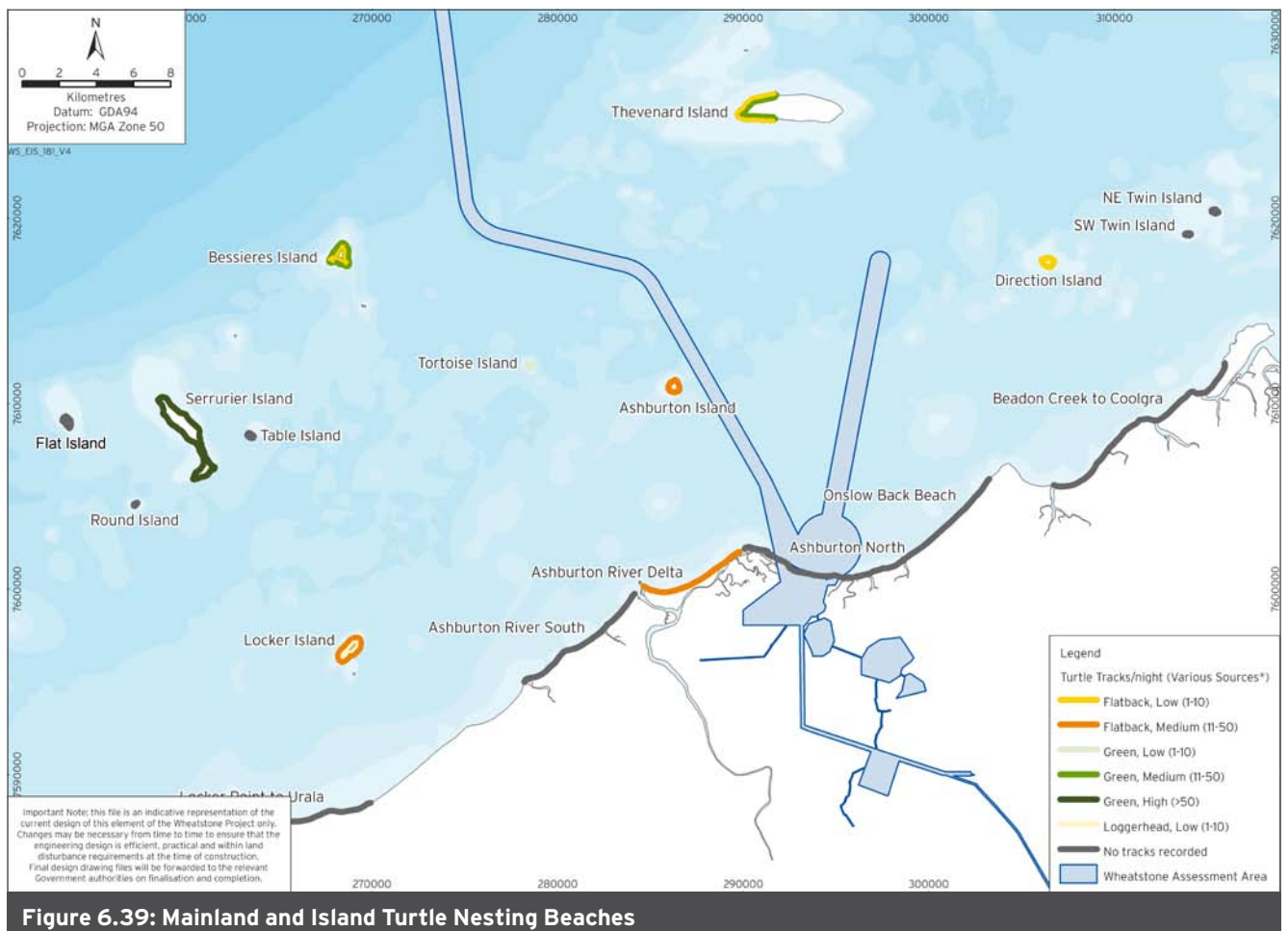


Figure 6.39: Mainland and Island Turtle Nesting Beaches

Source: Mau and Balcazar 2007, Pendoley Environmental 2009, and RPS 2010.

The findings are also consistent with a similar study undertaken in the same area by AECOM (Unpublished Report for AECOM). Other than the nesting at the Ashburton River Delta site, there is very little marine turtle nesting activity on the mainland beaches between Locker Point and Onslow, with only three nests recorded. Previous surveys have indicated that there is a low level of Flatback Turtle nesting in Onslow's Sunset Beach (known as "Back Beach") area (Pendoley Environmental 2009; Appendix O8). However, only two nests were recorded from the area during the AECOM survey—one at Sunset Beach and the other just south of the Onslow Salt jetty. Nesting has also recorded between Beadon Creek and Coolgra Point (RPS 2010a; Appendix O11), again confirmed by the AECOM study. All of the nesting activity observed on the mainland beaches in both studies was very low density with large sections of beach apparently having no nesting activity at all.

On the islands, nesting activity by a combination of Flatback and Green turtles was recorded on the large (Serrurier and Thevenard) and moderate sized (Bessieres, Locker and Ashburton) islands (Pendoley Environmental 2009; Appendix O8). Smaller islands such as Tortoise Island had very small areas of suitable nesting habitat, and very low density nesting activity. Other smaller islands such as Flat, Table, Direction and the Twin islands, have small areas of suitable habitat and only moderate levels of nesting activity (Pendoley Environmental 2009).

Approximately 40 Flatback tracks/night have been recorded on the southern and eastern beaches of Ashburton Island during the peak of the Flatback Turtle nesting season, with lower numbers recorded on the remainder of this island (RPS 2010a; Appendix O11). Preliminary nesting success studies indicate that approximately a quarter of all turtles that emerge to nest on Ashburton Island are successful, which is equivalent to density of about 9.8 nests/night for the southern and eastern beaches (RPS 2010a; Appendix O11).

Green Turtles nest predominately on the outer islands such as Bessieres and Serrurier, and the north and west coasts of Thevenard Island. These islands appear to support regionally significant nesting rookeries for this species; however, none of these rookeries approach the size of the Green Turtle rookeries at Barrow Island or the Dampier Archipelago (60 km and 200 km to the north respectively) (Pendoley Environmental 2009). Low density Hawksbill and Loggerhead turtle nesting has also been recorded on some of these islands (Mau & Balcazar 2007; Pendoley Environmental 2009; 2009a).

Turtle Internesting and Foraging Habitat

While the field survey focused on the beach nesting aspects of marine turtle ecology, opportunistic sightings of over 60 turtles swimming in nearshore waters were also recorded. Most of these were juvenile Green Turtles observed around the islands. These animals are likely to be residents at their foraging grounds. Foraging Green Turtles are likely to be found in seagrass and algal habitats near the Project area, and may utilise coastal mangrove habitats (Pendoley Environmental 2009). A boat-based survey (RPS 2010a; Appendix O11) found highest densities of turtles at shallow offshore reefs, suggesting this habitat is important for foraging compared with adjacent inter-reef habitat characterised by unconsolidated sediment.

One thousand and ninety one turtles were sighted during the aerial survey study period from mid-May to late December (CWR 2010) (Figure 6.40), but the species could not be distinguished from the air. Boat-based sightings by CWR from previous surveys suggest that the principal turtle species in the near shore Exmouth Gulf region during May to November is the Green Turtle. Turtles were predominantly located inside the 50 m depth contour. No concentrations of turtles were observed near the Project area at Ashburton North.

Turtles were sighted during all flights. Numbers sighted per flight varied from 14 to 261 over all surveys, but with no obvious temporal pattern (Figure 6.41). The detection rate of turtles from this type of survey is likely to be linked to sea state, which may explain the fluctuation in sightings over the data period. Therefore, while the data cannot be used as a reliable indicator of density, it does confirm that turtles are present in the area all year, particularly in the waters inside of the 50 m depth contour.

6.3.9.7 Other Marine Reptiles

The Saltwater Crocodile (*Crocodylus porosus*) occurs across northern Australia as well as throughout South-east Asia, Southern India and Palau (Kay 2004). This species is locally abundant in WA, particularly in the Kimberley, and is sighted occasionally in the Pilbara Nearshore bioregion. There have been recent sightings recorded both from the Port Hedland area and from the mouth of the Ashburton River upstream from the Three Mile Weir, the latter being confirmed by police. However, there has been no breeding activity recorded in the Pilbara and sightings in the Onslow area are likely to be of isolated individuals at the southern limit of their range.

Seasnakes also occur commonly in northern Australia in shallow waters along the coast, around islands and at river mouths.

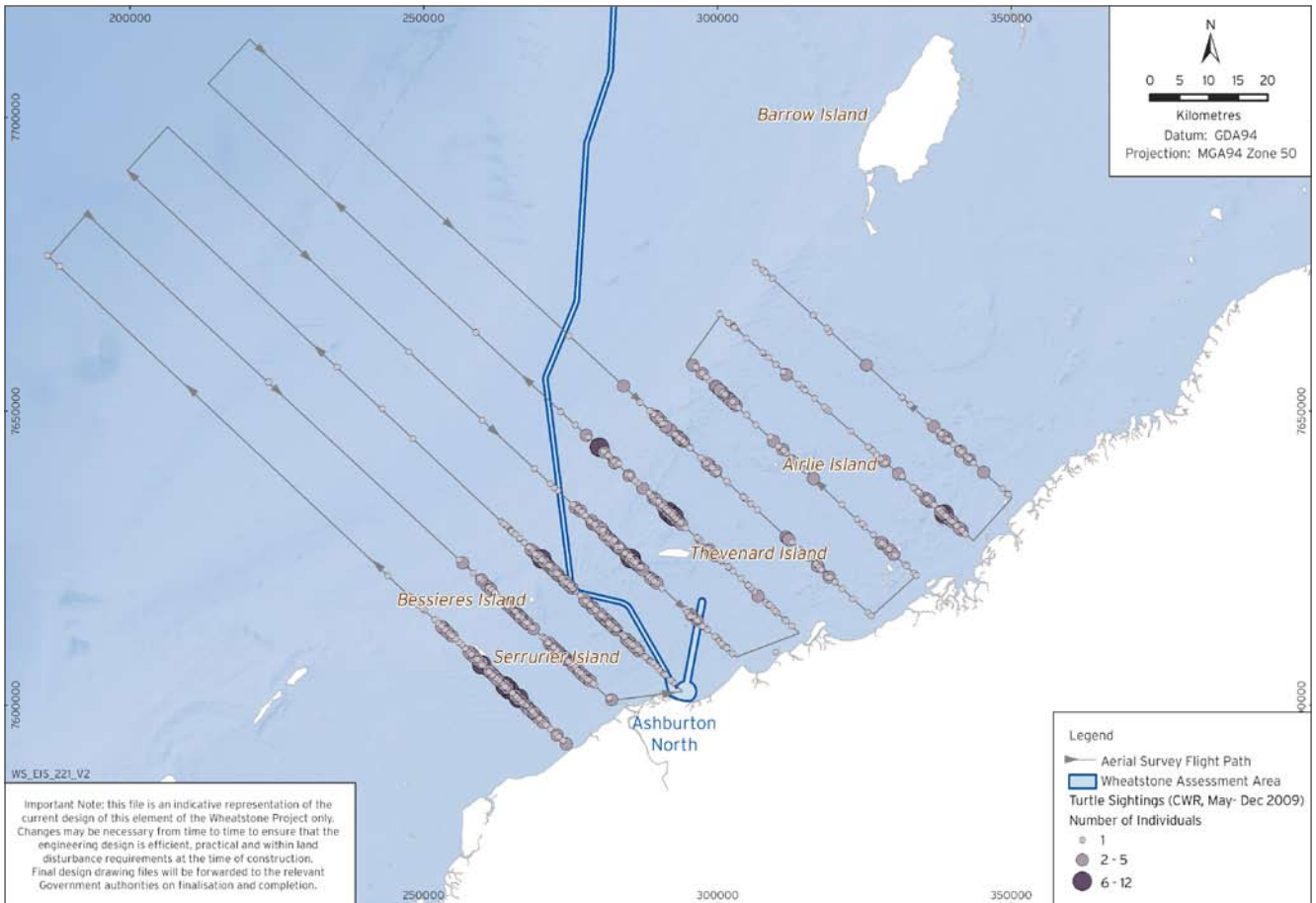


Figure 6.40: Turtle Sightings from CWR Aerial Surveys

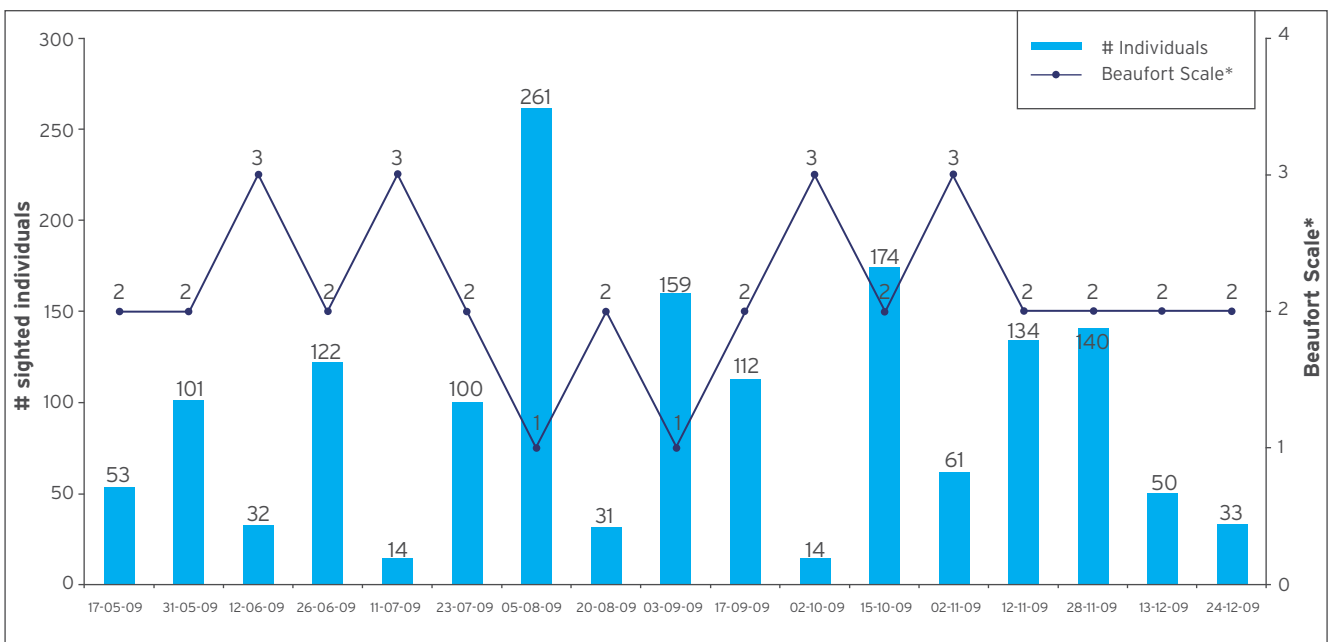


Figure 6.41: Number of Turtles Sighted from CWR Aerial Surveys conducted Mid-May to Late December 2009

Species distribution is generally very broad, extending across tropical and subtropical waters of the Pacific and Indian oceans, encompassing the African Coast, Indo-Malayan Archipelago, China, Indonesia, and the Australian region (Rasmussen 2001). A common species of northern Australian waters is the Olive Seasnake (*Aipysurus laevis*) which is distributed throughout north WA waters as far south as Exmouth. This species has small home ranges on inshore reefs and feeds primarily on fish and benthic invertebrates. Populations of Olive Seasnakes are thought to be vulnerable due to their slow growth rates and longevity (approximately 15 years) (Guinea 2007).

6.3.9.8 Fish

The Pilbara Nearshore bioregion has high fish diversity relative to other global regions of similar latitude, with approximately 736 species recorded from the Dampier Archipelago-Cape Preston area (Hutchins 2003) and 456 species from the Montebello Islands (Allen 2000). Most species have widespread Indo-Pacific distributions; however, a few exceptions such as the iconic Baldchin Grouper (*Choerodon rubescens*) are endemic to WA.

Many of the shallow-water demersal (bottom-dwelling) fishes that occur in the bioregion are associated with the hard substrata that form patch and fringing reefs. These include Coral Trout (*Plectropomus* spp.) and other groupers (family Serranidae), various species of parrot fishes (family Scaridae), damselfishes (family Pomacentridae), wrasses (family Labridae), butterfly fishes (family Chaetodontidae), and sharks and rays (family Elasmobranchii) (Hutchins 2003). In addition, the health of benthic habitats, such as corals or seagrasses, are of critical importance due to the obligate associations of some benthic species. Therefore, reef fish populations may be vulnerable to disturbance of benthic habitats. Furthermore, field investigations show that reef sharks (*Carcharhinus* spp.) and the Mangrove Jack (*Lutjanus argentimaculatus*), are encountered within the intertidal region of the mainland in the Project area. In November and December 2009, several sawfish (*Pristis* spp.) were sighted in the lower section of West Hooley Creek and the north-eastern Ashburton Lagoon (F Wells [URS] 2009, pers comm.). Pristids are listed as vulnerable under the EPBC Act (Cth) and are fully protected at State level under the Fisheries Act. No sawfish were seen during the April 2010 netting survey of these locations. However, 26 fish species were identified (Appendix O5). The dominant large species were Sea Mullet (*Mugil cephalus*) and Yellowfin Bream (*Acanthopagrus latus*). There were also a number of individuals of the Giant Catfish (*Arius thalassinus*). Hardyheads (*Craterocephalus* sp.) (< 80 mm) in standard length dominated in West Hooley Creek while the dominant small fish in the north-eastern Ashburton

lagoon were juvenile mullet (< 80 mm) (Family Mugilidae) and pony fish (< 60 mm) (Family Leiognathidae). A survey is planned for summer to document seasonal variation in fish composition of these habitats.

Syngnathids (seahorses and pipefishes) are widespread throughout WA waters, however the distribution of individual species within the Pilbara region is unknown (Kuiter 2009). All species of syngnathids are protected under the EPBC Act (Cth). A EPBC Protected Matters search identified 34 listed syngnathid species that may occur within the Project area. These fish are expected to be widespread in shallower benthic areas along the coastline and around offshore islands. They are not believed to be restricted to any critical habitats within the Project area.

Ninety-two Manta Rays (*Manta* spp. or *Mobula* spp.) and four Whale Sharks (*Rhincodon typus*) were sighted during the aerial survey study period (May to December inclusive) (CWR 2010). Manta Rays congregate inside the reef as well as in deep water in the Ningaloo Reef (Commonwealth of Australia 2002) area and are also common in other localities such as Shark Bay and the Dampier Archipelago. The Manta Ray is not listed as being migratory or threatened under the EPBC Act (Cth) and is considered abundant (Commonwealth of Australia 2002). During the aerial surveys, Manta Rays were distinguished from other rays by their distinctive shape, although it is possible that other species of bottom dwelling rays were mistaken for Manta Rays along the mangrove creek areas. Manta Rays were sighted during all but one of the 17 aerial survey flights and were broadly and sparsely distributed (CWR 2010).

Whale Sharks are broadly distributed in oceanic and coastal waters between latitudes 30 °N and 35 °S in tropical and warm temperate seas (DEH 2005). Despite the Whale Shark being well studied in the north-west of Australia, little is known about its distribution and abundance within the Project area (Meekan *et al.* 2008). It is estimated that 300 to 500 Whale Sharks aggregate at Ningaloo Reef in April and May with the majority of individuals being juvenile males. Satellite tagging has shown that Whale Sharks departing Ningaloo migrate generally toward the north-east, often into Indonesian waters (Meekan *et al.* 2008). This migration takes the Whale Sharks past the Project area along the offshore continental slope.

Whale Sharks are unique in shape and size and are commonly sighted and identified using aerial surveys (i.e. Ningaloo whale shark tourist industry) so misidentification is considered unlikely. Whale Sharks were sighted in May (one), November (two) and December (one) during the aerial survey study period (CWR 2010). Three sightings were approximately 30 to 50 km offshore of Onslow,

the fourth in excess of 50 km to the northeast, south of Barrow Island.

There are no known critical habitats or foraging areas for other species of sharks and rays within the Project area. Grey Nurse Sharks (*Carcharias taurus*) and Great White Sharks (*Carcharodon carcharias*) are protected under the EPBC Act (Cth). Regional records suggest it is unlikely that these species are present in the vicinity of the Project area. The Project area is outside the distributional ranges for both of these species as they primarily inhabit subtropical to cool temperate waters. Furthermore, they have not been recorded within the Project area during surveys conducted to date. As noted above, however, sawfish have been observed in West Hooley Creek and the north-eastern Ashburton lagoon, but the significance of these habitats to this taxa remains unknown.

6.3.9.9 Prawns

The WA Department of Fisheries (DoF) manages seven prawn trawl fisheries in WA, with a total value in 2006 of \$38 million. The Onslow Prawn Managed Fishery (ONPMF) is located on the north coast of WA, and is 39 748 km² in area. The average catch of 96.8 tonnes is dominated by

Tiger Prawns (60 per cent) and King Prawns (21 per cent), with significant contributions from Endeavour Prawns (10 per cent) and Banana Prawns (8.8 per cent). Minor species in the fishery include Moreton Bay Bugs, Squid, Blue Swimmer Crabs, Cuttlefish and other prawns such as Black Tiger and Coral Prawns, and some finfish species. Catches are variable, particularly for Banana Prawns, which have varied from zero to 90 tonnes in recent years (Figure 6.42). Refer to Section 6.5.3.1 for details on commercial fisheries.

The relationship between rainfall and abundance of Banana Prawns mirrors the situation in Queensland, where Vance *et al.* (1998) undertook a detailed six-year study of the fishery. They related the abundances of three life stages, planktonic postlarvae, benthic postlarvae and juveniles, to commercial catches, but found there was little relationship. Instead, wet season impacts were the primary determinant of variations in the commercial catch. Vance *et al.* (1998) concluded that increased emigration of juveniles from the estuaries positively correlated with rainfall. In turn, the primary determinant of juvenile populations in estuaries was the settlement of postlarvae from offshore. The greatest densities of larvae were in the upper reaches of small creeks, not in the major river systems.

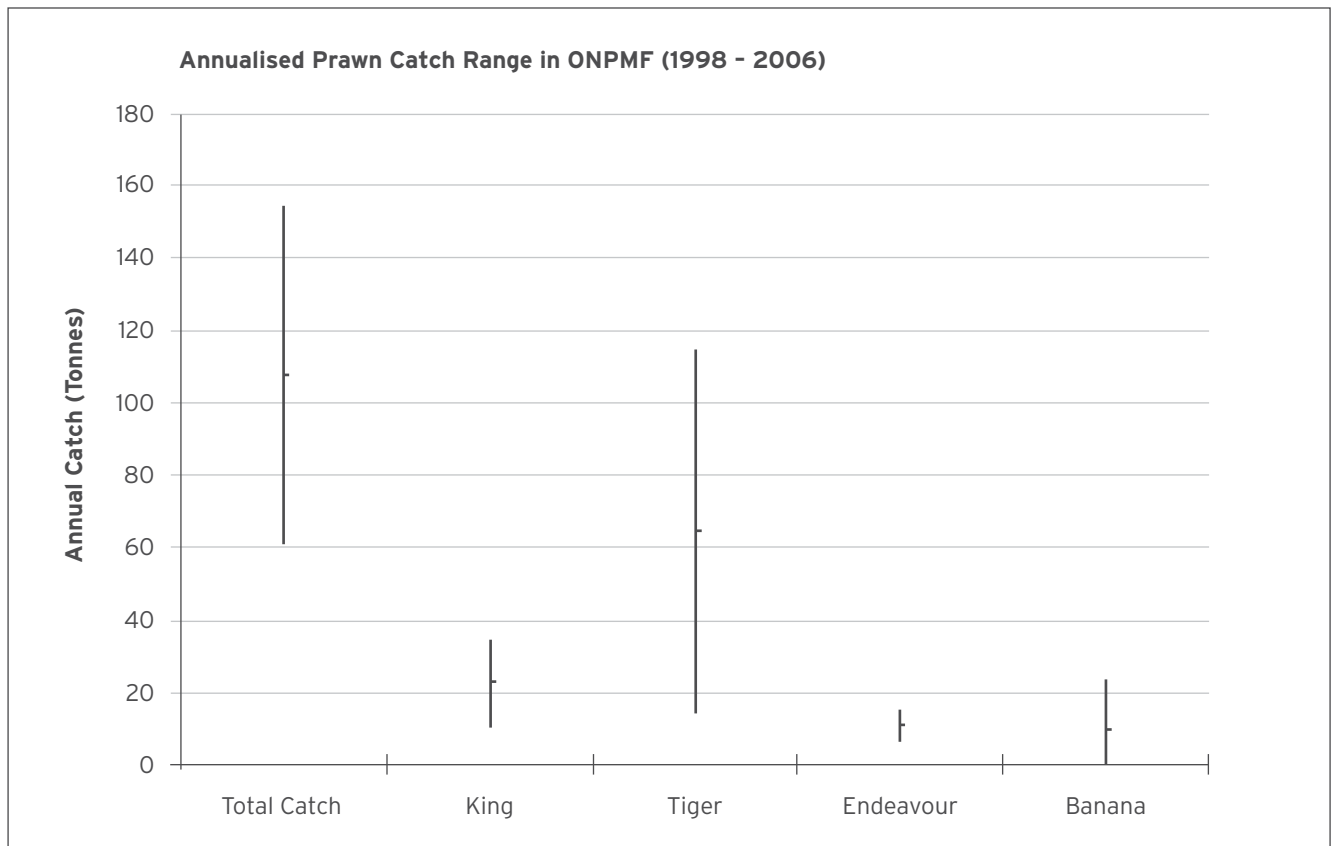


Figure 6.42: Annualised Prawn Catch Data (mean±SE)

6.3.9.10 Pearl Oysters

The Pearl Oyster Managed Fishery is the second largest fishery in WA, with an estimated value of \$122 million in 2003/2004. Marine farms for culturing seeded pearls of the Silver Lipped Pearl Oyster (*Pinctada maxima*) are managed by DoF under the provisions of the WA *Pearling Act 1990*.

The fishery operates along the entire north coast of WA from North West Cape to the Northern Territory border. Harvesting of wild pearl oysters occurs from Cape Leveque to Exmouth Gulf. In recent years hatchery grown spat have been increasingly used to supplement wild stock. No pearl farming occurs in the Onslow region. Refer to Section 6.5.3.1 for details on commercial pearling licences.

6.3.9.11 Other Benthic Invertebrates

The marine benthic invertebrate fauna of the Pilbara region is considered diverse due to the range of habitats available (Chevron Australia 2005). The Montebello, Lowendal and Barrow islands are thought to have high species richness in comparison to other tropical parts of WA (DEC 2007). The rocky shores of nearshore islands in the Project area support characteristic epifaunal assemblages of moderate diversity (URS 2009b; Appendix N10). Along the mainland coast, invertebrate assemblages associated with rocky shores are less common due to the predominantly sandy silty habitat (Appendix N11). Rocky shore habitats are present near the Hooley Creek delta and at Beadon Point but these areas support very low to moderate diversity assemblages of invertebrate fauna. Along the mainland beaches and intertidal areas, burrowing invertebrates such as ghost crabs (*Ocypode* sp.), bivalves and smaller crustaceans have been recorded. Mangrove communities are also known to support invertebrates such as oysters, barnacles, snails and crabs.

6.3.9.12 Introduced Marine Species

The majority of marine introductions worldwide have been through vessel movements, primarily international shipping. Ballast water on large ships was originally thought to be the primary vector for distributing marine pests, but it is now known that 75 per cent of species have been introduced through biofouling (refer to URS 2009j; Appendix R1). This can occur on any immersed surface, but there is less water flow in crevices and voids, and these areas are easier for species to adhere. Only a small fraction of introduced marine species become marine pests. The National Introduced Marine Pests Coordination Group (NIMPCG 2006) developed a target list of 55 pest species of concern to Australia. None of these have been recorded in the Project area, or elsewhere in the Pilbara Nearshore or Pilbara Offshore bioregions (Huisman *et al.* 2008).

One introduced marine species, the barnacle *Megabalanus tintinnabulum*, has been recorded in Onslow (Huisman *et al.* 2008). This species is not considered a "pest", and has been recorded at several other WA ports.

In recent years, there have been a number of widely publicised disease outbreaks that have heightened public awareness of the possibility of marine diseases being introduced into the Australian marine environment. There are a number of transmission vectors for these reported introductions of marine bacteria, viruses and parasites. They are most readily translocated from one area to another in their hosts. This has most commonly been reported in operations related to aquaculture (Ogburn 2007). The WA *Biosecurity and Agricultural Management Act 2007* (BAM Act) was recently passed to provide a stronger legislative base for managing all aspects of biosecurity, including the marine environment.

6.3.10 Conservation Significance

6.3.10.1 Matters of National Environmental Significance

Matters of National Environmental Significance (NES), as defined under the EPBC Act (Cth), are described in DEH (2006). Table 6.8 provides a summary of these and their relevance to the Project.

6.3.10.2 Marine Reserves and Conservation Areas

There are no protected areas in the immediate vicinity of the Project area, although a number of marine reserves and other conservation areas are centred along the chain of offshore islands that run from Exmouth to Dampier (Figure 6.43). By their isolated nature, islands provide refuge for indigenous flora and fauna. Examples in closest proximity to the Project area include:

- Thevenard, Serrurier (Long) and Airlie islands within Onslow's nearshore environment are protected under the *Conservation and Land Management Act 1984* as nature reserves. The management objective for nature reserves is "to maintain and restore the natural environment, and to protect, care for, and promote the study of, indigenous flora and fauna, and to preserve any feature of archaeological, historic or scientific interest".
- Boodie, Double and Middle islands (part of the Barrow group of islands) form a Class "C" Nature Reserve vested in the Conservation Commission for the purpose of Conservation of Flora and Fauna. The reserve includes the entire land masses of the islands down to the low water marks. A draft management plan for this reserve is currently being prepared.

- The Great Sandy Islands Nature Reserve includes more than 30 small islands that extend in a band off the coast from east of Cape Preston to the mouth of the Robe River. The islands range from 10 to 35 km off the continental coast and are important as nesting areas for seabirds and turtles and for other fauna. As the reserve extends only to the high water mark, it is not technically part of the marine environment.
- Barrow Island Marine Management Area covers 114 500 ha and includes most of the waters around Barrow Island and the waters around the Lowendal Islands. The port areas of Barrow Island and Varanus Island are excluded from the marine management area. Like the nearby Barrow Island Marine Park and Montebello Islands Marine Park, the marine management area is a significant breeding and nesting area for marine turtles and its waters support important coral reefs, unique mangrove communities and a diversity of tropical marine animals. Green, Hawksbill and Flatback turtles regularly use the sandy beaches of Barrow Island for breeding, and occasional nesting by Loggerheads has been recorded on the island. These four species of turtles are listed as threatened. There is a conservation area to protect marine invertebrates and seabirds in Bandicoot Bay.

Also of note are the mangrove habitats of the Ashburton River delta and Coolgra Point, listed as “regionally significant”, with very high conservation value (EPA 2001) (see Section 6.3.8.4 for further details).

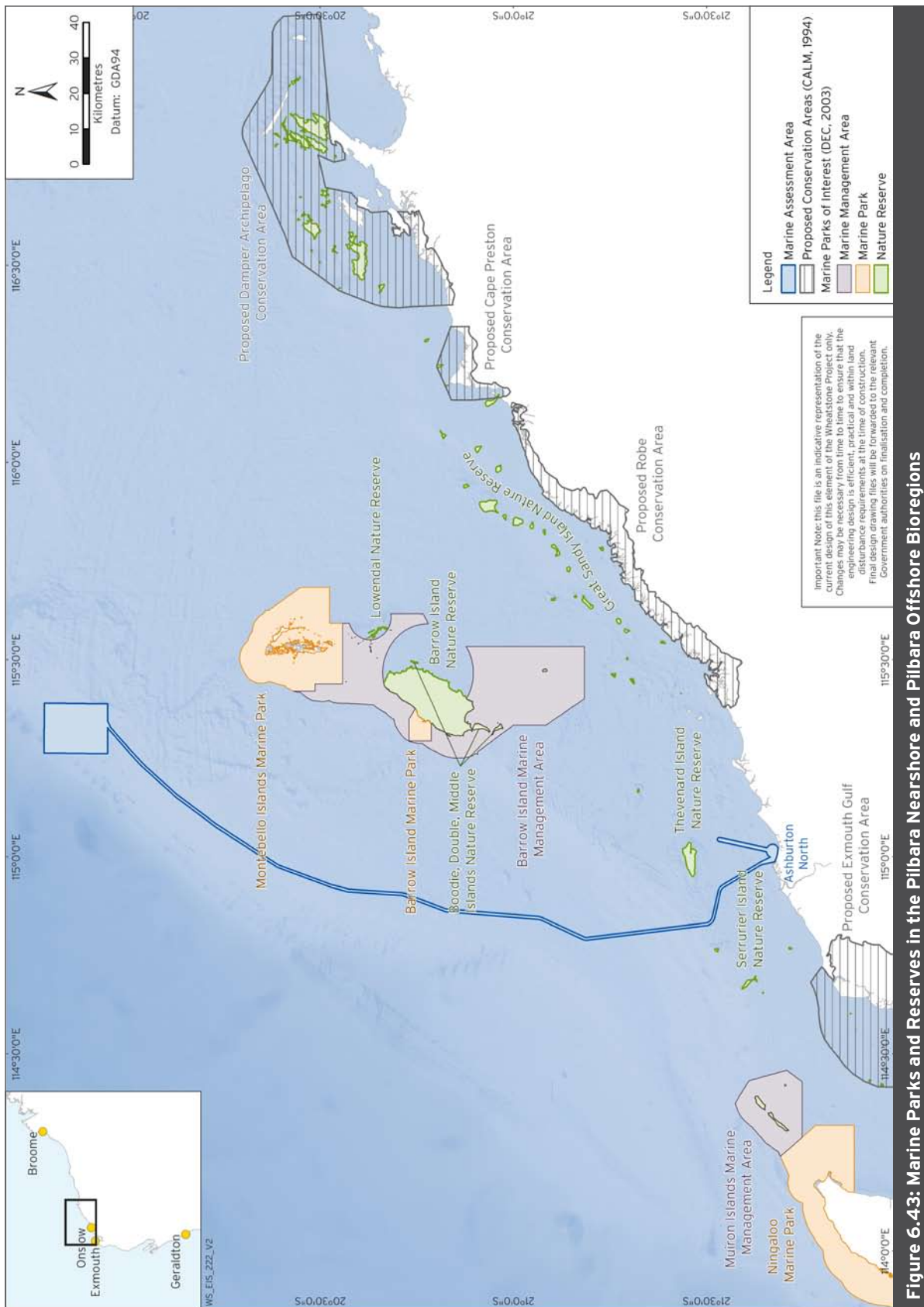
Further from the Project area, but in the wider Pilbara nearshore and Pilbara offshore bioregions are the following marine conservation areas:

- Montebello Islands Marine Park, north-east of the Project area, has an area of 58 331 ha. It has a very complex seabed and island topography including sheltered lagoons, channels, beaches and cliffs. This complexity has resulted in a myriad of different habitats in the reserves supported by high sediment and water quality. These habitats include subtidal coral reefs, macroalgal and seagrass communities, subtidal soft-bottom communities, rocky shores and intertidal reef platforms, which support a rich diversity of invertebrates and finfish. The mangrove communities are made up of six species and are considered to be globally significant because they occur in lagoons of offshore islands. The reserves are important breeding areas for several species of marine turtles and seabirds, which use the undisturbed sandy beaches for nesting. Humpback Whales migrate through the reserves and Dugongs occur in the shallow warm water.
- The Lowendal Islands Nature Reserve incorporates the islands of the Lowendal Archipelago, about 10 km north-east of Barrow Island and 15 km south of the Montebello Islands. There are 34 islands and islets in the group, with the largest being Varanus Island at 83 ha. The islands are limestone rocks that extend a few metres above sea level and have sparse vegetation.
- Barrow Island Marine Park was established by the State Government in 2004. Like the nearby Barrow Island Marine Management Area and Montebello Islands Marine Park, the park is a significant breeding and nesting area for marine turtles and its waters support important coral reefs and a diversity of tropical marine animals. A sanctuary zone covers 100 per cent of the Barrow Island Marine Park, giving the 4100 ha park the highest percentage of “no take” areas of any marine park in WA.
- Muiron Islands Marine Management Area, also off North West Cape, covers 28 616 ha. It contains a very diverse marine environment, with coral reefs, filter-feeding communities and macroalgal beds. In addition, the islands are important seabird and green turtle nesting areas.
- Ningaloo Marine Park is located off North West Cape and covers approximately 263 343 ha. Ningaloo Reef is the largest fringing coral reef in Australia. Temperate and tropical currents converge in the Ningaloo region, resulting in highly diverse marine life including spectacular coral reefs, abundant fishes and species with special conservation significance such as turtles, Whale Sharks, Dugongs, whales and dolphins. The region has diverse marine communities including mangroves, algae and filter-feeding communities and has high water quality. These values contribute to the Ningaloo Marine Park being regarded as the State’s premier marine conservation icon. Seasonal aggregations of Whale Sharks, manta rays, sea turtles and whales, as well as the annual mass spawning of coral, provide unique opportunities for visitors to observe marine fauna and key biological processes within the reserves.

Table 6.8: Implications for Matters of National Environmental Significance

Matter	Description	Assessment
World Heritage Property	A declared World Heritage property is an area that has been included in the World Heritage List or declared by the Minister to be a World Heritage property.	The Project will not directly or indirectly impact World Heritage Property because there are no World Heritage properties in or adjacent to the affected area. The closest property, Shark Bay, is located approximately 520 km from the Project site.
National Heritage List	The National Heritage List includes natural, historic and Indigenous places of outstanding heritage value.	The Project will not directly or indirectly impact National Heritage sites because the closest site, the Dampier Archipelago (including Burrup Peninsula) is located approximately 211 km north, and the Ningaloo coast is located approximately 117 km south from the Project site.
Wetlands of international importance (Ramsar wetlands)	The EPBC Act (Cth) enhances the management and protection of Australia’s Ramsar wetlands. A “declared Ramsar wetland” is an area that has been designated under Article 2 of the Ramsar Convention or declared by the Minister to be a declared Ramsar wetland under the EPBC Act (Cth).	The Project will not directly or indirectly impact Ramsar wetlands as there are no Ramsar wetlands in or adjacent to the Project site. The closest Ramsar wetland from any area of development is the Millstream Pools, a proposed Ramsar addition, located approximately 206 km north-east of the Project site.
Listed threatened species and ecological communities	The EPBC Act (Cth) provides for the listing of nationally threatened native species and ecological communities, native migratory species and marine species.	See detailed assessment in Sections 8.4, 9.5 and 9.6.
Listed migratory species	<p>Migratory species are those animals that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations. Examples of migratory species are species of birds (e.g. albatrosses and petrels), mammals (e.g. whales) or reptiles.</p> <p>(Cont’d)</p>	See detailed assessment in Sections 8.4 and 9.6.

Matter	Description	Assessment
Nuclear actions (includes uranium mines)	<p>Nuclear actions are:</p> <ul style="list-style-type: none"> • Establishing or significantly modifying a nuclear installation • Transporting spent nuclear fuel or radioactive waste products arising from reprocessing • Establishing or significantly modifying a facility for storing radioactive waste products arising from reprocessing • Mining or milling uranium ores, excluding operations for recovering mineral sands or rare earths • Establishing or significantly modifying a large-scale disposal facility for radioactive waste. A decision about whether a disposal facility is large scale will depend on factors including: <ul style="list-style-type: none"> • The activity of the radioisotopes to be disposed of • The half-life of the material • The form of the radioisotopes • The quantity of isotopes handled • Decommissioning or rehabilitating any facility or area in which an activity described above has been undertaken • Any other type of action set out in the EPBC Regulations. 	This Project involves no nuclear actions.
Commonwealth marine areas	<p>The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia’s exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters.</p> <p>The Commonwealth marine area stretches from 3 to 200 nautical miles from the coast. Marine protected areas are marine areas which are recognised as having high conservation value.</p>	<p>This Project will not directly or indirectly impact Commonwealth marine protected areas. The closest Commonwealth marine protected area, the Ningaloo Marine Park is 117 km from the Project area. The gas field is located in the outer part of the North West shelf, an oceanic region off the Pilbara and Kimberley coasts. Upstream facilities will be installed to access the gas and gas condensate reserves and transport these reserves to an onshore processing plant. Some of these upstream facilities will be located in Commonwealth waters in water depths ranging from 70 m to 200 m. A detailed assessment of the benthic assemblages in these areas is provided in Section 8.3. None of these facilities are in marine protected areas.</p>
The Great Barrier Reef Marine Park	<p>The Great Barrier Reef Marine Park Authority, along with Queensland Parks and Wildlife Service, use permits to ensure the conservation, reduce impacts and monitor activities upon the reef.</p>	<p>This Project will not have direct or indirect impacts on the Great Barrier Reef Marine Park. The Project is located approximately 3500 km from the Great Barrier Reef Marine Park.</p>



6.4 Local Terrestrial Environment

6.4.1 Introduction

The onshore Project area lies between the Ashburton River and Hooley Creek, approximately 12 km south-west of Onslow.

Terrestrial environmental studies were conducted over an area of approximately 12 260 ha, which covered the Ashburton North SIA, Shared Infrastructure Corridor (SIC), construction disturbance areas and the domgas pipeline corridor. The area surveyed varies for each of the terrestrial surveys conducted. Details of the areas surveyed are included in the discussion of each of the surveys undertaken.

Baseline surveys and studies were undertaken to develop a better site-specific understanding of:

- Air quality
- Soils and landforms
- Surface water and groundwater
- Flora and vegetation
- Fauna.

The following sections describe the findings of the surveys and studies.

6.4.2 Air Quality

6.4.2.1 Dust

Existing dust at Ashburton North is primarily wind blown. Minor anthropogenic sources of dust include tourist or local vehicles visiting the area along the Old Onslow Road near the Ashburton River and the Old Onslow heritage area.

The Ashburton North site is recognised for its relatively soft, silty/sandy soils due to the chenier geological formation (Section 6.4.4). This beach ridge formation is characterised by sand-sized material resting on clay or mud. When vegetation is removed, or the surface is disturbed by vehicles or by strong winds, dusty conditions can result.

Dust emissions generally exhibit a marked seasonal trend, related to the influence of the Pilbara's wet and dry seasons. This is not only due to the moisture content of the unsealed roads that are used for access in the area, but during the wet season, these roads are often impassable. During the dry season, visitors are more frequent to the Onslow area, and with the lowered moisture content of the air and soils, dust can be easily generated from unsealed roads and cleared areas.

The characteristically low height of the vegetation means that dust suspension and re-suspension is often visible from several kilometres. During the summer months, bushfires can also emit a large amount of particulate matter to the atmosphere.

The closest monitoring data for background concentrations in particulate matter (total suspended particulate matter, PM_{10} , $PM_{2.5}$) for which there is publicly available data is approximately 210 km to the north-east, in Dampier. Analysis of the PM_{10} concentrations at the Dampier Primary School indicates that from 2002 to 2006 the annual average was $22.9 \mu\text{g}/\text{m}^3$. Further monitoring in Karratha and Point Sampson recorded $21.4 \mu\text{g}/\text{m}^3$ and $21.8 \mu\text{g}/\text{m}^3$, respectively for the similar time period (SKM 2009). Based on these available data, the ambient background PM_{10} concentration for Ashburton North is assumed to be $22 \mu\text{g}/\text{m}^3$.

A monitoring program for existing concentrations of total suspended particulate matter, PM_{10} and $PM_{2.5}$ has been established to provide a baseline for the Project. The program utilises five monitoring sites located within and around the terrestrial assessment area. Figure 6.44 shows the location of the monitoring sites. The dust-monitoring program commenced in April 2009 and is planned to be ongoing. Note that the results of dust monitoring included in the following discussion are based on limited data collection and should therefore be considered preliminary.

Continuous particulate monitoring conducted at Monitoring Sites 1 and 2 provides daily mean quantities of total suspended particulates (TSP), PM_{10} and $PM_{2.5}$. Results for May 2009 to April 2010 are presented in Table 6.9. The results are an average of the mean daily levels recorded at each site.

Dust deposition gauges have been installed at five Monitoring Sites. These gauges provide an indication of the quantity of naturally deposited dust. The results from the five gauges are included in Table 6.10.

The baseline data collection will continue and will provide results on which to base the dust management plan throughout the life of the Project.

6.4.2.2 Gaseous Emissions

In the absence of sufficient local air quality data, standard recognised sources and dispersion modelling was used to identify the existing local air quality for gaseous pollutants (Appendix C1). Natural sources have been predominantly used as input into the dispersion modelling due to the absence of major anthropogenic gaseous emissions in the vicinity of the site.

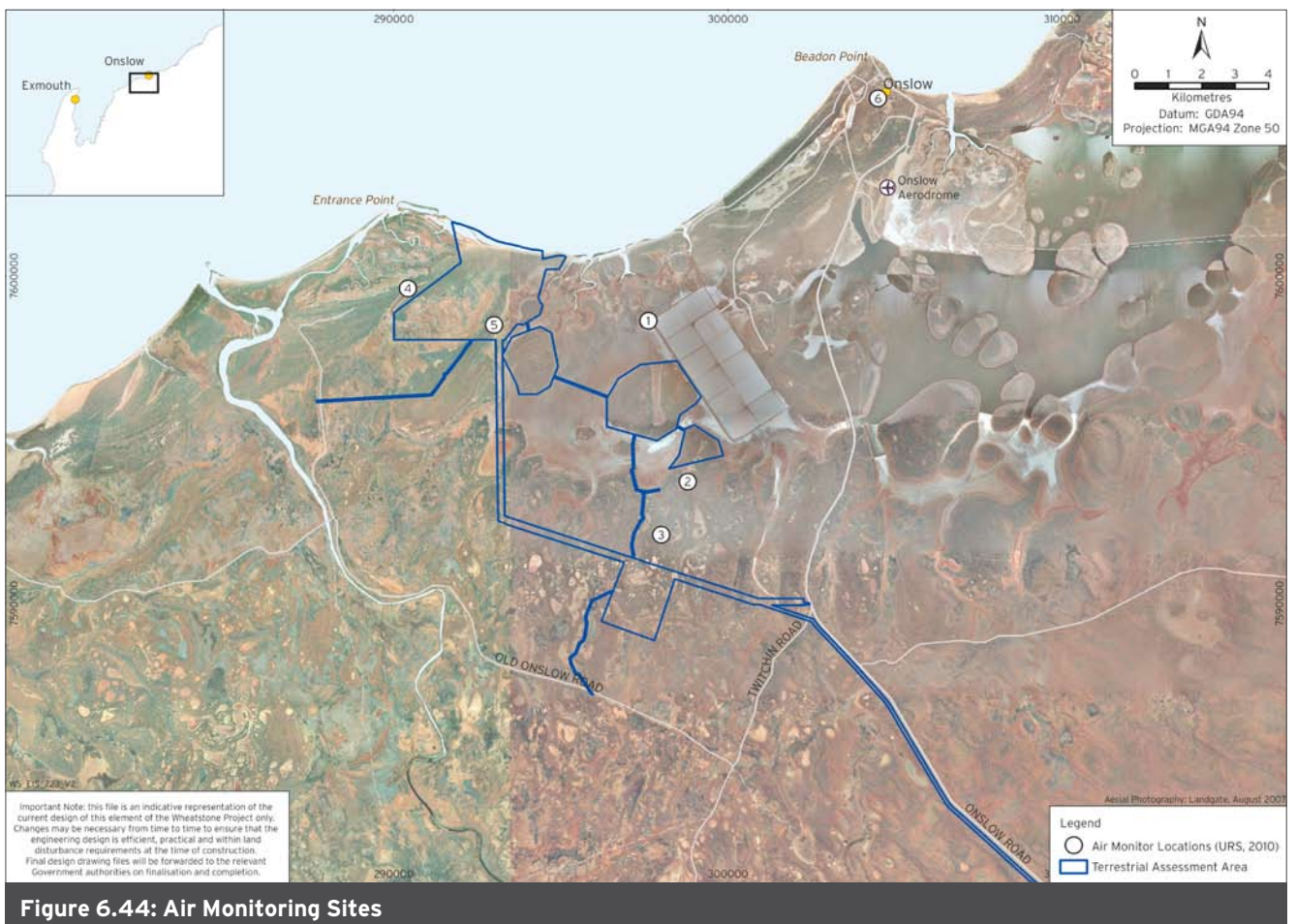
Table 6.9: Results of Continuous Particulate Monitoring

Site 1						
	Monthly Averages			Max		
	TSP (mg/m ³)	PM10 (mg/m ³)	PM2.5 (mg/m ³)	TSP (mg/m ³)	PM10 (mg/m ³)	PM2.5 (mg/m ³)
May 09	7.9	5.7	1.91	13.6	10.4	4.89
Jun 09	6.7	5.5	2.42	16.5	14.7	6.62
Jul 09	6.7	5.3	2.48	13.0	11.6	6.04
Aug 09	7.3	6	2.86	19.8	17.9	9.09
Sep 09	9.7	7.9	4.09	22.7	17.4	6.98
Oct 09	13.3	11.5	7.12	22.0	20.7	14.48
Nov 09	18.6	14.1	6.6	46.6	28.0	13.41
Dec 09	27.1	22.9	13.63	49.0	38.5	24.60
Jan 10	32.9	28.1	16.68	83.4	69.4	37.78
Feb 10	30.9	26.4	15.83	84.3	60.9	24.58
Mar 10	26.9	21.8	11.3	72.7	54.3	26.54
Apr 10	13.5	10.9	5.54	27.5	23.9	16.93
12 Monthly Average	16.8	13.8	7.54			

Site 2						
	Monthly Averages	Max	Monthly Averages	Max	Monthly Averages	Max
	TSP (mg/m ³)	PM10 (mg/m ³)	PM2.5 (mg/m ³)	TSP (mg/m ³)	PM10 (mg/m ³)	PM2.5 (mg/m ³)
May 09	9.3	6.3	1.84	16.9	11.3	5.16
Jun 09	8.9	6.6	2.34	25.0	14.8	5.90
Jul 09	9.2	6.5	2.34	18.0	14.0	5.38
Aug 09	10.3	7.6	2.77	39.9	24.0	9.36
Sep 09	19.6	13.6	4.44	76.2	47.1	7.76
Oct 09	28.8	22.1	7.99	113.0	74.4	14.92
Nov 09	28.7	20.3	7.44	98.3	69.6	18.40
Dec 09	51.3	38.6	17.3	142.7	88.5	24.76
Jan 10	67.1	49.7	21.01	155.0	104.2	34.93
Feb 10	54.6	43.4	22.18	117.2	81.5	28.60
Mar 10	30.4	23.9	11.53	75.4	56.9	29.02
Apr 10	16.7	12.6	5.55	45.7	30.4	18.57
12 Monthly Average	27.9	20.9	8.89			

Table 6.10: Results of Dust Deposition Monitoring

Dust Depositional Gauges		
Location	Sampling Period	g/m ²
Site 1	29/04/09 to 25/03/10	2.9
Site 2	01/05/09 to 25/03/10	5.1
Site 3	01/05/09 to 25/03/10	8.0
Site 4	18/11/09 to 25/03/10	1.0
Site 5	19/11/09 to 25/03/10	2.1



Minor sources do exist, however these are considered inconsequential to the background air quality. Some of the minor emission sources include motor vehicles in the surrounding area of Onslow and some small-scale power generation facilities at Onslow and Onslow Salt.

Volatile Organic Compounds (VOCs) and oxides of nitrogen (NO_x) are emitted from natural sources and these are known as biogenic emissions. VOCs are emitted from vegetation, while NO_x primarily comes from soil, biomass burning and lightning (Yienger and Levy 1995). Background ozone (O₃) concentrations are also included, because it is a secondary pollutant formed through complex chemical reactions with VOCs, sunlight and NO_x.

Existing (non-industrial) air quality is shown to be well below the NEPM criteria air quality limits for both the predicted one-hour and four-hour ground-level O₃ concentrations. Given the predominant wind conditions, maximum concentrations are predicted to occur offshore. The non-industrial sources influenced the one-hour and annual ground-level concentrations of NO₂. The modelled one-hour ground-level NO₂ concentration was 1.2 ppb, which represents 1 per cent of the NEPM criteria, and the annual ground-level NO₂ concentration was predicted to be 0.1 ppb, which represents 0.3 per cent of the NEPM criteria. Modelled existing concentrations are presented in Table 6.11.

Baseline monitoring for NO₂ and SO₂ commenced in April/May 2009, with installation of Radiello Tube Samplers at Monitoring Sites 1, 2 and 6 (Figure 6.44). Preliminary results collected from two sampling periods are included in Table 6.12.

6.4.3 Land Systems and Landforms

The Ashburton North SIA is dominated by topography consisting of undulating dunal systems, alluvial/colluvial plains and low-lying coastal systems. As such, “spot” heights for the Project area range between 5 m AHD and 21 m AHD (Landgate 2007), and are associated with the longitudinal dune network, fringing and coastal dunes. Similarly, areas of low relief are associated with the samphire and supra-tidal salt flats, claypans, tidal creeks and mangroves, which are generally below 5 m AHD.

Seven land systems were identified in the Project area. These are shown in Figure 6.45. Table 6.13 provides a description of the characteristics of each land system (adapted from [Payne *et al.* 1988]).

A landform and soil study was conducted over an area of approximately 12 200ha between Ashburton River and Hooley Creek (Figure 6.46) (URS 2009k). Eleven major landform units have been described within the terrestrial study area.

Landforms identified within the Terrestrial Study Areas are discussed in Table 6.14, and illustrated in Figure 6.46 to Figure 6.50. Detailed information regarding these landforms is provided in Appendix H1.

Table 6.11: Maximum Predicted Existing (Non-industrial) Ground-level Concentration on Modelled Grid

Pollutant	Modelled Grid	Average Period	Unit	NEPM Criteria	Maximum on Grid		Percentage of Criteria	
					On Grid	Onslow	On Grid	Onslow
NO ₂	1 km	1-hour	ppb	120	1.2	0.8	1.0%	0.6%
		Annual	ppb	30	0.1	0.1	0.3%	0.2%
O ₃	3 km	1-hour	ppb	100	23.8	19.5	23.8%	19.5%

Table 6.12: Preliminary Results of Background NO₂ and SO₂ Monitoring

Monitoring Site	Sampling Period	NO ₂		SO ₂	
		(µg/m ³)	ppb	(µg/m ³)	ppb
Site 1	30/04/09 to 25/03/10	1.05	0.94	0.58	0.20
Site 2	01/05/09 to 25/03/10	0.97	0.92	0.58	0.20
Site 6	02/06/09 to 25/03/10	1.02	0.93	0.31	0.11

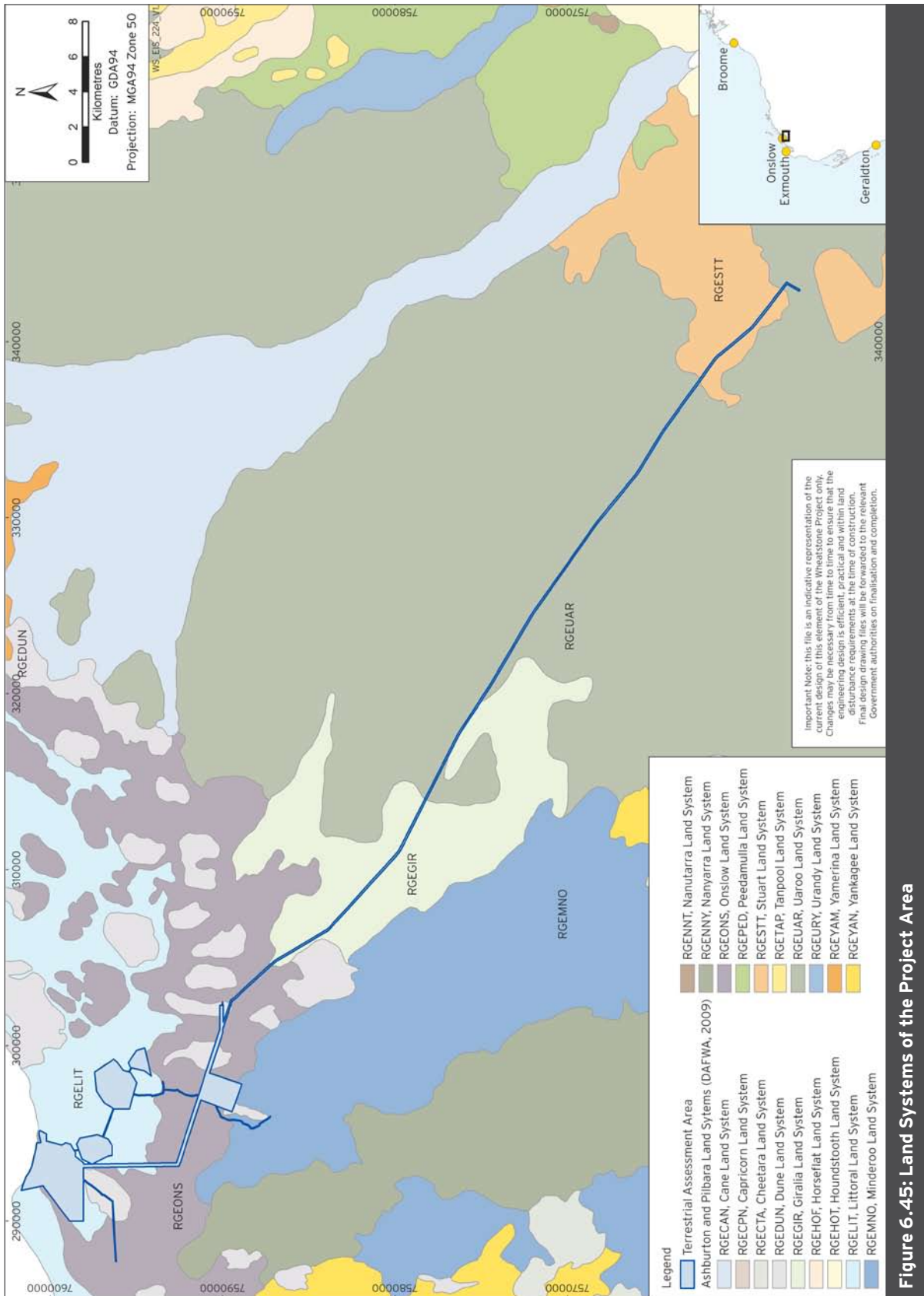


Table 6.13: Land System Descriptions

Land System	Associated Geomorphology
Onslow	Depositional surfaces include sandy plains, with non-saline clay plains subject to sheet flow, narrow drainage zones and minor depression. Coastal fringes of low sand plains interspersed with slightly less saline samphire flats and minor claypans, coastal dunes and beaches with a relief of up to 20 m in height.
Littoral	Depositional surfaces include saline coastal flats such as estuarine and littoral surfaces, with extensive bare saline mud flats that are subject to infrequent tidal inundation and slightly higher elevated samphire flats. Intense dissection patterns are identified where mangrove seaward fringes and tidal creeks are present. Minor linear dunes and sand plains with a relief up to 6 m in height are also present.
Dune	Depositional surfaces include dune fields, which comprise of sand dunes with a relief of up to 15 m in height, and swales with no organised drainage. Minor claypans, swamps and depressions are also identified.
Minderoo	Depositional surfaces include alluvial plains comprising old floodplains associated with the Ashburton River and plains formed by sheet flood and erosion with no organised drainage. Sand plains, up to 20 m in height. Claypans, swamps and depressions are also contained within this land system.
Giralia	Depositional surfaces include sandy plains formed by sheet flood and wind action, broad non-saline plains with thin sand cover and linear dunes trending north-south with no organised drainage but through flow areas receiving more concentrated sheet flow than adjacent plains. Calcrete plains and minor calcrete drainage zones and dune relief up to 30 m in height are also present.
Stuart	Erosional surfaces include gently undulating plains, broad lower plains and minor hills up to 25 m in height.
Uaroo	Depositional surfaces include sandy and non-saline sandy plains approximately 10 km in extent, with little organised drainage. There are pebbly surfaced plains, plains with calcrete at very shallow depth and minor low stony hills. Relief is mostly less than 5 m in height although isolated hills can be up to 30 m.

Table 6.14: Landform Units of the Terrestrial Study Area

Landform Unit	Landforms of Significance	Approximate Area of Landform within Terrestrial Study Area (ha)
Tidal Creeks, Intertidal Flats and Mangrove Swamp	None	326
Supratidal Salt Flat	None	300
Saline Flat	None	6
Samphire Flats	None	439
Claypans and Plains	None	320
Alluvial/Colluvial Plains	None	1798
Fringing and Coastal Dunes	None	100
Longitudinal Dunes and Interdunal Swales	None	387
Mainland Remnant Dunes	None	141
Stony Hills	None	1
Drainage Areas	None	13

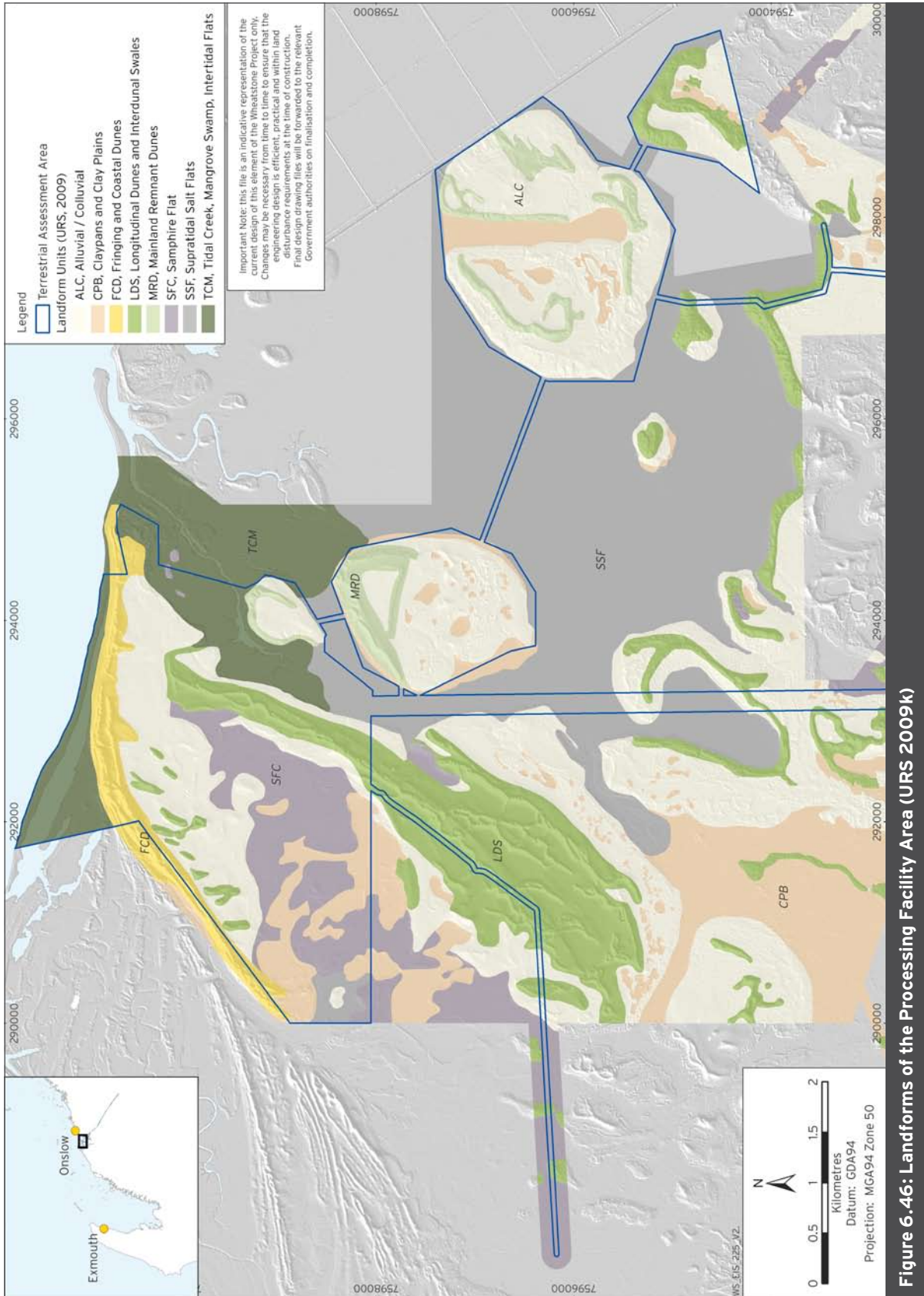


Figure 6.46: Landforms of the Processing Facility Area (URS 2009k)

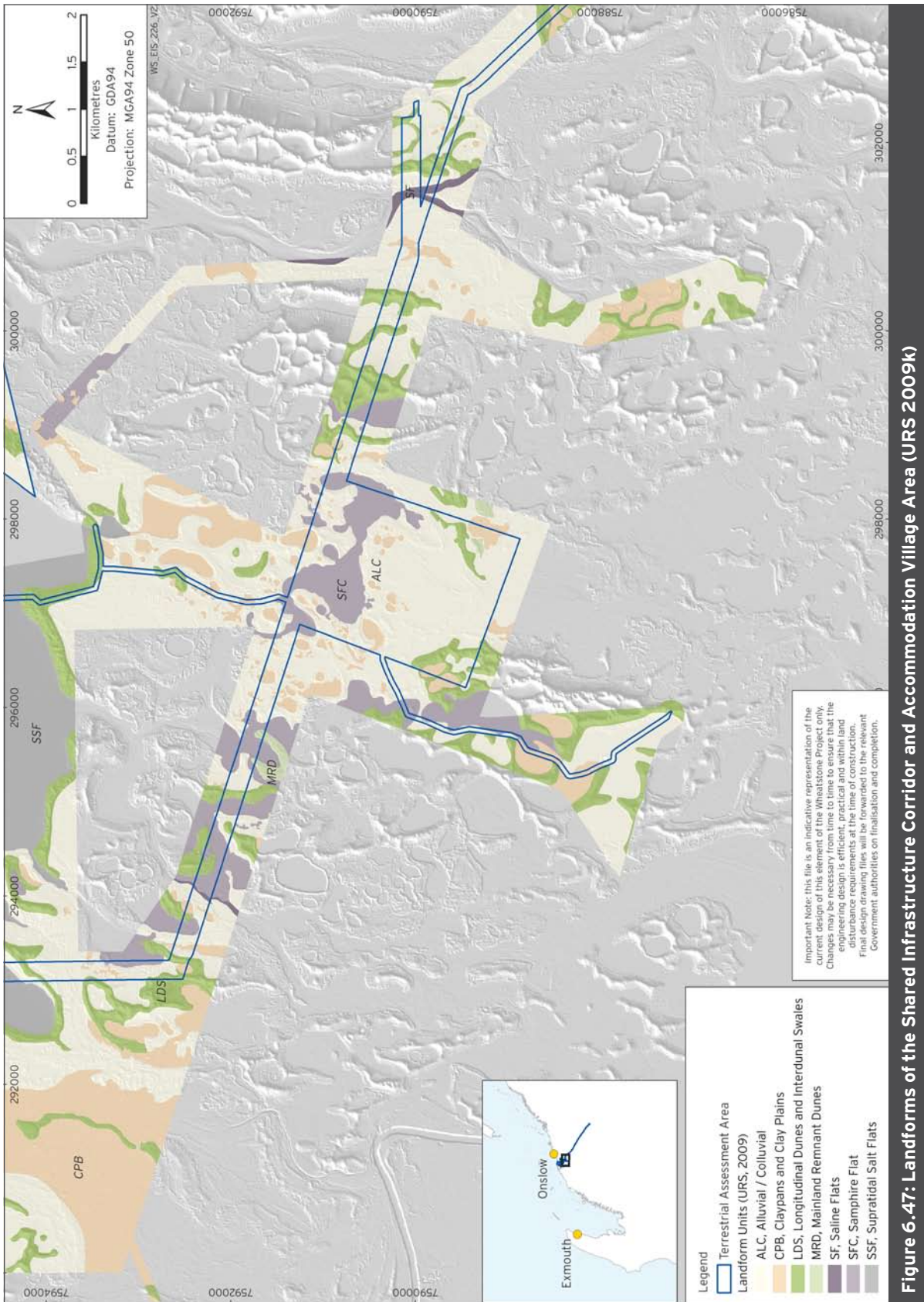


Figure 6.47: Landforms of the Shared Infrastructure Corridor and Accommodation Village Area (URS 2009k)



Figure 6.48: Landforms of the Domgas Corridor Assessment Area - Northern Section (URS 2009k)





Figure 6.50: Landforms of the Domgas Corridor Assessment Area - Southern Section (URS 2009k)

6.4.4 Soils

A baseline soil quality assessment was completed of the area depicted in Figure 6.46 and Figure 6.47, with the main objective being to provide sufficient information for the completion of a site-specific assessment of the soils. This included an assessment of the surface and shallow subsurface soils profile to approximately 3 m below ground level (mbgl).

The work included a desktop review of current and available literature, the completion of preliminary on-site intrusive works to assess soil types, and the completion of analytical testing to assess the potential acid generating capacity. Soil quality was assessed through the analysis of metals for the characterisation of the surface and subsurface profile.

The soil studies, including intrusive works, focussed on the proposed processing plant site and surrounds, and the SIC. These results are summarised in the following sections and are detailed in Appendix H1. No intrusive works have been completed for the remainder of the Project area, such as the accommodation village, construction study area and the domgas pipeline route. While intrusive works were not undertaken for these areas, it is considered that soils encountered were representative of the areas where no intrusive works were undertaken.

There were three major identifiable soil groups/types encountered in the shallow soil profile. These are summarised below.

- Red earths, otherwise known as "Ashburton Red Beds" (Coffey Geotechnics 2009), include:
 - Fine to coarse grained, red to red-brown sand/silty sand with minor clay content, quartz and minor feldspar. These soils are typically encountered within landform units associated with longitudinal dunes and interdunal swales, alluvial/colluvial plains and the fringing and coastal dunes
 - Low to medium plasticity, fine to medium grained, and red to red-brown clayey sand/sandy clay, with variable shell content. These soils are typically encountered within the landform units associated with the supratidal salt flat, samphire flats, claypans, alluvial/colluvial plains.
- Marine/organic deposits: These soils were typically characterised as low to high plasticity clay to clayey sand/sand, low to high plasticity, brown to dark grey; fine to medium grained, mottling may range from yellow and orange, firm to very soft. These soils are considered to be of marine/organic origin and are generally located within landform units associated with the intertidal

flats, tidal creek and mangrove swamp, the samphire flats and supratidal salt flats.

- Calcareous sands/rock: These soils/rock were typically characterised as moderately to very well cemented, fine to coarse grained sands to well cemented rock, pale brown to cream/white, and high shell content calcareous sand/sandstone. This soils/rock type was typically located at shallow depths underlying landform units associated with the alluvial/colluvial plains, fringing and coastal dunes and the longitudinal dunes and interdunal swales.

A soil erosion assessment for the various landform units and associated soil types found within the terrestrial assessment area identified three landform units (the fringing and coastal dunes, the longitudinal dunes and the mainland remnant dunes) which have a very high to extreme potential for wind erosion and a high potential for water erosion when disturbed. Results of the assessment are presented in Table 6.15.

Field dispersion tests were conducted on surface and subsurface clayey soil samples with the objective of determining soil sodicity across appropriate soil types. In summary, red brown clay and/or clayey soils identified generally slake (slightly) but are non dispersive (Class 4, 5 or 6). Brown to grey clay identified within Ashburton North and surrounds was generally identified as potentially dispersive (Class 3).

6.4.4.1 Heavy Metal Assessment

As part of the soils and landforms studies, an assessment of metal concentrations was conducted on shallow soils (approximately 3 mbgl) considered representative of the soil types and landforms encountered. The objective of the assessment was to determine baseline metal concentrations.

Detectable metal concentrations were identified for the majority of analytes across the study area with the exception of barium, cadmium and mercury. Elevated arsenic, chromium, manganese and nickel concentrations were detected above the adopted environmental investigation level trigger values within the north-western and north-eastern extent of the study area.

These concentrations are considered representative of background conditions given the absence of human induced disturbance within the terrestrial assessment area, the distance from the Onslow Salt operations and based on a comparison with other North West coast deltaic systems within the Pilbara region (Oceanica 2005).

Table 6.15: Soil Erosion Potential for Landform Units of the Terrestrial Assessment Area

Landform Type	Significant Landform	Water Erosion Potential (VL, L,M,H, VH, E)	Wind Erosion Potential ¹ Class I-V (VL, L,M,H, VH, E)	Assessment Area
Intertidal flats, mangrove communities and tidal creeks	No	L to M	L	North west of Ashburton North and surrounds and construction study area
Alluvial / Colluvial	No	L	L	Ashburton North and surrounds, SIC, accommodation village, domgas and construction study area
Claypans	No	M	L	Ashburton North and surrounds, SIC, accommodation village, domgas and construction study area
Fringing and Coastal Dunes	No	H	VH to E	Ashburton North and surrounds
Drainage Area ²	No	L	L	Domgas study area
Stony Hills	No	L	L	Domgas study area
Longitudinal Dunes and Interdunal Swales	No	H	VH to E	Ashburton North and surrounds, SIC, accommodation village, domgas study area and construction study
Mainland Remnant Dunes	No	H	VH to E	Ashburton North and surrounds and construction study area
Samphire Flat	No	L	L to M	Ashburton North and surrounds, SIC, accommodation village and construction study area
Supratidal Salt Flat	No	M	L	Ashburton North and surrounds, SIC and construction study area
Saline Flats	No	M	L	SIC study area

1. Wind potential assessed against *Land evaluation Standards for Land Resource Mapping Third Edition* Dennis van Gool, Peter Tille and Geoff Moore December 2005

2. Evaluation of drainage area, stony hills and saline flats undertaken through a landform assessment of erodibility only

It is considered that a general correlation exists between elevated metal concentrations and the proximity to landforms associated with marine and/or organic deposits.

Based on a review of the levels against published human health threshold levels, the background concentration of metals are not considered to pose an adverse risk to human health. Although some metal concentrations exceeded the relevant ecological threshold values, these metals are naturally occurring in the area and therefore will not pose an unacceptable risk to ecological receptors.

6.4.4.2 Acid Sulfate Soils

Acid sulfate soils (ASS) are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials. These soils are most commonly found in low-lying land bordering the coast, estuarine and saline wetlands in soils comprising marine/mangrove deposits. In an undisturbed anoxic state, these materials remain benign and do not pose a significant risk to the environment. They are known as potential acid sulfate soils (PASS) in this state.

Disturbance of PASS and subsequent exposure to water and oxygen leads to the production of acidic conditions, which have the potential to cause significant environmental and economic impacts. These impacts may include fish kills and loss of biodiversity in waterways, contamination of groundwater by acid, arsenic and heavy metals, and corrosion of concrete and steel.

A total of 44 samples were submitted for the assessment of PASS and acid neutralising capacity (ANC). The samples selected for analysis were primarily based on field test results and the soil profiles intercepted. In addition, 107 geotechnical bore logs / core photographs were reviewed to further delineate the vertical and horizontal extent of PASS. Representation of landform units typical of the study area was also considered.

The results of the assessment demonstrate that PASS is present at shallow depths ranging between 0.5 mbgl and 4.5 mbgl with a thickness ranging between 0.2 m and 3.5 m. It exists predominantly along the north-eastern extent of the survey area. Actual ASS material (or existing acidity) was identified at one location only, which was also along the north-eastern extent of the study area. The red and yellow mottling reported in the soil logs suggests historical oxidation around the depth of the water table. No intrusive works were conducted in the construction study area, accommodation village or domgas pipeline.

Soil profiles indicative of PASS material are considered to be of marine/organic origin and are generally located within landform units associated with the intertidal flats,

tidal creek and mangrove swamp, the samphire flats and supratidal salt flats. PASS was also reported in the underlying marine/organic deposits of the alluvial/colluvial plains, and fringing and coastal dunes of Ashburton North and surrounds. It is believed that these shallow marine/organic deposits may be associated with the bordering Ashburton River delta and the Hooley Creek catchment that underlies this landform unit as what has been identified as a chenier formation.

The ANC for soils of Ashburton North and surrounds and the SIC study area is generally high, however is typically absent in soil profiles identified as PASS. Soils with the highest ANC throughout Ashburton North and surrounds generally comprised of sands and sand clays with shell, limestone and/or sandstone interbedded throughout. ANC of the SIC study area was significantly lower with highest buffering capacity detected in the red clayey sands. Where net acidity concentrations in exceedence of the adopted action criteria were reported, corresponding ANC concentrations were nonexistent or negligible.

Based on the findings of the soils and landforms assessment a PASS map was produced identifying areas of low, moderate and high risk for PASS for the terrestrial assessment area. The PASS map was produced based on the understanding that high to moderate risk for PASS is classified as material within 3 m of natural soil surface that could be disturbed by most land development activities (DEC 2009). Soils were then further classified based on strategies provided by Atkinson *et al.* (1996) and Ahern *et al.* (1998) resulting in the site-specific criteria presented in Table 6.16.

Figure 6.51 and Figure 6.52 illustrate the areas identified as high, moderate and low risk based on the criteria in Table 6.16. High-risk areas have been delineated in the north eastern extent of Ashburton North and surrounds within the footprint of the LNG plant and where the majority of construction works have been proposed.

There is a moderate risk of intercepting PASS (assuming incidental excavation for these areas) for landform units associated with the samphire flats and the supratidal salt flats where PASS was typically located at shallow depths. These areas are generally within Ashburton North and surrounds and incidentally within the SIC and accommodation village study areas.

Given the landforms identified within the construction study area, it is unlikely that PASS will be intercepted. However as a precautionary measure, some areas are conservatively classified to be of moderate risk for intercepting PASS, given that no intrusive works have been undertaken.

Table 6.16: PASS Risk Map Criteria

Classification Criteria	PASS Classification		
	Low to No Risk	Moderate Risk	High Risk
Depth in the Soil Profile	Water table not intercepted or below 3 mbgl	PASS soils (field test identification only) typically at or below water table	PASS soils typically at or below the water table
Landform	Fringing, Coastal and Longitudinal Dunes and Interdunal Swales (unless underlying Chenier formation)	Samphire and Supratidal Salt Flats	Intertidal Flats, Tidal Creek, Mangrove Swamp and Chenier formations (and some fringing formations)
Elevation	Above 5 m AHD	Below 5 m AHD	Generally below 5 m AHD unless soils are below Chenier formation
Volume of Soil to be Excavated	None to Incidental (<1000 tonne)	None to Incidental (<1000 tonne)	Large scale (>1000 tonne) excavation/dredging/dewatering
Field pH Indicators	pH(f)>7.0 pH(fox)>5.5	Generally with a pH(fox) <5.5	Generally with a pH(fox)<4.0
Soil Type	Red earths sands/clays and sandstone/limestone pavement	CLAY/Clayey SAND: Medium to high plasticity, brown to grey	CLAY: medium to high plasticity, brown to grey
Sulfide Content	Non-detectable	No inorganic sulfide detected by analysis	Above 0.03 %S

There is considered to be low to no PASS associated with the longitudinal dune network of Ashburton North and surrounds, where soils are typically of terrestrial origin and contain significant authigenic carbonates (formed in-situ) and of the coastal dunes located to the east of the Ashburton River delta. The majority of the SIC study area is considered low to no risk areas for PASS, and the domgas corridor study area is not expected to contain PASS.

6.4.5 Groundwater

6.4.5.1 Site Investigations

Shallow groundwater flow systems of the Ashburton North site have been determined through interpretations of data collected during site investigations. The site investigations were conducted in two phases between March and September 2009. In total, 69 groundwater and 28 drive point piezometers were installed during the two phases. The groundwater bores consisted of shallow, intermediate and deep bores. Shallow bores were constructed to a depth

of 3 to 8 m, intermediate bores 7 to 18.5 m, and deep bores 21 to 67.5 m. Drive point piezometers were installed by hand to depths of 1.5 to 3 m.

Drilling and sampling locations from the site investigations are shown in Figure 6.53 and Figure 6.54.

6.4.5.2 Hydrostratigraphy

The interpreted hydrostratigraphy is based on the local geological profiles intersected during the site investigations and consists of Dune Sands, underlain by Ashburton River Delta alluvium, which in turn is underlain by the Ashburton River Delta Clay and Unconformity, and the confined Trealla Limestone. Table 6.17 provides details of the interpreted hydrostratigraphy of the Project area.

6.4.5.3 Effective Transmissivity

The hydraulic parameters interpreted from the site investigations for the individual hydrostratigraphic units are presented in Table 6.18.

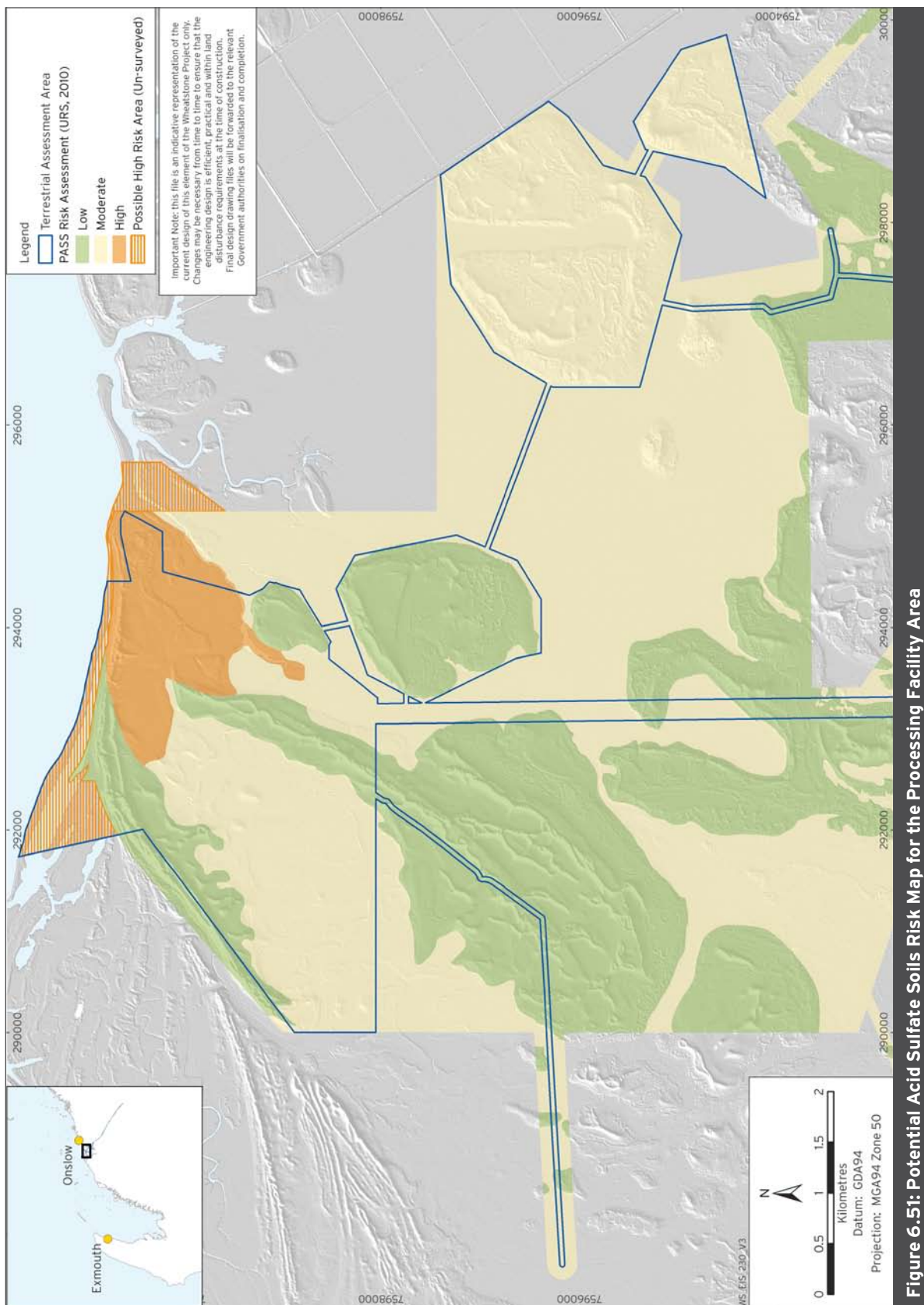


Figure 6.51: Potential Acid Sulfate Soils Risk Map for the Processing Facility Area

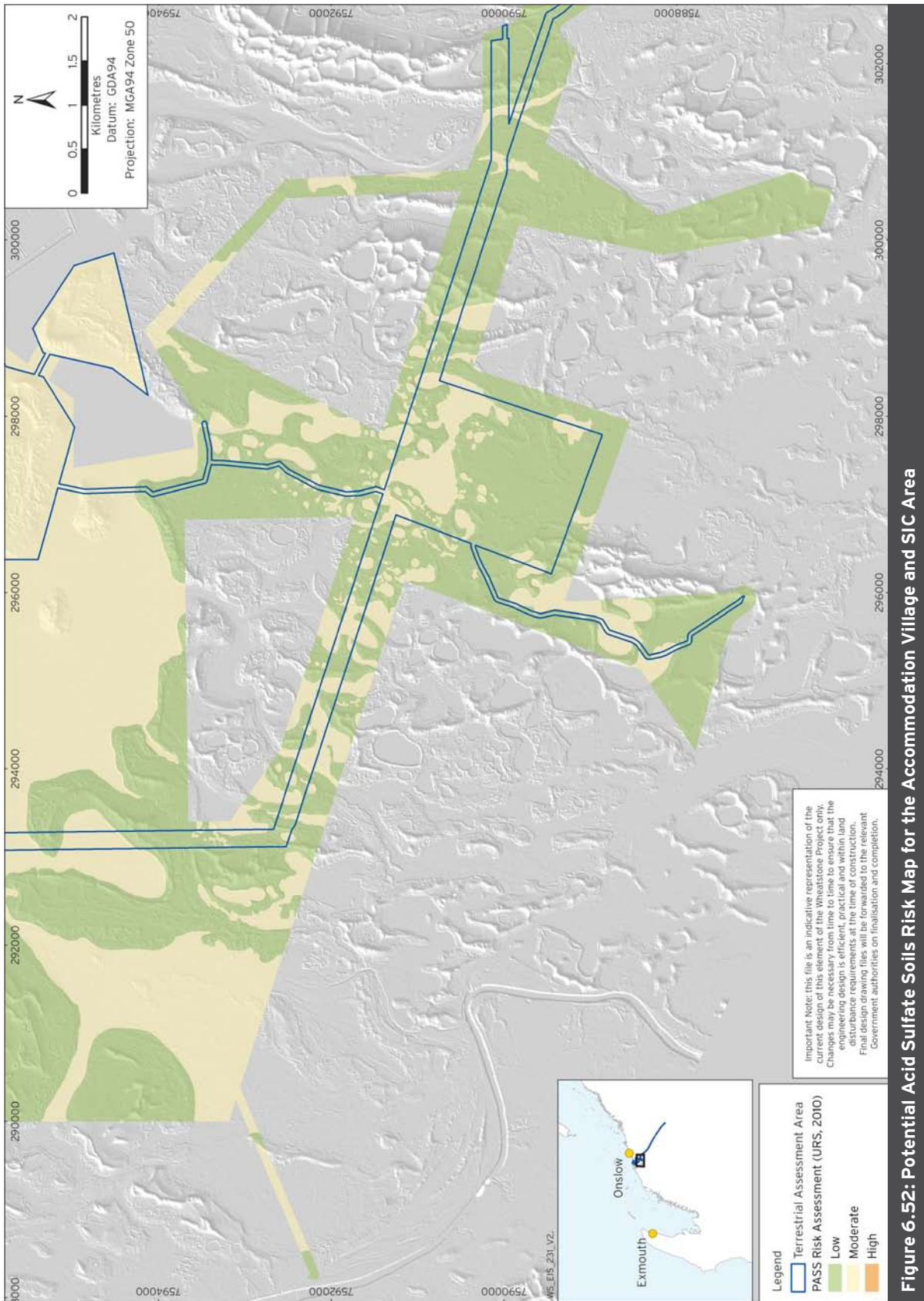
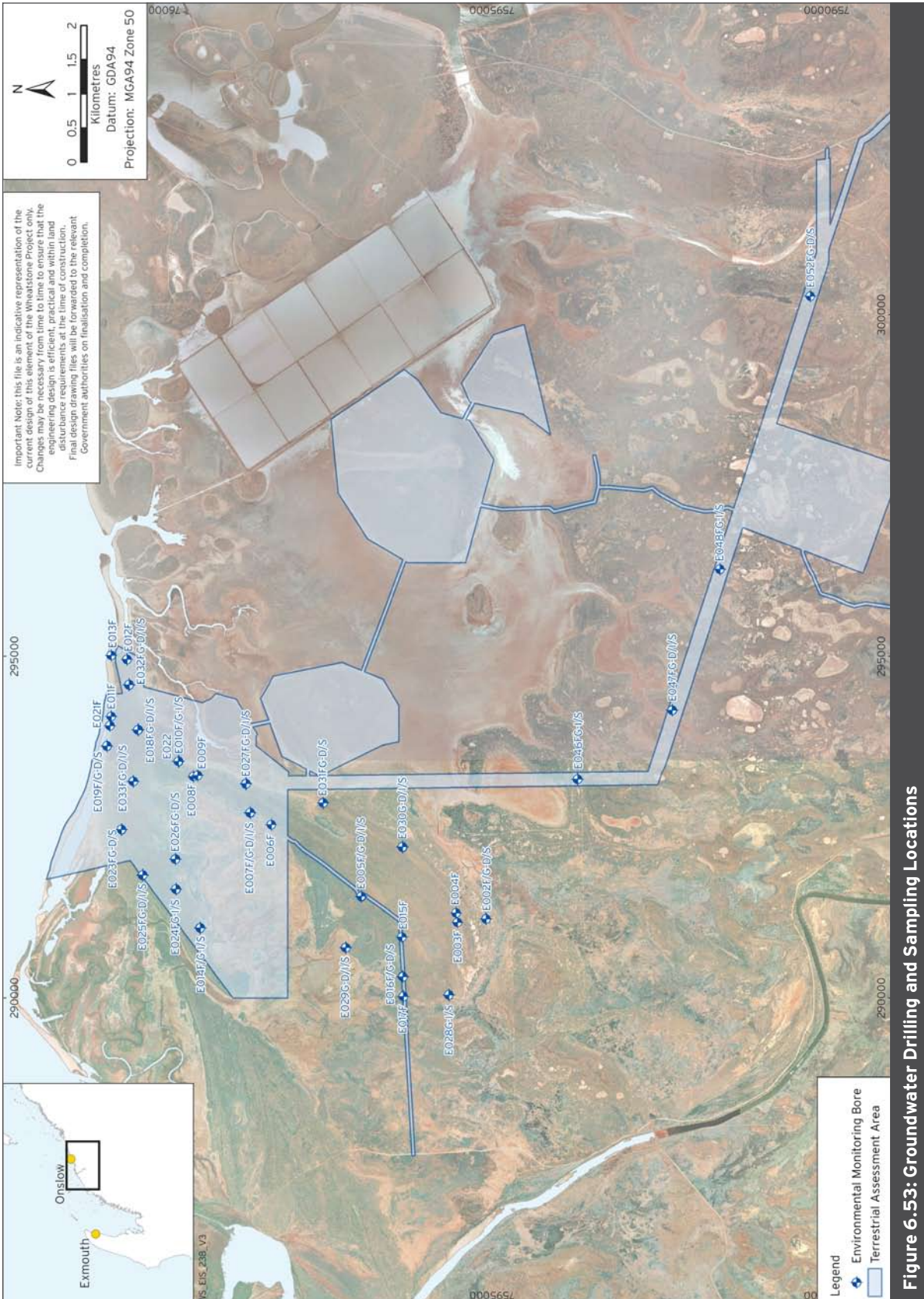


Figure 6.52: Potential Acid Sulfate Soils Risk Map for the Accommodation Village and SIC Area



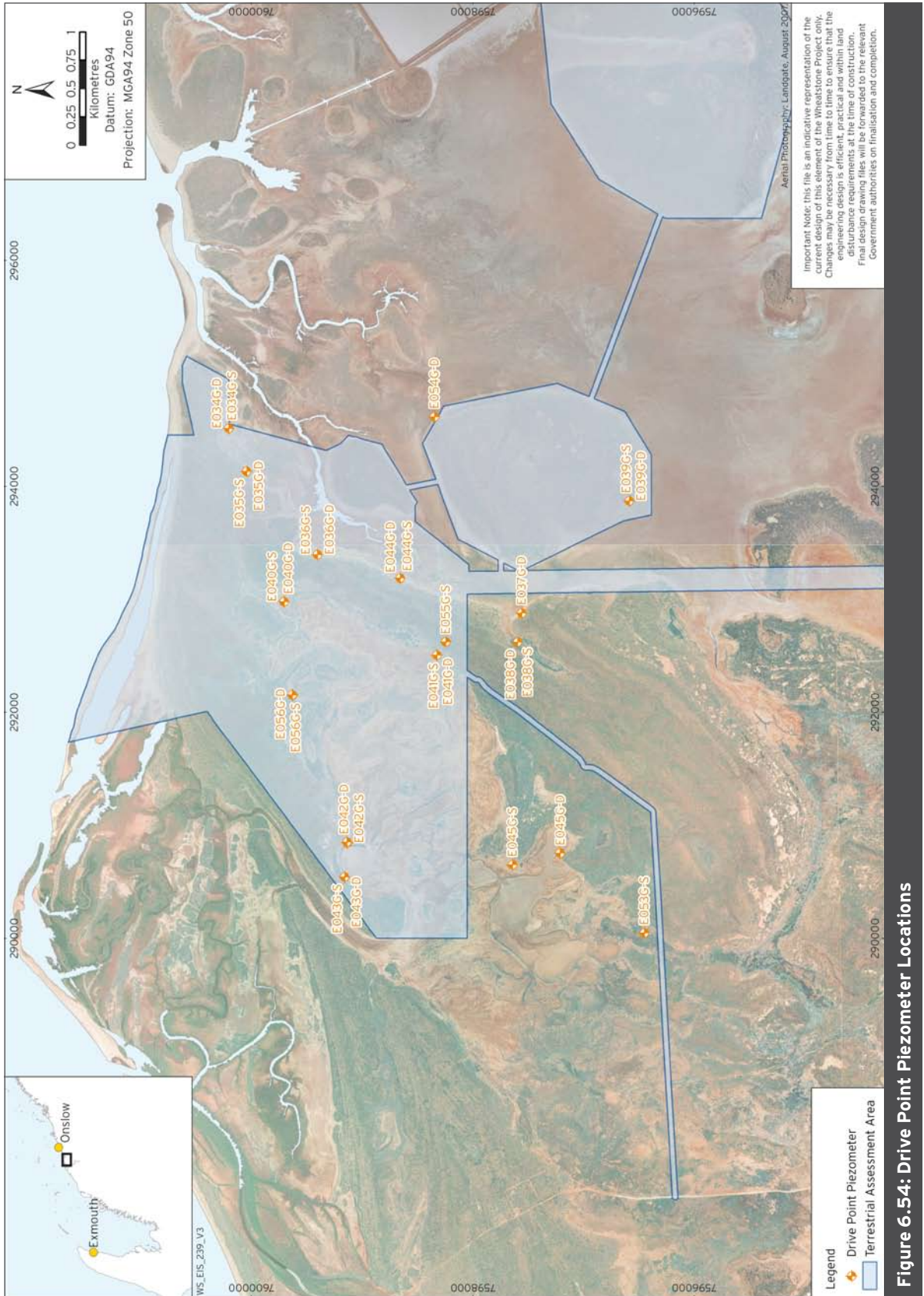


Figure 6.54: Drive Point Piezometer Locations

Table 6.17: Description of Interpreted Hydrostratigraphy

Hydrostratigraphic Unit	Aquifer Description		Typical Saturated Thickness (m)
	Storage Characteristics	Broad Lithology	
Quaternary/Recent Superficial Formations			
Dune Sands	Unconfined	Sands and sandstones	3
Ashburton River Delta Alluvium	Semi-confined and confined	Silty and sandy clays, interbedded sand and clay	20
Ashburton River Delta Clay and Unconformity	Confining layer and aquitard	Clay and claystone	5
Tertiary Successions - Carnarvon Basin			
Trealla Limestone	Confined	Limestone	30

Table 6.18: Interpreted Hydraulic Parameters

Hydrostratigraphic Unit	Hydraulic Conductivity (m/day)		Effective Transmissivity (m ² /day)
	Horizontal	Vertical	
Quaternary/Recent Superficial Formations			
Dune Sands	4 to 8	4	12 to 24
Ashburton River Delta Alluvium	0.5	0.05	10
Ashburton River Delta Clay and Unconformity	0.3	0.03	2
Tertiary Successions - Carnarvon Basin			
Trealla Limestone	5.0	5.0	50

6.4.5.4 Groundwater Flow

An assessment of the relationship between topography and measured shallow groundwater levels demonstrates that the water table is closely linked with topography, with groundwater flow being a reflection of the surface water catchments. Flow directions are from topographical highs in the dunes towards topographical lows of the tidal flats, mud flats and salt flats. In the deeper profiles of the Ashburton River Delta Alluvium and Trealla Limestone, the influence of the local topography remains evident but subdued and increasingly masked by regional groundwater flow influences and density effects.

Ashburton North is predominantly a groundwater discharge zone associated with the regional Carnarvon Basin successions. Exceptions occur seasonally, when the dunal terrain intercepts and transmits rainfall recharge. Notwithstanding, all shallow groundwater intercepted by the site investigations are interpreted to be accumulating salt, thus indicating low rates of net recharge and

predominant occurrence of groundwater discharge. The local shallow groundwater environments store accumulated salt. Interpreted seasonal recharge zones are shown on Figure 6.55.

Horizontal Groundwater Flow Dynamics

The water table elevation is based on the physical expression of the water table, as measured in monitoring bore and drive point piezometer standpipes, together with the understanding that the directions of flow closely conform to the topography. As such, the interpreted water table settings peak beneath the dunes, with groundwater flow perpendicular to the dune crests towards lowlands formed by the supra-tidal, samphire and tidal flats of the Southwest, Hooley Creek and Ashburton River Delta catchments. On the seaward side of the beach dunes, groundwater flows northwards, directly into the sea. Figure 6.56 shows the water table contours and flow directions of the Project area.

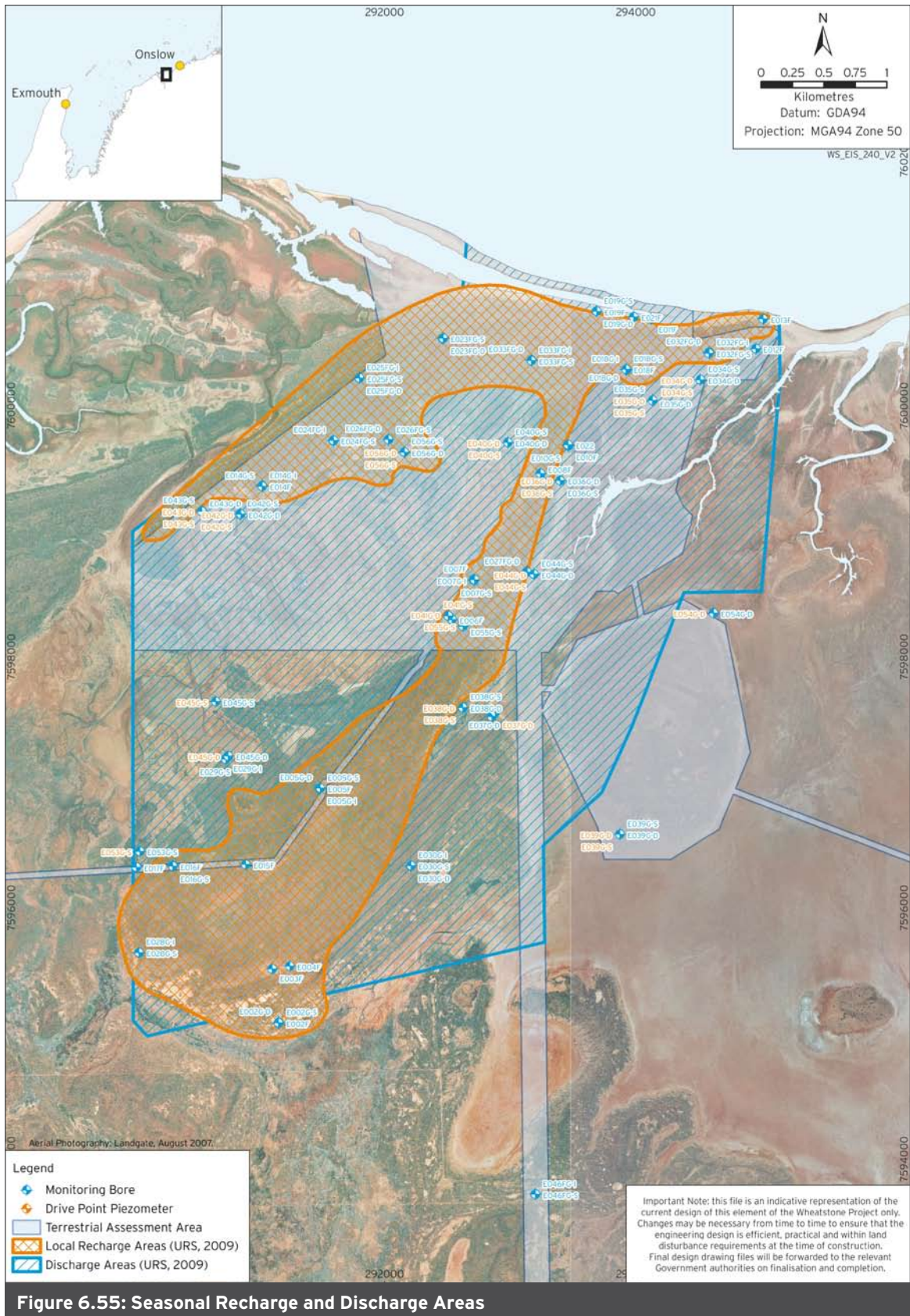
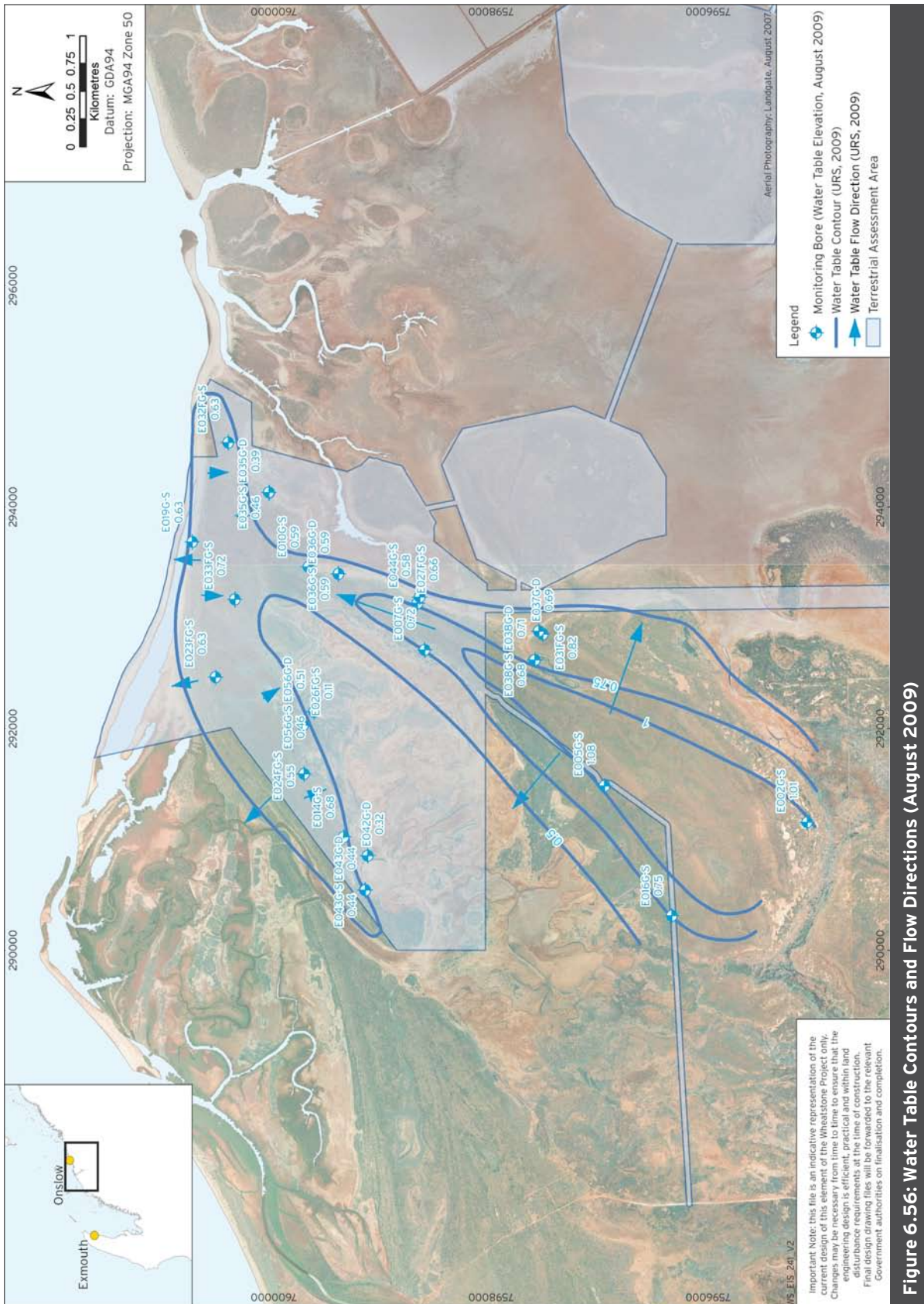


Figure 6.55: Seasonal Recharge and Discharge Areas



6.4.5.5 Vertical Flow Dynamics

Environmental heads compensate for, and equilibrate vertical density stratification due to accumulated salt. Interpreted environmental heads show broad conformance with the topography, with mounds beneath the dunes, and demonstrate vertically upward flow from the Trealla Limestone to the overlying successions. That is, the environmental heads are highest (typically 1.0 to 2.5 m AHD) in the Trealla Limestone, progressively decline (typically 0.75 to 1.0 m AHD) throughout the Ashburton River Delta Alluvium and are lowest (typically 0.25 to 0.75 m AHD) within the Dune Sands.

Figure 6.57 illustrates the interpreted vertical distribution of environmental heads in cross-section aligned along flow paths of the Ashburton North SIA. The figure illustrates the broad conformance of the environmental heads with topography, with mounds beneath the dunes, and vertically upward flow from the Trealla Limestone to the overlying successions. The upward flow gradients occur within the entire domain, but the cross-sections illustrate predominant flow to the lowland settings formed by the supra-tidal, samphire and tidal flats.

The interpreted vertical upward flow dominates the cross-sections and characterises Ashburton North as a regional groundwater discharge zone.

6.4.5.6 Groundwater Quality

The available quality data indicate the local groundwater is brackish to hypersaline, near neutral to slightly alkaline and of sodium-chloride type, similar to seawater. TDS concentrations range from 3560 to 204 000 mg/L, typically being higher in the Trealla Limestone. This aspect is supported by the electrical conductivity (EC) measurements, with values ranging from 12.7 to 187.6 m S/cm and being greatest in the Trealla Limestone.

TDS concentration ranges have been determined for the Dune Sands, Ashburton River Delta Alluvium and Trealla Limestone hydrostratigraphy. Accumulated salt within the deeper Carnarvon Basin successions is transmitted to the superficial formations. The measured TDS distributions show vertical salinity stratification, with Trealla Limestone containing hypersaline (156 000 to 200 000 mg/L TDS) groundwater and salinity being progressively diluted (typically 50 000 to 150 000 mg/L in the Ashburton River

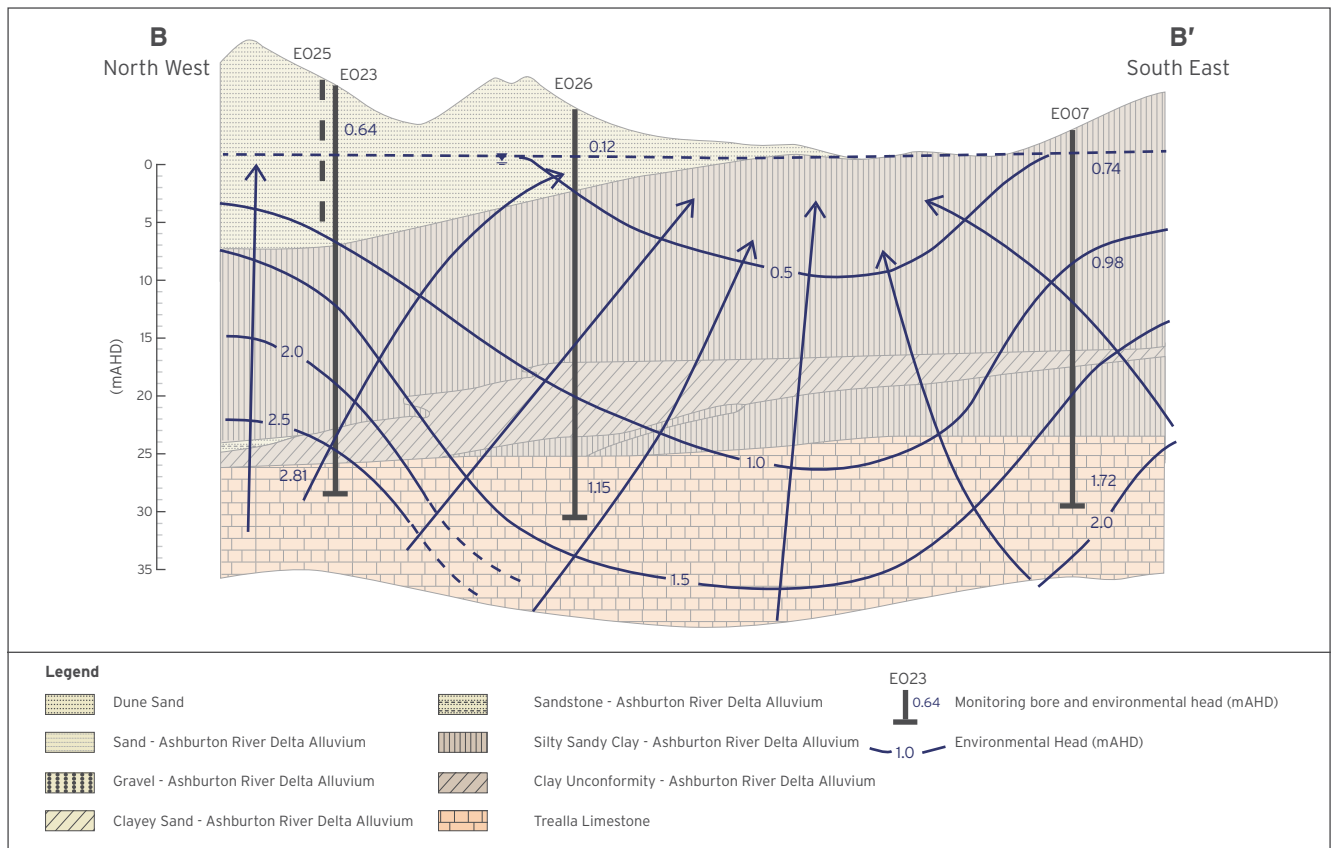


Figure 6.57: Environmental Heads and Flow Gradients (August 2009)

Delta Alluvium and 20 000 to 120 000 mg/L in the dune sands) in the shallow hydrostratigraphic units. The vertical distribution of TDS concentrations is shown in Figure 6.58. Typically, the salinity concentrations are less in the dune sands, beneath areas that may preferentially intercept and transmit rainfall recharge. Dune Sands contain some brackish groundwater, but distribution is irregular.

Measured TDS concentrations and associated groundwater densities combined with the vertically upward hydraulic gradients appear to locally limit seawater intrusion into the shallow water table zones. Presumably, the seawater interface in the groundwater environment occurs offshore.

Heavy metals were detected in most monitoring bores, with chromium, copper, nickel and zinc detected at the highest concentrations. As with the heavy metal assessment conducted for soils, these concentrations are considered representative of background conditions given the absence of human induced disturbance within the survey area.

The limit for reporting for the heavy metals was raised in several samples due to high EC recordings. Heavy metal concentrations occur above the marine ANZECC guidelines in many of the monitoring bores. The marine ANZECC

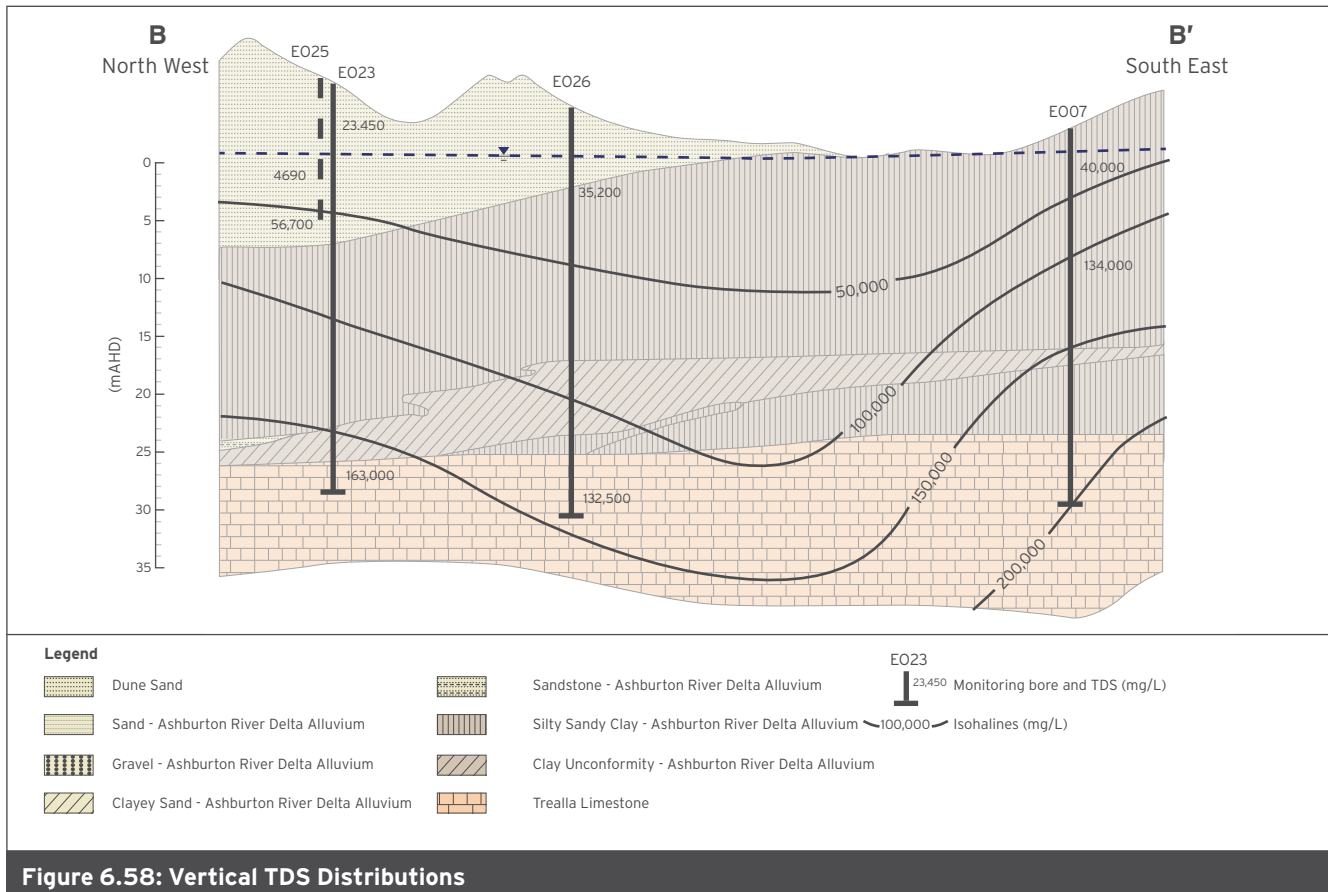
guidelines are used as a reference due to the typical high concentrations of salt in the shallow groundwater environment.

Groundwater analysis was undertaken on samples from all groundwater bores, with the results presented in the Project Groundwater Studies report, included in Appendix F1.

6.4.6 Surface Water

The surface water environment of Ashburton North is influenced by widely variable seasonal climatic conditions. The majority of the annual rainfall occurs in the summer season (October to April) when it can cause run-off from local catchments and the wider Ashburton River Catchment. Winter (May to September) is characterised by low rainfall and little or no surface water run-off. Section 6.2.2 provides more detail on the rainfall of the area.

Ashburton North is located in the Ashburton River Delta, which is characterised as a coastal flood plain. When the Ashburton River is in flood, its flood waters will spill onto the flood plain and may significantly add to the stream flow in the drainage lines of the Project area.



The catchment of the Ashburton River Delta contains the Ashburton River Mouth, Southwest, Hooley Creek and Northeast sub-catchments (Figure 6.59). The Project area is located on the catchment divide between the Southwest and Hooley Creek sub-catchments.

6.4.7 Hydrology and Drainage

6.4.7.1 Ashburton River Delta

The Ashburton River Delta is dynamic with historical evidence indicating numerous changes to the location of the main channel of the Ashburton River through the delta. The most recent change occurred in 1921 when the main channel shifted about 7 km west of its previous position. Such changes are caused by significant flood events that cause the deposition of large quantities of sediment. Deposition of sediment in the low-relief delta can cause stream flows to find an alternative path to the ocean.

The Ashburton River Delta is characterised by:

- A comparatively small catchment area
- Ephemeral run-off being ungauged and estimated to vary significantly dependent on local and regional rainfall.

Three main components influence the surface water characteristics of the Ashburton River Delta. These are:

- Tidal inundation by seawater
- Localised rainfall events
- Flooding of the Ashburton River.

These three components are not discreet or independent. Catchment divides between the Ashburton River Mouth, Southwest Catchment and Hooley Creek Catchment are of comparatively low topographical relief. As such, the catchment divides are comparatively frequently (ARI of less than two years) over-topped during flood events. Consequently, the Ashburton River in flood may affect flood levels and stream flow in both the Southwest and Hooley Creek catchments (URS 2009k).

The Hooley Creek Catchment has low relief and lower elevation reaches are tidal. In the tidal zone, the catchment is drained by Hooley Creek West, Hooley Creek East, Eastern Creek and Four Mile Creek.

The Southwest Catchment is located between the Ashburton River and the Hooley Creek Catchment. The low-lying areas of the catchment contain a series of interconnected clay pans.

In mid February 2009, Cyclone Dominic deposited 276 mm of rainfall in 24 hours at Onslow (BoM 2009). This rainfall event resulted in a peak flow rate of 411 m³/s at the Nanutarra Gauging Station, and localised flooding with an estimated recurrence interval of less than two years. The extent of local flooding mapped from satellite imagery is shown in Figure 6.60.

6.4.7.2 Tidal Variation and Storm Surges

Tidal fluctuations affect seawater levels in the lower reaches of the Ashburton River delta catchment. Landforms within the catchment are influenced by these tidal actions, which result in daily and temporal inundation by seawater. Tidal variations in the vicinity of Ashburton North have been recorded between +1.55 m AHD (the HAT) and -1.42 m AHD (the LAT), with a MSL of +0.06 m AHD. The tidal creeks breach gaps in the dune barrier systems and form networks of narrow drainage channels that enable tidal flows in to expansive tidal flat embayments extending several kilometres landward of the beach.

A study commissioned by the Shire of Ashburton at Onslow (GEMS 2000) to quantify storm surge inundation near the Onslow Salt Project estimated the 1:100-year ARI storm surge to be 4.8 m AHD in the vicinity of the Ashburton River mouth. Figure 6.61 illustrates the distribution of seawater within the Ashburton River Delta during a 1:100-year ARI storm surge.

6.4.7.3 Flood Assessments

A baseline flood assessment for five-year, ten-year, 25-year and 100-year ARI rainfall events was simulated by parameterising flow hydrographs from the Ashburton River and Ashburton River Delta, together with MSL, within a MIKE 21 model. The Ashburton River is seen to break its banks in all four design rainfall event simulations. These break-outs promote flows onto low-lying areas of the Southwest and Hooley Creek catchments. The surface water inundation extents and maximum water elevations in the Ashburton River delta for a 1:100-year ARI flood event is shown on Figure 6.62.

6.4.7.4 Surface Water Quality

Surface water quality at Ashburton North is a mixture of tidal seawater and run-off from local catchments, including the Ashburton River. The predominant surface water quality indicators include salinity from the tidal influence and evaporation effects, and turbidity from stream flow. Available surface water quality data for Ashburton North are sparse and incidental due to the terrestrial domain being inherently dry with sporadic rainfall events.

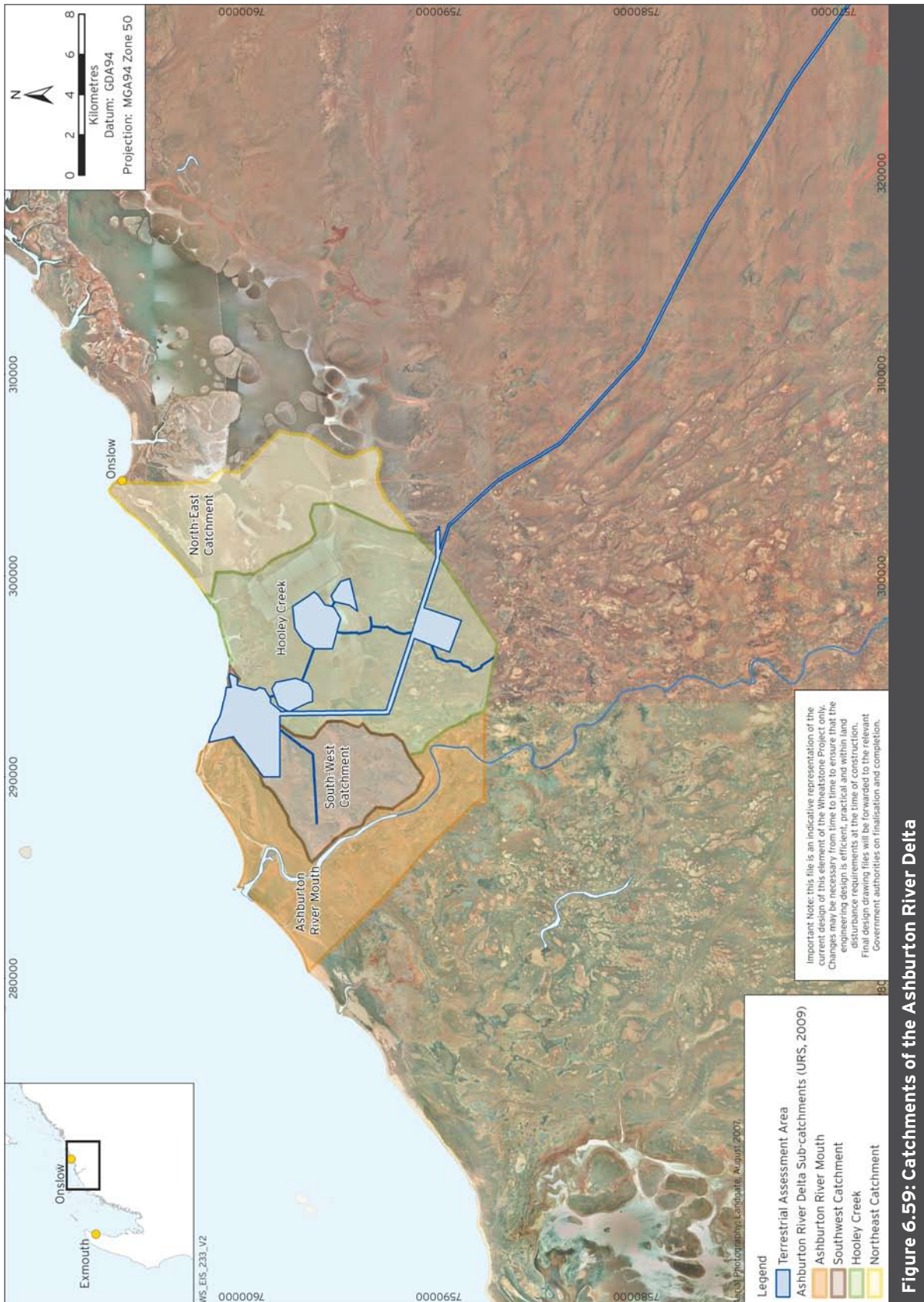
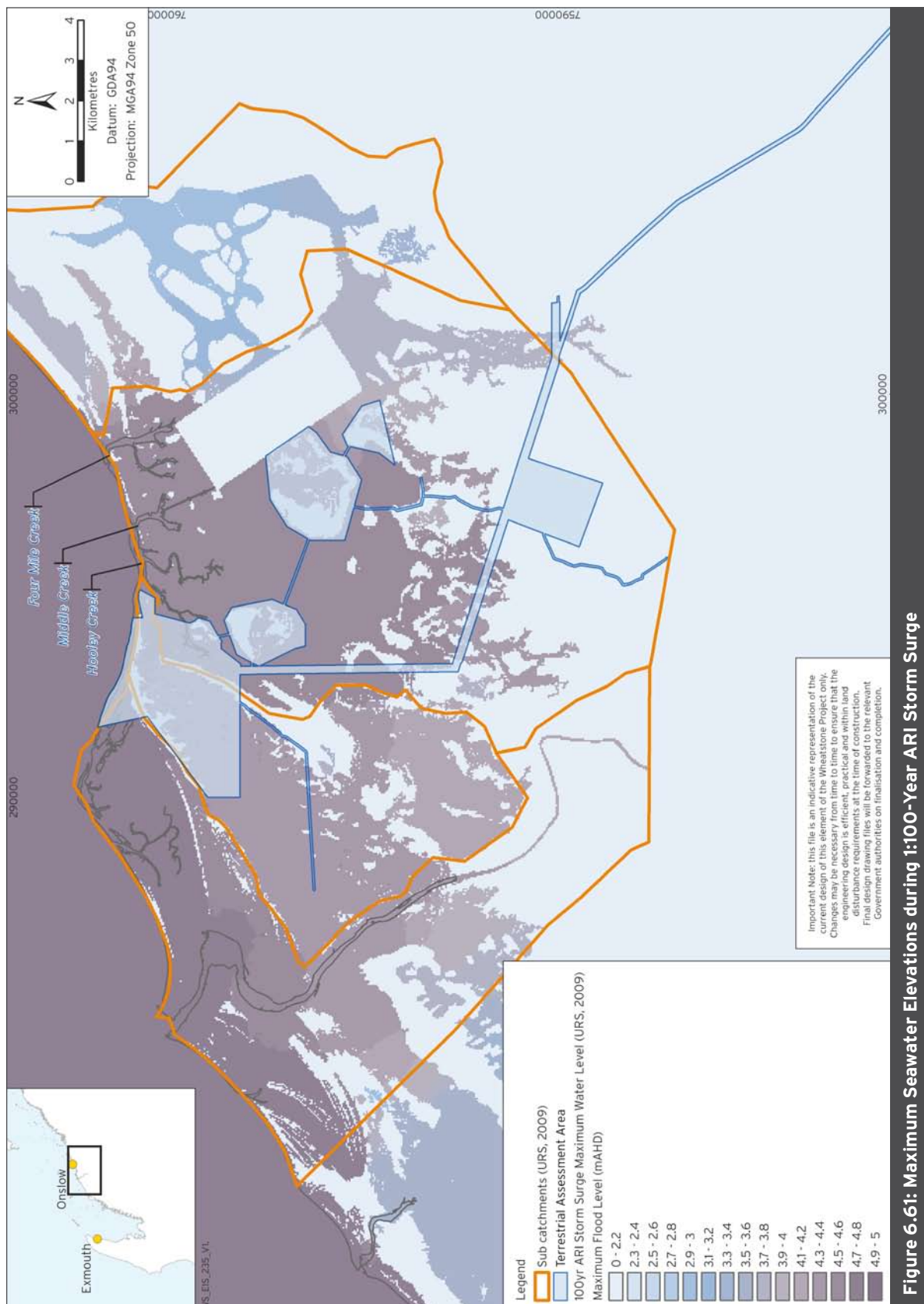
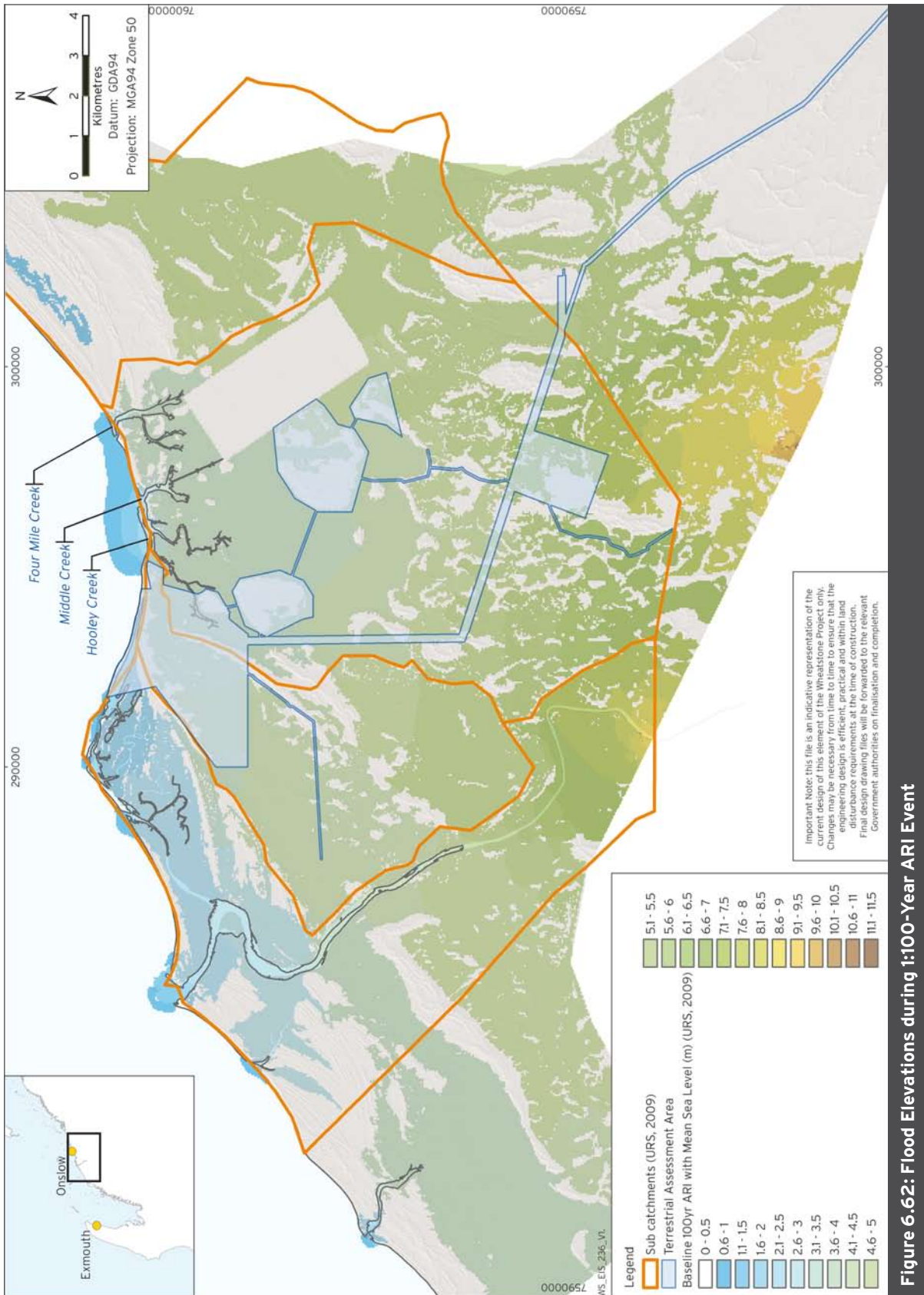


Figure 6.59: Catchments of the Ashburton River Delta







The DoW monitors surface water quality in the Ashburton River at Nanutarra Gauging Station. These data are supported by opportunistic surface water samples collected at Ashburton North by URS (2009) and Biota (Biota and Timms 2009). Surface water sampling locations are shown in Figure 6.63. Results of water quality analyses are presented in the Wheatstone Project Surface Water Studies report, included in Appendix G1.

Salinity

Ashburton River

The Ashburton River is generally fresh, with salinity of about 130 mg/L TDS (Ruprecht and Ivanescu 2000). Salinity generally decreases with increasing flow, becoming more saline during times of low flow.

Ashburton River Delta

The delta is mostly subject to marine tidal influence; hence surface water salinity is generally the same as seawater. However, hypersaline water also exists in areas that do not appear to be efficiently flushed by seawater. In these locations, salt is likely to be accumulated through evaporation processes and/or groundwater discharge. During river flow, salinity in the Ashburton River Delta is influenced by the freshwater run-off. At these times, the delta contains water of lower salinity.

Southwest Catchment

A small portion of the Southwest Catchment receives seawater from the Ashburton Delta during exceptionally high tides. In other parts of this catchment, surface water is sourced from local run-off of low salinity. During flood events, the Ashburton River spills comparatively low salinity fresh flows into this catchment. The catchment contains clay pans within which run-off collects and evaporates over time. As such, salinity of the surface water in the clay pans would increase over time. Salinity measured in a clay pan after a recent rainfall event was approximately half that of seawater (16 700 mg/L). Major ions show a typical marine distribution. Salinity in clay pans subject to tidal influences in March and April 2009 (Biota and Timms 2009) is close to, or above seawater (<41 820 mg/L), while further to the south and away from tidal influences water quality is fresh (200 mg/L), at least in the short term after rainfall.

Hooley Creek Tidal Flats

Hooley Creek tidal flats receive water either from sporadic rainfall events, spring tides and storm surges. Salinity measured in an opportunistic surface water

sample taken from the salt flats was 1.4 times that of seawater (48 700 mg/L), indicating high evaporation rates and concentration of salts.

Shared Infrastructure Corridor

Salinity measured in surface water samples taken from clay pans in February, March and April 2009 along the Shared Infrastructure Corridor is low (30-260 mg/L). These data indicate the samples were fresh local runoff from recent rain events. Salinity in a small creek near the southeast of the Shared Infrastructure Corridor, however, is about ten times seawater (347 000 mg/L).

Accommodation Village Area

Salinity measured in surface water samples taken from clay pans in the vicinity of the Accommodation Village (March 2009) is low (50-100 mg/L), indicating that the sample was predominantly influenced by fresh runoff from recent rain events.

Turbidity

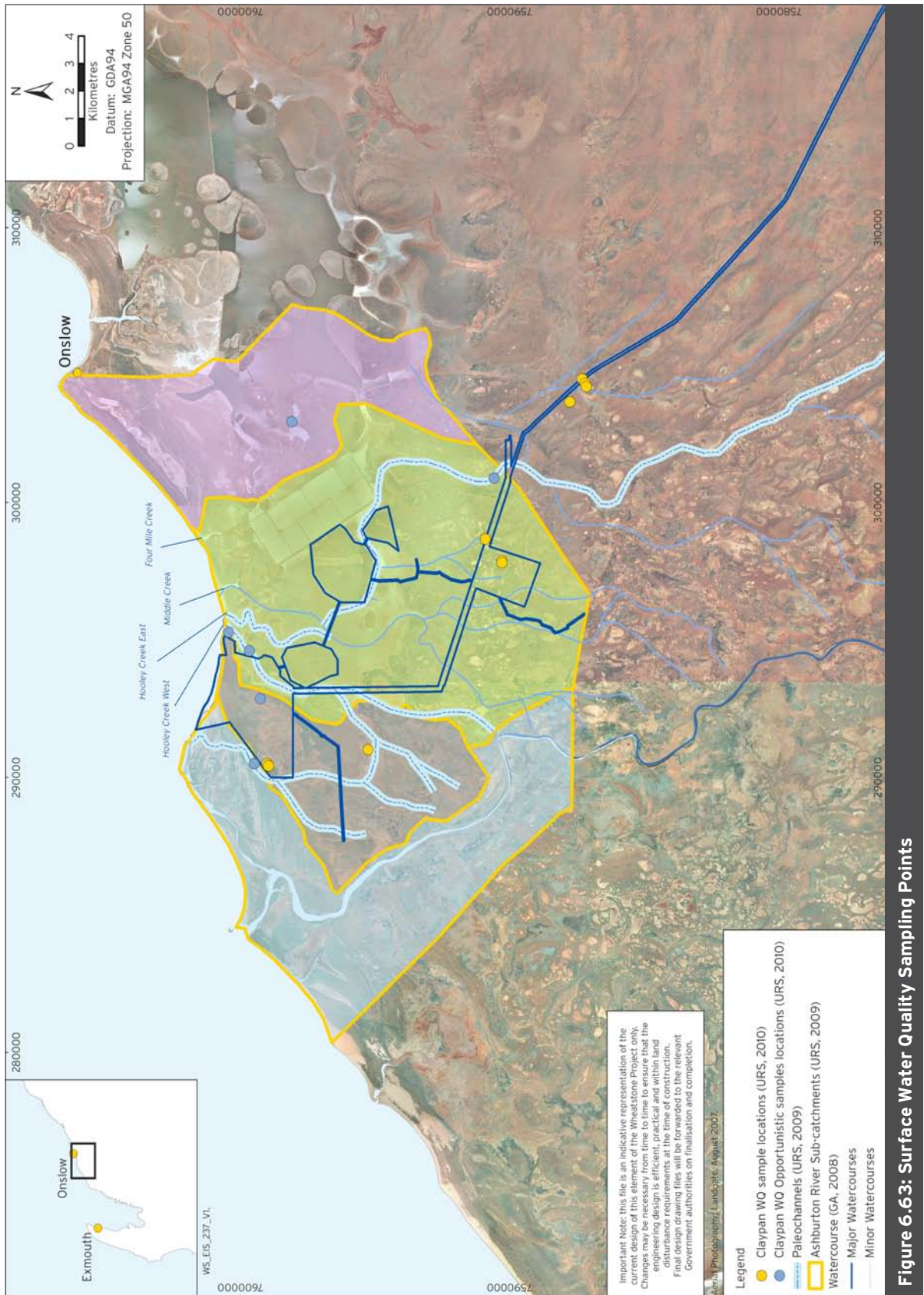
The hinterland of the coast in the Project area is low lying with vast areas of high tidal mud flats and supra-tidal salt flats. It has a highly dynamic coastline that is characterised by an exposed, sandy shore with both depositional and erosional processes ongoing.

Major sources of sediment on the coast include:

- Erosion of salt flats and mud flats by fluvial run-off and tidal creeks after flooding and tidal inundation
- Alluvial sediments discharged by the Ashburton River
- Erosion of dunes and rocky shores by near-shore processes
- Bio-production.

At a more localised scale, tidal creeks play a role in exchanging sediment between the terrestrial and marine environments. Inundation of the coastal wetlands by run-off during floods reinforces ebb currents and may contribute to erosional scour of the wetland margins as water levels fall after peak flows. In places where the flood-tide flows are dominant, the tidal creeks may deposit silty sands and mud on the mud flats.

When in flow, the Ashburton River mobilises sediment. The total annual average sediment load has been calculated to be 1 300 000 tonnes (URS 2009). This load is widely variable from year to year, dependent on river flow.



The total estimated annual sediment load between 1973 and 2008 ranged from 450 tonnes (in 2007 during a time of low rainfall and low flow) to 13 800 000 tonnes (in 1997 during a major flood event). Total TSS and turbidity in the Ashburton River are generally comparatively low, but increase as flows increase. The turbidity for the Ashburton River ranges from less than 10 NTU (about 15 mg/L TSS) at low flows of 30 m³/sec, to 3300 NTU (about 5000 mg/L TSS) at flow rates of 250 m³/sec and higher. The flow-weighted turbidity for Ashburton River is 1705 NTU, which is higher than other Pilbara rivers, which range from 10 to 587 NTU (Ruprecht and Ivanescu 2000). An estimated flow of 500 m³/sec is required for the Ashburton River to break its banks and for flood water to propagate onto the Ashburton North catchments. At this and higher flow rates, TSS concentrations of about 5000 mg/L would be expected.

Turbidity measured in surface waters in clay pans at Ashburton North between February and April 2009 ranged from zero to above 9000 mg/L TSS (Biota and Timms 2009). Notably, turbidity in claypans subject to tidal influences in the Southwest Catchment was comparatively low, at between 0 and 520 mg/L TSS. Conversely, the fresh water claypans in the south of the Southwest Catchment, shared infrastructure corridor and accommodation village site were typically highly turbid, with TSS in excess of 9000 mg/L.

6.4.8 Vegetation and Flora

6.4.8.1 Survey Effort

In order to characterise and map vegetation and flora within the survey area, four baseline vegetation and flora studies were undertaken by Onshore Environmental Consultants (OEC), Biota Environmental Sciences (Biota) in 2008 and 2009 and Outback Ecology Services (OES) in 2010. These comprised:

- A baseline dry season field survey in August 2008 conducted by OEC. This survey covered approximately 405 ha and intended to provide supporting information for vegetation clearing permits.
- A baseline wet season field survey in November 2008 conducted by OEC (2009). The survey covered approximately 2 200 ha and intended to provide supporting information for vegetation clearing permits.
- A baseline field survey in April 2009 following cyclonic rainfall was conducted by Biota (2009). The survey covered approximately 9 700 ha.

- A baseline wet season (below average) field survey in January 2010 conducted by OES (reported in Biota 2010). This survey covered approximately 3 423 ha.

Figure 6.64 shows the areas covered by each survey. The findings of these surveys have been consolidated into two reports. These two reports, along with further detail on the flora and vegetation studies conducted and utilised for the Project Environmental Impact Assessment, are provided in Appendix I1 and Appendix I2.

No field survey has been completed for borrow area 4 and a small section of road to the east of the Project area. However, these vegetation units were extrapolated based on interpretation of aerial photography signatures combined with site data and vegetation mapping for comparable adjacent areas.

Mangroves occur along Hooley Creek and to the north-west of the Project area. The mangroves are discussed in detail as part of the marine habitat descriptions (Section 6.3.8).

6.4.8.2 Vegetation

The studies identified 30 vegetation units within the survey area (OEC 2008; OEC 2009; Biota 2009, Biota 2010). Biota (2009) generally defined the vegetation condition as very good to excellent, as described by Trudgen (1988); however several vegetation units were heavily infested with weeds. Most of the vegetation units are representative of vegetation in the locality, or are substantially degraded by the invasion of buffel grass (*Cenchrus ciliaris*), and are therefore considered to be of low conservation significance (Biota 2009).

No vegetation units of regional significance were identified within the survey area. However, five of the 30 vegetation units are identified by the botanical consultants (Biota) as having some degree of local significance (high or moderate) as they:

- Either support, or potentially support, Threatened Flora, Priority Flora or other flora species of interest
- Are particularly susceptible to erosion and/or weed invasion following disturbance
- Contain a number of poorly recognised species
or
- Are in very good condition, as defined by Trudgen (1988 [Biota 2009]).

Table 6.19 lists the vegetation units of the survey area and whether they are of local conservation significance. Figure 6.65, Figure 6.66 and Figure 6.67 illustrate the mapped vegetation units within the survey area.

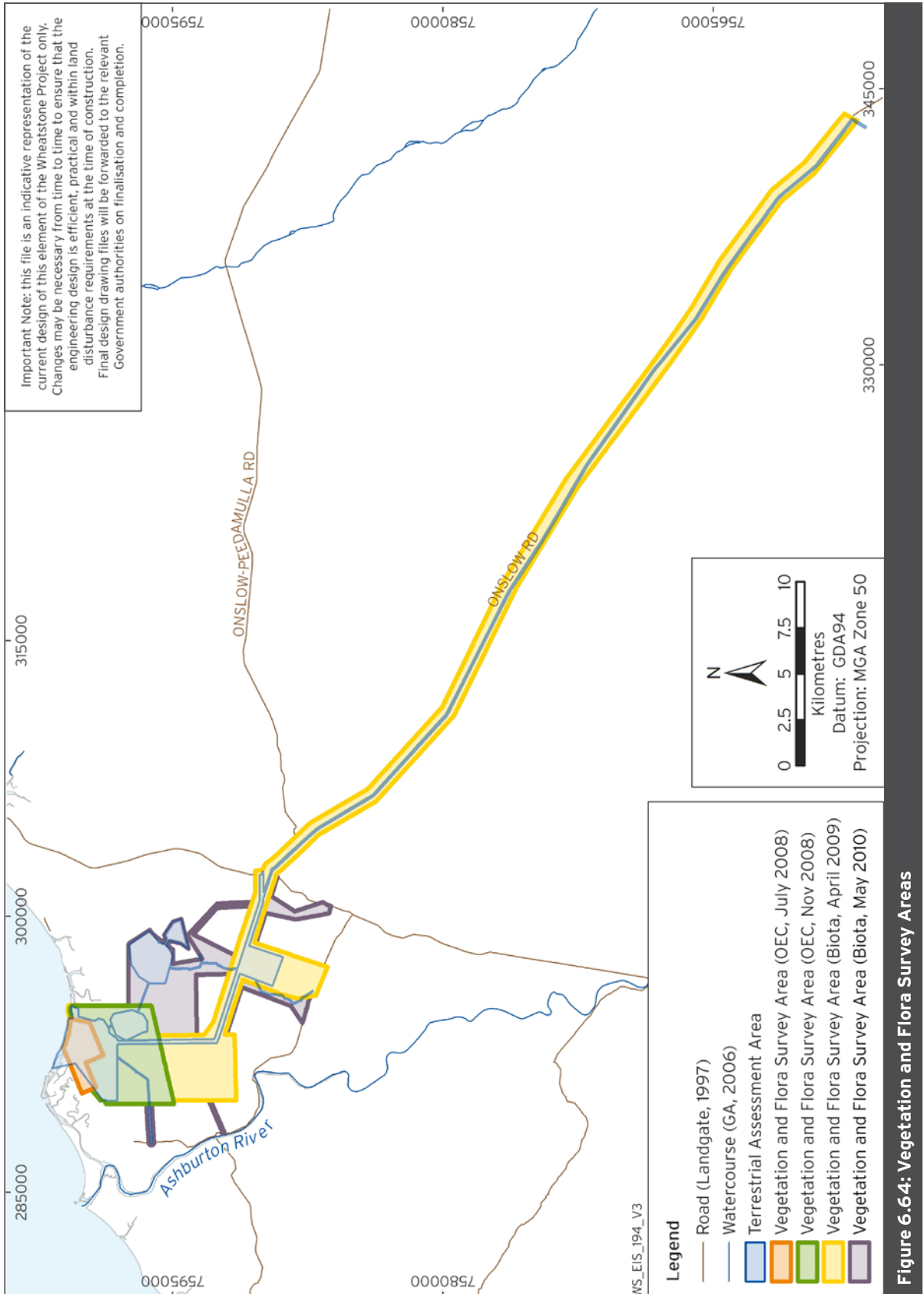


Figure 6.64: Vegetation and Flora Survey Areas

Table 6.19: Vegetation Units of the Survey Area

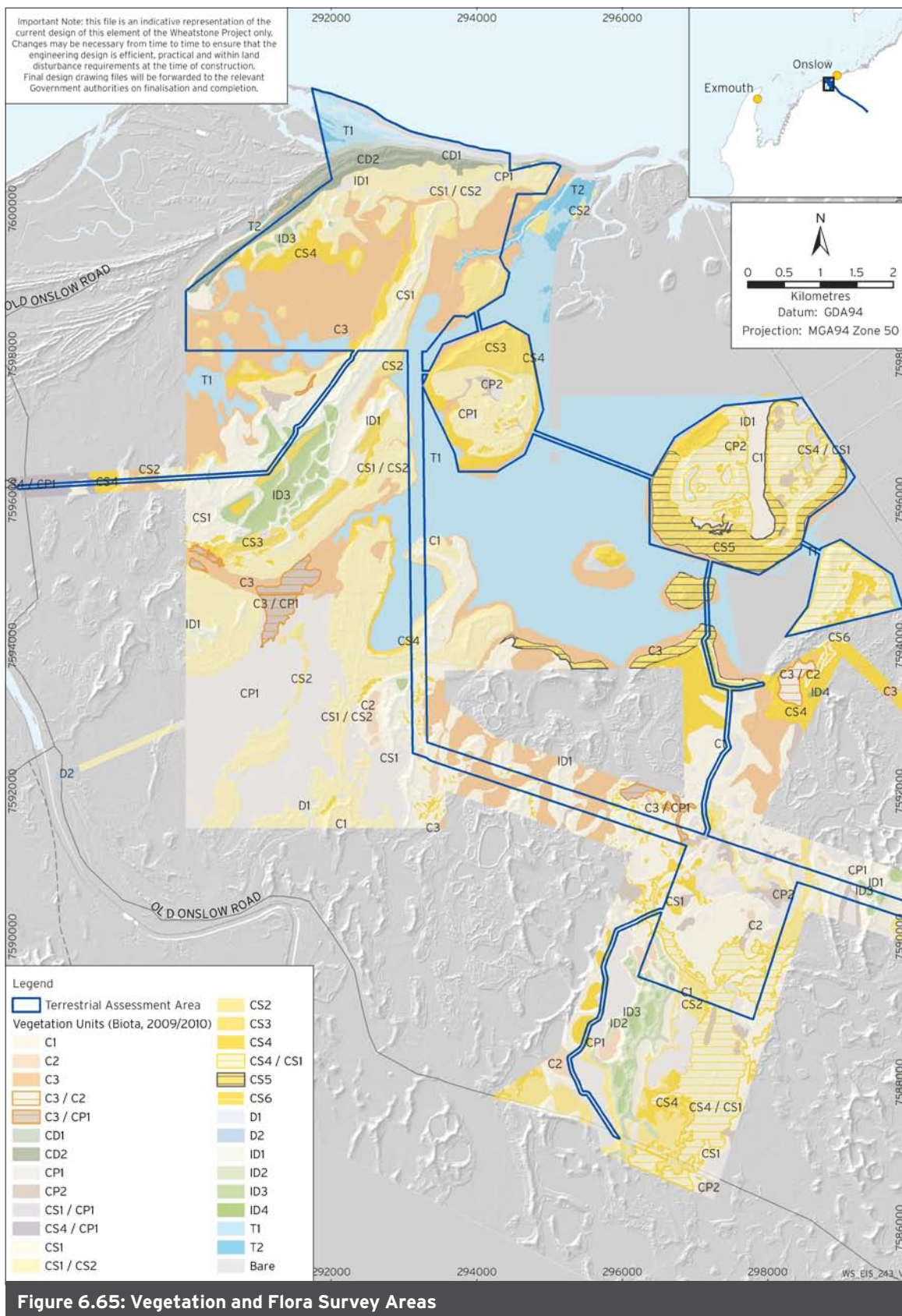
Habitat Type	Vegetation Unit	Local Significance	Vegetation Unit Description
Tidal Mud Flats	T1	Low	<i>Tecticornia</i> spp. scattered low shrubs on mud flats.
	T2	Mangal is generally recognised as being of conservation significance. This vegetation is discussed further in Section 6.3.8.	<i>Avicennia marina</i> open scrub along tidal creeks.
Coastal Sand Dunes	CD1	Low	<i>Acacia coriacea</i> subsp. <i>coriacea</i> , <i>Crotalaria cunninghamii</i> tall shrubland over <i>Spinifex longifolius</i> , with * <i>Cenchrus ciliaris</i> open tussock grassland on foredunes.
	CD2	Low	<i>A. coriacea</i> subsp. <i>coriacea</i> tall shrubland over <i>C. cunninghamii</i> , <i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i> open shrubland over <i>Triodia epactia</i> open hummock grassland with * <i>C. ciliaris</i> open tussock grassland on near-coastal dunes.
Inland Sand Dunes	ID1	This unit is considered to be of High conservation significance as it potentially supports Priority Flora (<i>Eremophila forrestii</i> subsp. <i>viridis</i> and <i>Triumfetta echinata</i>), species of interest (<i>Aenictophyton</i> aff. <i>reconditum</i>), and the dune features would also be particularly susceptible to erosion and weed invasion following disturbance to the soil profile.	<i>Grevillea stenobotrya</i> tall open shrubland over <i>C. cunninghamii</i> , <i>T. zeylanicum</i> var. <i>grandiflorum</i> open shrubland over <i>T. epactia</i> open hummock grassland on red sand dunes.
	ID2	This unit is considered to be of High conservation significance as it potentially supports Priority Flora (<i>Eremophila forrestii</i> subsp. <i>viridis</i> and <i>Triumfetta echinata</i>), species of interest (<i>Aenictophyton</i> aff. <i>reconditum</i>), and the dune features would be particularly susceptible to erosion and weed invasion following disturbance to the soil profile.	<i>G. stenobotrya</i> tall open shrubland over <i>C. cunninghamii</i> , <i>Hibiscus brachychlaenus</i> open shrubland over <i>Triodia schinzii</i> , (<i>T. epactia</i>) open hummock grassland on red sand dunes.
	ID3	Low	<i>Acacia stellaticeps</i> shrubland over <i>T. epactia</i> hummock grassland in swales.
	ID4	This unit is considered to be of High conservation significance as it potentially supports Priority Flora (<i>Eremophila forrestii</i> subsp. <i>viridis</i> and <i>Triumfetta echinata</i>), species of interest (<i>Aenictophyton</i> aff. <i>reconditum</i>), and the dune features would be particularly susceptible to erosion and weed invasion following disturbance to the soil profile.	<i>Grevillea stenobotrya</i> tall open shrubland with <i>Acacia stellaticeps</i> over <i>Triodia epactia</i> and * <i>Cenchrus ciliaris</i> open tussock grassland.

Coastal Sand Plains	CS1	Low	Acacia tetragonophylla scattered shrubs over T. epactia hummock grassland occurring broadly over sandy plains.
	CS2	Low	A. tetragonophylla scattered shrubs over T. epactia hummock grassland with *C. ciliaris open tussock grassland occurring on sandy plains, particularly fringing claypans.
	CS3	Low	A. tetragonophylla scattered shrubs over Scaevola pulchella, Indigofera monophylla low open shrubland over T. epactia hummock grassland on areas of calcrete.
	CS4	Low	*P. pallida, A. tetragonophylla, Acacia synchronicia scattered tall shrubs over T. epactia very open hummock grassland and *C. ciliaris open tussock grassland in scalded areas.
	CS5	Low	*P. pallida, Acacia sclerosperma subsp. sclerosperma, A. tetragonophylla scattered tall shrubs over Triodia epactia and *Cenchrus ciliaris open tussock grassland
	CS6	Low	*P. pallida scattered tall shrubs to open shrubland over A. tetragonophylla, A. Bunburyana shrubs over T. epactia open hummock grassland and *C. ciliaris open tussock grassland in scalded areas
Claypans	C1	Low	Bare claypan.
	C2	Low	Eriachne aff. benthamii open tussock grassland in claypans.
	C3	This unit is of High conservation significance as it potentially contains a number of poorly recognised samphire species, with their distribution difficult to determine in the region. This vegetation unit also potentially supports the Threatened Flora species Eleocharis papillosa.	Tecticornia spp. low shrubland in saline claypans.
	C4	Low (Cont'd)	*P. pallida, A. bunburyana open shrubland over T. epactia open hummock grassland and *C. ciliaris open tussock grassland.

Habitat Type	Vegetation Unit	Local Significance	Vegetation Unit Description
Clayey Plains	CP1	This unit is considered to be of Moderate conservation value, being generally in very good condition and supporting a suite of species specific to this substrate.	<i>Sporobolus mitchellii</i> , <i>Eriachne</i> aff. <i>benthamii</i> , <i>E. benthamii</i> , <i>Eulalia aurea</i> tussock grassland on low-lying clayey plains.
	CP2	Low	* <i>P. pallida</i> scattered tall shrubs to tall open shrubland over <i>A. tetragonophylla</i> , * <i>Vachellia farnesiana</i> shrubland over <i>E. aurea</i> , <i>Chrysopogon fallax</i> , <i>S. mitchellii</i> tussock grassland within drainage depressions in low-lying clayey plains.
	CP3	Low	<i>Acacia xiphophylla</i> tall shrubland over <i>T. epactia</i> open hummock grassland on clayey plains.
	CP4	Low	<i>A. xiphophylla</i> tall shrubland over <i>Triodia lanigera</i> open hummock grassland on elevated areas of clayey plains.
	CP5	Low	<i>A. xiphophylla</i> tall open shrubland over <i>Triodia brizoides</i> very open hummock grassland.
Inland Sand Plains	IS1	Low	<i>Corymbia hamersleyana</i> scattered low mallees over <i>Acacia ancistrocarpa</i> , <i>A. bivenosa</i> shrubland over <i>T. lanigera</i> hummock grassland occurring broadly over inland sandy plains.
	IS2	Low	<i>Acacia inaequilatera</i> tall open shrubland over <i>A. ancistrocarpa</i> open shrubland over <i>T. lanigera</i> open hummock grassland on slightly elevated areas of inland sandy plains.
Stony Hills	H1	Low	<i>A. inaequilatera</i> tall open shrubland over <i>T. lanigera</i> , <i>T. brizoides</i> open hummock grassland on stony hills.

Drainage Areas	D1	Low	<i>Eucalyptus victrix</i> open forest over <i>E. aurea</i> , * <i>C. ciliaris</i> tussock grassland in tributary of Ashburton River.
	D2	Low	<i>E. victrix</i> scattered low trees over <i>A. synchronica</i> , <i>A. bivenosa</i> shrubland over <i>T. epactia</i> hummock grassland in broad ill-defined drainage through clayey plain.
	D3	Low	<i>Corymbia hamersleyana</i> scattered low mallees over <i>Acacia tumida</i> var. <i>pilbarensis</i> , <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> tall open shrubland over <i>A. ancistrocarpa</i> open shrubland over <i>T. epactia</i> , <i>T. lanigera</i> open hummock grassland.
	D4	Low	<i>E. victrix</i> low trees over <i>A. tetragonophylla</i> , <i>A. synchronica</i> tall shrubland over <i>Hibiscus brachychaenus</i> shrubland over tussock grassland of * <i>C. ciliaris</i> .

* denotes introduced flora species



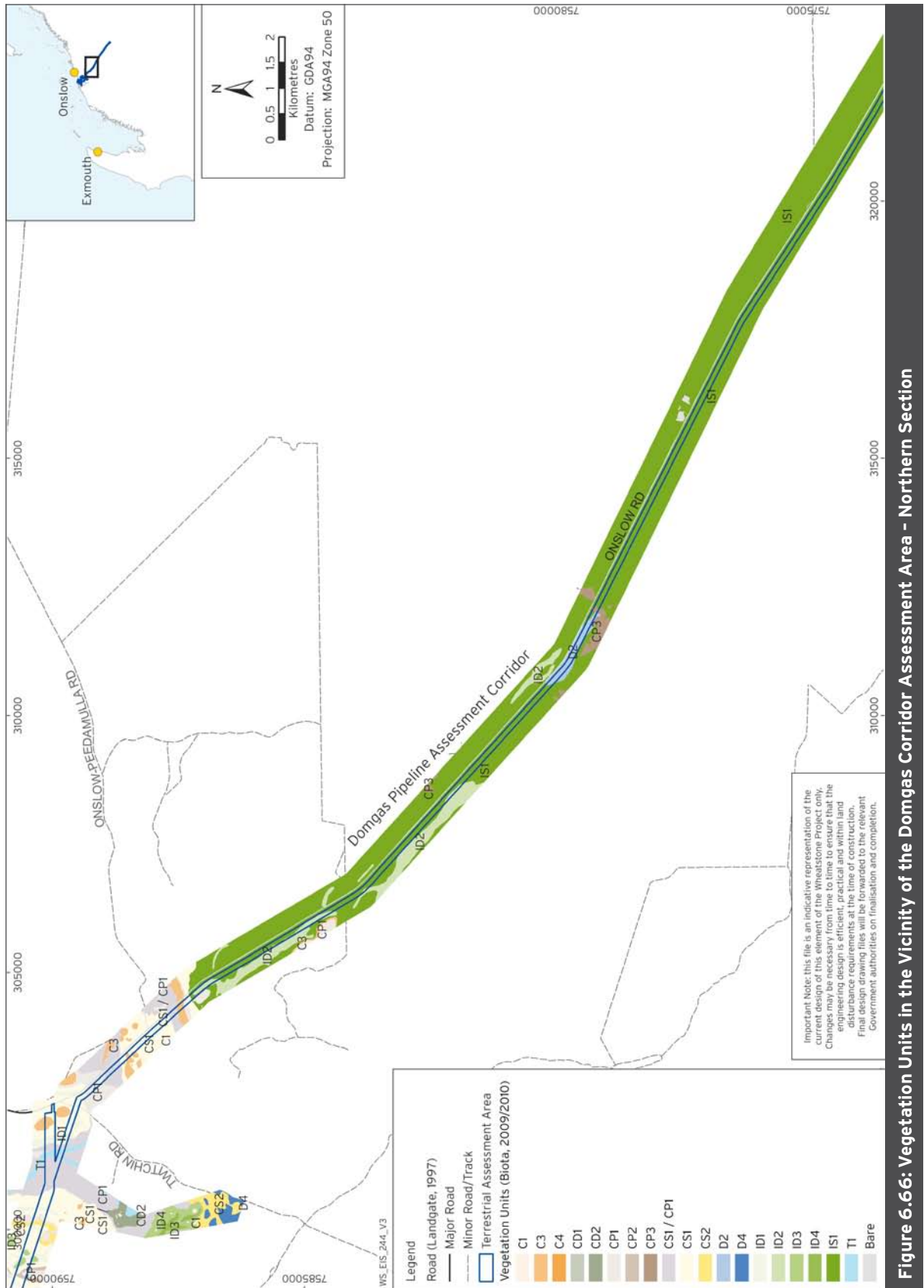


Figure 6.66: Vegetation Units in the Vicinity of the Domgas Corridor Assessment Area - Northern Section



Figure 6.67: Vegetation Units in the Vicinity of the Domgas Corridor Assessment Area - Northern Section

6.4.8.3 Threatened Ecological Communities

No TECs listed under the EPBC Act (Cth) or the WC Act (WA) occur in the survey area. No PECs listed by the DEC occur in the survey area.

Mangroves within the Ashburton Delta are considered regionally significant and are discussed in Section 6.3.8.

6.4.8.4 Groundwater Dependant Vegetation

None of the 25 vegetation units are likely to comprise ecosystems entirely dependent on groundwater, with the majority of species sourcing their water requirements from the unsaturated zone of the soil profile (Biota 2009). Notwithstanding this, three species have been identified that have some degree of groundwater dependency. These are:

- River Red Gum (*Eucalyptus camaldulensis*)
- Silver Cadjebut (*Melaleuca argentea*)
- Coolibah (*Eucalyptus victrix*).

The River Red Gum and Silver Cadjebut are the only potentially truly groundwater dependent species found in the area. They are deep-rooted and source the majority (or all) of their water requirements from groundwater. However, both of these species were only recorded as very occasional individuals in areas of ponding water adjacent to Onslow Road.

The Coolibah is generally believed to source its water requirements from the soil profile above the water table, however larger trees may source most (or all) of their water from the groundwater system. Coolibah trees greater than 10 m in height were observed within vegetation unit D1 (Figure 6.65).

6.4.8.5 Flora

A total of 422 taxa of native vascular plants from 161 genera belonging to 58 families have been recorded from the survey area (Biota 2009). These numbers include:

- 338 native taxa from 141 genera and 53 families, and 12 introduced flora species recorded during the Biota April 2009 survey
- 232 native taxa from 130 genera and 50 families, and seven introduced flora species recorded from the northern section of the LNG and domgas plant survey area by OEC (2008 and 2009). This number included over 60 taxa not recorded by Biota:
 - Over 60 per cent of these additional taxa were annual or weakly perennial species, including 10 daisy species (family Asteraceae), which would not have been present at the time of the Biota 2009

surveys but would be expected to be recorded following winter rainfall

- The remainder of the species were perennial shrubs, which are probably sporadically distributed in the locality, and would not necessarily have been encountered during the largely spot-sampling work conducted in 2009
- 66 native taxa from 46 genera and 21 families and two introduced flora species recorded from four quadrats assessed in the area by RPS (2009). This number included three taxa of perennial low shrubs not recorded by Biota.

One threatened species, the Dwarf Desert Spike-rush (*Eleocharis papillosa* [listed as Vulnerable under the EPBC Act (Cth)]) was recorded from a single location within the survey area. This species was located within samphire shrub land vegetation (C3) within a tidally influenced creek along the Onslow Road.

Figure 6.68 illustrates the other recorded locations of *E. papillosa* within Australia.

A search for additional individuals of this species adjacent to the LNG and domgas plant area (within the survey area but outside the Project area) was conducted by OEC in September 2009. No plants were located, however the search was not conducted during the preferred season for locating this species in the field, and its small size and seasonal growth habit can make it very difficult to observe. Biota (2009) considers that the species is likely to occur throughout this particular creek habitat and potentially further throughout the survey area.

No other flora species listed under the EPBC Act (Cth) have been recorded in the Onslow locality or are expected to occur in the habitats present in the survey area.

No species listed as DRF under the WC Act (WA) were recorded from the survey area, nor are they likely to occur based on the habitats present (Biota 2009).

Five Priority flora species were recorded during the surveys. These are listed in Table 6.20 and their locations are shown in Figure 6.69. Appendix I1 and Appendix I2 provides more detail of threatened flora species recorded and potentially found in the survey area.

While not formally listed as DRF or Priority flora, other species may be considered to be of conservation interest if they represent apparently new (undescribed) taxa, are poorly collected, or if the record represents a considerable range extension. Table 6.21 lists the flora species that are considered to be undescribed taxa of conservation interest.

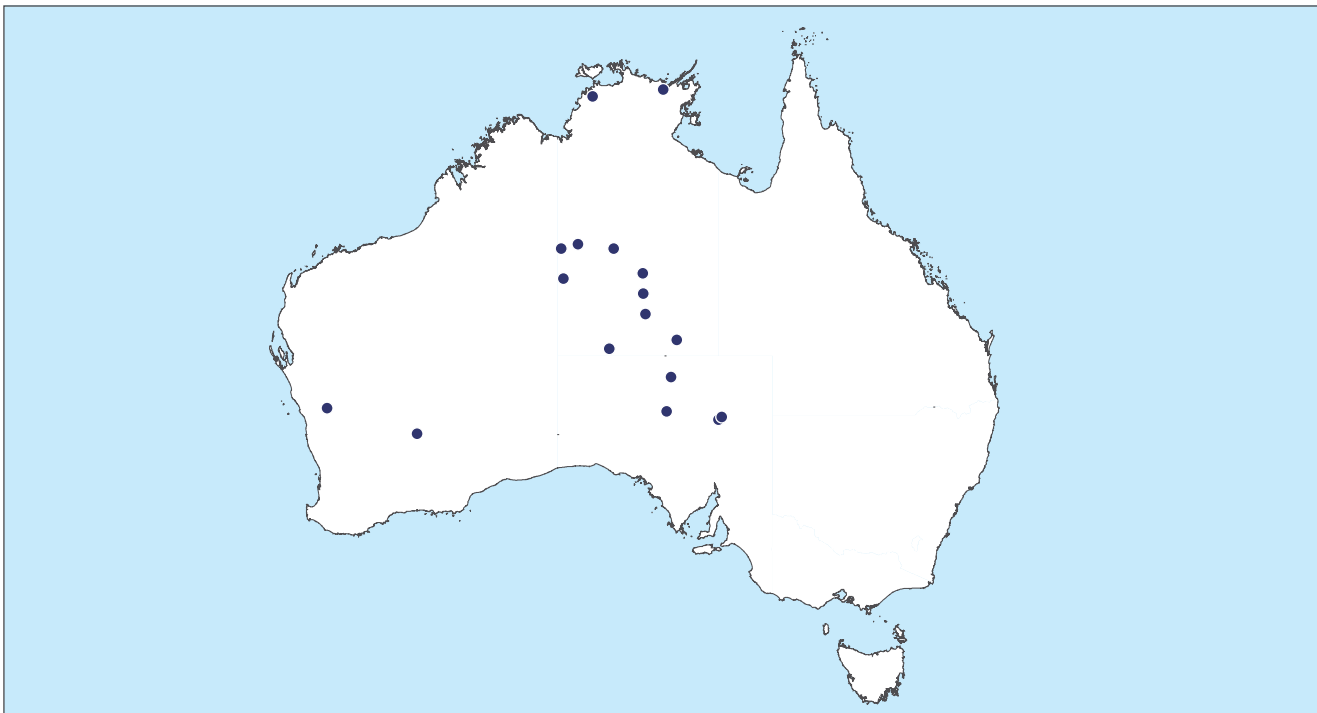


Figure 6.68: Distribution Map of *Eleocharis papillosa*

Source: Biota 2009

Table 6.20: Priority Flora Recorded in the Survey Area

Species	Status	Locations within the Survey Area
<i>Abutilon uncinatum</i> ms	Priority 1	Recorded at a single location in the domestic gas pipeline corridor. The known distribution of this low shrub extends over 65 km ² in the north-western corner of the Pilbara bioregion, with an outlying population approximately 120 km south-south-west of the survey area in the Carnarvon bioregion.
<i>Eleocharis papillosa</i>	Priority 3 (Vulnerable - EPBC Act)	Recorded from a single location within the survey area. This species was located within samphire shrubland vegetation (C3) within a tidally influenced creek along the Onslow Road. Figure 6.68 shows the recorded locations of <i>E. papillosa</i> .
<i>Atriplex flabelliformis</i>	Priority 3	Recorded from five locations in the southern plant area and surrounds and within the SIC. Additional populations have been recorded at several locations within the Pilbara and Kimberley regions.
<i>Eremophila forrestii</i> subsp. <i>viridis</i>	Priority 3	Recorded in 20 locations within the survey area. At least three records have also been noted of this taxa outside of the survey area.
<i>Triumfetta echinata</i>	Priority 3	Recorded in 30 locations throughout the survey area. Biota (2009) noted that this species have also been recorded at a number of locations outside the survey area.

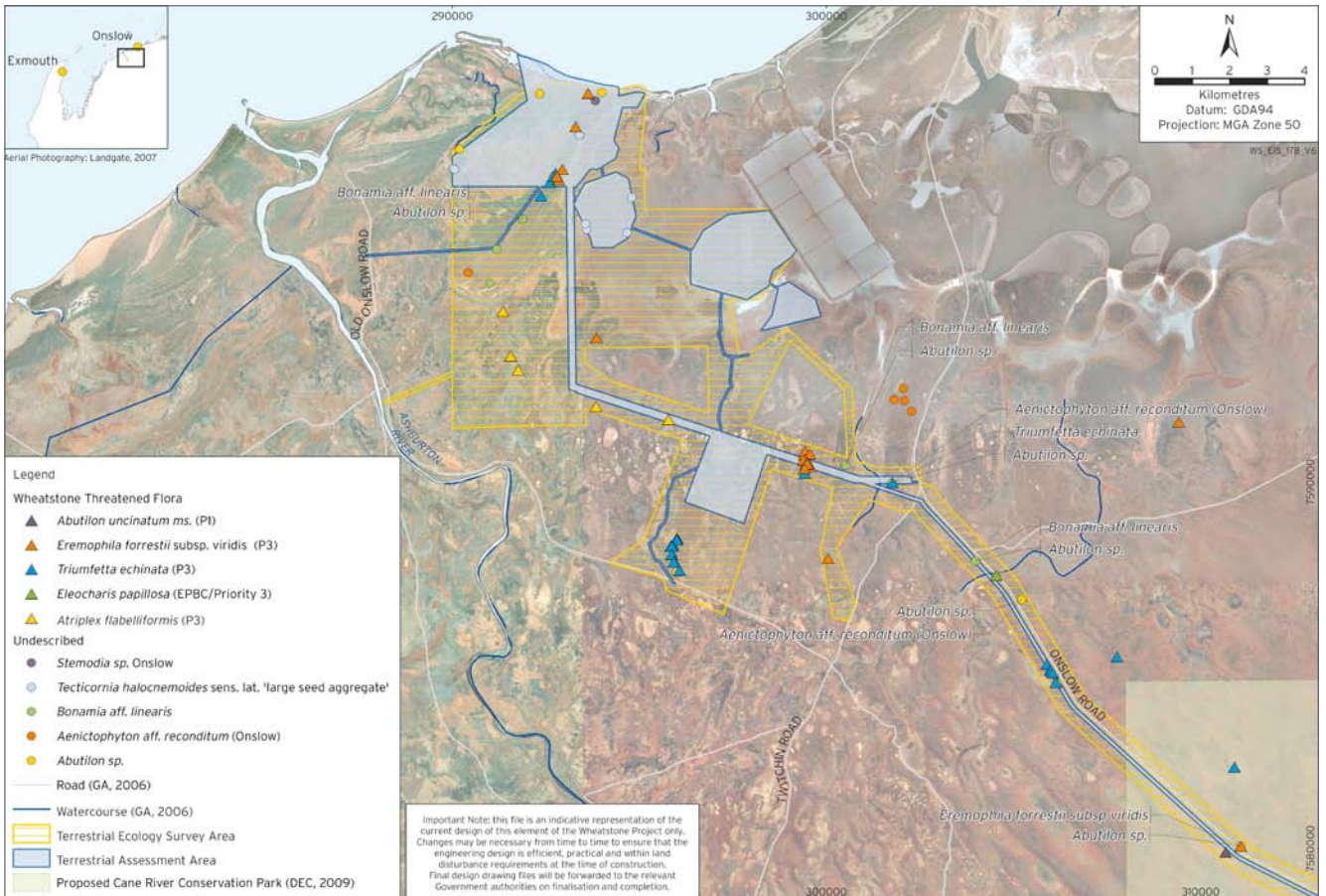


Figure 6.69: Priority and Conservation-significant Flora Recorded in the Study Area

Numerous plant groups in the Pilbara are poorly resolved at this time and include the genera *Abutilon*, *Bonamia*, *Eriachne*, *Euphorbia*, *Polygala*, *Sida* and *Triumfetta*. Undescribed taxa recorded during the vegetation and flora studies, other than those listed in Table 6.21, have been recorded more widely in the Pilbara region.

Several species recorded in the survey area represent range extensions of known flora populations. These species are discussed further in Appendix I1.

Table 6.22 and Table 6.23 provide definitions of the codes used for classification of threatened flora in WA and under the EPBC Act (Cth) respectively.

6.4.8.6 Introduced Flora

Twelve introduced flora species (weeds) were recorded in the survey area. Of these, two are listed as Declared Plants under the *Agriculture and Related Resources Protection Act 1976*– *Parkinsonia* (*Parkinsonia aculeata*) and Mesquite (*Prosopis pallida*).

Parkinsonia is listed as P1 (movement of plants or their seeds prohibited) and P2 (eradicate infestation to destroy and prevent propagation each year until no plants remain) for the Carnarvon and Exmouth districts. *Parkinsonia* is also listed as a “Weed of National Significance” by Thorp and Lynch (2000).

All *Prosopis* species are Declared Plants under the *Agriculture and Related Resources Protection Act 1976*, and listed as P1 and P2 for the Onslow locality.

Of the 12 introduced flora species recorded in the survey area, five were widespread (Biota 2009). These are:

- Mesquite (*Prosopis pallida*)
- Mimosa Bush (*Vachellia farnesiana*)
- Buffel Grass (*Cenchrus ciliaris*)
- Birdwood Grass (*Cenchrus setiger*)
- Purslane (*Portulaca oleracea*).

Table 6.21: Flora of Conservation Interest Recorded in the Study Area

Species	Significance	Locations within the Survey Area
<i>Aenictophyton aff. reconditum</i> (Onslow)	This undescribed pea appears to be restricted to sand dune habitats in the Onslow locality. This taxon has also been recorded at several other locations in the Onslow locality, though is not common in the area.	Recorded in seven locations on dunes of the survey area.
<i>Tecticornia</i> spp. (samphires).	Samphires are notoriously problematic to identify and have a tendency to be under-collected, as many appear superficially the same. Samphire specimens from survey area were identified as far as possible by the WA Herbarium who indicated that as many as nine different taxa may be represented within the sterile material collected, although some may be referable to existing named taxa or to each other. This includes undescribed taxa within the <i>T. halocnemoides</i> sens. lat. "large seed aggregate" at 12 locations.	The 12 locations of <i>T. halocnemoides</i> sens. lat. "large seed aggregate" were recorded from the LNG plant site and borrow area 2.
<i>Abutilon</i> sp.	Currently undescribed taxa that was matched to an indeterminate specimen at the WA Herbarium, also recorded near Onslow.	<i>Abutilon</i> sp. were recorded from 12 locations within the domgas pipeline corridor and the SIC.
<i>Bonamia aff. linearis</i>	This taxa had winged seeds, which is supposedly not a character of <i>B. linearis</i> in the typical sense (Jessop 1981).	<i>Bonamia aff. linearis</i> were recorded from nine locations within the domgas pipeline corridor and the SIC.
<i>Stemodia</i> sp. Onslow	This species has been recorded at several locations within the Pilbara, Gascoyne and Carnarvon regions.	Recorded in one location within the north-eastern section of the LNG plant site with 2 per cent cover recorded.

Table 6.22: Conservation Codes Used for Classification of Threatened Flora in Western Australia

The Department of Environment and Conservation Declared Rare and Priority Flora List for Western Australia	
Conservation Codes	
R: Declared Rare Flora - Extant Taxa	Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
X: Declared Rare Flora - Presumed Extinct Taxa	Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
1: Priority One - Poorly known Taxa	Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
2: Priority Two - Poorly Known Taxa	Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
3: Priority Three - Poorly Known Taxa	Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.
4: Priority Four - Rare Taxa	Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Note: The need for further survey of poorly known taxa is prioritised into the three categories depending on the perceived urgency for determining the conservation status of those taxa, as indicated by the apparent degree of threat to the taxa based on the current information.

Table 6.23: Conservation Codes Used for Classification of Threatened Flora under the EPBC Act 1999

Status	Code	Definition
Extinct	X	There is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	XW	It is known only to survive in cultivations, in captivity or as a naturalised population well outside its past range, or It has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	CE	It is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	E	It is not critically endangered; and It is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	V	It is not critically endangered or endangered; and It is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependant	CD	The species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered OR The following subparagraphs are satisfied: <ul style="list-style-type: none"> • The species is a species of fish • The species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised • The plan of management is in force under a law of the Commonwealth or of a State or Territory • Cessation of the plan of management would adversely affect the conservation status of the species.

The most common introduced flora identified in the survey area were Buffel Grass and Mesquite (Biota 2009). The vegetation units worst affected by introduced flora were CD2, CS2 and CS4 with Birdwood Grass and Mimosa Bush scattered throughout these units. The vegetation units of the clayey plains towards the northern end of the domgas pipeline corridor (CP1 to CP5) also contained Mesquite, with Buffel Grass along the verges of Onslow Road. Figure 6.70 shows the location of major introduced flora infestations within the survey area. Mesquite, Mimosa Bush, Buffel Grass and Birdwood Grass are found extensively throughout the survey area and have not been mapped.

6.4.9 Fauna

6.4.9.1 Vertebrate Fauna

Two vertebrate fauna studies were conducted for the Project. A Level 2 baseline terrestrial vertebrate fauna study was conducted in April 2009 by Biota (2009a). A migratory waterbird study was conducted in November 2008 and March 2009 by Bamford (2009). An additional six fauna surveys have been conducted in the area, with the results of these surveys providing useful contextual information on the local fauna diversity.

The findings of these studies are summarised below, with additional detail provided in Appendices J1 and K1.

Vertebrate Fauna Studies

Biota (2009a) recorded a total of 128 vertebrate fauna species in the survey area comprising 47 reptile species, four frog species, 60 bird species and 17 mammal species. Appendix J1 provides further information on the species recorded in the area.

Six fauna species of conservation significance, or secondary signs of these species, were recorded in the survey area, comprising:

- Little Northern Freetail Bat (*Mormopterus loriae cobourgensis* [Priority 1])
- Australian Bustard (*Ardeotis australis* [Priority 4])
- Western Pebble-mound Mouse (*Pseudomys chapmani* [Priority 4])
- Rainbow Bee-eater (*Merops ornatus* [Migratory])
- Fork-Tailed Swift (*Apus pacificus* [Migratory])
- White-bellied Sea Eagle (*Haliaeetus leucogaster* [Migratory]).

Searches of the DEC’s Threatened Fauna Database, the NatureMap database and the EPBC Act (Cth) Protected Matters database returned an additional nine listed species that may occur in the survey area. The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantius*) was listed in database searches but is not considered further due to the lack of suitable cave roosts sites in the survey area (Biota 2009a). The Northern Quoll (*Dasyurus hallucatus*) was also listed in database searches but is not considered further as none of the core land systems in which it occurs are present in the survey area. There are also no records of the Northern Quoll from previous surveys in the locality (Biota 2009a). Table 6.24 lists the threatened species present or potentially occurring in the area, discusses their status and the likelihood of them occurring in the survey area.

Database searches also indicated that an additional ten bird species listed as Migratory under the EPBC Act (Cth) could potentially occur in the area. None of the additional ten database-listed migrants are associated with or dependent on the terrestrial habitats of the Project area and are therefore not discussed further in this EIS/ERMP.

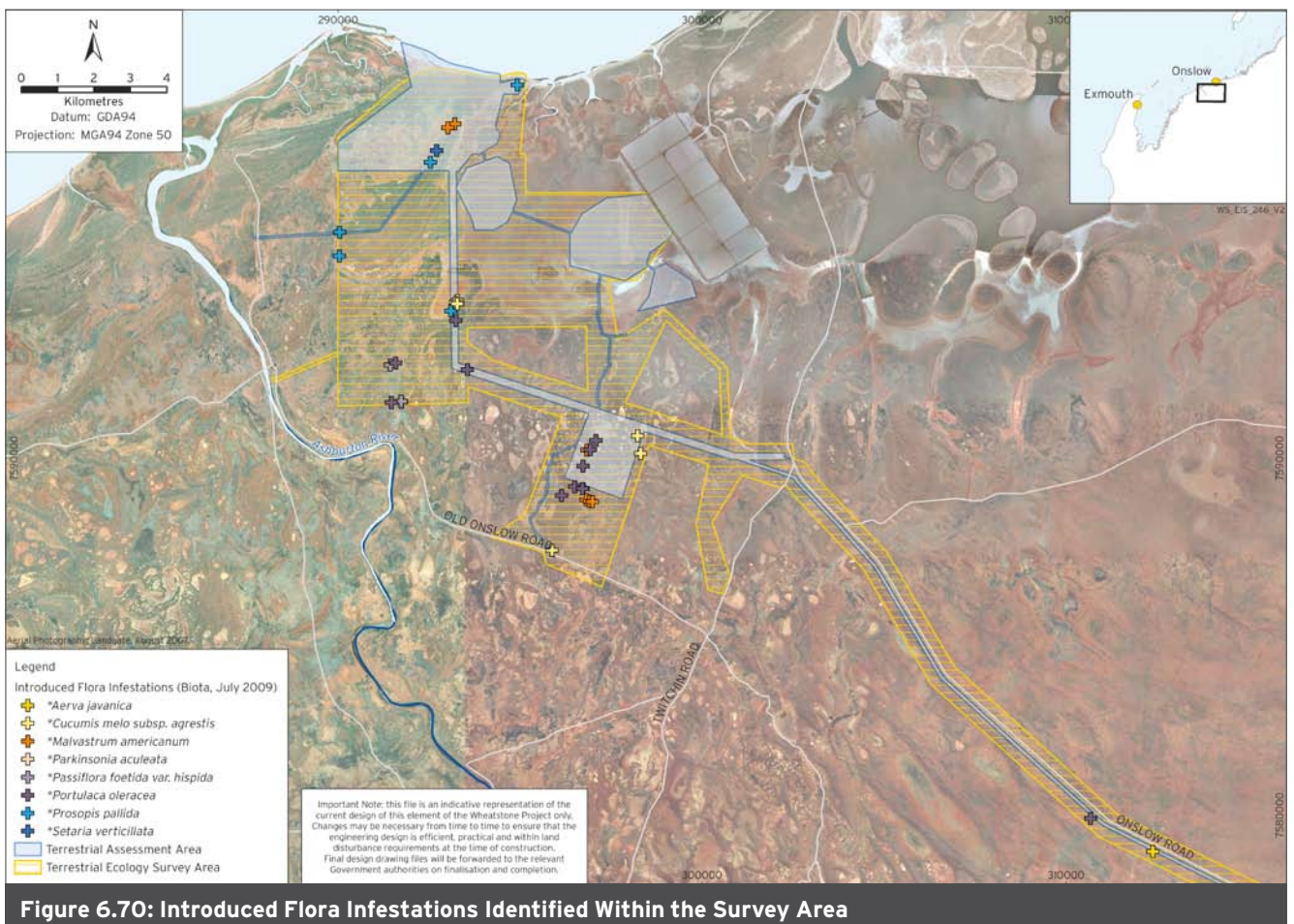


Figure 6.70: Introduced Flora Infestations Identified Within the Survey Area

Table 6.2.4: Threatened Fauna Present or Potentially Occurring in the Survey Area

Species	Conservation Significance		Ecology	Distribution	Likelihood of Occurrence in the Survey Area
	State	Federal			
Night Parrot (<i>Pezoporus occidentalis</i>)	Schedule 1, Endangered	Critically Endangered	Night Parrots typically inhabit areas where there is dense, low vegetation, which provides them shelter during the day. Most records come from hummock grasslands with spinifex (<i>Triodia</i> spp.), from areas dominated by samphire or, particularly, where these two habitats are juxtaposed.	Night Parrots have been reported from every state on the Australian mainland. Suitable habitat occurs, or has occurred, across most of the inland, covering at least half of the continent. Records are sparsely distributed; however, there do appear to be concentrations of records in western Queensland and the eastern Pilbara (Higgins 1999). This species was last recorded in the vicinity of the survey area in 1967 near Mount Stuart, approximately 40 km east of the Northwest Coastal Highway approximately 80 km south east of the proposed LNG plant site.	Highly unlikely: The Night Parrot is highly unlikely to occur within the survey area due to a lack of preferred habitat and the level of feral predator activity and the period since the last reliable sighting in the west Pilbara (over 40 years).
Peregrine Falcon (<i>Falco peregrinus</i>)	Schedule 4	-	The Peregrine Falcon is a relatively long-lived species, with low reproductive rates and low population density. This species inhabits a wide range of habitats including forest, woodlands, wetlands and open country (Pizzey and Knight 1997).	The Peregrine Falcon has an almost cosmopolitan distribution, but is absent from most deserts and the Nullarbor Plain (Johnstone and Storr 1998).	Possible: Not recorded in the survey area. It is possible that the area falls within the home range of this species and it may periodically be present, although no birds were observed within the vicinity of the survey area, which it would require for nesting sites.

Little Northern Freetail Bat (<i>Mormopterus loriae cobourgensis</i>)	Priority 1	-	This species is a mangrove specialist, restricted to mangrove forest and adjacent areas (Churchill 1998). Individuals emerge early in the evening in groups of up to 100 above the mangrove canopy, before dispersing to forage alone or in pairs. <i>M. loriae</i> prey on insects above and beside the forest canopy. They give birth to single young, which are born in the wet season (summer) (Churchill 1998).	Endemic to Australia, this species' distribution encompasses the WA coastal areas from Derby to the Exmouth Gulf (Churchill 1998).	Present: This species was recorded in the survey area via echolocation call.
Long-tailed Dunnart (<i>Sminthopsis longicaudata</i>)	Priority 4	-	This species typically occurs on plateaus near breakaways and scree slopes, and on rugged boulder-strewn scree slopes.	Inhabits the Pilbara and adjacent upper Gascoyne region, and east to the central Northern Territory and South Australia (Menkhorst and Knight 2001).	Possible: Not recorded in the survey area. This species has been recorded near Onslow by the Western Australian Museum and could potentially occur within the survey area. However, it is restricted to its preferred specific habitat, of which there is very little within the survey area.
Brush-tailed Mulgara (<i>Dasymercus blythi</i>)	Priority 4	-	Inhabits spinifex grasslands, and feeds on a diet of small vertebrates and larger invertebrates. Little is known about the breeding of Brush-tailed Mulgara, although research shows that females with up to six young in the pouch have been captured in September.	Occurs across the arid zone of WA, the Northern Territory and Queensland. Mulgara were formerly widespread in sandy deserts but they are now rare and patchily distributed, although known to occur in the Pilbara.	Possible: There are no records of Mulgara from the survey area within the Western Australian Museum FaunaBase database or the DEC Threatened and Priority fauna database. However, the Brush-tailed Mulgara may potentially occur within the survey area based on its broader distribution.

Species	Conservation Significance		Ecology	Distribution	Likelihood of Occurrence in the Survey Area
	State	Federal			
Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>)	Priority 4	-	Found on stony hillsides with hummock grasslands (Menkhorst and Knight 2001) and well known for its behaviour of constructing extensive mounds of small stones covering areas from 0.5 to 9.0 m ² (Van Dyck and Strahan 2008). Mounds are most common on spurs and gentle slopes where suitably sized stones are present.	Confined to the central and eastern Pilbara (Menkhorst and Knight 2001), although common to very common in suitable habitat within the Hamersley and Chichester subregions of the Pilbara bioregion.	Likely: No individuals were collected within the survey area, although an abandoned mound was recorded within the survey area at the eastern end of the domgas pipeline corridor .
Short-tailed Mouse (<i>Leggadina lakedownensis</i>)	Priority 4	-	The primary mainland habitat for this species comprises areas of cracking clay and adjacent habitats, although it has also been recorded from hilltops (Kendrick 2003) and sandy coastal areas near Onslow.	Since 1997, the number of records of this species has increased substantially, such that it has now been recorded extensively in the Pilbara (Biota database). In WA, the distribution of this species includes the Pilbara and Kimberley regions (Menkhorst and Knight 2001).	Likely: Although not recorded during the recent survey, <i>L. lakedownensis</i> has been recorded in the vicinity during previous surveys.
Australian Bustard (<i>Ardeotis australis</i>)	Priority 4	-	Prefers open or lightly wooded grassland, including <i>Triodia</i> sp. sandplains, and is considered scarce to common depending on season and habitat (Johnstone and Storr 1998).	Occurs over much of WA, with the exception of the more heavily wooded southern portions of the State.	Present: Was recorded on four occasions at a single site within the survey area. Records from previous surveys demonstrate that this bird is relatively common within the area.
Bush Stone-curlew (<i>Burhinus grallarius</i>)	Priority 4	-	Nocturnal and inhabits sparsely grassed, lightly timbered forest or woodland.	Widespread throughout much of Australia. It remains common in tropical Australia but has declined significantly particularly in temperate regions (Marchant and Higgins 1993). Populations appear secure in the Pilbara (Johnstone 2003).	Possible: Although not recorded during this study, this species may potentially occur within the survey area.

Star Finch (<i>Neochmia ruficauda subclarescens</i>)	Priority 4	-	Typically recorded from reed beds and adjacent vegetation communities along permanent waterways in the Pilbara. It is considered to be resident in most of its range but individuals can wander widely. The main threat to the species is considered to be overgrazing by stock along waterways, which destroys the riparian vegetation on which it depends (Garnett and Crowley 2000).	Found from the Pilbara to southern eastern Australia. It remains most common in the tropics where its abundance is highly variable.	Likely: Although not recorded during the recent study, the species is known to occur in the vicinity (Western Australian Museum records) and is recorded in the DEC threatened fauna database near Onslow.
Grey Falcon (<i>Falco hypoleucos</i>)	Priority 4	-	Mainly inhabits lightly wooded coastal and riverine plains (Johnstone and Storr 1998). May also occur near wetlands where surface water attracts prey. Preys primarily on birds though reptiles and mammals are also taken.	A scarce species in WA that typically occurs north of 26°S.	Likely: Not recorded during the survey, however it has been recorded in the vicinity in the DEC threatened fauna database and suitable habitat occurs in the wider locality.
Eastern Curlew (<i>Numenius Madagascariensis</i>)	Priority 4	Migratory	Occurs mainly on tidal mud flats and sandy beaches, rarely near coastal lakes, including salt field ponds (Johnstone and Storr 1998). Breeds in northern Asia and is a summer migrant to Australia.	Occurs throughout coastal WA, south to Bunbury (Johnstone and Storr 1998). It is moderately common in the Pilbara.	Possible: Although this species has the potential to occur within the survey area, its preferred habitat is tidal mud flats. Suitable habitat does not exist within the survey area but can be found in the local area.
Fork-tailed Swift (<i>Apus pacificus</i>)	-	Migratory	With its irruptive nature, this species may on occasion be present over most open habitats. It is present in WA from September to May, and is noted as often occurring prior to or after cyclone activity (Johnstone and Storr 1998).	Distribution is temporally and spatially extremely patchy, but the species visits most parts of the State (Johnstone and Storr 1998).	Present: Two individuals of this species were recorded at site WHT05 during the survey, but would not be resident in this location.

Species	Conservation Significance		Ecology	Distribution	Likelihood of Occurrence in the Survey Area
	State	Federal			
Rainbow Bee-eater (<i>Merops ornatus</i>)	-	Migratory	Forages aerially for insects and nests in burrows in the ground (Higgins 1999). It occurs in lightly wooded habitats that provide suitable (sandy) soil for nesting and a tall stratum of vegetation for perching.	Occurs through the majority of the western third of WA where free water is relatively readily available. May occur in many areas as either a casual or a transitory species.	Present: Was recorded 23 times during the survey and is likely to be a routine visitor to the survey area.
White-bellied Sea Eagle (<i>Haliaeetus leucogaster</i>)	-	Migratory	Diet comprises mostly fish, nesting seabirds and coastal ground fauna. Breeding activity is almost entirely limited to islands (Johnstone and Storr 1998).	Occurs in most coastal habitats around WA, in addition to much of eastern Australia (Johnstone and Storr 1998).	Present: Was recorded opportunistically twice from the study area, both in coastal locations. The species is likely to be a routine visitor to the coastal portions of the survey area.

Source: Biotax2009a

Table 6.25 and Table 6.26 provide definitions of the codes used for classification of threatened fauna in WA and under the EPBC Act (Cth). Migratory bird species are also protected under the EPBC Act (Cth). The national list of migratory birds consists of those species listed under the following international conventions: JAMBA, CAMBA, Bonn Convention, and ROKAMBA.

Three introduced mammal species were also recorded during the terrestrial fauna survey. These were:

- House Mouse (*Mus musculus*)
- Cat (*Felis catus*)
- Domestic Cattle (*Bos taurus*).

Migratory Waterbirds Study

The Bamford (2009) study focused on determining the presence of important habitat for migratory waterbirds in the Onslow locality and the Project area. Sites are recognised as being important habitats when they regularly support large numbers of waterbirds. The most widely used criteria are those of the Ramsar Convention (Ramsar Convention Bureau 2000), which recognise sites as important if they support in excess of 20 000 waterbirds, 1 per cent of a species' population, or 0.25 per cent of a migratory species' population during migratory passage.

Review of FaunaBase (now Fauna Map [WA Museum]), the Birds Australia Atlas Database, the DEC Threatened and Priority Fauna Database, and the EPBC Protected Matters Search Tool indicate that up to 38 migratory waterbird species may frequent the Onslow locality. Bamford (2009) has recorded 26 of these species in the Onslow locality, and those not observed are likely to only occur as infrequent visitors to the area. Appendix K1 contains further details on the survey, and the migratory species and habitats identified.

Of these 26 species, the counts for numbers of waterbird species are all well below any criterion of international significance, except for the Common Tern (*Sterna hirundo*). The subspecies *Sterna hirundo longipennis* breeds in northern Asia and spends the non-breeding period in South-east Asia and northern Australia, and has a minimum population estimate of 25 000 (Scott and Delaney 2002). The count of 285 on Town Beach, approximately 13 km from the Project area, meets the 1 per cent criterion for this species, based on the minimum population estimate. However, it should be noted that Scott and Delaney (2002) provide a population range of which the maximum is 1 000 000 and, with such uncertainty, the Town Beach count is therefore likely to be of less significance.

Three migratory species, the Whimbrel (*Numenius phaeopus*), Eastern Curlew (*Numenius madagascariensis*) and Sanderling (*Calidris alba*), may be present in regionally important numbers at the Ashburton River delta, Beadon Creek and Town Beach. However, this again is based on uncertain and conservative estimates of regional populations (Bamford *et al.* 2008) and these areas are outside of the Project area.

Bamford (2009) concluded that the Project area and surrounds does not support important numbers of migratory waterbirds.

Bamford (2009) also observed 20 Plumed Whistling Ducks (*Dendrocygna eytoni*) on a freshwater marsh along Onslow Road in March 2009. This could be of regional interest because the birds are on the edge of their normal range, but the species is abundant further north. The ducks were considered likely to be passing through the area (Bamford 2009). This freshwater marsh is on the boundary on the domgas pipeline corridor.

6.4.9.2 Fauna Habitat

Biota (2009a) identified ten main fauna habitats within the survey area. These were distinguished on the basis of differences in substrate, vegetation, soils and landform. None of the habitats present in the survey area are listed as TECs; however, the ephemeral creek line drainage communities and mangrove communities adjoining the survey area are considered "ecosystems at risk" at a subregional scale. The remaining fauna habitats are well represented in the locality and wider region and not of elevated conservation significance.

The Bamford (2009) survey concluded that the Project area and surrounds does not provide habitat supporting significant numbers of migratory waterbirds.

6.4.9.3 Invertebrate Fauna

Invertebrate studies for the Project were conducted by Biota and Dr Brian Timms. These studies included:

- A single-phase level 2 terrestrial short range endemic (SRE) invertebrate fauna study conducted in April 2009 (Biota 2009a)
- A three-phase claypan ephemeral invertebrate fauna study conducted in February, March and April 2009 (Biota and Timms 2009)

The findings of these studies are summarised below, with additional detail provided in Appendices J1 and L1.

Table 6.25: Conservation Codes Used for Classification of Threatened Fauna in Western Australia

Western Australian Wildlife Conservation Act 1950-1979
Wildlife Conservation (Specially Protected Fauna) Notice 2008
Schedule 1
Taxa are fauna, which are rare or likely to become extinct and are declared to be fauna in need of special protection.
Schedule 2
Taxa are fauna which are presumed to be extinct and are declared to be fauna in need of special protection.
Schedule 3
Taxa are birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, which are declared to be fauna in need of special protection.
Schedule 4
Taxa are fauna that are in need of special protection, otherwise than for the reason mentioned under Schedule 1, 2 or 3.
Department of Environment and Conservation Priority Codes
1: Priority One - Taxa with few, poorly known populations on threatened lands
Taxa which are known from a few specimens or sight records from one or a few localities on lands not managed for conservation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
2: Priority Two - Taxa with few, poorly known populations on conservation lands, or taxa with several, poorly known populations not on conservation lands
Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
3: Priority Three - Taxa with several, poorly known populations, some on conservation lands
Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
4: Priority Four - Taxa in need of monitoring
Taxa which are considered to have been adequately surveyed or for which sufficient knowledge is available and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands. Taxa which are declining significantly but are not yet threatened.
5: Priority Five - Taxa in need of monitoring
Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Table 6.26: Conservation Codes Used for Classification of Threatened Fauna under the EPBC Act

Status	Code	Definition
Extinct	X	There is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	XW	It is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range, or It has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	CE	It is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	E	It is not critically endangered; and It is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable	V	It is not critically endangered or endangered; and It is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependant	CD	The species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered OR The following subparagraphs are satisfied: <ul style="list-style-type: none"> • The species is a species of fish • The species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised • The plan of management is in force under a law of the Commonwealth or of a State or Territory • Cessation of the plan of management would adversely affect the conservation status of the species.

Short-range Endemic Fauna

SREs are taxonomic groups of invertebrates with naturally small distributions and are characterised by poor dispersal capabilities, confinement to disjunct habitats and low reproductive potential (Harvey 2002; Ponder and Colgan 2002; EPA 2009a). Systematic trapping and opportunistic searches were conducted within the survey area for invertebrate fauna, specifically targeting suitable habitat and the following invertebrate groups considered to potentially support SRE taxa (Biota 2009a):

- Mygalomorphae (trapdoor spiders)
- Diplopoda (millipedes)
- Pulmonata (land snails)
- Pseudoscorpionida (pseudoscorpions).

Despite thorough searching, no SRE taxa were identified within the survey area (Biota 2009a).

Ephemeral Claypans Invertebrate Fauna

A three-phase study was designed to analyse the succession of invertebrate life cycles in ephemeral claypans of the survey area and surrounds immediately after the claypans had filled with water following Tropical Cyclone Dominic. Sampling encompassed a selection of representative claypans and temporary water bodies within and adjacent to the survey area. A total of 24 sites (12 survey area sites and 12 reference sites) were sampled during the study. Figure 6.71 shows the location of the sample sites. These were broadly categorised as turbid or clear water claypans, and were further subdivided into six habitat types based on water salinity, turbidity and extent of vegetation cover. The majority of the claypans present in the survey area were turbid in nature.

The study recorded a total of 59 taxa of zooplankton and 82 taxa of macro-invertebrates, including 12 classes and 21 orders of invertebrate fauna (Appendix L1). The clear water habitats sampled were more diverse than the turbid sites.

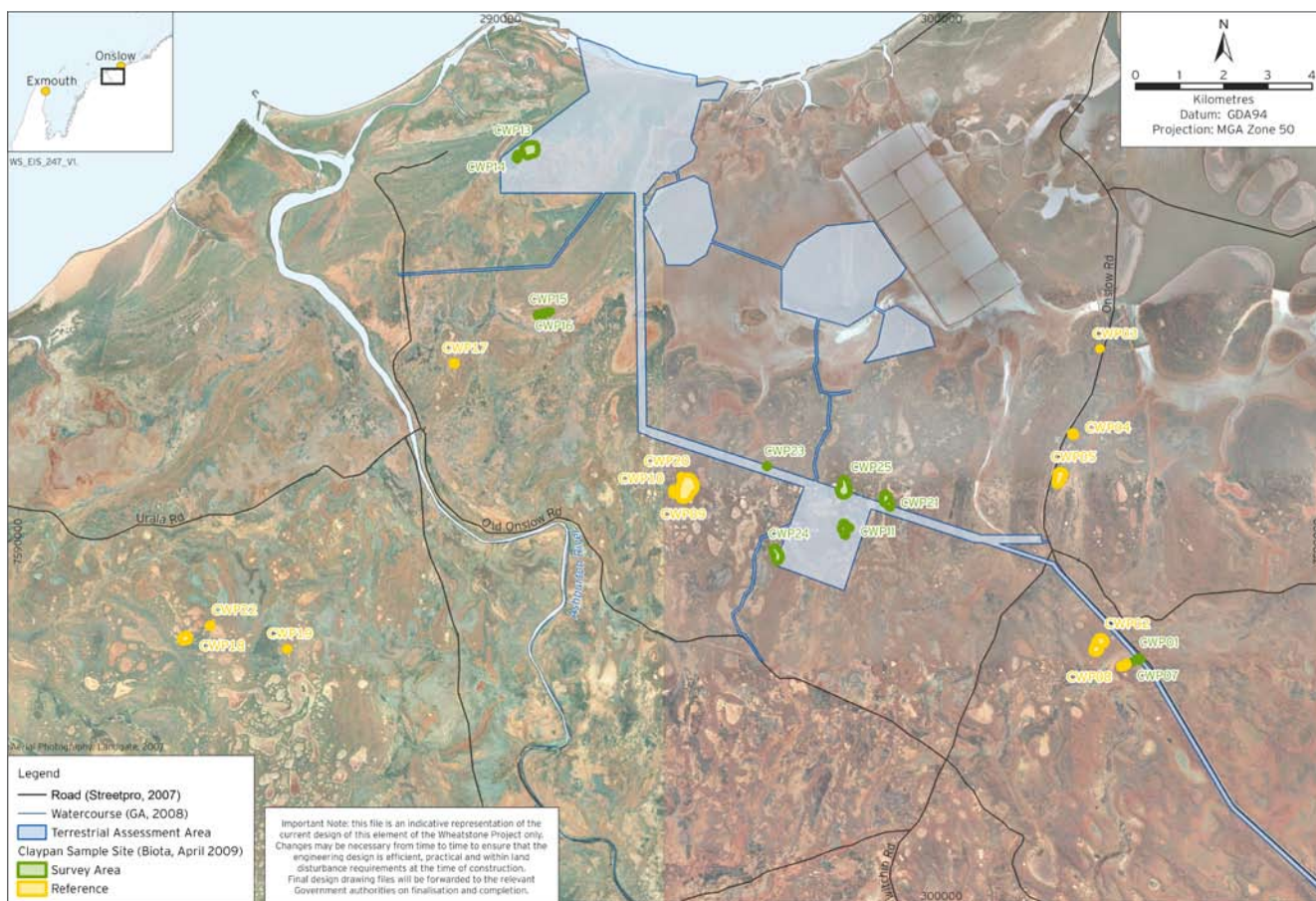


Figure 6.71: Claypan Invertebrates Study Sample Sites

Four previously uncollected and undescribed species were recorded during this study. Of the four species, the Clam Shrimp, *Limnadia n. sp.*, was collected at a single site in the survey area—CWPO1 (Figure 6.71). A flatworm, *Mesostoma sp.*, was also found only within the survey area, again at site CWPO1. This site is a manmade water body formed alongside Onslow Road. As such, it seems very unlikely that these records represent natural locally endemic distributions (Biota & Timms 2009).

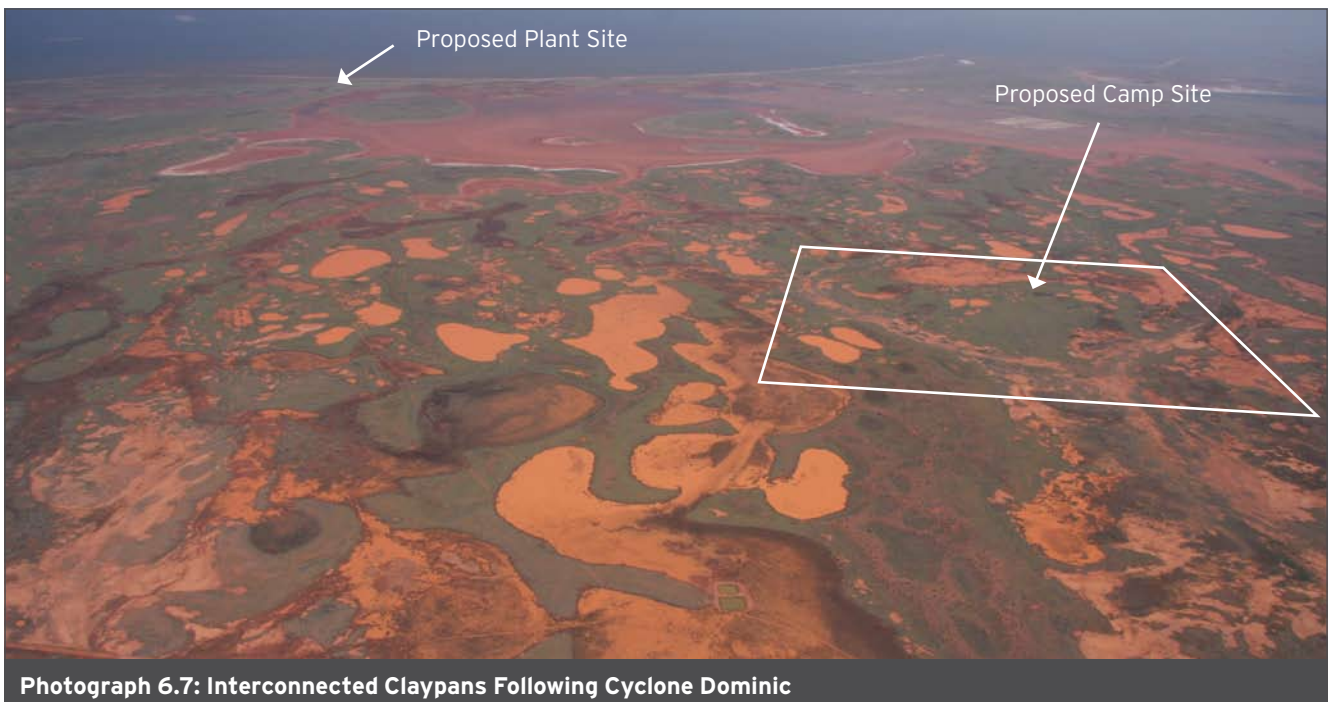
Similarity analysis of the site assemblage data indicate that the survey area sites contain effectively equivalent suites of invertebrate fauna to those represented in the reference sites. This pattern of equivalent suites of species in similar units appears consistent with landscape-scale processes that occur in the area during flood events. Evidence from TC Dominic, and the nature of the topography, suggests that the aquatic habitats of many of the claypans become interconnected during major flood events. Photograph 6.7 shows the interconnected claypans following TC Dominic (also refer to Figure 6.8). The extent of this connection would be related to the magnitude of the flood event. However, given the low elevation of the topography and the proximity of the Ashburton River, it is likely that the

majority of cyclones would result in similar patterns of surface hydrology. This suggests a relatively minor risk of species isolation to individual claypans at this local scale.

6.4.9.4 Subterranean Fauna

A subterranean fauna study for the Project was conducted by Biota (2009b), focussing on the area with the most potential for subterranean disturbance, the LNG and domgas plant. Sampling was conducted within the LNG and domgas plant and surrounding area in June, July, September and October 2009. Additionally, a desktop assessment of the likelihood of subterranean fauna being found within this area and within the SIC (hereafter referred to as the study area) was conducted. Due to the proximity of the study area to the accommodation village, it is believed that the results of the study are representative of the accommodation village area. The study did not include the domgas pipeline corridor as this area would have limited subterranean disturbance and this would be restricted to the soils layers.

Figure 6.72 illustrates the locations of the bores sampled. The findings of these studies are summarised below, with additional detail provided in Appendix M1.



Photograph 6.7: Interconnected Claypans Following Cyclone Dominic

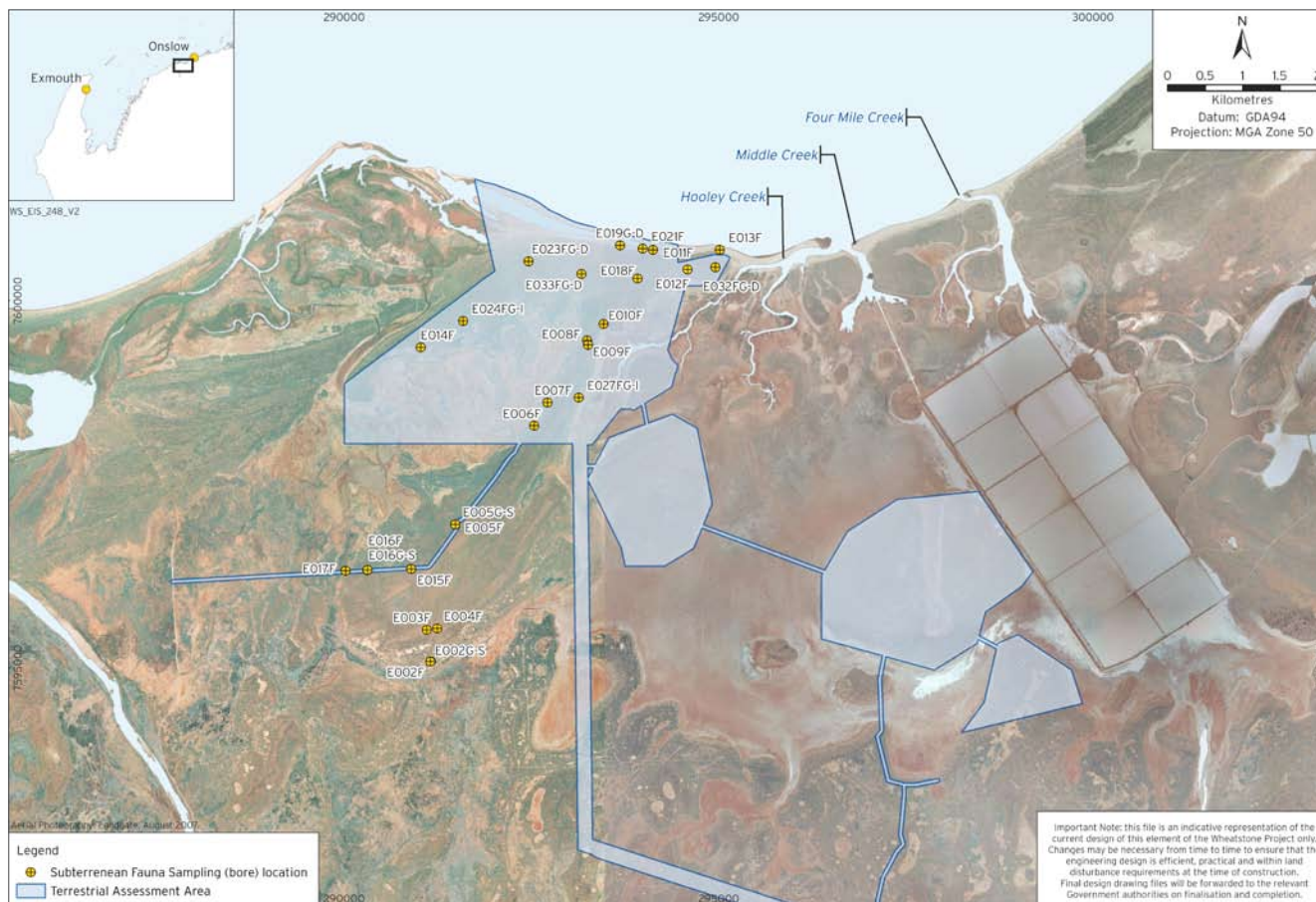


Figure 6.72: Subterranean Fauna Sampling Locations

Troglofauna

Three phases of troglofauna sampling have been conducted within, or adjacent to, the LNG and domgas plant area. These surveys include:

- Phase I: 32 troglofauna traps installed in 18 bores on June 9, 2009 and recovered on July 22, 2009
- Phase II: 32 troglofauna traps installed in 18 bores on July 22, 2009 and recovered on September 7, 2009
- Phase III: 32 troglofauna traps installed in 18 bores on September 7, 2009 and recovered on October 26, 2009.

While a range of soil invertebrates were recovered from the sampling, no troglobitic fauna were collected from any of the 96 traps. This result confirmed the desktop assessment conclusion (Biota 2009b) that the study area would have a low likelihood of a significant troglobitic community having persisted over the long term and currently occurring.

This is because:

- The above water table lithology of the study area is dominated by sands, silts and clays; none of which would provide suitable habitat space for troglofauna
- Some drill log locations do show a thin strata of sandstone and oolitic limestone which are formations that can contain void space; however, in most this is comprised of separate clasts, oolites and very narrow cemented bands interspersed with up to 75 per cent sand rather than massive or karstic formations
- There is only a very thin stratum (on average 2.5 m and less then this in many areas) of available potential habitat between the ground surface and the water table. This indicates that in most situations there is generally only what would be regarded as soil and subsoil strata present before the relatively shallow water table is reached

- The broader coastal plain of the study area is periodically inundated by major flood events associated with cyclones, hinterland flows and storm surge
- There are no major hill, mesa or rocky ridge landforms present that may have been continuously emergent during these historical events to act as potential refugia (Biota 2009b).

Stygofauna

Three phases of stygofauna sampling and a desktop assessment have been conducted within, or adjacent to, the LNG and domgas plant area. These surveys include:

- Phase I: 18 bores sampled within, or adjacent to, the LNG and domgas plant area and three regional bores sampled at Onslow Salt Pty Ltd, on July 22, 2009
- Phase II: nine bores sampled within, or adjacent to, the LNG and domgas plant area on September 7, 2009
- Phase III: 18 bores sampled within, or adjacent to, the LNG and domgas plant area, on October 26, 2009.

The desktop assessment assigned a moderate likelihood of the study area supporting stygofauna based on the following:

- The saturated strata in the study area are dominated by sands, sandstone, silt and clays, that generally do not contain large voids and do not normally support as diverse stygal
- Communities as more transmissive units such as calcrete and alluvial aquifers. Typical fauna present in sand aquifers include worm taxa, and copepods and ostracods. These smaller body sized animals reflect the smaller interstices available in these types of units
- Considering the aquifer habitats present, and that stygal animals have been collected in the locality, it is probable that stygofauna occur in the study area. These are likely to occur in superficial brackish lenses in sand and sandstone aquifers within the study area and the immediate vicinity, and other fauna may occur in larger aquifers associated with the Ashburton River in the wider locality further outside of the study area
- The nature of the groundwater systems, geology and lithology of the area suggest that this fauna may be limited to a subset of smaller body-type taxa of marine lineage.

The desktop assessment result was confirmed through the surveys where stygofauna were collected from just three of the 27 bores sampled within, or adjacent to, the LNG and domgas plant area. The two stygal taxa collected comprised copepods *Phyllopodopsyllus thiebaudi* from bore E013F and an oligochaete worm *Enchytraeidae* sp. 1 collected from each of bores E005G-S and E005F.

The copepod *P. thiebaudi* (crustacean) is a widespread species that has previously been recorded from Barrow Island (Biota 2007), among other locations, and is not restricted to the Onslow locality. Bore E013F is situated on the beach, almost into the intertidal habitat, which appears consistent with the marine lineage of this genus (Biota 2009b).

The oligochaete *Enchytraeidae* sp. 1 specimens were both juvenile, which means that identification to the species level is not possible. The morphological nature of the taxa (small and vermiform [worm-like] body size and structure) is consistent with the types of strata and aquifers present. Given the ecology and distributional patterns of stygal oligochaetes in similar habitats elsewhere in the region (for *Enchytraeidae* sp. 1), it is unlikely that this taxon is restricted to the study area (Biota 2009b).

The study results therefore suggest that a diverse or significant stygal community does not occur in the aquifers beneath the study area and surrounds. The results from the field sampling in the LNG and domgas plant and surrounding area, and the similarity of the habitats within the SIC and accommodation village, suggest there is no requirement for sampling in these areas. Both the fauna recorded during field surveys, and the nature of the subterranean habitats, suggest a low level of risk that any stygal species would be restricted to the study area (Biota 2009b).

6.4.10 Conservation Significance

6.4.10.1 Matters of National Environmental Significance
Matters of NES are defined under the EPBC Act (Cth) and described in detail in DEH (2006). Matters of NES are afforded particular protection during the environmental impact assessment process. Only two of the seven matters of NES are relevant to the onshore Project area, being Migratory species and threatened flora species.

A total of four migratory fauna species have been recorded in, or could potentially inhabit, the Project area. These are described in further detail in Section 6.4.9.

One EPBC listed flora species—the Dwarf Desert Spike-rush, listed as Vulnerable under the EPBC Act (Cth)—was recorded from a single location within the Project area. For further detail, refer to Section 6.4.8.

The Project area does not contain any World Heritage Properties, National Heritage Properties or Ramsar Wetlands of International Significance.

Chapter 9, *Terrestrial Risk Assessment and Management* provides details of the potential impacts and proposed management of migratory and threatened fauna species.

6.4.10.2 Parks, Reserves and Conservation Areas

A number of parks, reserves and conservation areas occur within the Pilbara and Carnarvon bioregions. These include:

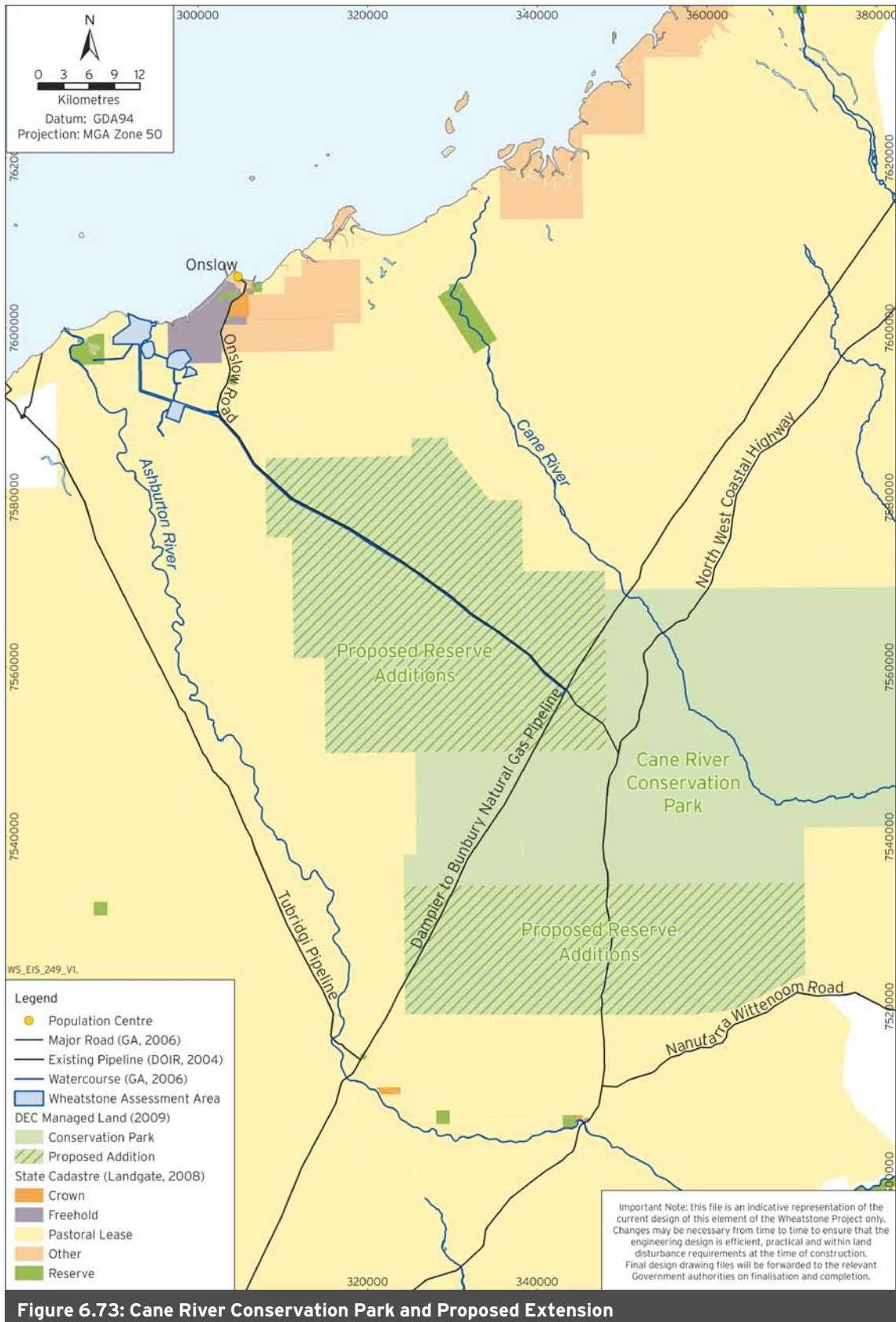
- Cane River Conservation Park
- Kennedy Range National Park
- Cape Range National Park
- Millstream Chichester National Park
- Karijini National Park.

Of the above, the C-class Cane River Conservation Park is the only conservation area in the vicinity of the Project. The park is approximately 4.5 km to the east of the eastern end of the domgas pipeline corridor, approximately 100 km south-east of Onslow, and extends over 148 000 ha.

The purchase of the Cane River pastoral station was jointly funded by the WA State and Commonwealth governments in 1996, and converted into the Cane River Conservation Park as the area includes several landforms and vegetation types of particular significance that were not found to have been protected in other conservation reserves in the region.

The Pilbara bioregion is listed as a medium priority for funding for land purchase under the National Reserves System Co-operative Program due to the limited representation of the area in conservation reserves. Portions of various pastoral leases in the region have been nominated for exclusion for public purposes in 2015, when the leases come up for renewal. Many of the submissions are from the DEC, with the intention of adding these areas to the existing conservation estate in order to provide a comprehensive, adequate and representative reserve system.

The National Reserves System Co-operative Program's current proposals include extensions to the Cane River Conservation Park to include the Mt Minnie Pastoral Lease (110 921 ha), and part of the Nanutarra Pastoral Lease (70 030 ha). Once this extension of the Cane River Conservation Park is implemented, the eastern 44 km section of the domgas pipeline would potentially be located within the park (Figure 6.73).



6.5 Socio-economic and Cultural Environment

This section profiles the existing socio-economic and cultural environment of the proposed Project. It will focus on the Shire of Ashburton and township closest to the Project - Onslow, located in the Pilbara region of WA's north-west.

Profiling provides insight into key attributes of an area and its communities, helps to identify key stakeholders, and uncovers relevant issues to be explored in subsequent assessment. A community's response to change is driven by elements of the social context in which people live, work and play. Behaviour is often shaped by the setting or social context in which individuals function.

Social context is best conceptualised as a series of interacting social systems - such as families, neighbourhoods, workplaces, and institutions (e.g. health and education) - in which changes to one social system influence other systems.

Furthermore, community impacts associated with the Project are likely to be driven by the functional and affective relationship between the community and the Project area. The functional relationship is related to land use, recreation, employment opportunities and activities

that occur in the area. The affective relationship is related to perceptions, values, attitudes and emotions that are the feelings of attachment and belonging that members of the community have with their locality.

The data/information used to inform the profile development has been obtained from secondary data review and primary contact with key stakeholders. Further detail of the methodologies employed in relation to the social aspects of the EIS/ERMP are detailed in Chapter 10, *Social Risk Assessment and Management*.

6.5.1 The Pilbara Region

The Pilbara region covers an area of approximately 507 896 km² and comprises three distinct geographic areas. The northern and western third is coastal sand plain, and the middle section is home to the Karijini National Park, noted internationally for its gorges and watering holes. The eastern third of the region is mostly desert, sparsely populated by a small number of Aboriginal communities. The region is defined by four local government areas including the shires of Ashburton, Roebourne and East Pilbara, and the Town of Port Hedland.

According to the Australian Bureau of Statistics (ABS) Census (1996-2006), the Pilbara's population increased by about 14.6 per cent over a ten-year period, but declined

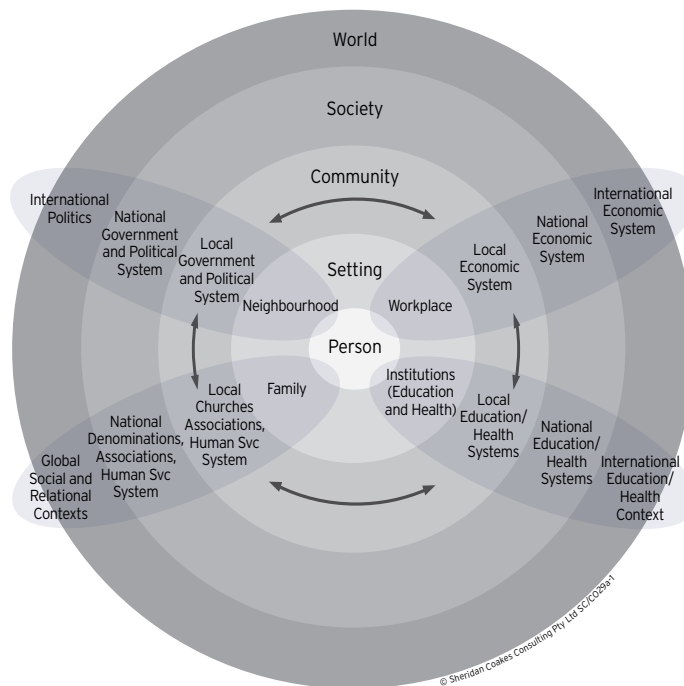


Figure 6.74: Social Ecology

Adapted from Maton (2000)

slightly in 2001. This trend is indicative of a strong resource-industry presence in the region, reflecting the transient nature of construction and operational workforces servicing the Pilbara's extensive resource projects.

A predominant proportion of Pilbara residents live in the Shire of Roebourne (37.6 per cent), which includes the major towns of Karratha and Dampier, as well as Cossack,

Point Samson, Roebourne and Wickham. A further 25.8 per cent live in the Town of Port Hedland and 20.8 per cent in the Shire of East Pilbara, which includes the townsites of Newman, Jigalong, Marble Bar, Nullagine and Telfer. The Shire of Ashburton, with the smallest proportion (15.7 per cent) of the region's population, includes the towns of Tom Price, Paraburdoo, Onslow and Pannawonica.

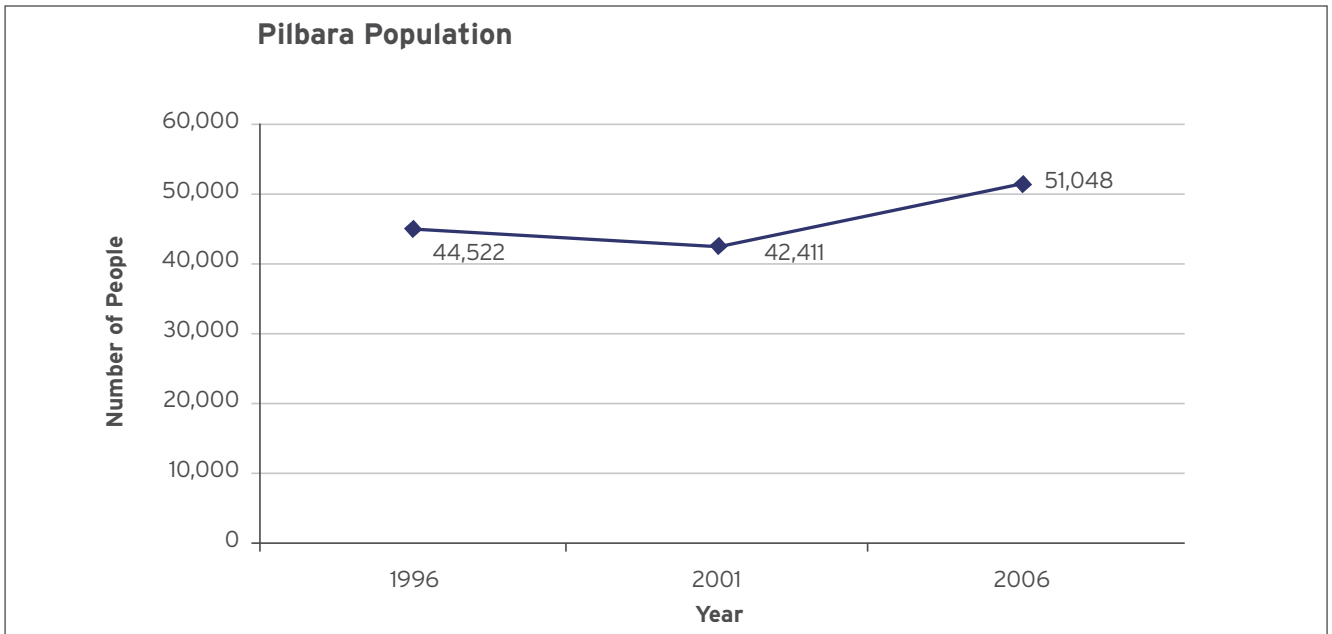


Figure 6.75: Pilbara Population Change over Time (Excludes Overseas Visitors)

Source: ABS Census (2006) (Place of enumeration)

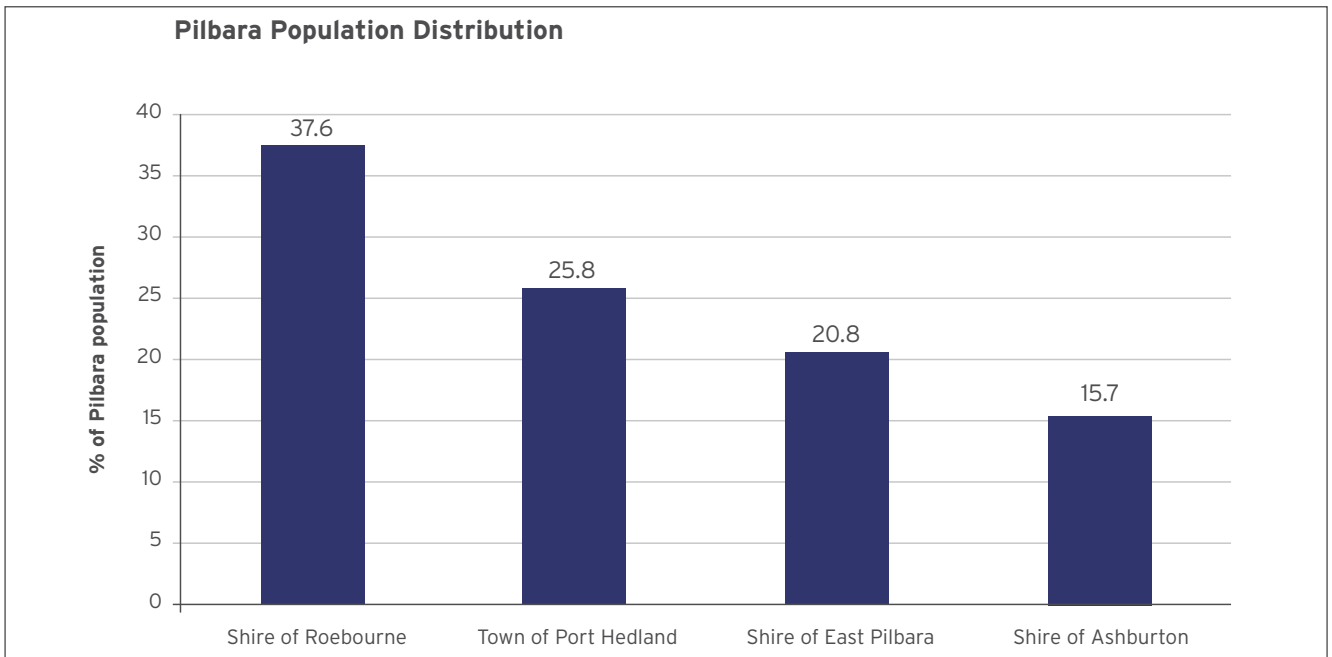


Figure 6.76: Population Distribution across Pilbara Local Government Areas

Source: ABS Census (2006) (Place of enumeration)

The Pilbara economy is dominated by the mining and petroleum industries, with iron ore, oil and condensate, LPG, LNG and natural gas among WA's largest export revenue earners. Given the region's access to abundant minerals and natural resources, the Pilbara is fittingly known as the "engine room of the nation" (Pilbara Development Commission 2006).

Commercial activities in the Pilbara exist primarily to service the resources sector. They include engineering, surveying, personnel and equipment hiring services. During the 2006 Census, the mining and construction sectors employed 29.4 per cent and 10.7 per cent of the Pilbara's workforce, respectively. The manufacturing sector, comprising mainly small businesses supplying the regional market, had an estimated sales income of \$309 million during the period of 2004 to 2005 and employed up to 4.3 per cent of the region's workforce (Pilbara Development Commission 2006).

In August 2008, the Pilbara Industry's Community Council (PICC) examined population projection trends in the Pilbara to 2020 (PICC 2008). Total employment generated by the Pilbara's resource activities has been projected to double between 2006 and 2015. Residential employment is also projected to grow at an annual rate of five per cent during the same decade, when fly-in, fly-out (FIFO) employment is expected to grow at a much steeper 24 per cent per annum.

Although transient in nature, this type of workforce is likely to impose further strains on existing Pilbara infrastructure and services.

Iron ore projects tend to be the primary drivers of long-term employment in the Pilbara, particularly during the production stages. In contrast, oil and gas projects are usually more capital intensive, with a greater demand for a construction workforce but less for operational staff during production.

Based on individual company forecasts and investment prospectuses, construction employment in the Pilbara has been projected to peak between 2010 and 2012, attributable to the commencement of several proposed projects in the area (Figure 6.79). These include the Project, as well as the ExxonMobil and BHP Billiton's Scarborough LNG Plant, the BHP Billiton Macedon domestic gas plant, construction of Woodside's Pluto plant and the Port Hedland harbour expansion.

Figure 6.80 outlines the predicted residential population change for key Pilbara towns and communities where significant resource development projects are proposed.

Table 6.27 summarises the magnitude of this population change across individual Pilbara towns.

It is particularly interesting to note the projected 271 per cent increase in Onslow's population between 2005

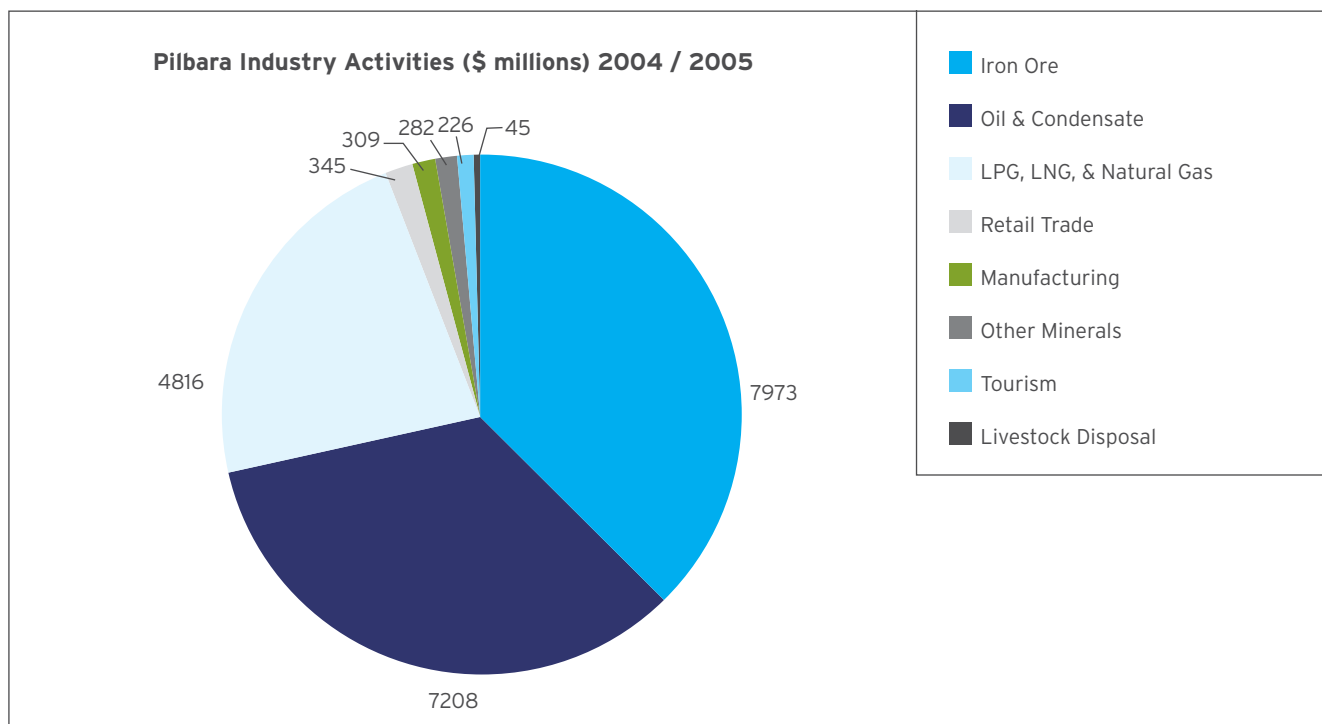


Figure 6.77: Value of Industry Activities in the Pilbara

Source: Pilbara Development Commission 2006

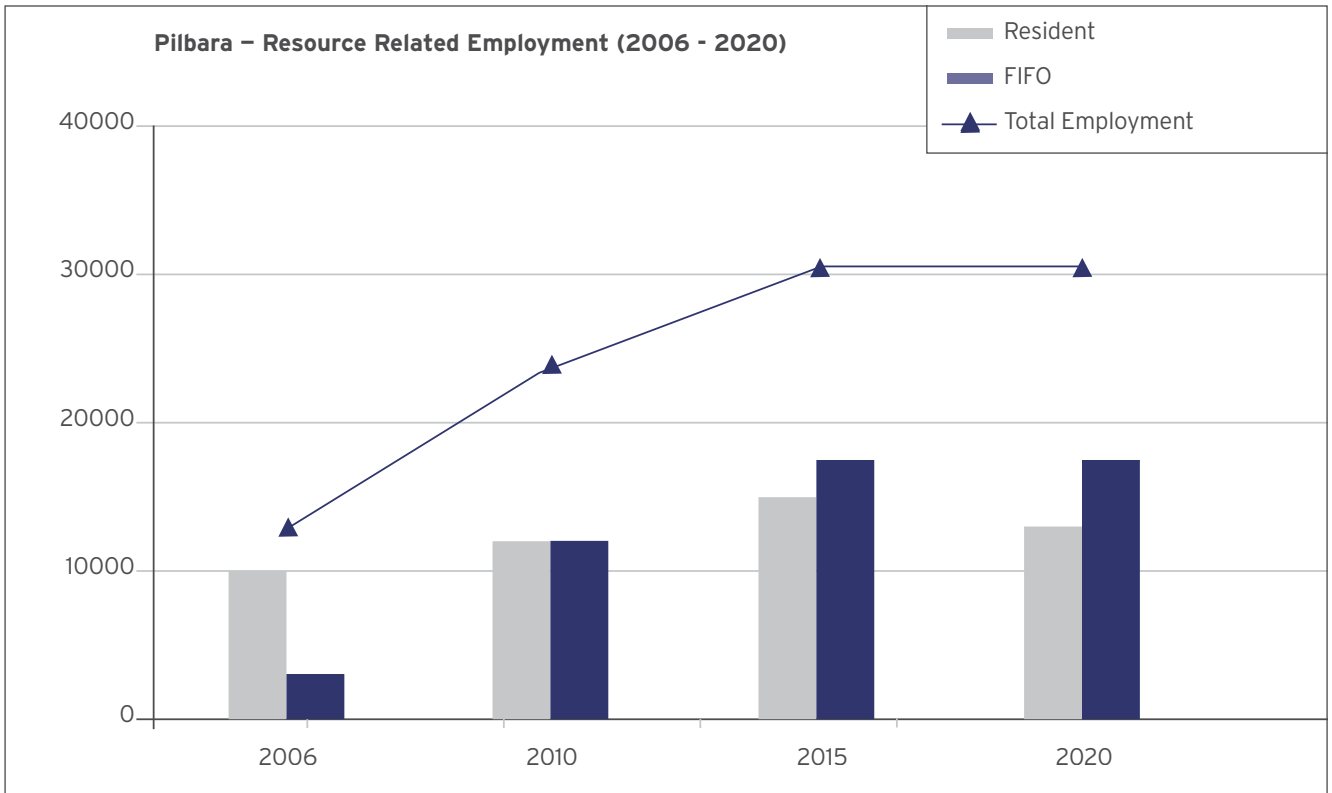


Figure 6.78: Projected Resource-Related Employment Growth in the Pilbara

Source: PICC 2008



Figure 6.79: Projected Construction Employment Figures in the Pilbara

Source: PICC 2008

and 2020, in contrast to neighbouring localities, many of which have developed as mining towns to service the industry. Indeed, the ABS data for Onslow suggests that it is atypical of a Pilbara mining town (ABS 2006a). Therefore, commencement of significant resource projects in the area and the associated influx of workers and heightened activity is likely to cause substantial change to the population and socio-economic way of life. Proposed developments at the Ashburton North SIA include the Project, ExxonMobil/BHP Billiton’s LNG processing plant and BHP Billiton’s domestic gas plant.

Table 6.28 provides a summary of the Pilbara’s socio-demographic trends over the census periods from 1996 to 2006. This data has been retrieved from the ABS time series, and is based on the respondent’s place of enumeration (where the respondent was on the night of the census) rather than place of usual residence. As mining workforces in the region are increasingly transient (e.g. FIFO), analysing census data on the basis of place of enumeration provides a clearer indication of the total number of people likely to be present in the region at a particular time.

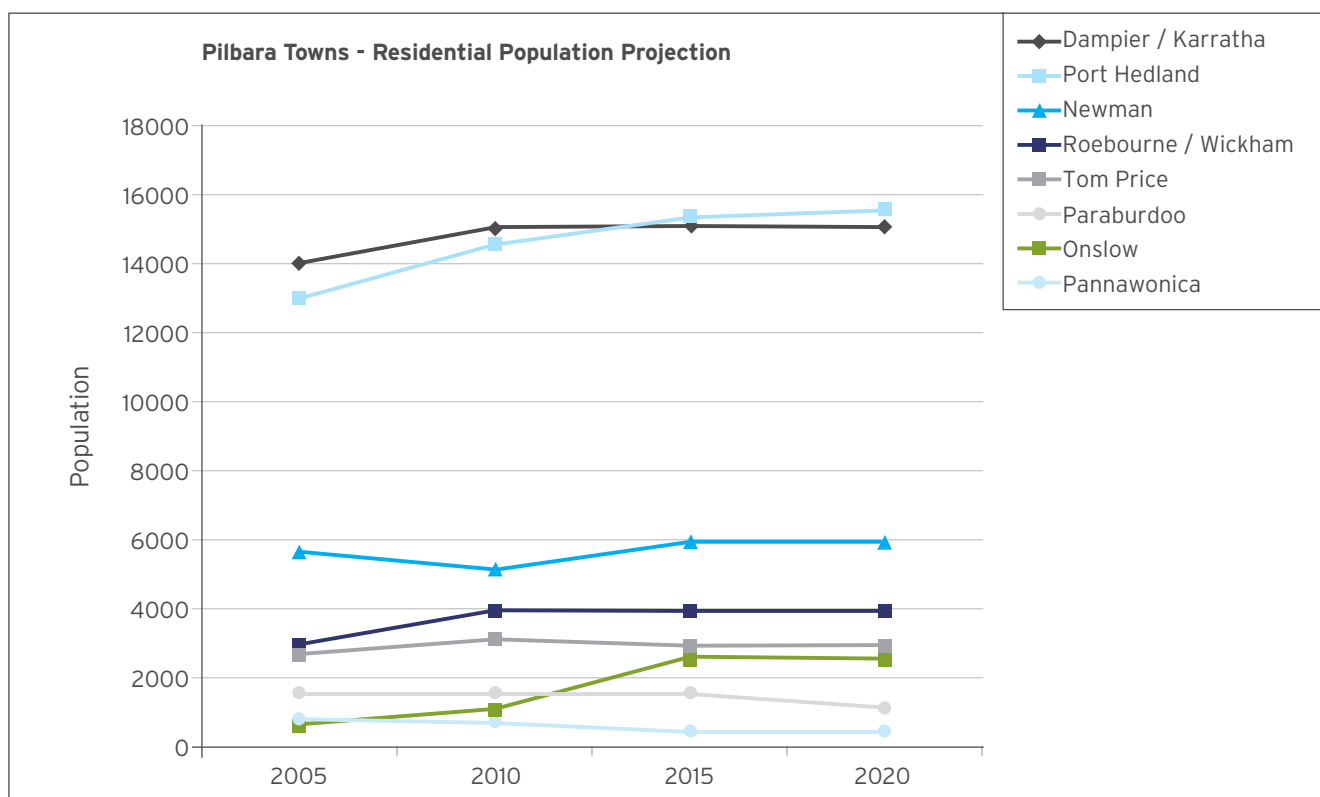


Figure 6.80: Residential Population Projections for Pilbara Towns

Source: PICC 2008

Table 6.27: Population Change across Pilbara Towns

Pilbara Town	% Change
Onslow	↑ 271.0
Roebourne/Wickham	↑ 33.3
Port Hedland	↑ 19.2
Dampier/Karratha	↑ 7.5
Tom Price	↑ 7.1
Newman	↑ 5.3
Paraburdoo	↓ 25.0
Pannawonica	↓ 37.5

Source: PICC 2008

Table 6.28: Pilbara's Socio-demographic Trends

Pilbara region	1996	2001	2006	Trend 1996-2006
Population	44 522	42 411	51 048	–
Age Structure				
Percent aged 14 and below	25.8%	24.4%	20.6%	↓
Percent aged 15 to 64 (workforce population)	70.6%	71.7%	75.8%	↑
Percent aged 65 and above	4.3%	4.7%	4.6%	–
Employment				
Unemployment rate	5.4%	4.7%	3.0%	↓
Education				
Percent with non-school qualification	33.2%	36.5%	37.0%	↑
Income				
Median individual income (\$/weekly)	513	584	944	↑
Median family income (\$/weekly)	1196	1507	2178	↑
Median household income (\$/weekly)	1065	1231	1865	↑
Household Composition				
Couple family with children	38.3%	35.0%	20.4%	↓
Couple family with no children	18.4%	19.5%	19.0%	–
One-parent family	6.1%	7.1%	5.5%	–
Lone household	16.2%	16.8%	14.7%	–
Dwellings				
Separate house	66.3%	64.7%	68.7%	–
Semi-detached	13.4%	15.2%	11.1%	–
Flat, unit or apartment	7.3%	5.7%	5.4%	↓
Tenure				
Fully owned	12.6%	13.7%	16.1%	↑
Being purchased	33.2%	27.5%	21.9%	↓
Rented	53.1%	55.3%	60.8%	↑

Source: ABS Census (1996 - 2006)

This data is calculated using time series profile and excludes:

- overseas visitors
- respondents who did not adequately answer the question
- respondents who did not answer the question

Note: – indicates no trend from 1996 to 2006

↑ indicates an increasing trend from 1996 to 2006

↓ indicates a decreasing trend from 1996 to 2006

6.5.2 The Shire of Ashburton

The Shire of Ashburton covers an area of approximately 105 647 km² and includes the towns of Onslow, Tom Price, Paraburdoo and Pannawonica. Tom Price is the Shire's largest town and administration centre. The Shire is also home to a large Aboriginal population, some of whom reside in or near Onslow, including the small Aboriginal communities of Bellary, Wakathuni, Youngalina, Ngurawaana, Bindi Bindi and Peedamulla.

The Shire is located within the Federal electoral division of Kalgoorlie, which covers an area of approximately 2 295 354 km². This division covers most of rural WA, from the South Australian and Northern Territory borders in the east, the Indian Ocean in the west, the Southern Ocean in the south and to the Timor Sea in the north.

Ashburton's state electoral district, North West Coastal, stretches along the north-west coast of WA from the Murchison River to an area east of Roebourne. The towns within the electorate include Karratha, Carnarvon, Denham, Coral Bay, Exmouth, Onslow, Dampier and Roebourne.

The proposed Project site will require planning approval from the Ashburton Shire Council, in accordance with the Shire of Ashburton Town Planning Scheme. In relation to social impacts, the Shire will consider in its assessment any social issues affecting the locality's amenity, cultural significance and heritage, as well as the capacity of the site and surrounding locality to support the development (such as access, generated traffic, public transport services and community services). The Shire will also consider potential loss of community benefit or service resulting from the planning approval.

In 2006, the Shire of Ashburton's population was reported to be 8033, marking an 18.5 per cent increase since 2001. As the towns of Tom Price, Paraburdoo and Pannawonica are key to servicing Rio Tinto's expansive iron ore mining activities in the Pilbara, this growth is suggestive of a significant Rio Tinto workforce influx into the Shire, most likely attributable to the company's ramp up of production activities during the State's resource boom between 2001 and 2006. A small portion of the population expansion also related to the commencement of production at Onslow Salt Pty Ltd.

In addition to iron ore mining, a large proportion of the land in the Shire comprises pastoral leases, where agricultural and pastoral activities such as cattle stations as well as fishing continue to contribute to the local economy. According to the 2006 Census, the agricultural and fishing sector employed approximately two per cent of the Shire's total workforce, relative to the substantial 49.9 per cent

employed in mining (ABS 2006b).

Tourism is another key industry sector within the Shire of Ashburton, with several tourist activities based out of Tom Price and Onslow. During the period between 2007 and 2008, approximately 46 per cent of domestic and international visitors came to the Shire for leisure purposes, with most engaging in outdoor and recreational coastal activities, as well as heritage trails and tours (Tourism Research Australia 2008). Tourism-related industries in the Shire, such as accommodation and food services and retail trade, employ up to six per cent of the total workforce (ABS 2006b).

Table 6.29 provides a snapshot of the Shire's socio-demographic trends during the period of 1996 to 2006. Notably, there has been a consecutive decrease in the number of families with children living in the Shire since 1996; while the number of lone households has increased by over two per cent.

Of particular interest is the significant decline in the proportion of persons who are in the process of purchasing their place of residence (54.1 per cent in 1996 compared to 9.1 per cent in 2006), alongside a corresponding increase in the number of persons reportedly renting (30.7 per cent in 1996 relative to 72.4 per cent in 2006). These trends suggest growing housing pressures as a result of an increasing industry workforce, issues that are quite common in regional mining areas in WA.

6.5.3 Onslow's Community Capitals - Baseline Demographic Analysis

With a current population of approximately 576 (ABS Census 2006b), Onslow comprises approximately 9.5 per cent of the Shire of Ashburton's total population. In coming years, it is expected to undergo significant change in population and socio-economic way of life, with development of the Project and other industrial developments, including the proposed Ashburton North SIA. In contrast to its current status as a laid-back coastal fishing town, Onslow is set to become another major regional hub servicing the Pilbara's extensive oil-and-gas industry.

This section will document a baseline analysis of Onslow's current socio-economic and demographic trends, through assessment of key community capitals - natural, economic, physical, human, and social. These capitals form the fundamental building blocks of a community's resilience and sustainability and are critical in informing its "state of health".



Figure 6.81: State Electoral District of North West Coastal

Source: WA Office of the Electoral Distribution Commissioners(2009)

Table 6.29: Shire of Ashburton's Socio-demographic Trends

Shire of Ashburton	1996	2001	2006	Trend 1996-2006
Population	8719	6777	8032	-
Age Structure				
Percent aged 14 and below	26.1%	24.2%	21.0%	↓
Percent aged 15 to 64 (workforce population)	70.1%	71.6%	74.5%	↑
Percent aged 65 and above	4.6%	5.7%	5.7%	↑
Employment				
Unemployment rate	2.4%	2.1%	1.8%	↓
Education				
Percent with non-school qualification	37.0%	37.0%	41.8%	↑
Income				
Median individual income (\$/weekly)	605	594	1015	-
Median family income (\$/weekly)	1240	1764	2398	↑
Median household income (\$/weekly)	1123	1373	1898	↑
Household Composition				
Couple family with children	43.4%	34.7%	32.6%	↓
Couple family with no children	17.3%	18.5%	19.0%	↑
Lone household	13.2%	15.6%	15.3%	-
Dwellings				
Separate house	77.5%	71.0%	75.7%	-
Semi-detached	7.4%	6.8%	3.1%	↓
Flat, unit or apartment	2.2%	2.4%	1.8%	-
Tenure				
Fully owned	13.0%	17.4%	17.1%	-
Being purchased	54.1%	37.8%	9.1%	↓
Rented	30.7%	40.7%	72.4%	↑

Source: ABS Census (1996 - 2006)

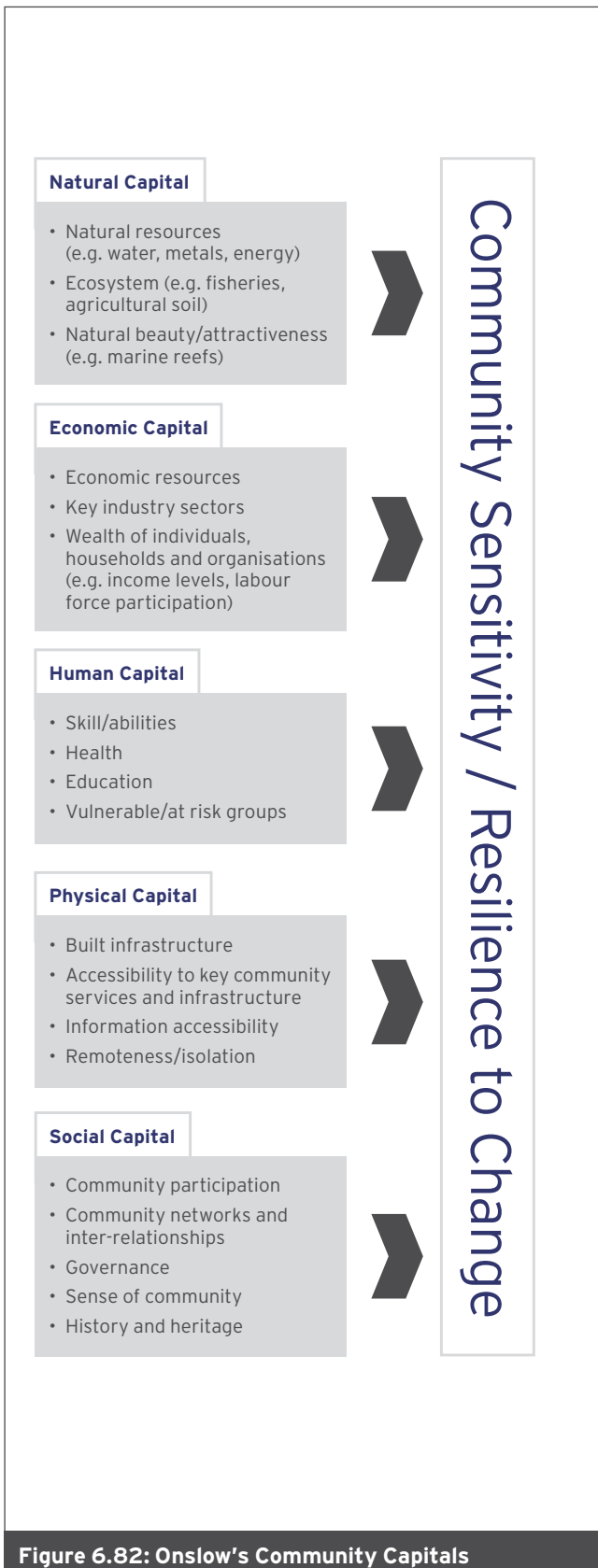
This data is calculated using time series profile and excludes:

- overseas visitors
- respondents who did not adequately answer the question
- respondents who did not answer the question

Note: - indicates no significant trend from 1996 to 2006

↑ indicates an increasing trend from 1996 to 2006

↓ indicates a decreasing trend from 1996 to 2006



The capitals framework is based on the assumption that key community capitals are fundamental in determining the resilience of a community; and that the community's capacity to adapt to changes in way of life is dependent on the status of its capitals. It is particularly useful in identifying the strengths and weaknesses of a community's key capitals and assets enabling the implementation of indicators and tools to assist policy and decision makers. Strategies can direct investment efforts towards strengthening the weaker capitals, or further optimise stronger capitals, thereby enhancing overall capacity and enabling an effective adaptation to positive drivers of change.

Also central to the framework is the inter-relationship that exists between capitals. Where one capital is depleted, other community capitals are also likely to become compromised. For instance, should human capital be depleted, in terms of deterioration in education levels or community health; the subsequent maintenance of built capital (e.g., economic infrastructure) is also likely to be affected.

Figure 6.82 illustrates the interplay between community capitals in determining community resilience.

6.5.3.1 Natural Capital

Natural capital - or environmental asset - is defined as any stock or natural resource, such as oceans, forests, oil and gas, or agricultural land that generates sustainable economic and commercial activity.

Onslow is also one of the nearest population centres to several offshore oil-and-gas field and production platforms. This makes it an ideal location for development of further onshore processing facilities to support offshore production fields. This has the potential to generate significant economic benefits to the town and Shire. In addition to the Project, other large-scale industrial developments are proposed for the Ashburton North SIA.

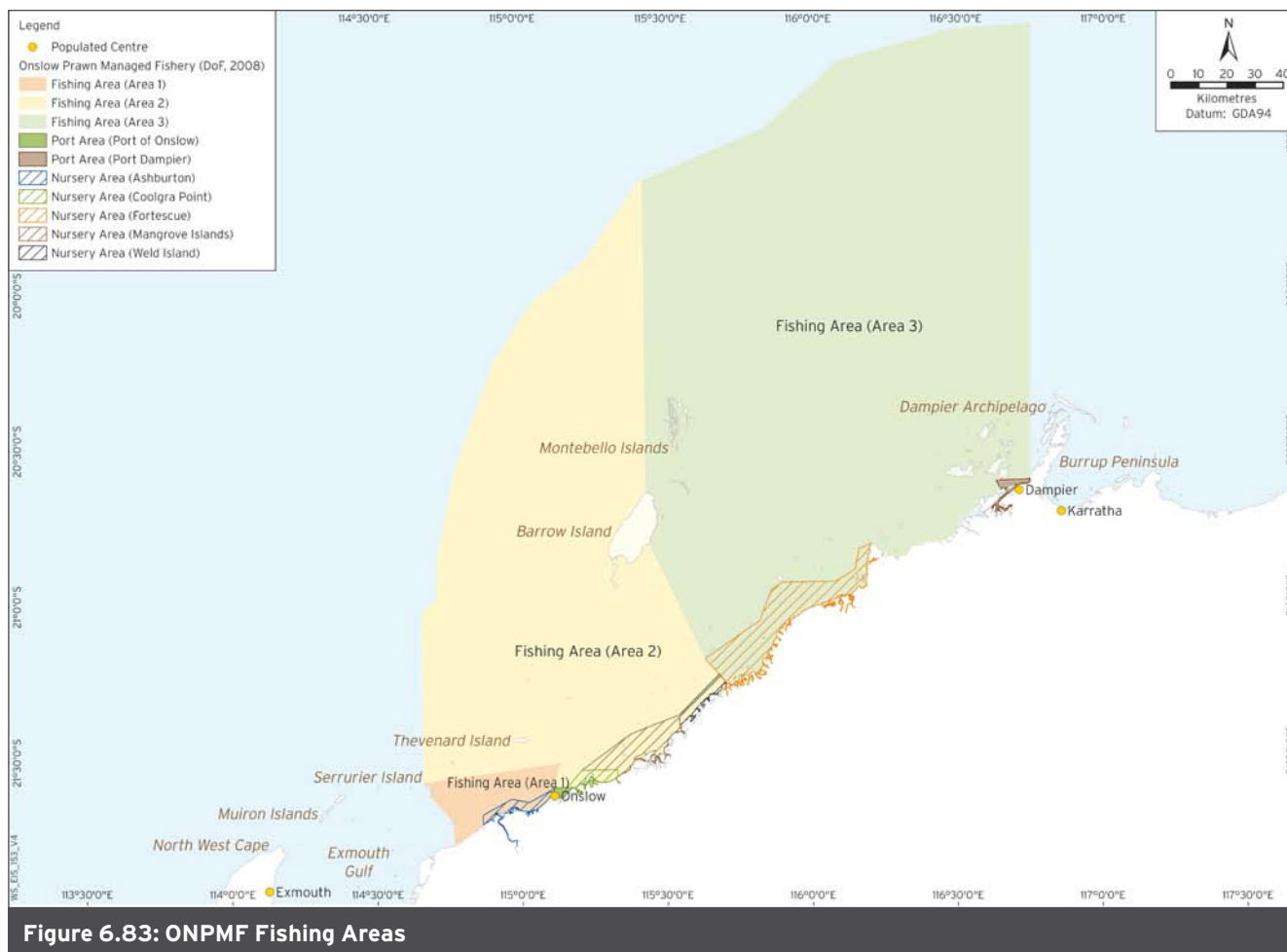
Given its proximity to an array of natural resources and a diverse economic base defined by fishing (commercial and recreational), salt, oil and gas and pastoral activities, Onslow has the potential to capitalise on the natural capital assets of the area, relative to neighbouring towns. Each of these natural assets is described in more detail in the sections below.

Commercial Fishing

The waters off the Pilbara coast are home to many managed commercial fisheries including prawn, demersal scalefish, demersal finfish, mackerel, oyster and several types of tuna. The fisheries in closest proximity to Onslow are managed by the Department of Fisheries (DoF), and include:

- Onslow Prawn Managed Fishery (ONPMF)
- Pilbara Managed Trap Fishery
- North Coast Blue Swimmer Fishery
- Pearl Oyster Managed Fishery
- Pilbara Line Fishery
- Mackerel Managed Fishery
- Specimen Shell Managed Fishery
- Marine Aquarium Fish Managed Fishery.

The ONPMF is a combination of three areas and four associated Size Management Fish Grounds (SMFG) totalling 39 748 km² (See Figure 6.83). Area 1 is a small section in the southwest corner of the fishery off the mouth of the Ashburton River. Area 2 is essentially the western half of the fishery, including most of the shoreline of Barrow Island. Area 3 extends from the eastern shores of Barrow Island east to 116°45' east longitude. The ONPMF is very large and extends from the shore out to the 200 m depth contour, but only a very small portion (<5 per cent) of the region is consistently fished. The mouth of the Ashburton River (Area 1) is the key site for Banana Prawns; up to 50 per cent of this region is trawled. Construction of the Project, including dredging of a MOF and construction of an LNG and PLF, would most directly affect Area 1, which also includes the Ashburton SMFG.



The ONPMF primarily targets Western King Prawns (*Penaeus latisulcatus*), Brown Tiger Prawns (*Penaeus esculentus*), Endeavour Prawns (*Metapenaeus endeavouri*) and Banana Prawns (*Penaeus meguiensis*). The prawns are caught by bottom trawling using twin or quad rigged otter trawls and the catch exhibits a large range in natural variability as illustrated in Figure 6.84. The fishing effort reported in 2006 was 214 boat days, which is much less than the 790 boat days reported in 2004. In 2006, the estimated annual value of the prawn fisheries was \$0.65 million (54 tonnes) down from \$2.2 million (194 tonnes) in 2004 (Sporer *et al.* 2008, 2007, 2006, 2005). In 2007, with only one boat operating a total of 53 boat days, just four tonnes of biomass was landed and a value is not recorded. In 2008, again just one boat operated in Area 1 of the managed fishery producing a reported catch of around 30 tonnes with a retail value of perhaps \$1.2m (Manifis 2009). Following heavy rains in the 2008/09 summer, pre season sampling by the DoF indicated the 2009 catch would be relatively large.

Though the results are still preliminary, the fishing data for 2007 show a huge decline in the fishing effort and economic value of the ONPMF. Only one boat was reported to have fished the 2007 season with 53 fishing days, producing a total season landing of 3.9 tonnes.

On average, between 70 and 80 per cent of the ONPMF catch is exported, primarily to Asia. There are currently many measures to sustain the Onslow prawn managed fisheries, including limited entry, seasonal and area closures, gear control, boat size, vessel monitoring systems and by-catch reduction devices. Similar results were seen in the Exmouth fishery, indicating that previous overfishing in the Onslow area is not the cause of the decline in the landings (Kangas *et al.* 2008).

Table 6.30 provides an overview of the 2003 to 2007 Onslow fishing season's catch, economic value and boating days.

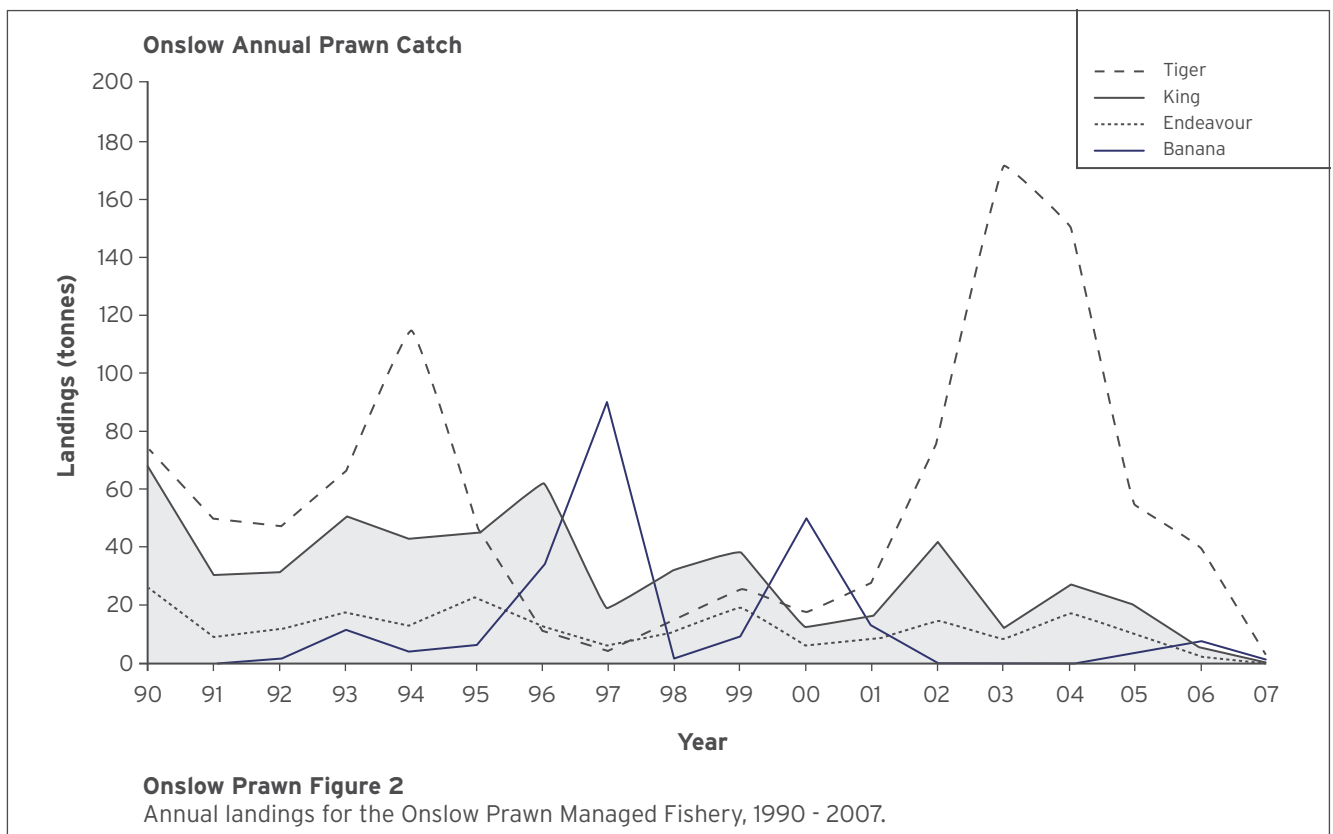


Figure 6.84: Annual Landings for the Onslow Prawn Managed Fishery 1990-2007

Source: Kangas *et al.* 2008

Table 6.30: ONPMF Economic Profile (2003 - 2007)

Year	Boat days	Change in boat days from previous year	Total catch (tonne)	Change in total catch from previous year	Economic value	Change in economic value from previous year
2003	785	-	193	-	\$2.4 million	-
2004	790	(+) 5	194.1	(+) 0.8	\$2.2 million	(-) 0.2 million
2005	523	(-) 267	84.9	(-) 109.2	\$1 million	(-) \$1.2 million
2006	216	(-) 307	53.2	(-) 31.7	\$0.65 million	(-) \$0.55 million
2007	53	(-) 163	3.9	(-) 49.3	\$0.3 million	(-) \$0.35 million

Source: Onslow prawn managed fishery status report. In: Sporer et al. 2005, 2006, 2007, and 2008)

Pearling

Onslow was one of the first commercial pearling centres in WA, since the commencement of the State’s commercial pearling industry during the nineteenth century. Good pearls were found in the Exmouth Gulf and the town eventually became a home port to a fleet of pearling luggers. These luggers stayed in local waters until the Second World War, when most were either seized by the armed forces or destroyed for security reasons. The post-war period saw pearling recommence on a small scale, and the last lugger was sold in 1965.

Pearling licence and quota holders in WA are outlined in Table 6.31. Since 1992, the health of wild oyster stock (the basis for pearl farm production) and the market price of WA pearls have been controlled by a production (output) quota. Quota units are allocated to licence holders (572 units existed in 2006) with one quota unit normally allowing 1000 shells (though there may be annual variations).

Figure 6.85 also provides an overview of licensed aquaculture and pearl farming sites in the North Coast bioregion. According to the DoF (2009), the main pearling licence holders in the Onslow area are Fantome and Paspaley Pearls. However, most of their respective commercial pearling activities take place out of Broome and they do not currently operate in the Onslow area.

Recreational Fishing

Fishing is one of the key recreational activities in Onslow, drawing tourists and contributing to Onslow’s identity as a small fishing town. A local charter vessel services the Mackerel Islands Resort on Thevenard and Direction islands offering diving, whale watching and recreational fishing. Charter and tourist boats, usually from Exmouth and Dampier, offer fishing trips and visits to offshore islands including the Montebello Islands.

Beadon Creek has a small boat ramp, which services local residents and recreational fishers. Recreational fishing locations depend greatly on the type of boat; larger vessels can travel to waters around Thevenard, Direction, The Twin, and Ashburton islands. Most recreational fishers target fish for consumption, such as trevally, red emperor and coral trout. Those with smaller boats often travel north and south of Beadon Creek, staying close to the coastline and accessing creek systems. Popular fishing creeks include Second Creek just north of Beadon Creek, Four Mile, Middle and Hooley creeks, False Entrance and Secret Creek located to the west.

Recreational fishing activities in Onslow also occur from shore. Many locals and tourists fish off the wharf and groyne at Beadon Creek and at Four Mile Creek, located about 8 km west of the townsite and accessible via a paved road.

In 1999 to 2000, the DoF completed a survey of recreational fishers in the Pilbara region. Figure 6.86 illustrates the overall recreational fishing effort within and around the Onslow area.

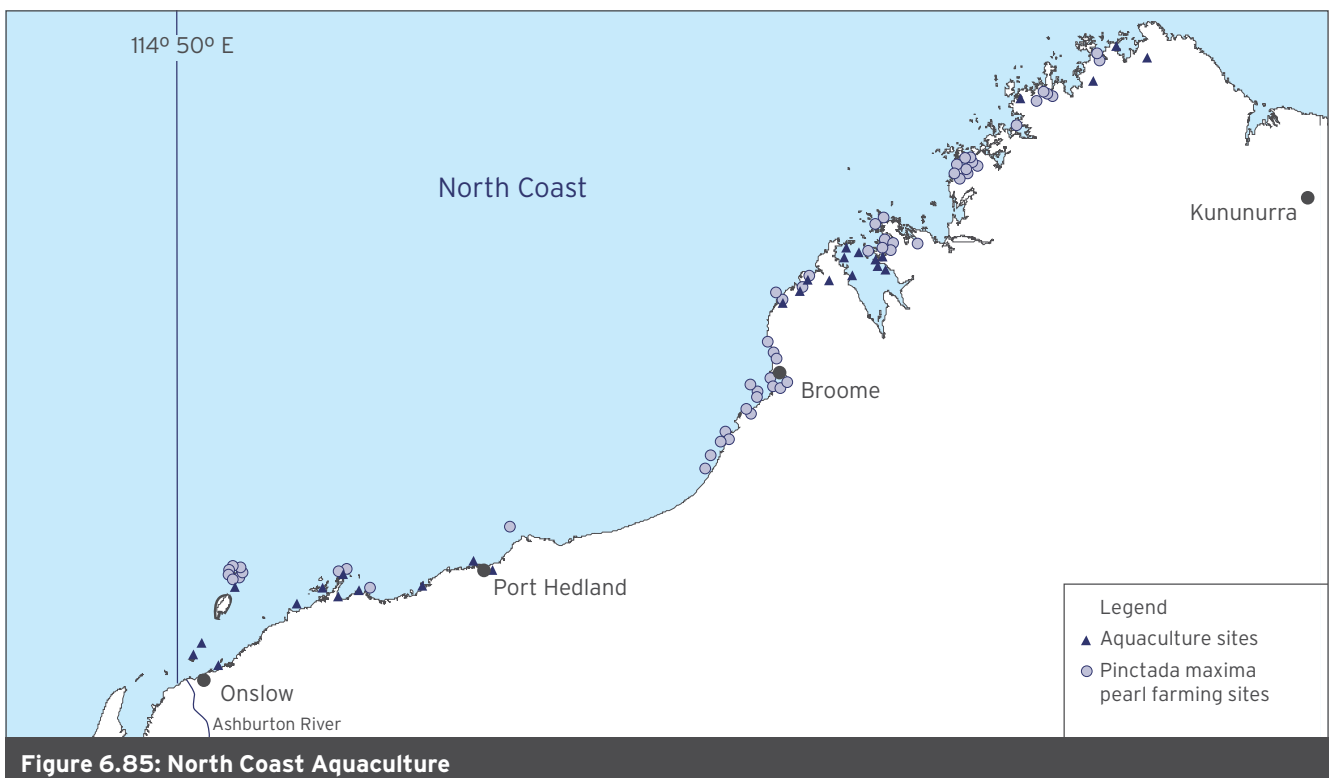
Shore-based sampling was stratified into two separate areas. The Onslow-to-Dampier area included Secret Creek, Hooley Creek, Ashburton River, Old Onslow, Four Mile Creek, Sunset Beach (locally known as “Back Beach”), Sunrise Beach (locally known as “Front Beach”) and Beadon Creek. The survey revealed that general fish, bottom fish and green mud crabs were the most frequently targeted species for shore-based fishing in the area.

More recent intercept surveys of recreational fishers undertaken by Coakes Consulting (between April and June 2009) suggest that recreational fishers to Onslow include those from neighbouring Tom Price and Pannawonica, who visit specifically to fish, as well as people travelling in caravans, who stopover for a day or two during fishing seasons.

Table 6.31: Pearling Licence and Quota Holders - WA

Company Name	Quota Units
Arrow Pearls	15
Australian Sea Pearls	70
Blue Seas Pearling	45
Blue Seas Pearling (Administration)	30
Clipper Pearls	37
Cygnets Bay Pearls	75
Dampier Pearls	35
Exmouth Pearls	35
Fantome Pearls	45
Hamaguchi Pearls	35
Maxima Pearls	35
Morgon & Co	65
NorWest Pearls	35
Paspaley Pearls	120
Pearls Pty Ltd	100
Roebuck Pearl Producers	75
The Australian South Sea Pearl Company	70
Total	922

Source: McCallum 2007



Source: Fletcher and Santoro 2008

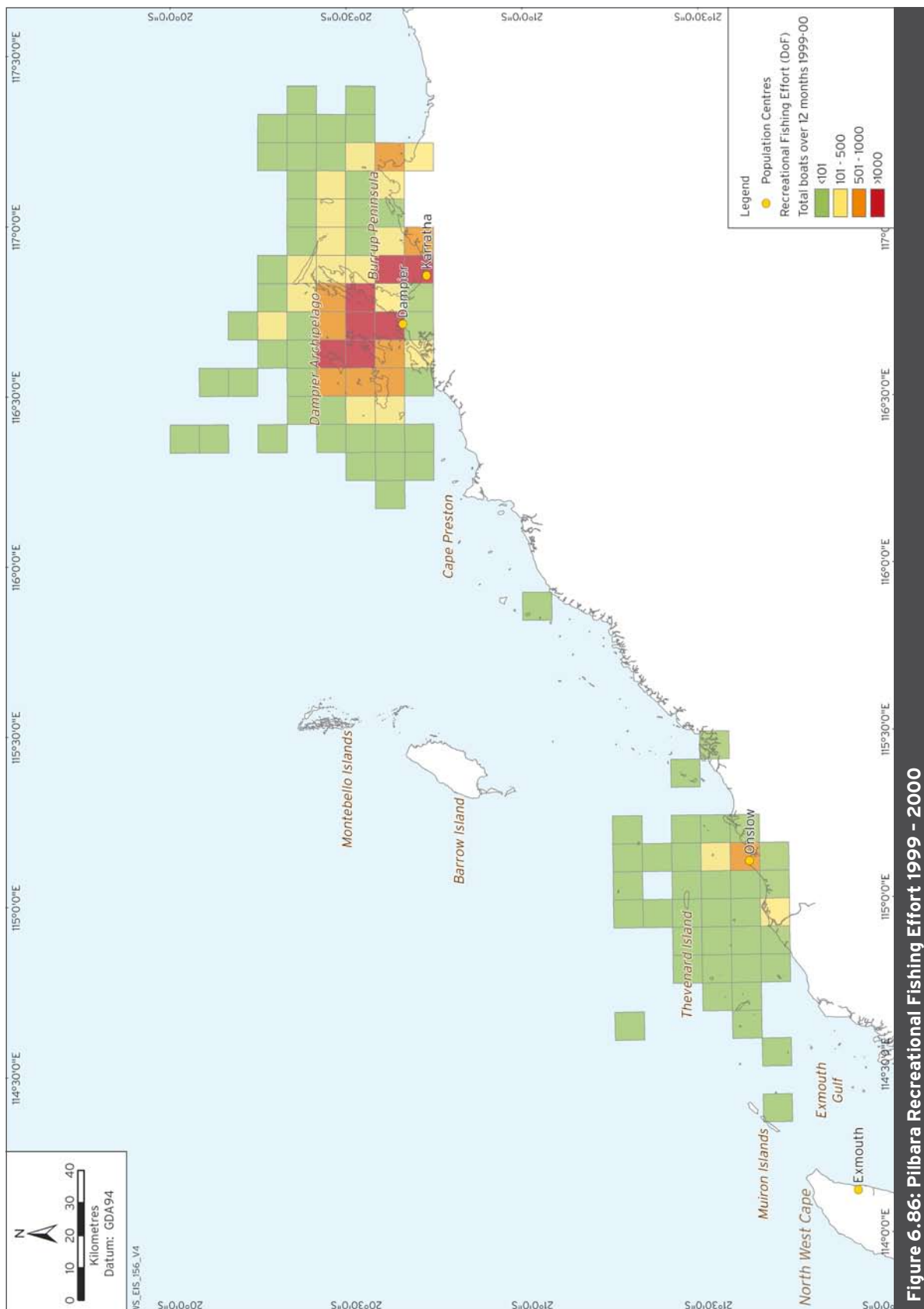


Figure 6.86: Pilbara Recreational Fishing Effort 1999 - 2000

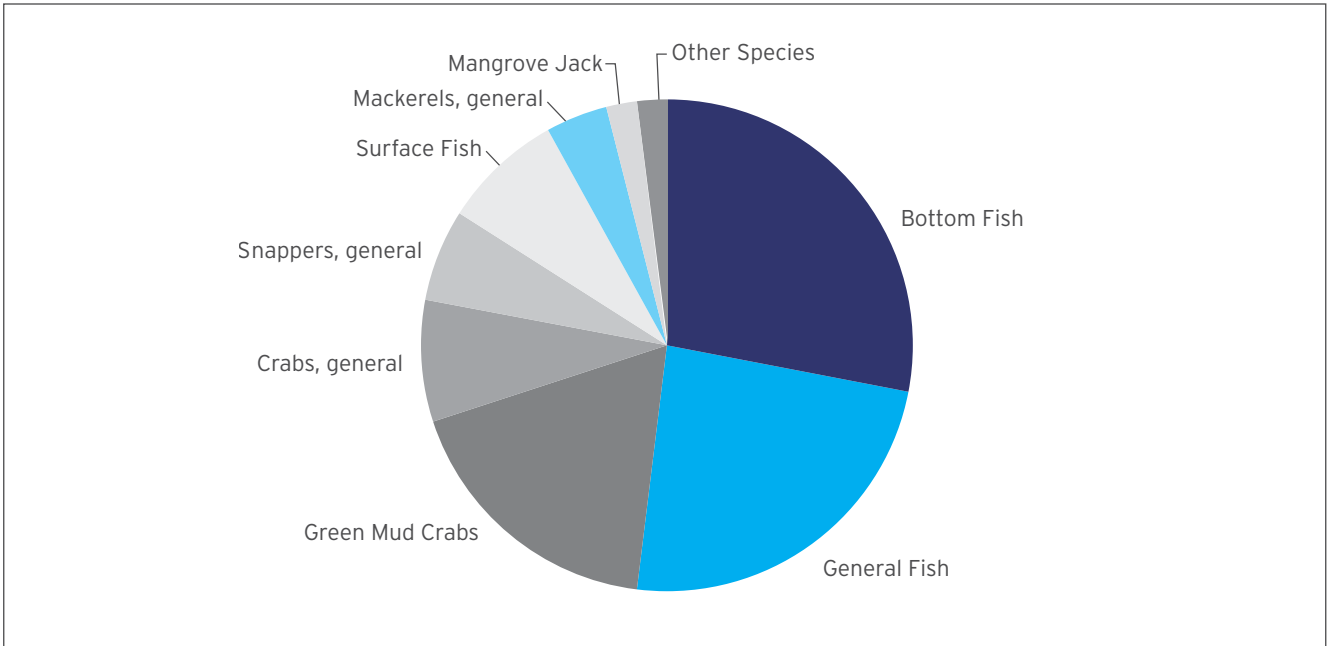


Figure 6.87: Onslow Target Species (1999 - 2000)

Source: Williamson et al. 2006

Onslow is also visited by so-called “grey nomads” who stay in the area for about three to four months at a time, fishing about four days a week, for recreational purposes and for food.

Tourism

Onslow’s proximity to the ocean and the Ashburton River attracts many visitors in pursuit of recreational coastal activities. Intercept surveys undertaken with visitors to the area, as part of the Social and Health Impact Assessment for the Project, highlighted that visitors were predominantly from WA (76.7 per cent), interstate (21 per cent) or overseas (2.3 per cent). The majority were staying in the area for one to two days (36.6 per cent) or for three to four months (26.8 per cent). Fishing was the most common leisure and recreational activity (69.6 per cent of visitors engaged in this activity). Visitors seeking recreational fishing have access to cruises and fishing charters to many islands off Onslow’s coast. For instance, the Mackerel Islands, 22 km from the Onslow coast, comprises ten small islands and is known as one of Australia’s best fishing and diving destinations. The largest island of the group, Thevenard, has a range of resort accommodation and offers a 6 km-long coral atoll with white beaches and spectacular corals for snorkelling.

Visitors to Onslow also use heritage trails and tours highlighting the town’s rich history. Near the mouth of the Ashburton River, the ruins of the Old Onslow Townsite, including the gaol and courthouse can still be seen. The Onslow Tourist Centre, located in the Goods Sheds Museum in Onslow and known for memorabilia and relics, attracts tourists interested in the history of the town and neighbouring areas.

Pastoral Leases

The Project accommodation village and Shared Infrastructure Corridor (SIC) spans Minderoo Station, one of the Pilbara’s largest cattle stations, and the Urala pastoral station. Minderoo is a 226 585 ha station with 10 000 cattle. The station’s pastoral lease was purchased in 2009 by Andrew Forrest, whose family originally founded the station in the late 1870s and held the lease until 1998.

BHP Billiton acquired the Urala’s pastoral lease in 2005, which also covers the site of the Griffin onshore pipeline, the Griffin export facility, and the recently decommissioned Tubridgi gas plant. Active cattle farming takes place at the station, with the pastoral lease manager contracted by BHP Billiton to assist in station maintenance and management.

Onslow Salt Works

The Onslow Solar Salt Project (OSSP) holds a lease covering a site immediately east and adjacent to the proposed Project site. In 1990, a proposal was submitted by Gulf Holdings Pty Ltd to develop a new salt field near Onslow to produce and ship salt from a new port facility to be built near Beadon Point. In 1995, Onslow Salt Pty Ltd replaced Gulf Holdings Pty Ltd as the proponent of the \$80 million OSSP, with capacity to produce up to 2.5 million tonnes of sodium chloride per year.

Onslow Salt has handling facilities to transport, process, store and load salt into ships for export via a 0.3 km steel-trestle jetty off Sunset Beach. The company loaded its first commercial shipment of salt in 2001.

While Onslow Salt has shipping activity, Onslow and the surrounding coastal area is not a high-density shipping channel. Greater shipping activity occurs in neighbouring locations including Exmouth, Dampier and Port Hedland (AMSA 2008).

Oil and Gas Production

The Pilbara coast and its North-West Shelf offshore facilities form the centrepiece of the State's oil and gas industry. Oil and gas development began in the region in 1967 in the Barrow Island oil fields. Offshore oil and gas production commenced in 1984 with LNG first exported in 1989. Since 1985, the region has provided the vast majority of sales value for the WA petroleum sector. Facilities off the Pilbara coast account for 96 per cent of the State's crude oil and condensate production, all of the LNG, and 97 per cent of natural gas production. Gas reserves in the offshore region represent 56 per cent of the nation's total (Department of Industry and Resources 2008). The State has 82 identified offshore oil and gas fields off the Pilbara coast, of which 42 have operating production facilities (Pilbara Development Commission 2006).

Figure 6.88 provides an overview of current petroleum leases and permits in the North-West Shelf (NWS).

Oil is produced from a number of small fields located in shallow waters offshore from Onslow. These include the Saladin, Coaster, Roller and Skate fields. Further offshore are the BHP Billiton operated Griffin oilfield, the Chevron operated Barrow Island facility and the Gorgon gas field development, as well as Apache's Varanus Island operations. Key island facilities for oil and gas processing, storage and shipping facilities are located on Barrow, Thevenard, Airlie and Varanus islands. Gas gathering pipelines from the Griffin and Roller fields come ashore west of Onslow, near Urala Station.

A new structure plan is being developed for Onslow to complement the proposed Ashburton North SIA, which was endorsed in December 2008 to support further opportunities for gas processing plants development in the area. The Ashburton North SIA would cover approximately 8000 ha and include the Project, BHP Billiton/Apache Macedon Domgas plant and ExxonMobil/BHP Billiton Scarborough LNG plant. The Ashburton North SIA would also have optimal access to the coast, a buffer of about 12 km from the Onslow townsite and would accommodate various gas related industrial land uses.

The proposed Ashburton North SIA is currently in its detailed planning stage with the State Government, focusing on a port precinct, multi-user facilities along the coastal strip and a multi-user infrastructure corridor. The aim is to ensure that any new infrastructure can be shared between Chevron, BHP Billiton, ExxonMobil and other major land users.

6.5.3.2 Economic Capital

Economic capital is broadly defined as the extent of financial or economic resources within a community. A community's economic capital has significant implications for its resilience and capacity to adapt to change. In assessing a community's economic capital, economic resources associated with individuals and families need to be considered. Strained economic capital and resources at an individual or household level is likely to affect the community's overall capacity to embrace and adopt new economic opportunities. The influx of an affluent industry into a community, which characteristically earns less than average wages, is also likely to create social divides, segregating the community into the "haves" and the "have nots".

Onslow is more socio-economically disadvantaged than the broader shire and Pilbara region. Its average workforce participation (45.8 per cent) is substantially less than the Shire of Ashburton (67.2 per cent) and Pilbara (62.5 per cent). In addition, Onslow had a higher-than-average unemployment rate of ten per cent and less-than-average full-time employment rate of 55.3 per cent during the 2006 Census. Sporadic and part-time employment trends reflect a transient and seasonal workforce. This suggests that residents may be employed across a number of jobs in Onslow and other towns in the Shire, with employment being mostly seasonal (such as commercial fishing, construction for local development projects and tourism).

Table 6.32 outlines key determinants of Onslow's individual and household economic capital, as informed by the 2006 ABS Census (ABS 2006a).

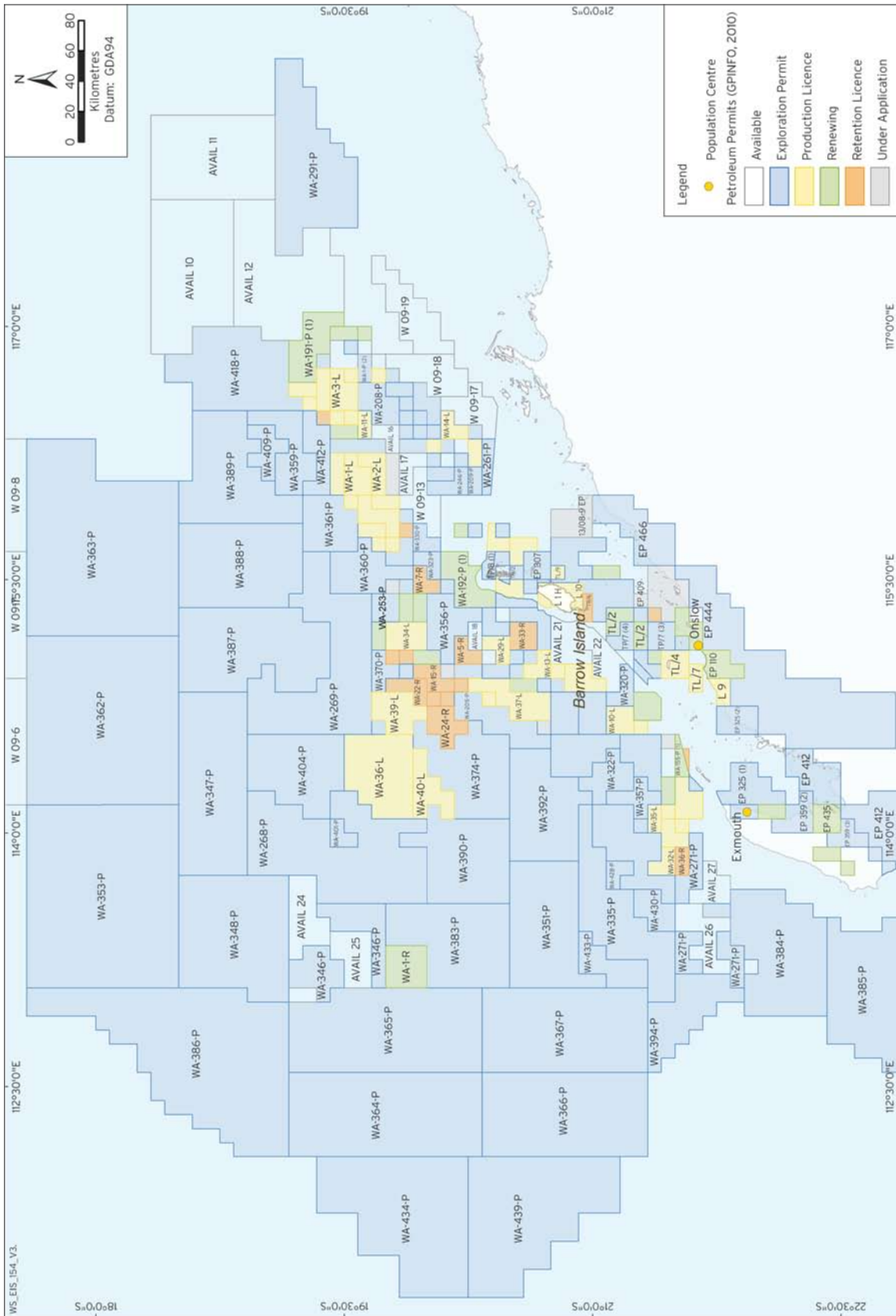


Figure 6.88: Current Petroleum Titles around the Project Area of Interest (September 2009)

Table 6.32: Onslow’s Individual and Household Economic Resources

Economic characteristics	Onslow	Shire of Ashburton	Pilbara
Income			
Median individual weekly income	\$428	\$1058	\$887
Median household weekly income	\$961	\$2143	\$2178
Median family weekly income	\$1133	\$2398	\$1969
Housing			
Median rent/week	\$90	\$37	\$80
Percent of household income spent on rent	9.4%	1.7%	4.1%
Percent owning	17.8%	5.1%	9.6%
Percent purchasing	14.9%	10.6%	24.5%
Percent renting	67.3%	83.2%	64.9%
Percent of renters in Government housing	27.1%	5.7%	18.8%
Single parent families	15.1%	7.1%	10.7%
Lone household	32.1%	20.9%	20.2%
Employment			
Percent unemployed	10.0%	2.3%	3.0%
Labour force participation rate	45.8%	67.2%	62.5%
Labour Force Participation			
Employed part-time	17.3%	14.5%	15.5%
Employed full-time	55.3%	73.4%	73.0%

Source: ABS Census 2006a

The income and housing data is calculated using usual place of residence while employment and labour force participation is calculated using place of enumeration, all data excludes:

- overseas visitors
- respondents who did not adequately answer the question
- respondents who did not answer the question

Note: Light Blue = Shire / Pilbara average **less** than Onslow
 Dark Blue = Shire / Pilbara average **greater** than Onslow

Overall income levels are also substantially lower compared to the broader region. Weekly household and individual income levels are less than half of the broader shire and Pilbara averages. As the figure below shows, a significant proportion of Onslow’s workforce earned less than \$600 per week.

Interestingly, a greater proportion of Onslow’s residents were also noted to be renting from government housing (27.1 per cent). Onslow is also notably characterised by a higher-than-average proportion of single-parent families, outlining potential economic burdens across a number of households in the community.

Assessing economic resources associated with a town’s business and commercial activities is another useful way of determining the extent of that town’s economic capital.

The diversity and range of industry/commercial economic activities is a key indicator of that community’s capacity to accommodate further industry diversification and hence, economic growth.

To quantify Onslow’s commercial and industrial diversity, the town’s Herfindahl Index was calculated. This index measures industry concentration and is obtained by squaring the market-share of various commercial and industry sectors, and then summing those squares (Bradley and Gans 1998). The index takes into account employment numbers across the diverse range of industry sectors informed by the ABS Census Australian and New Zealand Standard Industry Classification (ANZSIC), and has a range from zero to one. A higher index value represents greater industry concentration and limited industrial diversification.

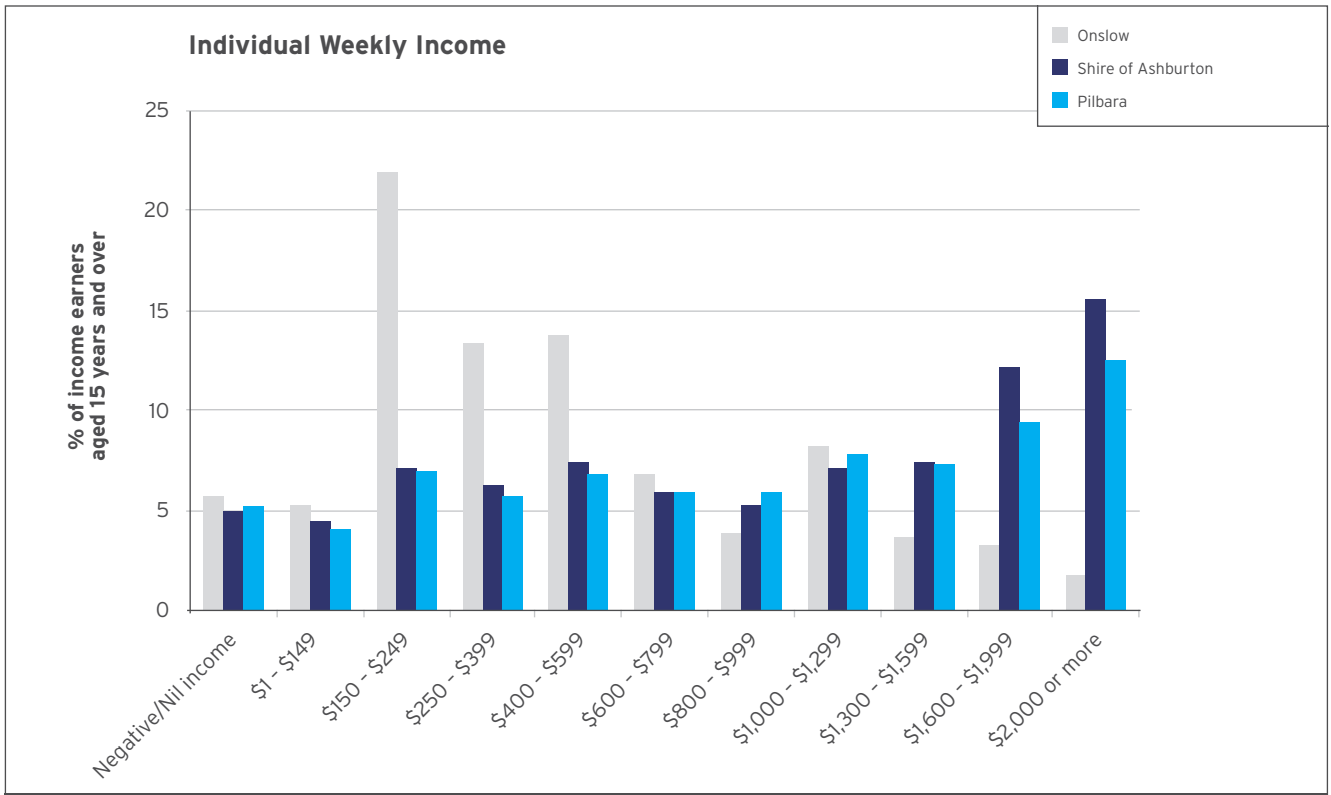


Figure 6.89: Individual Weekly Income - Onslow, Shire of Ashburton, Pilbara Region

Source: ABS Census 2006, 2006a, 2006b (Place of enumeration)

Taking into account Onslow's employment proportions across a range of diverse industry sectors, based on the ANZSIC of industries by employment, the town's Herfindahl Index is currently 0.944, which is comparable to the broader Pilbara region's index value of 0.950. Notably, the Herfindahl Index is significantly higher at 0.983 for Karratha, which is characteristic of a key regional oil and gas service hub.

A review of current services and business sectors in Onslow has identified that most local businesses in the town serviced the construction industry. These businesses predominantly offered contracting services to other key industry sectors in Onslow and neighbouring localities, including residential, commercial and industry construction/trade requirements. A number of local businesses in Onslow also serviced the retail trade sector, as well as the accommodation, cafes and restaurants industries. Onslow currently has only a small

number of local businesses that service a limited spectrum of industry sectors.

Like Onslow, the Pilbara region's commercial activities are not broadly diversified across a range of industry sectors. Most businesses in the Pilbara exist predominantly to service the mining and resources sector. For instance, the Pilbara Small Business Capacity Survey (Pilbara Development Commission 2007) reported that around 80 per cent of its respondents supplied goods and services to the resource sector, with a further one-third of respondents noting that 50 per cent or more of their business revenues were contingent on activities from the resources sector.

While the status of Onslow's economic capital does not suggest predominant influence by the resources sector, Onslow's relatively substantial commercial base within the construction/trades industry offers a basis

Table 6.33: Local Business Sectors in Onslow

Business Category	Number of Businesses in Onslow
Construction	16
Retail trade	9
Accommodation, cafes and restaurants	8
Transport and storage	4
Personal and other services	3
Agriculture, forestry and fishing	2
Cultural and recreational services	2
Property and business services	1

for opportunities of further growth for local businesses within this sector, with the imminent influx of large-scale industry development within the locality. As such, this could potentially increase the products of both Onslow’s household and commercial economic capital.

6.5.3.3 Human Capital

Human capital refers to the health and welfare of human beings, their knowledge and skills, as well as their overall capacity to contribute to community sustainability.

Education, Skills, and Industries of Employment

Key indicators of human capital relate to education and skills. For example, a community with less education and lower-skills tends to be more vulnerable to potential risks and threats to livelihood. Some studies have also shown that less skilled communities are also less likely to initiate positive community change (Black and Hughes 2001).

Facing large-scale industrial development a less educated and lower-skilled community may find it harder to integrate existing skill-sets with those of a professional industry workforce. This could widen the gap and create further rifts between current and future residents. Furthermore, a community of mostly lower-skilled workers is also less likely to embrace new opportunities generated by development, such as employment and business opportunities.

Table 6.34 summarises Onslow’s educational and employment trends, in comparison to the Shire of Ashburton and the broader Pilbara region.

The 2006 ABS Census has documented nil students attending secondary school in Onslow. This may be because the high school in Onslow forms part of the town’s primary school, thus confounding reports of secondary school enrolment trends. However, according to records of the 2009 academic year from the Department of Education and Training (DET), Onslow School recorded 38 students

in pre-compulsory years (kindergarten/pre-primary), 66 students in years 1 to 7, and 30 students in years 8 to 12 (DET 2009). Further to this, attendance rates for Onslow School were 80 per cent for primary school years and 60 per cent for years 8 to 12. While these attendance rates show a significant increase from previous academic years, the rate is well below State averages (DET 2009).

A smaller proportion of Onslow’s workforce completed Year 12 studies (28.3 per cent), relative to the Shire of Ashburton (39.6 per cent) and the broader Pilbara region (39.4 per cent). The graph below illustrates that in 2006, most Onslow residents had vocational qualifications (63.8 per cent), with a further 17.4 per cent holding advanced diplomas. These trends are typical of WA regional areas where vocational training qualifications tend to be pursued in response to higher demand for trade-based skills.

The most frequently chosen field of further education training in Onslow was engineering and related technologies (41.2 per cent). This is comparable to the Shire (44.9 per cent) and Pilbara region averages (43.7 per cent). Notably, a number of Onslow’s residents were also enrolled in management and commerce (12.8 per cent), and in architecture and building (10.9 per cent).

Onslow residents tend to be employed in trade-based industries such as mining and construction. Mining remains a dominant sector, employing up to 19.9 per cent of the town’s workforce. A majority of this mining workforce is engaged in the area’s salt mining and harvesting activities. Other key employment sectors include construction (10.9 per cent), and transport and warehousing (6.4 per cent). These trends reflect the dominant activities of the Northern Transport Company and Northern Transport Contracting, operated by the same management out of Onslow. The transport company coordinates freight, courier and transport of supplies from other parts of the region to Onslow (such as local business supplies, personal

Table 6.34: Onslow's Education Trends

Education characteristics	Onslow	Shire of Ashburton	Pilbara
Education Institutions Attending			
Attending Primary School	63.0%	56.3%	49.5%
Attending Secondary School	0%	13.4%	22.5%
Attending Technical/Further Educational Institution	16.0%	10.9%	6.2%
Highest Level of Education Completed			
Completed Year 10	33.6%	32.8%	32.5%
Completed Year 12	28.3%	39.6%	39.4%
Certificate	63.8%	63.8%	61.9%
Graduate Diploma/ Certificate and Advanced Diploma/Diploma	20.3%	15.1%	16.0%
Bachelor and Postgraduate Degree	13.3%	21.1%	22.1%
Industry of Employment (Top 3)			
1	Mining	Mining	Mining
2	Construction	Construction	Construction
3	Retail trade, Healthcare & social assistance	Retail trade	Retail trade
Occupation of Employment (Top 3)			
1	Technicians and Trades Workers	Technicians and Trades Workers	Technicians and Trades Workers
2	Professionals	Machinery Operators and Drivers	Machinery Operators and Drivers
3	Labourers	Professionals	Professionals

Source: ABS Census 2006, 2006a, 2006b

This data is calculated using place of enumeration and excludes:

- overseas visitors
- respondents who did not adequately answer the question
- respondents who did not answer the question

Note: Light Blue = Shire / Pilbara average **less** than Onslow
Dark Blue = Shire / Pilbara average **greater** than Onslow

Onslow – Educational Institutions Attending

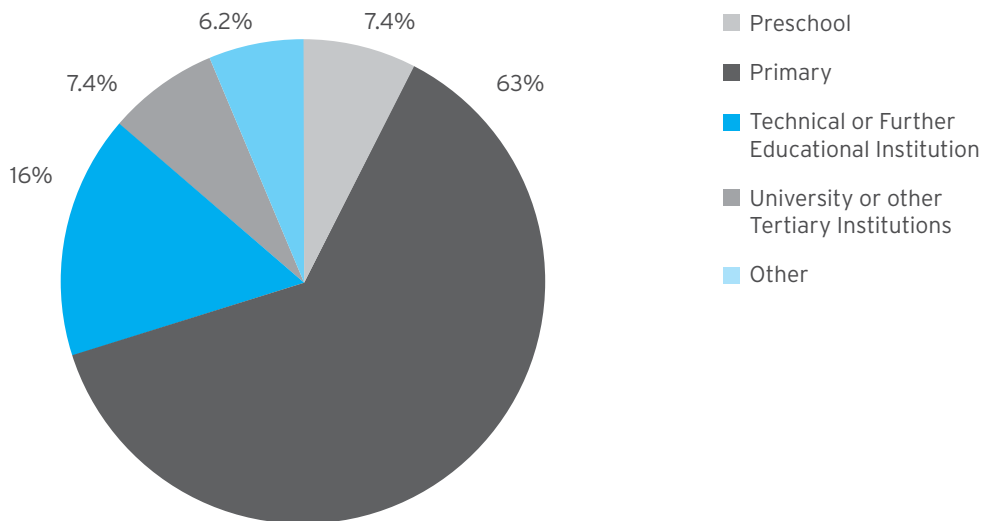


Figure 6.90: Educational Institutions Attending - Onslow

Source: ABS Census 2006a (Place of enumeration)

Onslow – Educational Qualifications

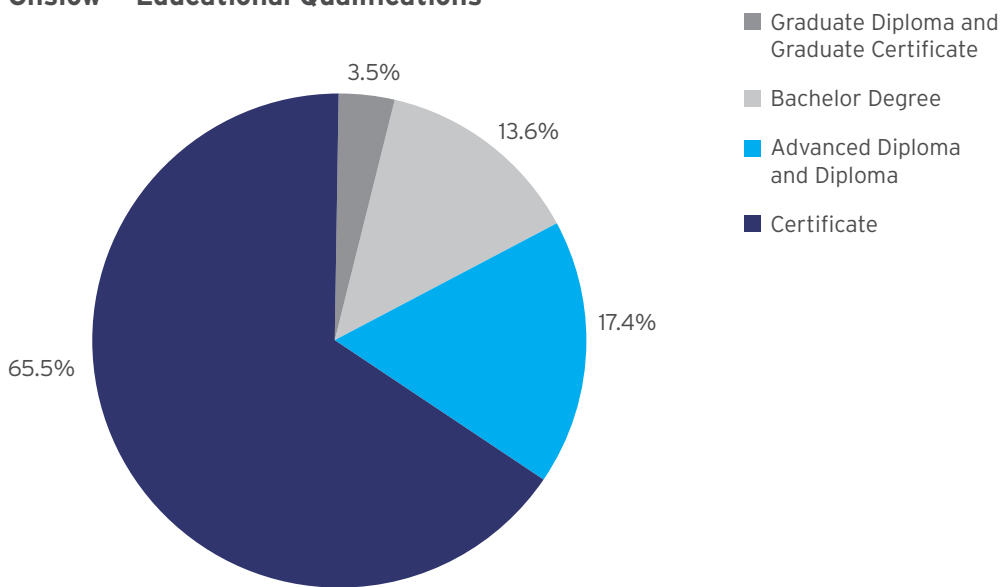


Figure 6.91: Educational Qualifications - Onslow

Source: ABS Census 2006a (Place of enumeration)

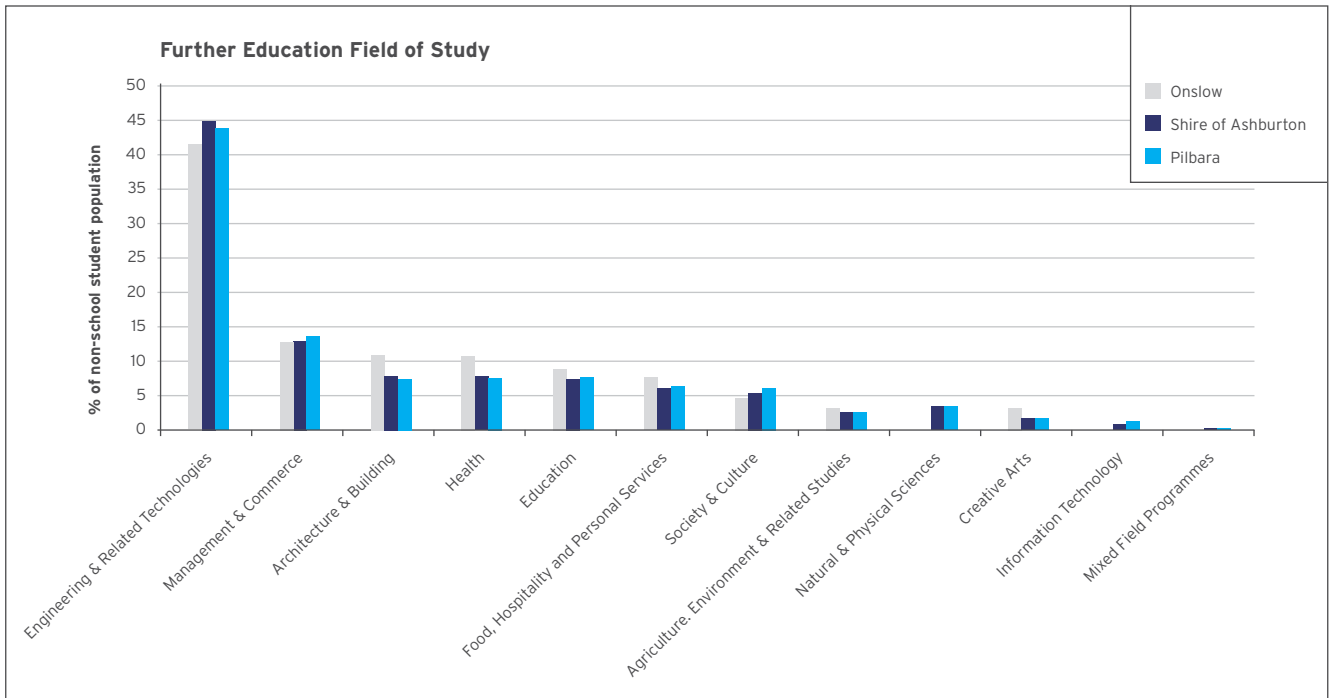


Figure 6.92: Further Education Field of Study - Onslow, Shire of Ashburton, and the Pilbara Region

Source: ABS Census 2006, 2006a, 2006b (Place of enumeration)

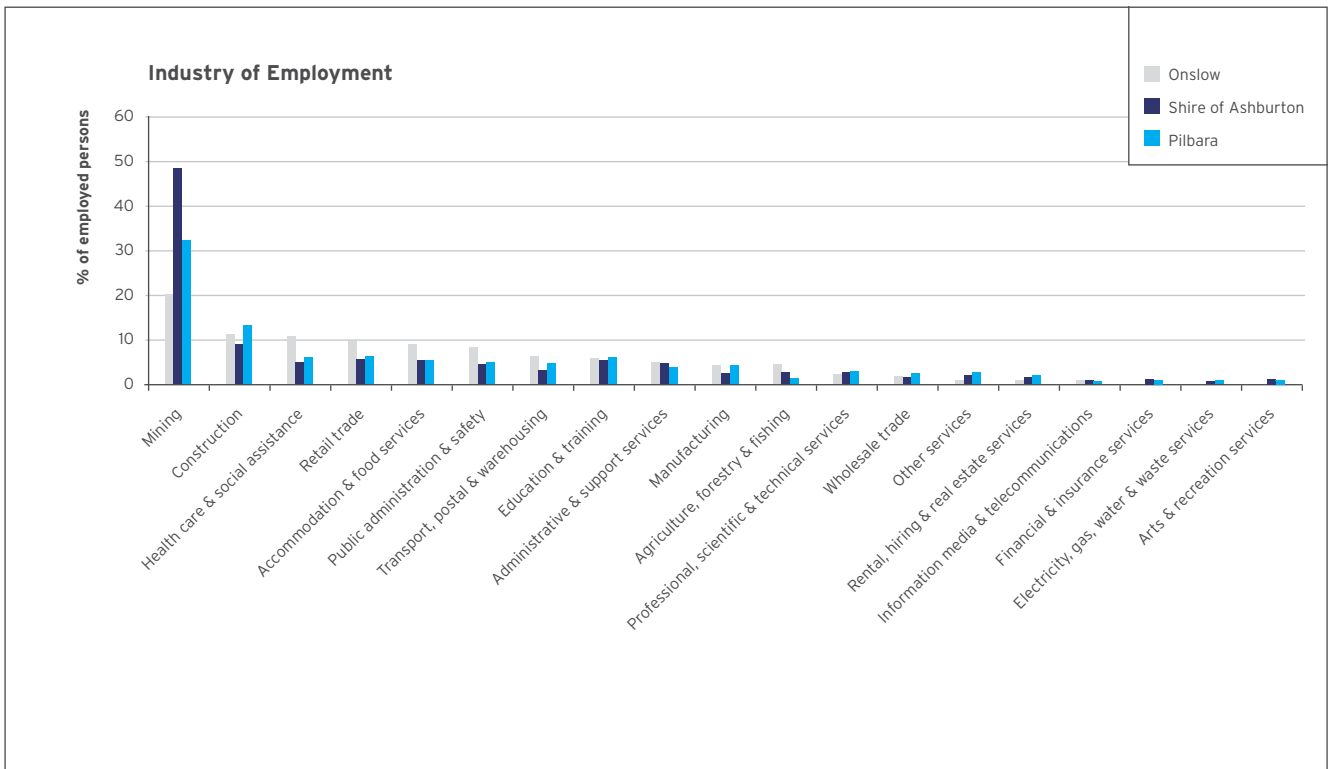


Figure 6.93: Industry of Employment - Onslow, Shire of Ashburton, and the Pilbara Region

Source: ABS Census 2006, 2006a, 2006b (Place of enumeration)

freight and courier services); the contracting company undertakes civil works projects in the region, including earth moving, drainage, and leasing of heavy machinery to other industries in the area.

A number of Onslow residents are also employed in tourism-related industries such as accommodation and food services, and in retail. Notably, a higher-than-average proportion of the workforce is also employed in public administration and safety, suggesting employment with the local shire. This is most likely because the Shire of Ashburton has an administrative centre in Onslow.

As shown in Figure 6.94, Onslow's workforce is characterised by trades and technicians with specialised trade-based skills in sectors such as mining and construction. However, a large proportion of its workforce tends to be professionals, followed by labourers and machinery operators and drivers.

Given the experience of Onslow's workforce in construction and mining, employment opportunities might be generated by the Project and other industrial developments in the area, particularly during the construction phases.

However, development of oil-and-gas infrastructure tends to require highly specialised technical skills. As a result, construction workers are likely to be sourced from elsewhere. In addition, smaller construction and contracting businesses in the region may lack the necessary health-and-safety standard requirements to carry out work on the Project site.

At-risk/Vulnerable Groups

Another useful indicator of human capital is the prevalence of potentially at-risk and vulnerable groups within the community. A community with a greater proportion of at-risk or disadvantaged groups - such as Indigenous people, and the very young or elderly - may be less resilient in effectively managing community change.

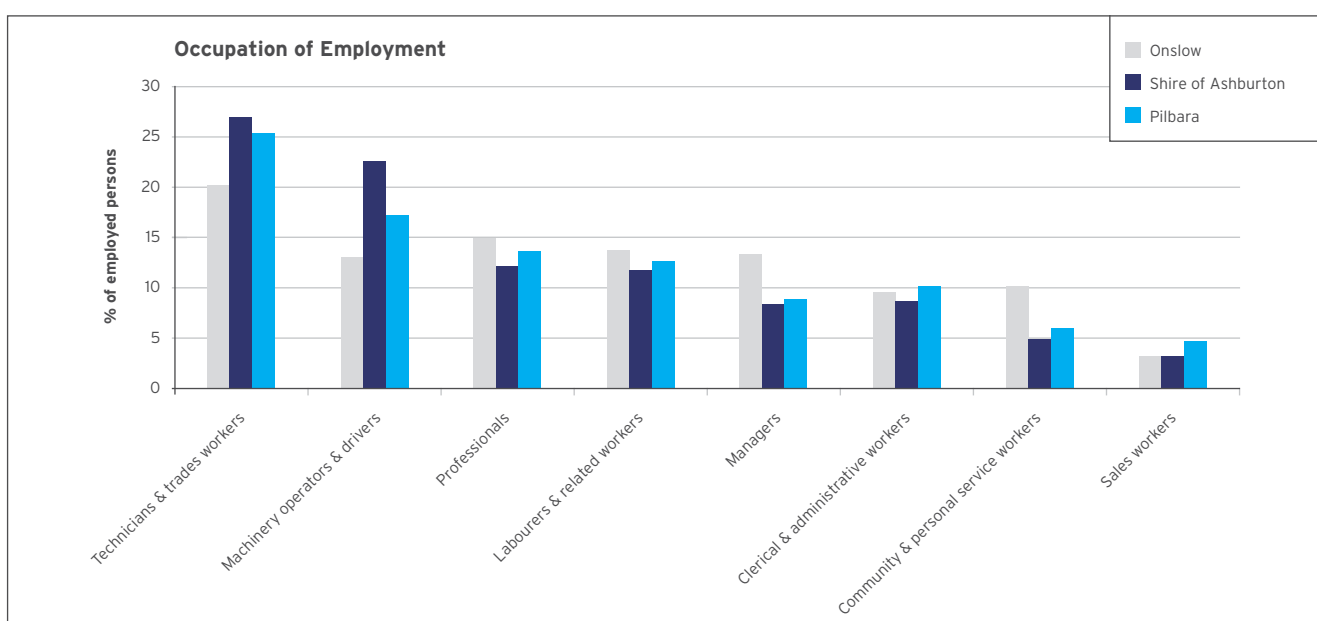


Figure 6.94: Occupations of Employment - Onslow, Shire of Ashburton, and the Pilbara Region

Source: ABS Census 2006, 2006a, 2006b (Place of enumeration)

Indigenous Profile

The following statistics are primarily derived from the ABS 2006 Census. The figures specifically relate to respondents who have identified themselves as “Indigenous” or “Non-Indigenous”. Respondents who did not state their status in this regard have been omitted.

It is important to note that the Indigenous statistics gathered by the ABS are generally considered incomplete and prone to inaccuracy. This is due to problems with establishing contact with all Indigenous Australians and methods used to record Indigenous status. Consequently, this data is likely to misrepresent the Indigenous population in the area and should be interpreted cautiously.

Onslow has a significant Indigenous population – 37 per cent of the total population of Onslow, which is almost 3.5 times the percentage in the Shire of Ashburton and more than 2.5 times the percentage in the Pilbara region (Table 6.35). However, all three areas have a very similar age distribution (Figure 6.95), with the greatest proportion aged between 25 and 44 years and the smallest proportion aged 65 years and above. It is, however, interesting to note that Onslow is characterised by a greater proportion of elderly Indigenous dependents over the age of 65 years, relative to both the Shire of Ashburton and the broader Pilbara region (Figure 6.95).

In comparison to the non-Indigenous population, the Indigenous population of Onslow has significantly different levels of schooling (Figure 6.96).

Table 6.35: Number of Indigenous and Non-Indigenous Persons by Age Group (Ashburton, Onslow, Pilbara)

	Onslow		Ashburton		Pilbara	
	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous	Indigenous	Total
0-4 years	20	20	64	547	581	2510
5-14 years	41	24	129	799	1302	4434
15-24 years	28	25	83	455	1030	3966
25-44 years	60	101	195	2025	1715	13 625
45-64 years	32	132	96	969	825	9488
65 years and over	11	30	19	71	239	1670
Total	192 (37%)	332	585 (11%)	4866	5692 (14%)	11158

Source: ABS Census 2006, 2006a, 2006b (Usual place of residence)

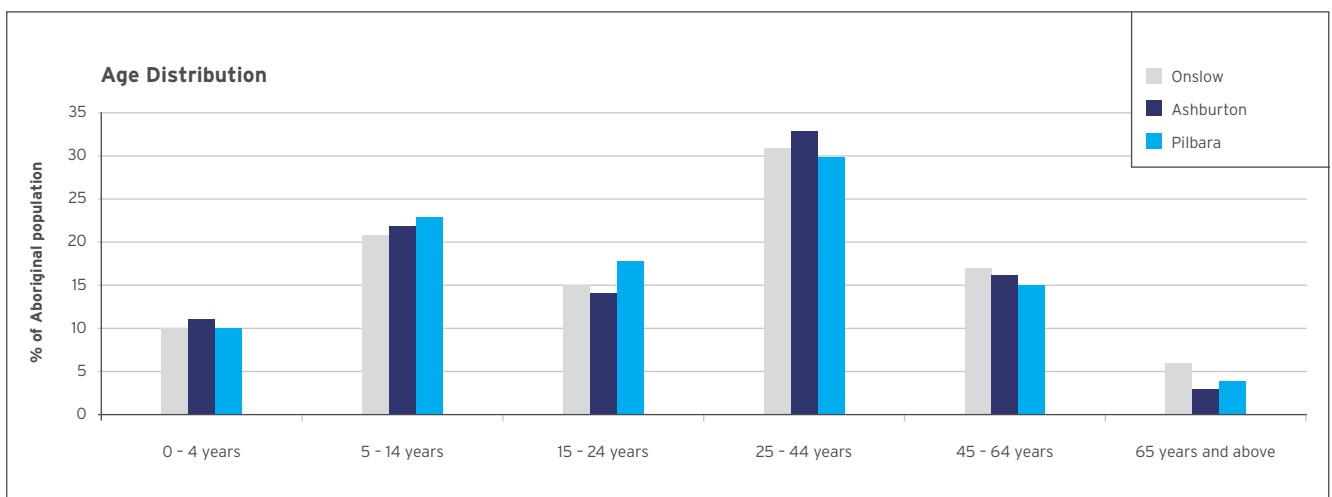


Figure 6.95: Age Distribution of Indigenous Population – Onslow, Ashburton, Pilbara

Source: ABS Census 2006, 2006a, 2006b (Usual place of residence)

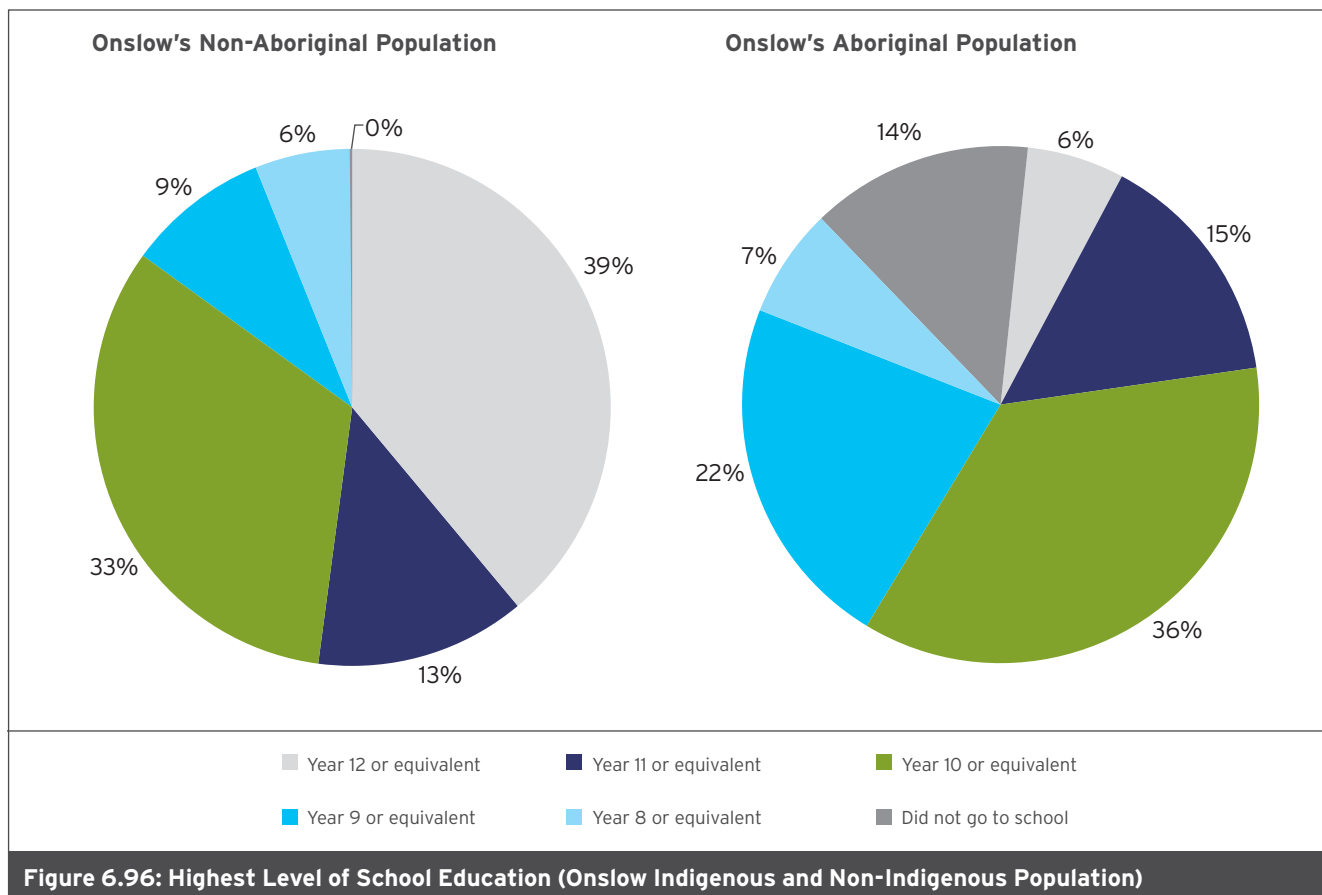


Figure 6.96: Highest Level of School Education (Onslow Indigenous and Non-Indigenous Population)

Source: ABS Census 2006a (Usual place of residence)

For example, all non-Indigenous respondents have attended school to some degree, whereas 14 per cent of Indigenous people have never been to school and only six per cent (compared to 39 per cent of non-Indigenous people) reported having completed a Year 12 or equivalent education.

For those in Onslow who proceeded with education beyond their school years, the majority - 67 per cent of Indigenous and 63 per cent of non-Indigenous persons - attained a certificate level. Around one third of Indigenous persons with a non-school qualification also held an Advanced Diploma. However, according to ABS figures, no Indigenous persons had achieved a Bachelor-level degree.

At the time of the 2006 Census, 12 Indigenous persons identified themselves as students seeking a non-school qualification, with Figure 6.97 illustrating that half were enrolled in the field of engineering and related technologies. This was also the dominant choice of further education within the non-Indigenous sector. Other Indigenous students were enrolled in the fields of natural and physical sciences, and management and commerce.

In comparison to the Shire of Ashburton, the Onslow population has a much greater unemployment rate for both Indigenous and non-Indigenous persons (Table 6.36). This is consistent with reports suggesting that the worst Indigenous unemployment rates are often recorded in small towns. Overall, Indigenous Australians are the most disadvantaged in the labour market due to insufficient resources and personal contacts for accessing jobs. Such issues are intensified in a small town.

Figure 6.98 charts the industries within which people in Onslow are employed. As the figure illustrates, a relatively high proportion of the population (25 per cent indigenous and 22 per cent non-Indigenous) are employed in the mining sector. A further 23 per cent of the Indigenous population held public administration and safety roles.

In 2006, 13 per cent, seven per cent and four per cent of the non-Indigenous workforce were employed within the construction, transport, posting and warehousing, and manufacturing industries respectively. No Indigenous respondents worked in any of these industries.

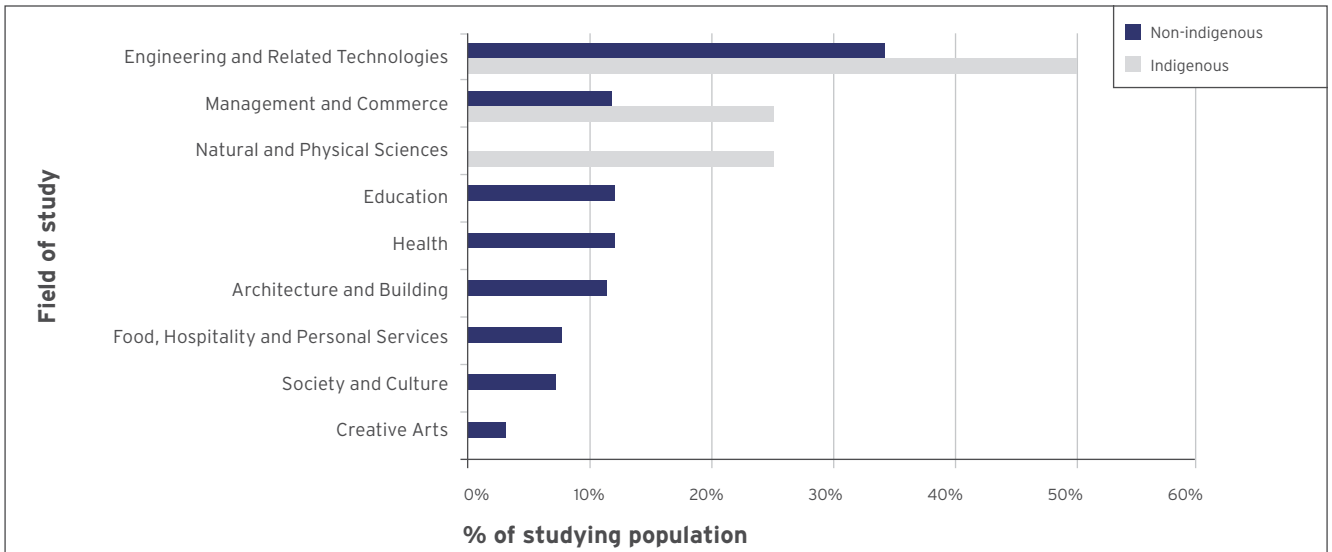


Figure 6.97: Field of Study (Onslow Indigenous and Non-Indigenous Population)

Source: ABS 2006a (Usual place of residence)

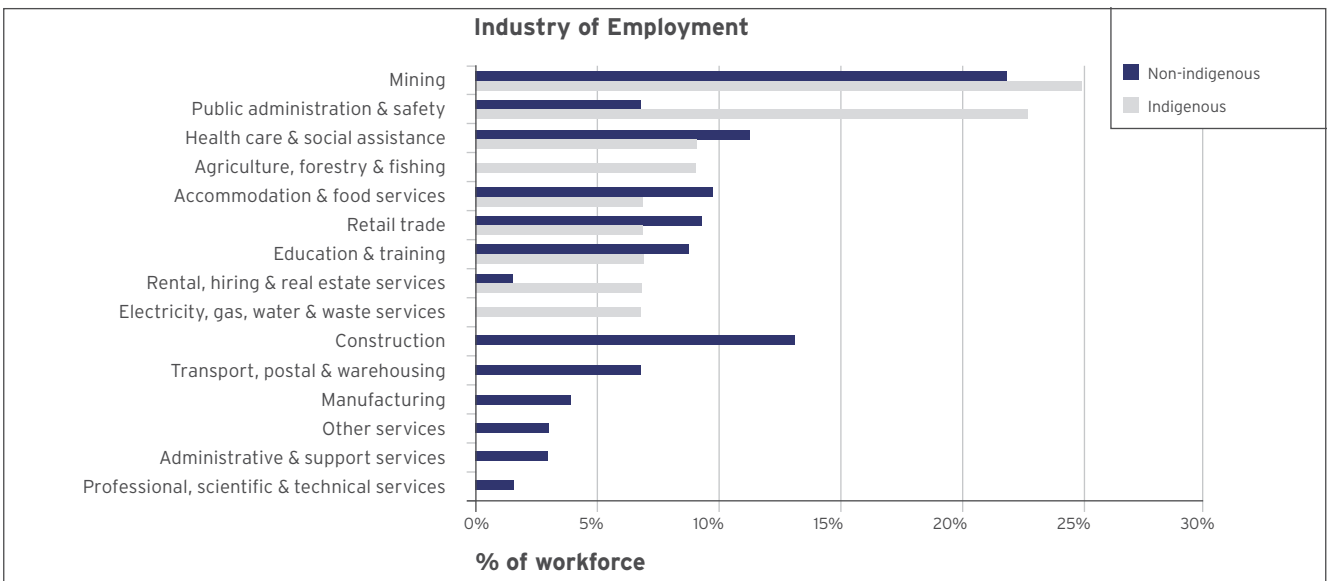


Figure 6.98: Industry of Employment by Percentage of Indigenous and Non-Indigenous Workforce (Onslow)

Source: ABS Census 2006a (Usual place of residence)

Table 6.36: Employment Figures for the Indigenous and Non-Indigenous Population (Onslow, Ashburton)

	Onslow		Ashburton	
	Indigenous	Non-Indigenous	Indigenous	Non-Indigenous
Total labour force	70	226	238	3003
Employed (a)	51	215	209	2955
Unemployed	19	11	29	48
Not in labour force	58	54	132	462
Labour force not stated	9	8	22	55
Unemployment(b)	27.1%	4.9%	12.2%	1.6%
Labour force participation(c)	51.1%	78.5%	60.7%	85.3%
Employment to population(d)	37.2%	74.7%	53.3%	83.9%

Source: ABS Census 2006a, 2006b (Usual place of residence)

Note: (a) Community Development Employment Project participants are counted as employed.

(b) Number of unemployed persons expressed as a percentage of the total labour force.

(c) Number of persons in the labour force expressed as a percentage of persons aged 15 years and over.

(d) Number of employed persons expressed as a percentage of persons aged 15 years and over.

Age-Dependent Population

The median age for Onslow is 51 years, which is considerably older than the average workforce age of 34 years in both the Shire of Ashburton and the broader Pilbara region. Notably, Onslow’s median age is also substantially higher than the State average of 36 years.

As shown in Figure 6.99, Onslow has a lower proportion of dependents under the age of 15 years, relative to the Shire of Ashburton and the broader Pilbara region. In contrast, elderly residents over the age of 65 years constitute approximately 9.2 per cent of Onslow’s total population. Indeed, the proportion of elderly dependency in Onslow is significantly higher than in the Shire of Ashburton (5.6 per cent) and the broader Pilbara region (5.1 per cent).

This trend of a significantly older population in Onslow, relative to the broader region, needs to be considered in the planning of service delivery and assessment of population change implications. With a number of large-scale development projects planned for the area, a significant increase in Onslow’s population is likely to place strains on existing services that are most critical to particular age groups within the community (such as health care).

Health

The health of a community is another key indicator of human capital. A community that is in poor general health tends to be more vulnerable and thus, less able to adopt effective coping mechanisms in response to change.

To date, extensive research has been undertaken in the development of indicators to evaluate the health status of a locality. However, this research has typically been conducted at global and national levels, and has used indicators such as health expenditure per capita as a proportion of the country’s GDP. In evaluating Onslow’s community health, it would be important to select *community* health indicators that are context specific and capture an accurate snapshot of the community’s health.

A useful indicator of community health is remoteness and accessibility to key health services. Onslow is remote and isolated, with most health care services, such as doctors, specialists and allied health care, flown in periodically. The town has a community health centre staffed by one full-time community health nurse and an Aboriginal health worker, both of whom coordinate specialist visits, Indigenous health care, as well as other health prevention planning in areas such as sexual health, birth control, sexually transmitted diseases (STDs) and immunisation. With only one staff member coordinating all health requirements for the community, centre resources are stretched thin.

The town’s hospital is staffed by nurses and visited by a rotation of general practitioners three times a week. However, the facility is run down and in need of upgrade. The hospital also lacks emergency/trauma services.

Onslow’s emergency health services are also noted to be severely lacking in human resources, with emergency

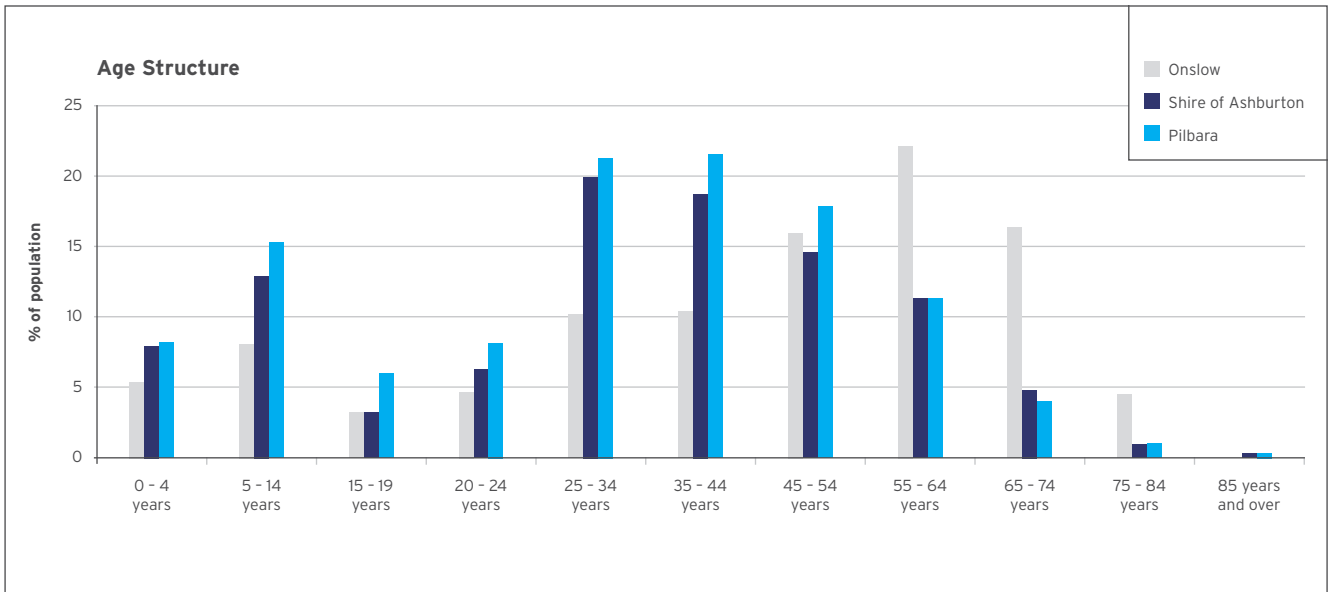


Figure 6.99: Age Distribution - Onslow, Shire of Ashburton, and the Pilbara Region

Source: ABS Census 2006, 2006a, 2006b (Place of enumeration)

services such as Fire and Emergency Services Authority of WA (FESA) and St John Ambulance reporting significant obstacles in attracting and retaining volunteers. Onslow’s hospital also does not offer respite care. Patients who are terminally ill or require access to ongoing medical treatment are required to relocate to neighbouring regional centres or to Perth. Indeed, the lack of accessibility to ongoing medical and health-care services at all times is concerning, given that the Onslow community is comprised of 10 per cent elderly age-dependents who are likely to require ongoing access to health and medical services.

Another key indicator of community health relates to behavioural risk factors, which include behavioural health risks such as overeating and obesity, alcohol and other substance abuse, as well as smoking. Given the remoteness and isolation of Onslow, a lack of lifestyle activities such as recreation and entertainment are often key triggers for early-age drinking. The prevalence of alcohol abuse may also result in other flow-on social implications, such as domestic violence and socially dysfunctional behaviour.

In countering the effects of alcohol and substance abuse, particularly among the youth, it is important for the community to have adequate access to allied health services supporting mental health counselling, as well as education and awareness programs on healthy lifestyle choices and the implications of substance abuse. However, Onslow’s remoteness means access to such services is severely restricted. Health-care service providers such

as mental-health professionals, counsellors and health-awareness program facilitators visit infrequently.

There is a prevalence of at-risk groups potentially in need of access to substantial health-care support, including elderly age-dependents as well as members of the Indigenous community and youth with substance-abuse problems. This suggests a further population increase in the town is likely to place significant strain on an already limited social support system.

Healthcare professionals already experience strains on service capacity during peak tourism periods and the health planning and prevention initiatives put forward by the Community Health Centre are supported by constrained resources. Therefore, a further influx of population, without additional support to Onslow’s current medical and health care services, is likely to increase the vulnerability of the community’s at-risk groups.

6.5.3.4 Physical Capital

Physical capital, also known as “built capital”, refers to a town’s infrastructure and services. This includes public amenities and infrastructure (such as roads, energy networks, telecommunications and residential land availability), social infrastructure (such as hospitals and schools), as well as soft infrastructure/service provision (such as health care, aged care and childcare).

A sound level of physical capital is important in optimising a community's other key capital areas. A highly remote community, lacking access to basic amenities, social services and community infrastructure, may lack the capacity to enhance its local human skills base. It might also fail to capitalise on opportunities for further industry development and economic capital growth.

Township Amenities /Public Utilities

Table 6.37 summarises the town's accessibility to public utilities, including power supply, water supply, wastewater management, gas supply and sewerage.

Currently power supply operates at close to capacity. Under summer peak load conditions, the Onslow power station requires support of temporary diesel generation, which tends to be more costly and inefficient. Therefore, an additional increase in population and potential industrial expansion will require a review of current generation strategy and gas supply (Western Australian Planning Commission (WAPC) 2008).

Other public utilities operating at or close to capacity include the management of wastewater and sewerage, as well as waste disposal. According to the Water Corporation, capacity of the current wastewater management is only adequate for Onslow's existing population, with an individual benchmarked requirement of 200L per person/day. Therefore, a further significant increase in population, as well as industrial expansion, will require the existing wastewater management plant to be expanded, or a new plant constructed.

The current landfill for waste disposal, managed by the Shire of Ashburton, is nearing capacity. Chevron played a role in filling the landfill with domestic solid waste from its Barrow and Thevenard islands oil operations. According to the Shire, residents also tend to tip rubbish into the landfill without charge. As such, a new and better-managed facility is needed, as the DEC will not continue to sanction the use of the landfill after the 2011 expiry of its licence.

In relation to hard infrastructure, Onslow is serviced by an airport, as well as an integrated network of roads and highways. The current Onslow airport services smaller charter planes and the Royal Flying Doctor Service (RFDS). The runway is too short to be used for large commercial flights and is sometimes inundated after a storm or severe weather event. At the time of writing, it was unclear whether the Shire plans to upgrade the airport. If an upgrade takes place, the airport is either likely to be re-developed on the current site, or constructed at a new site due to the current location's vulnerability to flooding or potential disruption to residential expansion within the town.

Residential Land Availability

Undeveloped land zoned for urban development lies mainly south and west of the existing town and comprises more than 90 ha. There is also some land to the north also currently being developed. Table 6.38 outlines the size of developed and undeveloped zoned lands within Onslow.

In recent years, very few residential lots have been created in Onslow, with only a small number of lots under current conditional approval.

With potential industrial development and expansion in Onslow, the town is likely to experience increased demand for housing. Should ExxonMobil/BHP Billiton proceed with the proposed Scarborough LNG plant development in Onslow and Onslow Salt increase its production, it is estimated that a further 230 dwellings will be required, taking into account direct, indirect and consequential employment (WAPC 2008).

Commencement of operations for the Project is likely to see a further increase in demand for residential dwellings within the town. According to the draft review of the Onslow Structure Plan, development areas in Onslow could potentially yield up to 370 or more dwelling units (WAPC 2003). However, the rate at which residential land can be made available is a significant issue. Most of the identified future development areas are located on unallocated crown land, which is likely to be subject to native title. Land assembly processes may be lengthy and land may not be available in time to meet demand. In addition, land supply in Onslow is constrained by flooding, airport, noise and buffer impacts. Therefore, it is anticipated that with any further population influx into the area, adequate time for planning and development needs to be allocated.

Social Infrastructure/Community Services

As outlined in earlier chapters, Onslow is remote and social infrastructure and community services are limited. Neighbouring regional centres such as Exmouth and Karratha are approximately 300 km away and most community services are either provided by larger neighbouring towns, or flown in from elsewhere. Therefore, Onslow residents do not have regular access to key community infrastructure and social support services at all times.

Table 6.40 provides an overview of community access to key social services and infrastructure in Onslow, as well as the capacity of these services to accommodate further population growth. The information presented has been sourced through a desktop review of secondary data, outcomes of service capacity surveys undertaken with key

Table 6.37: Onslow Public Utilities

Utility Service	Utility Service Provider	Current Capacity	Current Use	Potential Issues associated with Population Change and Industrial Expansion
Power	Horizon Power	1.5 MW reciprocating gas fired plant; standby 1 MVA diesel generator; supply from Griffin field uncertain and Horizon considering link to DBNGP	<ul style="list-style-type: none"> Summer peak 1.1 MW - approximately 75 per cent of capacity; Population growth of more than 20 additional houses would mean significant investment required 	<ul style="list-style-type: none"> Additional power demand for environmental/engineering studies unknown Additional 200 kVa sets could be added (sufficient for approximately 22 households - based on 9 kVa per household) Maximum number of additional sets would require electrical engineering design study Load planning for sub-division typically 1.5 to three years
Water	Water Corporation	Water Corporation licensed to abstract 350 000 kL per year from the Cane river borefield which 2005 study indicates is maximum capacity	287 connections with average yearly consumption of 460 kL/year	<ul style="list-style-type: none"> Exploratory bores being conducted on Sunset Beach to develop desalination option with around 2.4 ML pa capacity requiring about 3 ha Planning to operation is two years with environmental and heritage approvals on critical path During construction, potable water needs to be shared
Wastewater Management	Water Corporation	Current rating of 1000 equivalent population, which is adequate for the current population of 934 (2006 ABS, place of enumeration data)	Less than 80 per cent of capacity	Typical requirement is 200 L pp/day. Therefore, with a large increase in the population as well as industrial expansion, the expansion of the existing plant, or construction of a new plant, would be necessary.
Waste Disposal	Shire of Ashburton		Landfill is currently close to capacity; State average waste generation is 692 kg per person (Cont'd)	The landfill's license will expire in two years, during which the landfill will be relocated away from the town where the community will not have access to it.

Utility Service	Utility Service Provider	Current Capacity	Current Use	Potential Issues associated with Population Change and Industrial Expansion
Telecommunications: Mobile	Telstra: Next G Network	Mobile coverage extends approximately 5 km from town for regular mobiles, approximately 12 km for those with better antennas	n/a	<ul style="list-style-type: none"> There is transmission/backhaul capacity connecting the Onslow Exchange with the rest of the Telstra Network sufficient for forecast growth. Capacity at this location can be upgraded on the current fibre connections via Peedamulla. There are issues of physical protection of the transmission link- the only connection is by the 80km fibre spur from the NW Coastal Highway. There are no current plans to provide physical transmission diversity for Onslow.
Telecommunications: Internet	Telstra	ADSL 2+	Approximately 150 households using ADSL 2+	
Telecommunications: Landlines	Telstra	n/a	Approximately 500 PSTN, existing on copper cables from Telstra Exchange situated at Simpson St	

Table 6.38: Developed and Undeveloped Zoned Lands in Onslow

Zone	Developed (ha)	Undeveloped (ha)
Residential R12.5	9.7	0
Residential R12.5/30	15.9	0
Urban Development R12.5/30	0	93.8
Total	25.6	93.8

Source: Western Australian Planning Commission et al, 2008

Table 6.39: Residential Lot Creation Activity in Onslow

Residential lots created (2001/2 - 2005/6)	Residential lots created (2006/7)	Residential lots created (2007/8)	Residential lots with current conditional approval	Proposed LandCorp releases (next two years)
3	2	0	8	Subject to demand

Source: Western Australian Planning Commission et al, 2008

Note: The number of residential lots created was the result of subdivision (i.e. does not include survey or vacant lot strata). Construction for residential lots with conditional approval has yet to commence, or is currently under way.

service providers in Onslow, as well as consultation with the general Onslow community and key stakeholders.

Table 6.41 outlines temporary accommodation providers located within the town.

6.5.3.5 Social Capital

When assessing a community’s resilience and capacity to adapt to change, it is also important to consider how its individuals, groups, organisations and institutions interact and cooperate.

Social capital - the degree of social cohesion and interconnectedness between community members - is a multi-faceted concept. It is broadly defined as the dynamics and strength of relationships and interactions within a community. Its elements (such as relationship networks, trust and norms, altruism and reciprocity, and sense of community) act as resources facilitating collective action and driving positive community outcomes.

Aboriginal and Cultural Heritage

On September 18, 2008, the Federal Court of Australia determined that the Thalanyji people were the native title holders for the onshore area around Onslow including the Ashburton North SIA. In accordance with the Native Title Act 2003 (Cth), the Buurabalayji Thalanyji Aboriginal Corporation was incorporated to hold the native title on trust for the traditional owners. Located near Sunset Beach, Buurabalayji was a traditional camping ground for the Thalanyji and Nhuwala people, where they obtained fresh water and hunted shellfish.

Figure 6.100 portrays individual languages and language families within which similar dialects are grouped. Historically, the Thalanyji have strong economic, socio-cultural and linguistic relationships with the speakers of other Kanyara languages. However, there is also evidence of similar relationships between other neighbouring language communities. Insofar as it is possible, these relationships continue today.



Figure 6.100: Aboriginal Language Groups of the Pilbara

Source: Wangka Maya Pilbara Aboriginal Language Centre, 2008

Table 6.40: Onslow Social Infrastructure and Community Services

Service Area	Facilities	Current Services	Current Context / Quality of Service Provision	Capacity to Handle Population Increase
Health	Onslow Hospital	<ul style="list-style-type: none"> Staffed by nurses, with rotational visits by doctors three times per week Provides general medicine and outpatient services No emergency/trauma services No surgical services No respite care 	<ul style="list-style-type: none"> Limited bed capacity of six beds Facilities are run down and in need of upgrade 	No
	Onslow Community Health Centre	<ul style="list-style-type: none"> Staffed full time by a community health nurse Provides community, child, and Aboriginal health services Coordinates specialist visits, as well as health prevention planning in areas such as sexual health, birth control, and STD 	<ul style="list-style-type: none"> Currently under-resourced and under-staffed Recently employed an Aboriginal health worker, who remains to be trained 	No
	Specialist/ Allied Health Care	<ul style="list-style-type: none"> Infrequent specialist and allied health care visits to the town ranging from fortnightly to a maximum of three months, or on a needs basis Specialist visits include paediatrician, occupational therapist, physiotherapist, speech pathologist, as well as audiologist Allied health-care services include mental health counselling, as well as education/ awareness programs in areas such as healthy lifestyle choices and diabetes prevention/ treatment 	<ul style="list-style-type: none"> Infrequent visits by specialists and allied health care professionals increase the vulnerability of highly dependent / at-risk groups (e.g. alcohol or substance dependent youths) Lack of continuity of care by a single doctor/specialist for community residents 	No
	Dental Care	<ul style="list-style-type: none"> No dentist in town 	<ul style="list-style-type: none"> Visiting dentist has not visited Onslow for an extended period of time Community members do not usually visit the dentist Emergency cases would have to travel to neighbouring regional centres such as Karratha for dental care 	No

Education	Onslow Primary School	<ul style="list-style-type: none"> Kindergarten through to Year 12 Current capacity of approximately 120 students from pre-primary through to higher primary Approximately 65 per cent of students are of Indigenous descent 	<ul style="list-style-type: none"> Recently upgraded to service additional classroom space for kindergarten, pre-primary, four primary rooms, as well as two secondary rooms Staffing is not an issue as teachers receive incentives to teach in the local region Families typically send their children to boarding schools in Perth/larger regional towns for Year 12 studies 	Yes The school has indicated flexibility in accommodating further population growth through the construction of demountables. However, adequate planning time needs to be provided.
	Pilbara TAFE	<ul style="list-style-type: none"> Situated close to the Onslow Primary School and operates out of two demountable classrooms Currently has one full-time and one part-time teacher 43 enrolled students in four classes including WorkStart in conjunction with CDEP; a Year-10 equivalent bridging course; computing; and arts/ceramics 	<ul style="list-style-type: none"> Provides local youths with practical industry/skills-based training Regarded as a practical option for students who do not wish to complete their high-school studies 	Yes The TAFE has indicated flexibility in renting out other buildings in town to accommodate further population growths
Child Care	Onslow Occasional Childcare	<ul style="list-style-type: none"> Operates daily from 8:30 am to 3 pm Staffed by a supervising officer as well as an additional child care worker Centre licensed to care for three babies aged up to two years, and 11 children aged two-to-five years at any one time 	<ul style="list-style-type: none"> Centre is currently running at capacity Over the past ten years, the centre has closed and reopened a number of times due to volatility in staffing, licensing, and ongoing funding 	No

Service Area	Facilities	Current Services	Current Context / Quality of Service Provision	Capacity to Handle Population Increase
Aged Care	Shire of Ashburton	<ul style="list-style-type: none"> Retirement housing provided for both Indigenous and non-Indigenous residents through the shire, in a small village located in the centre of town Five units in the village are reserved for Indigenous retirees, while a further five are reserved for non-Indigenous 	<ul style="list-style-type: none"> There is usually a waiting list to occupy village units Unit allocation done on a basis of those most in need Aged-care services currently stretched beyond limits given high prevalence of elderly age-dependents in Onslow Many retirees forced to move to larger towns away from their homes if they cannot be placed with their families in the same retirement village 	No
Youth/ Recreation	Onslow Youth Outreach Program	<ul style="list-style-type: none"> Operates Monday, Wednesday and Friday Provides a lunch meal and respite for elderly age-dependents HACC also delivers lunch meals to the homes of elderly age-dependents who are unable to visit the HACC residence Service also extends to those residents in the retirement village in town Established in 2006, the group targets children aged ten to 17 years Operates on Tuesdays to Fridays, after-school hours Varying activities each term including modelling, cooking, guitar and drumming lessons, basketball, movie nights, as well as pool and video games Activities hosted at the Shire Hall Group also participates in activities outside Onslow 	<ul style="list-style-type: none"> Provides support and assistance, as well as respite care, to elderly age-dependents in Onslow Seen as a valuable aged-care service provision in Onslow Provides social networking opportunities and peer support to local youths, given remoteness of Onslow and an overall lack of recreational and entertainment facilities 	No
				Yes

<p>Retail/ Commercial Facilities</p>	<p>Various</p>	<ul style="list-style-type: none"> Local retail facilities include the General Store/Posties as well as two service stations Also serviced by a supermarket, which includes a liquor department and a hardware store Dining facilities include a pub and a restaurant 	<ul style="list-style-type: none"> With Onslow's remote location, fresh food is delivered to the supermarkets once a week. Therefore, lack of access to fresh produce is of concern to local residents 	<p>No</p>
<p>Information Accessibility</p>	<p>Public Library</p>	<ul style="list-style-type: none"> Located in the shire building Offers fiction and non-fiction readings, as well as DVDs, publications, reports and current magazines Library is open during shire office hours, from 8:30 am to 4 pm 	<ul style="list-style-type: none"> Extensive range of publications and media for Onslow residents of all ages Quality of service provision perceived as excellent by regional standards 	<p>Yes</p>
	<p>Cane River Telecentre</p>	<ul style="list-style-type: none"> Open Monday to Friday from 9 am to 1 pm Equipped with ten computers, all of which have internet access Provides access to a photocopier, printer, and photograph processing machine Centrelink and other employment programs (e.g. JobFutures) are also facilitated through the centre 	<ul style="list-style-type: none"> Valuable resource in the town Provides capacity building and other relevant government support programs (e.g. employment opportunities) to local residents Frequented by locals as well as tourists 	<p>No</p>

Table 6.41: Accommodation Providers in Onslow

Accommodation Providers	Current Capacity	Occupancy Rates		Potential Expansion	Can absorb population increase?
		2008-2009	Average (5 yrs)		
Motels					
Onslow Sun Chalets	7 motel rooms, 9 self contained chalets	-	85 per cent winter 30 per cent summer	Limited by Shire Restrictions	No
Onslow Mackerel Motel	17 rooms	-	90 per cent winter 60 per cent summer	Potential to expand to 43 rooms	-
Club Thevenard Accommodation Village	11 self contained units 30 motel rooms	-	40 per cent overall year	In the process of development	Yes
Total Rooms/ Units	74				
Hotels					
Beadon Bay Hotel	12 rooms Two dongas	75 per cent	-	Land to expand but limited by investment capital	-
Total Rooms	14				
Serviced Apartments / Caravan Parks / Cabins					
Kuarilu Retreat	4 rooms with ensuite and 1 caretaker self contained unit	-	-	Currently building two new self contained units	Unsure
Beadon Bay Village	4 cabins, 53 caravan sites, 10 camp sites, 4 sea view rooms, 48 single rooms, 20 ensuite rooms, 12 staff quarters	-	100 per cent winter 40 per cent overall year	Plan to expand facility to provide ensuites to more of the rooms	No
Ocean View Caravan Park	8 units, 140 powered sites		100 per cent winter 30 per cent overall year	No plans for expansion	No
Total Rooms/ Sites	304				

Of the languages nearest the town of Onslow, Nhuwala (Noala) and Martuthunira (Martuyhunira) are extinct (no fluent speakers, but some individuals identify themselves as being part of that language group and may speak some words), and Thalanyji (Dhalandji) is highly endangered as only five elders, who live in Onslow, speak it fluently and only about 20 young people speak it partially/passively. The younger speakers live in Onslow, Port Hedland, Tom Price or Carnarvon.

Indigenous occupation of the western area of the Pilbara is estimated to have begun around 25 000 years ago. During colonisation, many Thalanyji people spent time in the Carnarvon Mission and on rural stations working as housemaids, mustering cooks and station hands. When citizenship rights were introduced in 1967, the majority of people were removed from stations and moved closer to Onslow for work, living in the old Native Reserve (now the Bindi Bindi community). Many of the families resisted sending their children to mission schools and hostels, deciding instead to keep them with them in the town.

Today, several Thalanyji families who live in the Ashburton and Onslow area are considered the traditional owners. Furthermore, descendants of Nhuwala are now considered part of the Thalanyji community resident in Onslow and other North-west towns. Thalanyji people also continue their traditions. For example, elders take children out to show them how to hunt, fish, recognise and gather edible berries and fruits in the traditional way. Many traditions are still observed and handed down. The traditions of burial, conception, marriage, ceremonial events and bush medicine are also passed down from the elders.

Chevron has sponsored projects by the Thalanyji people relating to preservation of language and culture including the preparation of storybooks for children.

European Cultural Heritage: Land

The first European settlement of the North-west occurred at the Harding River in 1863. The settlement of the Ashburton River region in 1879 was the first successful expansion of this frontier beyond the Roebourne area. The area was supplied via a landing place and goods shed on the Ashburton River, near what later became the site of the town of Onslow. The first residents were the storekeepers of the goods shed, James Clarke and John McKenzie. After their arrival in 1883, the town grew into a pastoral and pearling port with a small urban population.

Between 1885 and 1897, an increase in the size of coastal trading vessels and siltation at the river landing caused problems for vessels using the shallow Ashburton River to access the river landing. This led to attempts to construct

a sea jetty and a connecting tramline in 1897. However, the jetty was destroyed by a cyclone before completion. A second sea jetty was built closer to the river mouth and opened in 1901. The sea jetty did not function well, therefore a third jetty was built at Beadon Point, and the Beadon Creek area became the town site that exists today.

Investigation carried out in this area (Nayton, 2009) confirms that shore-based evidence of the two jetties has been completely removed by cyclonic activity. It is unlikely that any jetty piles remain in the seabed unless the timber of the pile snapped to leave the lower section in place. Less likely to be affected by cyclonic activity is artefact evidence that was used in the area, dropped overboard from the jetty or from tethered vessels during loading or unloading. Such evidence from the long jetties at Fremantle and Albany shows that artefact spread around jetties can be quite extensive. Investigations of the land-based port activities has been more fruitful with a variety of cut landforms associated with the land backed wharf and port buildings and some surface evidence of foundations and artefacts mapped throughout the port area.

Under the *Heritage of Western Australia Act 1990*, the Heritage Council of Western Australia is charged with registering and protecting the heritage values of significant European Cultural Heritage sites within WA. The Old Onslow Townsite is located approximately 4 km from the proposed Ashburton North SIA and is registered as place 3444 on the Western Australia Register of Heritage Places. It consists of visible portions of ruins of the river landing and tramway. The registered area associated with the former jetty consists of both land and seabed areas. The sea jetties are located outside the townsite and their remains are not visible. Sites of significance that may be affected by the Project include the northern end of the Aboriginal prisoner-built 1897 tramway, cast-iron telegraph poles (dating uncertain, possibly 1897 or 1899), the 1897 and 1899 sea jetties, the 1899/1901 timber landing and warehouse, as well as a circa 1901 store. The site is also listed on the Shire of Ashburton's municipal inventory, which was compiled under the direction of the *Heritage of Western Australia Act 1990*.

Figure 6.101 illustrates the relevant areas of the Old Onslow Town Site included on the Register of Heritage Places. The site of the old jetty and a section of the old tramway (Areas 2, 3, 4, 6, 7 and 8) fall within the potential Ashburton North SIA.

European Cultural Heritage: Marine

Historical shipwrecks over 75 years of age are protected by the Commonwealth *Historic Shipwrecks Act 1976*, with those lost before 1900 protected under the *Maritime Archaeology Act 1973*.



Figure 6.10: European Cultural Heritage Restricted Area

The first recorded maritime activity on the west coast of Australia relates to shipwrecks of at least four Dutch and one English vessel, using the southern route to the Spice Islands. None of the known shipwrecks from this period lies within the study area. Ships supplying the new Swan River colony took the Great Circle route, which skirted the southern coast. However, north-west colonial settlement in 1863 began coastal trade, which passed the study area. The first shipwrecks from this trade were the *New Perseverance*, wrecked at Cossack in 1866, and the *Emma*, wrecked in 1867 at Coral Bay.

Table 6.42, from the Department of Marine Archaeology, Western Australian Maritime Museum Shipwreck database, lists shipwrecks by name, vessel, date wrecked and location obtained. The inclusion of comprehensive maps of these wrecks in this report has not been possible, due to limited location information for most of the vessels.

Between 1868 and 1971, the WA shipwreck database records eight vessels lost in the Onslow area. Henderson and Cairn's *Unfinished Voyages* (1995), suggested a further three. None of these shipwrecks have been located, but the location of the general area of loss is known by many. *Rose*, *Bell* and an unidentified lugger were part of the pearling fleet caught in a cyclone in 1893. Most of the fleet were lost in Exmouth Gulf, however the three mentioned above appear to have been lost further north with maps placing them either at the mouth of the Ashburton River or at the mouth of Beadon Creek. This was because the river mouths once offered the only form of shelter on this stretch of coast and captains were likely to have tried to access them. However, as the wrecks have not been found they could have been driven ashore anywhere along the coast.

The *Ellen*, noted as being lost at Onslow in 1905, may also fall within the study area, which covers what was the Onslow port at that time. However, there is currently no further information available on the loss of the *Ellen* to determine whether it was wrecked near Onslow. In 1995, the fishing vessels *Harmony* and *Lady Pamela* sank during Tropical Cyclone Bobby, failing to reach the safe anchorage of Beadon Creek. Four of the seven crew who died on the trawlers were from Onslow.

Governance

The extent to which local government actively encourages community development is another important predictor of social capital. A community that lacks governance, or where the shire does not promote community values and community development initiatives, is unlikely to be motivated to initiate and embrace positive change for the future of the community.

The Shire of Ashburton has an ongoing commitment to community development across its key towns and has adopted initiatives to further improve community infrastructure. The Shire's strategic five-year plan (2007 to 2011) considers the needs of its communities, and the importance of creating opportunities that enhance and sustain community development. Key features of the plan are outlined in Table 6.43.

One of the Shire's administration centres is based in Onslow. Therefore, Onslow residents have access to Shire support across various facets of community infrastructure and public services. In addition, the community can also be more directly involved in Shire decision-making processes. Indeed, the level of community input in local governance

Table 6.42: Listing of Known Shipwrecks in the Onslow Area

Vessel	Wrecked	Location
Ariel	1868	Lockyer Point 50 km west of Ashburton
Airlie	1889	Mouth of the Ashburton River
Rose (Pearling Lugger)	1893	General area
Bell (Pearling Lugger)	1893	General area
Unidentified Lugger	1893	Onslow
Dolphin	1902	Off Beadon Creek, Onslow
Ellen	1905	Onslow
Boreas	1932	Weld Island
Rosebud	1933	Airlie Island
Viking	1969	Beadon Creek, Onslow
Mulga	1971	Onslow

Source: Henderson and Cairn 1995

Table 6.43: Shire of Ashburton Strategic Plan (2007 - 2011)

Focus Area	Objectives
Economic Development	<ul style="list-style-type: none"> To boost the tourism sector To create further opportunities for residential, commercial and industrial land development To encourage an increase in new industry investments and opportunities within the shire To encourage new retail and service trades businesses
Community Engagement	<ul style="list-style-type: none"> To encourage the development of arts and culture, including upgrading the facilities and services of public libraries To improve the functionality of community amenities and functions To provide the community with improved access to health and medical facilities and services, including dental services and aged care
Accessibility	<ul style="list-style-type: none"> To create greater transport and communication accessibility for residents within the shire by upgrading roads and pathways, improving public transport services as well as existing communication networks To provide better broadband services and mobile coverage
Environment and Culture	<ul style="list-style-type: none"> To deliver more efficient waste recycling and resource use, as well as better water management To maintain historical conservation of heritage buildings and town sites of significance within the shire
Community Safety	<ul style="list-style-type: none"> To implement robust emergency-management measures and crime-prevention strategies that ensure shire crime rates do not exceed the Pilbara average

Source: Shire of Ashburton 2008

and strategic planning processes is a key determinant of social cohesion, as a community which has greater involvement in council activities and planning for the community is more likely to be motivated to administer change that leads to positive outcomes. According to the Western Australian Electoral Commission (2009), approximately 70 per cent of Onslow’s residents enrolled to vote in the local government elections, indicating a relatively high level of civic participation and involvement in local governance and planning processes.

Shire initiatives in Onslow include further improvements to existing community infrastructure and public amenities that promote the region as a centre for tourism, such as upgrades to the airport, and redevelopment of the Beadon Point Lookout. Investment initiatives include development of a multi-use sporting complex housing an indoor basketball court, childcare centre and office

accommodation. In partnership with State Government agencies, there are also plans to redevelop existing health facilities to create a more integrated primary health care service (Department of Health 2008, cited in WAPC 2008). Initiatives are also underway to undertake ongoing monitoring of school site requirements, to support the existing Onslow Primary School in accommodating additional students.

At a town level, Local Government initiatives focus on community development, providing further support to local infrastructure, physical and public amenities, as well as social services. Onslow’s key capital areas have the opportunity for further development and enhancement with support from these initiatives. However, it will be important that the community’s aspirations and needs be recognised as part of the planning for future growth in Onslow.

Community Participation

A key indicator of social capital is the degree of community participation or involvement in processes that maintain or enhance community well-being. These may include participation in community groups, or not-for-profit voluntary activities in addition to professional commitments, driven by a non-self-motivated desire to achieve better outcomes for the community collectively.

Onslow has a number of services designed to promote community well-being, through support of at-risk or vulnerable groups. Most services, including HACC, the Youth Group, Leaping Lizards, as well as the Safe House, are managed through local or State government agencies with local community members assisting in administration as part of paid employment.

According to the 2006 ABS Census, approximately 16 per cent of Onslow's residents identified themselves as volunteers in charitable or community organisations. However, emergency services - FESA, St John Ambulance and the Onslow Volunteer Marine Sea Rescue Group - and community groups such as the Sports Club, Community Garden, Streetscape Committee and Rodeo, reported ongoing struggles to recruit and retain volunteers. A small

group of community members tends to volunteer across multiple groups and services. This suggests a weakness in Onslow's level of community cohesion.

6.5.3.6 Vulnerability of Onslow's Community Capitals

To help quantify the status of Onslow's capital areas, the socio-economic determinants of each capital were standardised and weighted to a composite sensitivity/vulnerability index³ for each capital area. Figure 6.102 illustrates Onslow's relative capital vulnerabilities. Capital areas with low vulnerability indices reflect higher optimisation of those capitals, whereas capital areas with higher vulnerability indices reflect weaker optimisation and a potential need for capacity building to further enhance the product of that capital area.

It is important to recognise that while the various capital areas may be distinctly categorised and are comprised of different socio-economic variables, these capital areas are not mutually exclusive. For instance, weak human capital such as low educational qualifications and skills is likely to accompany lower levels of economic capital. This is largely because the population's capacity to diversify its economy and adopt new business initiatives is compromised.

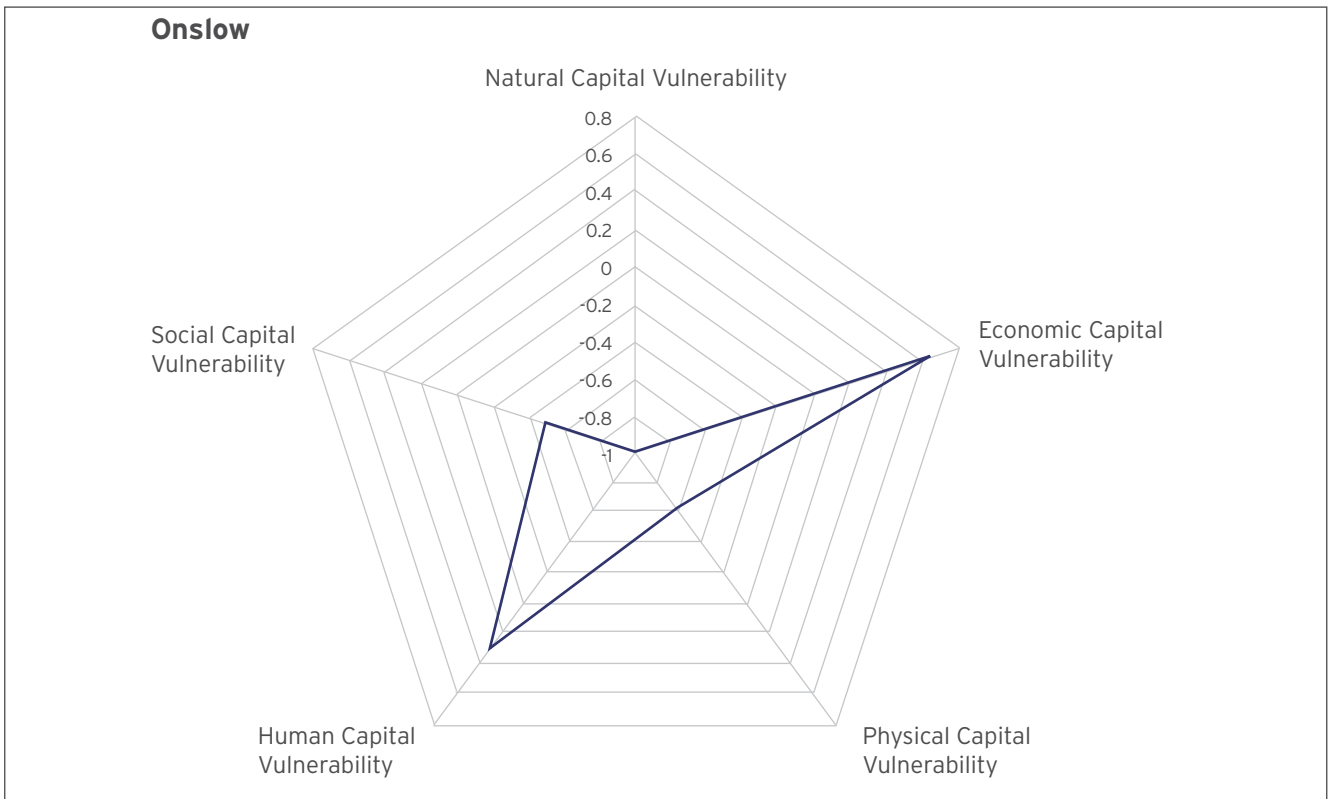


Figure 6.102: Onslow's Capital Vulnerability Indices

Onslow’s natural capital is notably well endowed relative to its other capital areas. As discussed, the town’s proximity to many natural resources means Onslow’s economic base remains diverse and its environmental assets and opportunity for further capitalisation. Onslow’s economic and human capitals are most vulnerable by comparison, and do not fit the profile of a typical Pilbara resource-industry town. Onslow’s physical capital vulnerability is also relatively high, due largely to the town’s remoteness.

The diagram below summarises a hypothetical approach to promoting the ongoing sustainability and resilience of the Onslow community. It demonstrates that adequate physical capital is critical in developing all other capitals.

For instance, given the lack of general youth and recreational activities, families tend to leave Onslow or send their children to other neighbouring regional towns/boarding schools in Perth to complete their secondary education. This departure of youth may potentially deplete social and peer network support structures, and have a further impact on the town’s economic and human capital development as youth who leave in pursuit of education opportunities are unlikely to return to remote localities to capitalise their skills. Therefore, Onslow’s physical capital needs to be strengthened to potentially support the development of local skills and minimise the vulnerability of at-risk groups.





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