Gorgon Gas Development
Revised and Expanded Proposal

Public Environmental Review

EPBC Referral 2008/4178

Assessment No. 1727

September 2008

Operated by Chevron Australia
in joint venture with

ExxonMobil

Gorgon Project

Disclaimer

This Public Environmental Review (PER) has been prepared by Chevron Australia Pty Ltd on behalf of the Gorgon Joint Venturers. In preparing the PER, Chevron Australia has relied on information provided by specialist consultants, government agencies and other third parties who are identified in the PER. Chevron Australia has not verified the accuracy or completeness of the findings, conclusions and observations of these consultants, government agencies and other third parties, except where expressly acknowledged in the PER.

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Title: Public Environmental Review for the Gorgon Gas Development Revised and Expanded Proposal

An Invitation to Comment on Gorgon Gas Development Revised and Expanded Proposal Public Environmental Review

Invitation to Make a Submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. Submissions will be shared with the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA). The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, the EPA advises that no decisions have been made to allow this proposal to be implemented.

A proposal by the Gorgon Joint Venturers (GJVs) to construct two liquefied natural gas (LNG) trains and associated infrastructure on the Barrow Island class A nature reserve was approved by the Western Australian Minister for the Environment on 6 September, 2007 and by the Commonwealth Minister for the Environment and Water Resources on 3 October, 2007.

The EPA notes that the current proposal under assessment involves a revised and expanded version of the previously approved proposal (Chevron Australia 2005a, 2006; EPA 2006), notably an expansion from two to three LNG trains. In this document the previously approved proposal is referred to as the Approved Development and the subject of this assessment is called the Revised Proposal.

This document is the Public Environmental Review (PER) prepared by the GJVs for the Gorgon Gas Development Revised and Expanded Proposal (Revised Proposal).

The Revised Proposal was referred separately to the Commonwealth Government under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) and Western Australian Government under the *Environmental Protection Act 1986* (WA) (EP Act). It was determined that the assessment of Commonwealth matters associated with the Revised Proposal will be undertaken by the Western Australian Government under the terms of the *Bilateral Agreement between the Commonwealth and the State of Western Australia under Section 45 of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 Relating to Environmental Impact Assessment.*

At the conclusion of the assessment the Commonwealth and Western Australian Governments will separately determine whether or not to approve the Revised Proposal and any conditions that might apply. Accordingly, the PER has been prepared in conformance with the Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2002 of the EP Act, and to satisfy the requirements for assessment under the EPBC Act.

The Approved Development comprises a range of offshore and onshore components to recover gas from the Gorgon gas field west of Barrow Island, to process gas from the Greater Gorgon gas fields at a Gas Treatment Plant on Barrow Island and ship gas to market via tankers. The Revised Proposal comprises a number of changes to the Approved Development; the main changes being:

- addition of a five million tonnes per annum (MTPA) LNG train, increasing the number of LNG trains from two to three

- changes to the Reservoir Carbon Dioxide Injection System to allow an increased injection rate associated with the addition of one LNG Train, increasing the number of injection wells and surface drill centre locations
- revision of the causeway and the Materials Offloading Facility (MOF) designed to access deeper water to avoid hard rock material and reduce the amount of drilling and blasting otherwise required, and
- other consequential changes to pipeline and plant layouts to accommodate the changes and additions above.

The Gas Treatment Plant, which is part of both the Approved Development and the Revised Proposal, is proposed to be located on the east coast of Barrow Island at Town Point, with Associated Terrestrial Infrastructure located at other locations on the Island. The Reservoir Carbon Dioxide Injection System is located north of the Gas Treatment Plant on the east side of Barrow Island. The MOF, which is also part of both the Approved Development and Revised Proposal, would be located within the Port of Barrow Island and extend offshore from Town Point on the east coast of Barrow Island.

This PER has been prepared to describe this proposal and its likely effects on the environment.

Comments from government agencies and from the public will assist the EPA and DEWHA to prepare their assessment reports in which they will make recommendations to their respective Ministers.

Where to Get Copies of this Document
Printed and CD-ROM copies of this document may be obtained from:

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Hard copies of the PER may be purchased at a cost of $10.00 per copy, or a CD-ROM version will be provided (no charge). The PER may also be accessed through the proponent's website at: www.gorgon.com.au, or at the following locations:

Department of Environment and Conservation Library
Level 4, the Atrium
168 St Georges Terrace
Perth WA 6000

Department of Industry and Resources
1st Floor, 100 Plain Street
East Perth WA 6000

Research and Information Centre
Department of Industry and Resources
1 Adelaide Terrace
East Perth WA 6000

Department of Environment, Water, Heritage and the Arts Library
John Gorton Building
King Edward Terrace
Parkes ACT 2600

Ashburton Shire Council
Onslow Public Library
Second Avenue
Onslow WA 6710

Karratha Community Library
Millstream Road
Karratha WA 6714

Battye Library
Alexander Library Building
25 Francis Street
Perth WA 6000

Why Write a Submission?
A submission is a way to provide information, express your opinion and put forward your suggested course of action – including any alternative approaches. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Electronic submissions will be acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing their assessment reports for their respective Ministers, the EPA and DEWHA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (WA) and the Commonwealth *Freedom of Information Act 1982*, and may be quoted in full or in part in each report.

Why not join a Group?
If you prefer not to write your own comments, it may be worthwhile joining with a group or groups interested in making a submission on similar issues. Joint submissions may help to reduce the work for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to ten people) please indicate the names of all participants. If your group is larger, please indicate how many people your submission represents.

Developing a Submission
You may agree or disagree with, or comment on, the general issues discussed in the PER or with the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific elements of the PER:

- clearly state your point of view
- indicate the source of your information or argument, if this is applicable
- suggest recommendations, safeguards or alternatives.

Points to Keep in Mind
By keeping the following points in mind, you will make it easier for your submissions to be analysed:

- attempt to list points so that the issues raised are clear; a summary of the submission is helpful
- refer each point to the appropriate section, chapter or recommendation in the PER
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering
- attach any factual information you wish to provide and give details of the source; make sure your information is accurate.

Remember to include:

- your name
- your address
- the date
- whether you want your submission to be confidential.

Closing Date for Submissions

The PER is available for a public review period of eight weeks from Monday 15 September 2008. The closing date for submissions is **Monday 10 November 2008**.

The EPA prefers submissions to be sent in electronically using one of the following:

- the submission form on the EPA's website: www.epa.wa.gov.au/submissions.asp
- by email to: submissions.eia@dec.wa.gov.au

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bay 33, CLOISTERS SQUARE WA 6850, Attention: Mr Warren Tacey
- delivered to the Environmental Protection Authority, Level 4, The Atrium, 168 St Georges Tce, PERTH, Attention: Mr Warren Tacey
- faxed to (08) 6467 5557, Attention: Mr Warren Tacey

If you have any questions on how to make a submission, please ring the EPA assessment officer, Mr Warren Tacey on (08) 6467 5000.

PREFACE

This preface provides a summary of the environmental assessment and approvals process for the Approved Gorgon Gas Development, located on Barrow Island, Western Australia, that is applicable to the subject proposal. In particular, it details the process subsequent to the release of the Western Australian Environmental Protection Authority (EPA) Report and Recommendations to the Western Australian Minister for the Environment (Bulletin 1221 issued on 6 June 2006).

The purpose of this preface is to provide the context for this Public Environmental Review (PER).

Environmental Approval of the Gorgon Gas Development (September – October 2007)
The Western Australian Minister for the Environment determined in December 2006 (ref: 229/06) to uphold aspects of the Gorgon Joint Venture Participants' appeal against the EPA's Report and Recommendations (Bulletin 1221) to the extent that the original proposal has been approved for implementation subject to Ministerial Conditions. In making this finding, the Minister explained the basis on which his decisions were grounded.

In relation to the key grounds of appeal, the Minister came to the following conclusions (in summary):

Ground 1 – Dredging, Dumping and Pipelines

- The permanent loss of 23.2 hectares of coral in the Barrow Island marine area is environmentally acceptable based on the loss being approximately 3% of the total coral present in all of the management units and that conditions can be set for the proposal to ensure this level of impact is not exceeded.
- The conditions set by the Minister require the GJVs to implement a comprehensive monitoring program with conservative coral health monitoring triggers and to establish a scientific link between coral health and water quality. Any decision to change the water quality indicators requires Ministerial endorsement based on the advice of appropriately qualified and independent scientific experts.
- The conditions also require the GJVs to implement a management response when impacts on coral health reach certain levels, and to report to the Minister where the approved impact limits are close to being exceeded (giving the Minister a mechanism to order a direct suspension of dredging activities if required).

NOTE: the conditions resulting from the Minister's approval (Statement No. 748) also require the GJVs to establish a Construction Dredging Environmental Expert Panel (CDEEP) to develop, implement and interpret data collected from the monitoring program, as well as to provide advice as requested by the Minister.

Ground 2 – Impacts on Flatback Turtles

- Barrow Island represents a significant nesting site for flatback turtles.
- Light emissions have the potential to impact on nesting behaviour of females, disorientation of hatchlings and increased predation where hatchlings are attracted to light sources.
- The GJVs proposed management options for addressing light impacts may not reduce light emissions to an acceptable level.
- The GJVs proposal to:

- fund a North West Flatback Turtle Conservation Program to increase protection of the population at other locations within the Pilbara
- fund further actions to improve recruitment to the population, including establishing hatcheries, should it be demonstrated that the project is having a significant impact on the flatback turtle population
- maintain the capacity to apply strict conditions to the proposal in relation to light management, beach access, vessel movement and ongoing monitoring and adaptive management, satisfies the Minister that any adverse impacts to the flatback turtle population can be acceptably managed.

♦ There will also be a requirement for continuous improvement and adaptive management with oversight provided by an expert advisory group.

Ground 3 – Introduced Non-Indigenous Organisms

♦ By virtue of its scale, the Gorgon proposal presents a significantly greater quarantine risk than the existing oil operation on Barrow Island.

♦ The Minister agreed with the Appeals Committee that (based on the standard that it would be unacceptable for a non-indigenous species to be introduced and become established on the Island; and the requirement for implementation of a suitable Quarantine Management Plan subject to the review of an independent expert panel), the risk of a non-indigenous organism being introduced to Barrow Island as a result of the implementation of the Gorgon proposal is low.

♦ The GJVs proposal to fund monitoring and eradication of non-indigenous species located on Barrow Island following the commencement of the project, and the provision of a financial guarantee to cover Government costs for eradication of non-indigenous species located on Barrow Island following the commencement of the project, along with appropriate conditions and the implementation of a "whole of island" quarantine regime, result in an acceptably low level of risk.

Ground 4 – Subterranean Fauna

♦ The GJVs were able to produce survey results indicating that the number of subterranean fauna species previously found only to occur on the proposed development site had been reduced from nine to four.

♦ The GJVs indicated that further studies would be undertaken to identify the species at other locations outside of the development footprint.

♦ There is only a small risk that the taxa will not be found elsewhere and any conditions of approval should require the GJVs to undertake surveys until the species are located.

Ground 5 – Greenhouse Gas Emissions

♦ A clear driver for the location of the Gorgon Gas Treatment Plant on Barrow Island was the availability of subsurface geology suitable for geosequestration of carbon dioxide.

♦ The GJVs should be required to design, construct and operate infrastructure on Barrow Island to inject reservoir carbon dioxide from the Gorgon gas stream beneath Barrow Island.

♦ The GJVs will be required to address the remaining greenhouse gas emissions from the Gorgon Gas Treatment Plant through the preparation of a Greenhouse Gas Abatement Program.

The Gorgon Gas Development proposal was subsequently approved by the Western Australian Minister for the Environment on 6 September 2007 by way of Ministerial

Implementation Statement (Statement) No. 748, and by the Commonwealth Minister for the Environment and Water Resources on 3 October 2007 (EPBC Reference: 2003/1294). Both approvals are subject to a suite of comprehensive environmental conditions (Appendix A). These conditions of approval comply with the requirements of the Western Australian Minister for the Environment as stated in his appeal finding of December 2006 (ref: 229/06). A copy of this letter is also attached in Appendix A.

The Commonwealth Minister for the Environment and Water Resources also approved a Sea Dumping Permit (No. SD2004/0030) subject to conditions, on 3 October 2007 for the Approved Development as required under section 19 of the *Environmental Protection (Sea Dumping) Act 1981* (Cth).

Additional GJV undertakings which formed part of this approval and were stated in Statement No. 748 include:

1. North West Shelf Flatback Turtle Conservation Program

The GJVs will fund a 30-year North West Shelf Flatback Turtle Conservation Program to increase protection of the population in areas away from Barrow Island, at a cost of $32.5 million.

The program will include activities to:

- survey, monitor and research turtle populations
- mitigate the loss by reducing interference to key feeding and breeding locations
- establish information programs to support protection.

2. North West Shelf Flatback Turtle Intervention Program

If the abovementioned monitoring clearly demonstrates that the Proposal is having a significant impact on the flatback turtle population, the GJVs will be required to take or fund further actions to improve recruitment to the turtle population, including the establishment of hatcheries. Additional funds will be capped at $5 million.

3. Threatened Species Translocation and Reintroduction Program

The GJVs will fund a 12-year Threatened Species Translocation and Reintroduction Program for selected species from Barrow Island to other Pilbara islands at a cost of $10 million.

The program will include the initial translocation actions, plus ongoing island management. The State will manage the program and be responsible for the translocation and reintroduction outcomes.

4. Eradication of Non-Indigenous Species

The GJVs have responsibilities for the eradication of non-indigenous species that establish on Barrow Island following commencement of the Gorgon Project.

In addition to stringent quarantine management conditions outlined in Statement No. 748, the GJVs will provide a financial guarantee of $10 million to cover Western Australian Government costs for eradication of non-indigenous species established on Barrow Island, other than through natural causes, and following commencement of the Gorgon Project.

5. Dredging

The GJVs will fund the Western Australian Government's costs for auditing and surveillance of marine activities during dredging and marine construction, and ongoing auditing of the marine environment response and recovery ($2.5 million over two years).

In addition to the information presented in Appendix B, through ongoing studies the GJVs have acquired additional information relating to the key issues raised by the EPA in Bulletin 1221. This information is presented in this PER to assist the EPA in their assessment of the Revised Proposal. Substantial progress has also been made towards drafting the management plans and other deliverables that are requirements of the Western Australian environmental approval (Statement No. 748) and Commonwealth environmental approval (EPBC Reference 2003/1294) for the Approved Development.

Environmental Assessment of Gorgon Gas Development Revised and Expanded Proposal (January 2008 – Current)

Since obtaining Western Australian and Commonwealth environmental approval, the GJVs have determined the need for changes to the Approved Gorgon Gas Development, which is termed within this PER as the 'Approved Development'. This has led to the preparation of a Revised Proposal which comprises changes to some elements of the Approved Development. The Revised Proposal was referred to the Western Australian EPA and the Commonwealth Minister for the Environment in February 2008 (Chevron Australia 2008b) and April 2008, respectively (Chevron Australia 2008c). It was determined that the Revised Proposal should be formally assessed at the Public Environmental Review (PER) level under the Western Australian *Environmental Protection Act 1986* (EP Act) and in alignment with the Bilateral Agreement between the Western Australian and Commonwealth Governments (DEWHA 2008 and EPA 2008b). Further detail on the assessment and approval process for the Revised Proposal is contained in Sections 1.6 and 1.7 of this document.

Other Changes (May 2008)

In addition to the approval being sought for the Revised Proposal described above, approval was granted in May 2008 (EPA 2008) (Appendix A), under section 45C of the EP Act, for the following minor changes to the Approved Development:

- excavation of a berthing pocket at the Barge Landing facility
- installation of additional communications facilities (microwave communications towers)
- relocation of the seawater intake
- modification to the seismic monitoring program.

EXECUTIVE SUMMARY

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

Introduction

Chevron Australia Pty Ltd (Chevron Australia) is the operator and proponent for both the Approved Gorgon Gas Development (Approved Development) and the Revised Gorgon Gas Development Proposal (Revised Proposal; the proposal described in this document) on behalf of the following companies (collectively known as the Gorgon Joint Venturers [GJVs]):

- Chevron Australia Pty Ltd
- Chevron (TAPL) Pty Ltd
- Shell Development (Australia) Proprietary Limited
- Mobil Australia Resources Company Pty Limited.

The Approved Development comprises a range of offshore and onshore components to recover gas from the Gorgon gas field west of Barrow Island and to process gas from the Greater Gorgon gas fields at, and ship it from, a Gas Treatment Plant on Barrow Island. The Revised Proposal comprises a number of changes to the Approved Development, the main changes being:

- addition of a five million tonnes per annum (MTPA) liquefied natural gas (LNG) train, increasing the number of LNG trains from two to three in order to generate more clean-burning natural gas sooner in a rapidly growing global energy market
- changes to the Reservoir Carbon Dioxide Injection System to allow an increased injection rate associated with the addition of one LNG Train, increasing the number of injection wells and surface drill centre locations
- revision of the causeway and the Materials Offloading Facility (MOF) designed to access deeper water to avoid hard rock material and the need for an extensive drilling and blasting program.

The Approved Development was approved by the Western Australian Minister for the Environment on 6 September 2007 by way of Ministerial Implementation Statement No. 748 (Statement No. 748) and the Commonwealth Minister for the Environment and Water Resources (now Minister for the Environment, Heritage and the Arts) on 3 October 2007 (EPBC Reference: 2003:1294) (Appendix A).

Location

Barrow Island is located approximately 70 km off the north-west coast of Western Australia (Figure ES0.1).

Tenure

In 1953, the oil discovery at the Rough Range well near the present day town of Exmouth, highlighted the hydrocarbon potential of the Carnarvon Basin and saw an increase in exploration activities in the area including around Barrow Island. Oil and gas exploration crews first operated on Barrow Island in 1957 and drilled the successful Barrow No. 1 well in 1964. The petroleum lease L1H which extends over the land mass of Barrow Island was granted on 27 February 1967 and oil production operations commenced soon after. The petroleum lease remains in place to this day.

Barrow Island is reserved under the Western Australian *Conservation and Land Management Act 1984* (CALM Act) as a Class A nature reserve for the purposes of 'Conservation of Flora and Fauna'. However, the *Barrow Island Act 2003* (WA) allows for the implementation of the Gorgon Gas Development and makes provision for land on Barrow Island to be used for gas processing project purposes.

The State waters around Barrow Island are part of the Montebello/Barrow Islands Marine Conservation Reserves. The Conservation Reserves contain the Barrow Island Marine Park incorporating the Bandicoot Bay Conservation Area. These Conservation Reserves are also reserved under the CALM Act.

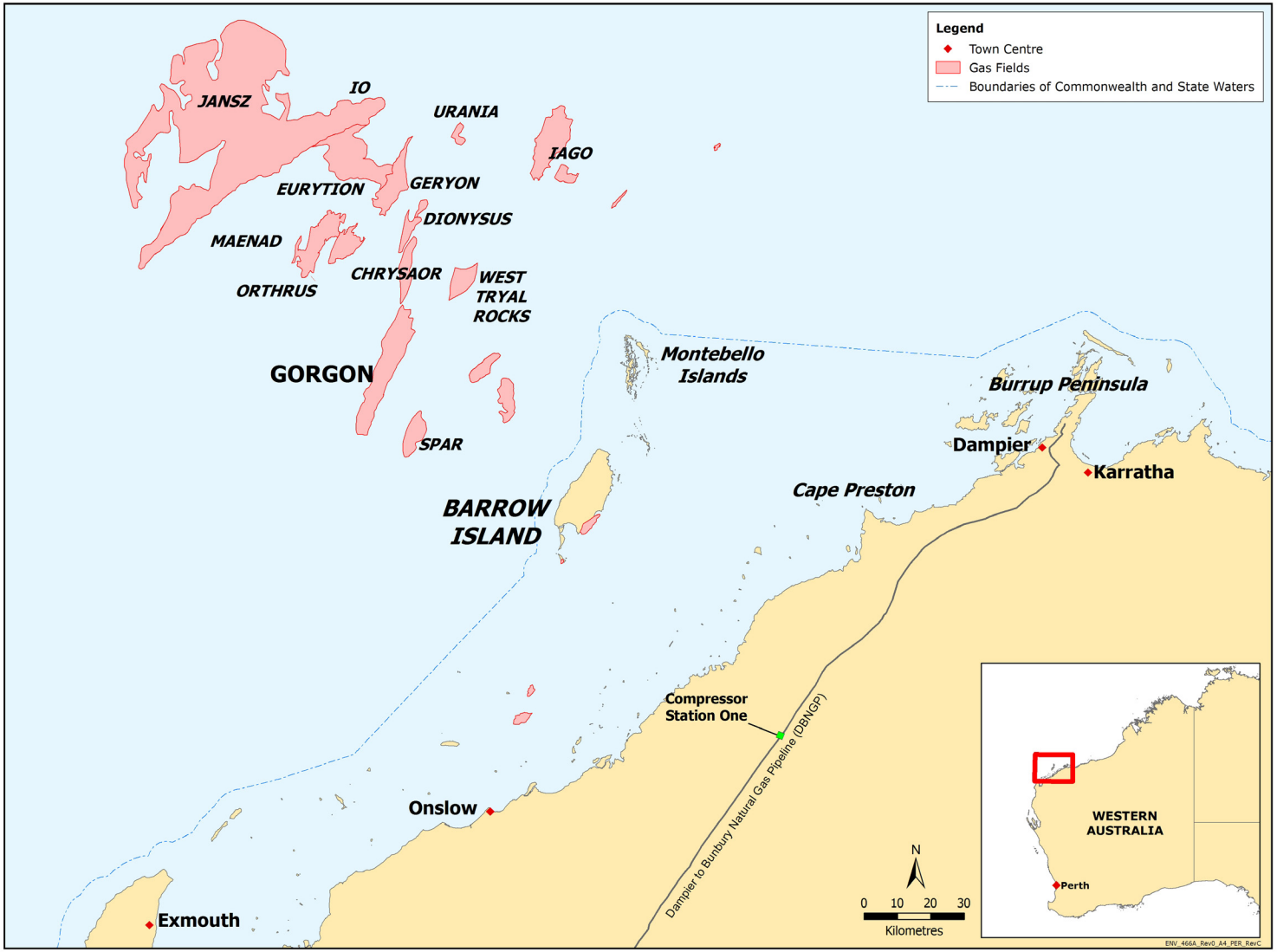

Figure ES0.1: Regional Location of the Revised Proposal

Assessment Process

The Revised Proposal was referred to the Western Australian Environmental Protection Authority (EPA) under section 38 of the Western Australian *Environmental Protection Act 1986* (EP Act) on 22 February 2008 (Chevron Australia 2008b). On 17 March 2008, the EPA assigned the Revised Proposal a Public Environmental Review (PER) level of assessment with an eight week public review period. The Commonwealth assessment of the Revised Proposal is in alignment with the Bilateral Agreement between the Western Australian and Commonwealth Governments (DEWHA 2008 and EPA 2008b) and is therefore also at the level of PER.

The Revised Proposal was referred to the Commonwealth Minister for the Environment, Heritage and the Arts under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 21 April 2008 (Chevron Australia 2008c). On 23 May 2008, the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) advised that the action was considered to be a 'controlled action' under the EPBC Act due to the following controlling provisions:

- listed threatened species and communities (sections 18 and 18A)
- listed migratory species (sections 20 and 20A).

These species listed under the EPBC Act are known as matters of National Environmental Significance (NES).

An Environmental Scoping Document was prepared to seek EPA endorsement regarding the scope of the assessment of the Revised Proposal as well as providing an indicative timeline for the assessment process. The Draft Environmental Scoping Document was submitted to the EPA on 1 May 2008. It included a summary of the potential environmental impacts, their significance and possible management responses, proposed scope of work to obtain information for the PER, key legislation, stakeholder consultation program, project and assessment schedule and study team. The Final Environmental Scoping Document was endorsed by the EPA on 10 July 2008, following EPA review and comment.

The Revised Proposal

The key components of the Revised Proposal are described in Table ES0.1 and depicted in Figure ES0.2 and Figure ES0.3.

All other key Approved Development characteristics described in Schedule 1 of Statement No. 748 are either:

- not subject to change
- will change, but have been approved by the Western Australian Minister for the Environment under section 45C of the EP Act (EPA 2008) because the changes are not considered to have a significant detrimental effect on the environment in addition to or different from the effect of the Approved Development (Appendix A).

The Approved Development was based on the shipment of a large quantity of building materials to construct much of the Gas Treatment Plant 'from the ground up' (otherwise called a 'stick-build' construction approach). Some of the larger components of the Gas Treatment Plant were to be pre-fabricated as large modules and shipped to Barrow Island on heavy lift vessels. As the engineering design of the Approved Development and the subsequent Revised Proposal has matured, opportunities to perform off-island construction tasks have been adopted, resulting in larger and more complete pre-

fabricated modules for the Revised Proposal, and also result in less direct human impact from the construction workforce on Barrow Island.

Table ES0.1: Key Characteristics of the Revised Proposal

Aspect	Element	Description of Approved Development Elements	Description of Revised Proposal Elements
Terrestrial Infrastructure			
Gas Treatment Plant	Number of LNG trains	2	3
	Gas Processing Drivers	4 x 80 MW dry low NOx (DLN) gas turbines.	6 x 80 MW (nominal) dry low NOx (DLN) gas turbines.
	Power Generation	4 x 116 MW conventional gas turbines without DLN burners.	5 x 117.5 MW (nominal) conventional gas turbines with DLN burners.
	Condensate Production Rate	2,000 m^3/day	Approximately 3,600 m^3/day.
	LNG Tank Size	2 x 165,000 m^3 (net)	2 x 180,000 m^3 (net).
	Condensate Tank Size	2 x 60,000 m^3	4 x 35,000 m^3 (net).
Associated Terrestrial Infrastructure			
	Utilities Area	Located near the Gas Treatment Plant.	Located within the Gas Treatment Plant site.
Carbon Dioxide (CO_2) Injection System	CO_2 pipeline (aboveground)	Length approximately 5 km. Easement approximately 6 ha.	Length approximately 10 km. Easement approximately 8 ha.
	CO_2 injection wells	Approximately 7 injection wells directionally drilled from 2 or 3 surface locations.	Approximately 8 - 9 injection wells directionally drilled from 3-4 drill centres. NOTE: The final location of the drill centres and injection wells is subject to ongoing technical assessment.
	Pressure Management wells	Pressure management well (or wells) may be required once injection performance is established.	Approximately 4 pressure management wells (or water production wells) will be required to manage reservoir pressure in the Dupuy formation. NOTE: The final location of the wells is subject to ongoing technical assessment.
	Pressure Management Water Injection Wells	Not included in Schedule 1 of Statement No. 748.	Approximately 4 pressure management water injection wells for the re-injection of produced water from the pressure management wells. NOTE: The final location of the wells is subject to ongoing technical assessment.

Aspect	Element	Description of Approved Development Elements	Description of Revised Proposal Elements
	Anode wells	Not included in Schedule 1 of Statement No. 748.	Four shallow drilled anode wells are required for each CO_2 injection well for the purposes of cathodic protection. Anode wells are also required for cathodic protection of pressure management wells and pressure management water injection wells. NOTE: The final location of the wells is subject to ongoing technical assessment.
Feed Gas Pipelines	Length onshore (Barrow Island)	Approximately 14 km	Approximately 14 km (no change to pipeline length). Minor realignment over a distance of approximately 500 m to accommodate changes to the Gas Treatment Plant footprint.
Marine Facilities			
Marine Offloading Facility (MOF)	Causeway length	Approximately 800 m	Combined length of approximately 2,120 m. (re-alignment and lengthening of the MOF structure [causeway and offloading facilities] by approximately800 m).
	MOF length	Approximately 520 m	
	MOF access	Constructed channel approximately 1.6 km long x 120 m wide, dredged to 6.5 m relative to chart datum.	Constructed channel approximately 750 m long x approximately 165 m wide Dredge volumes are anticipated to remain consistent with those considered acceptable during the assessment of the Approved Development.
LNG Jetty	LNG jetty length	Approximately 2.7 km	Approximately 2.1 km.
	Turning basin and access channel design	Turning basin 1 x 700 m circle (approximately), channel 300 m wide (approximately) Dual berth facility	Shape of turning basin has been revised as shown in **Figure 2.3** (dredging volumes remain the same as for the Approved Development, i.e. 6.5 million m^3) Dual berth facility (redesigned to meet safety requirements).
Clearing	All elements	Clearing of native vegetation for the purpose of implementing the Proposal.	Clearing of native vegetation for the purpose of implementing the Revised Proposal.

NOTES:

- *Some of the proposed changes described in Table ES0.1 are based on investigations that are continuing and as such, may vary as a result of further investigations during detailed design of the Gorgon Gas Development.*
- *All other key Approved Development characteristics described in Schedule 1 of Statement No. 748 are either (a) not subject to change, or (b) will change, but have been approved by the EPA under section 45C of the EP Act (EPA 2008) because the changes are not considered to have a significant detrimental effect on the environment in addition to, or different from, the effect of the Approved Gorgon Gas Development Proposal.*
- *The Approved Development permits processing of domestic gas sourced from the Greater Gorgon Gas Fields. Options to source domestic gas from other gas fields in the Greater Gorgon Area are currently*

under consideration and approval for extraction from such fields will be obtained separately, although processing has already been approved.

- *Domestic gas will be exported via a domestic gas pipeline from Barrow Island to tie into the Dampier to Bunbury Natural Gas Pipeline on the mainland (as described in the Approved Development). A minor realignment of this pipeline at the Barrow Island end will be required as a result of the changes to the marine infrastructure. As was described in the EIS/ERMP (Chevron Australia 2005a) the route for this pipeline is yet to be finalised, but will be modified to avoid sensitive benthic habitat where practicable, as the design develops.*

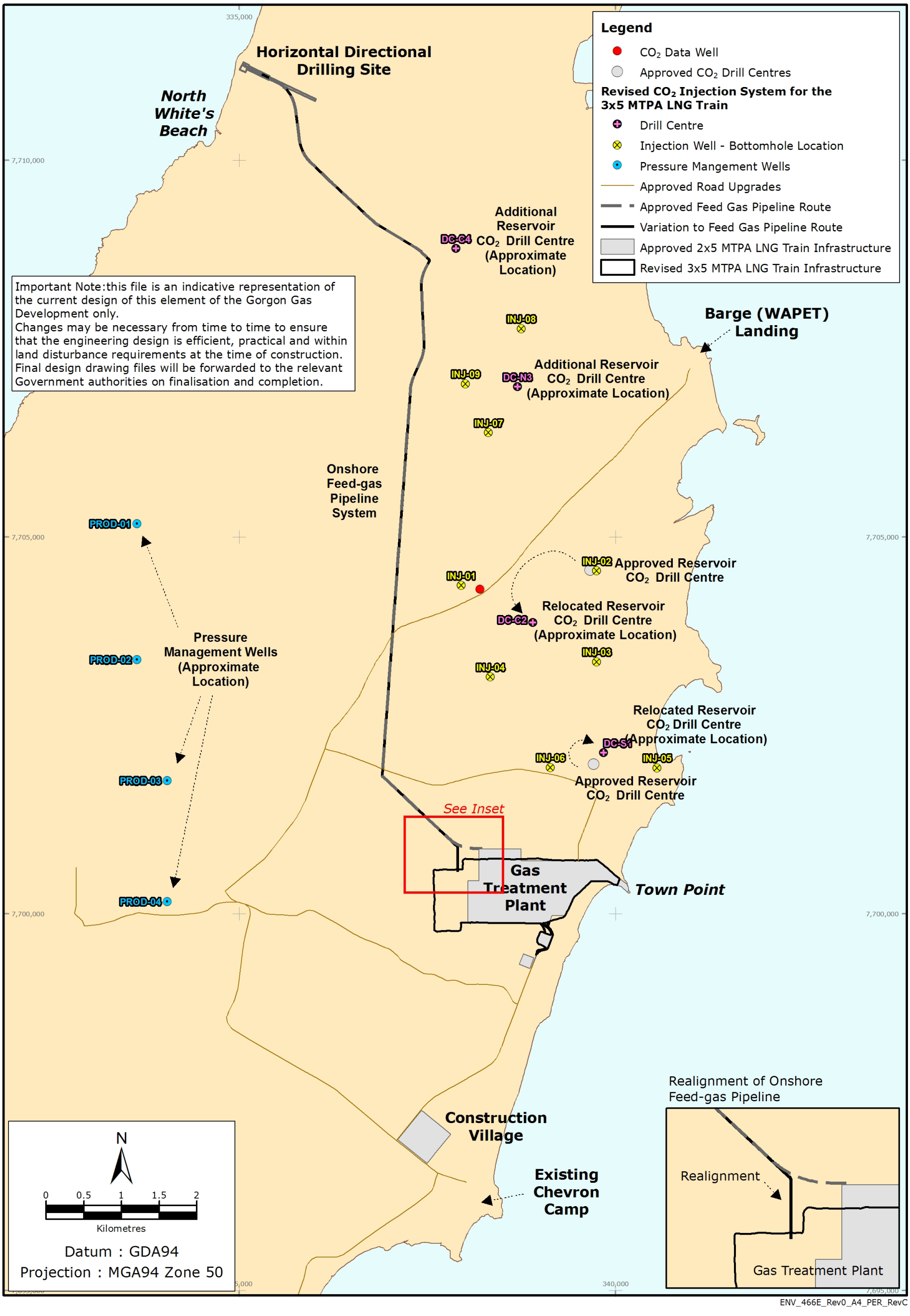

Figure ES0.2: Location of the Approved and Revised Gorgon Gas Development Terrestrial Facilities on Barrow Island

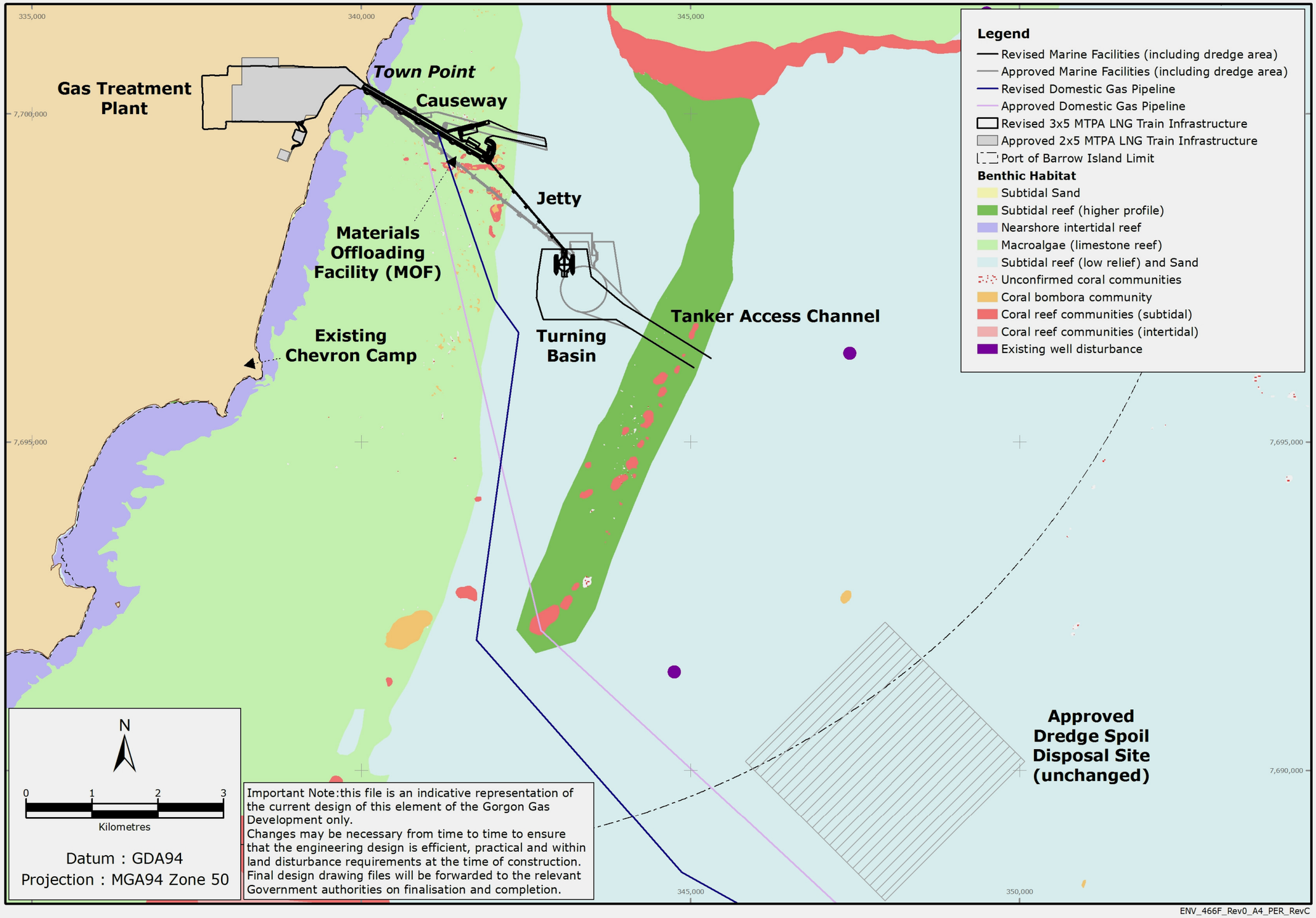

Figure ES0.3: Location of the Approved and Revised Gorgon Gas Development Marine Facilities off the East Coast of Barrow Island

Stakeholder Consultation

The GJVs have initiated a stakeholder consultation program for the Revised Proposal, which included consulting Commonwealth and Western Australian Government agencies, non-government organisations, the local government authority (Shire of Ashburton), and a range of community interest groups. The main issues raised by stakeholders related to:

- effects on fauna (terrestrial, subterranean and marine)
- effects on marine water quality and marine benthic primary producers
- increased air emissions, including greenhouse gases
- accelerated rate of reservoir carbon dioxide injection
- quarantine.

The issues raised by stakeholders have been addressed in this PER, and specifically, the following studies were commissioned to investigate key areas of concern:

- **Dredge plume modelling study:** to determine the changes that may occur as a result of the revision of the dredging program.
- **Coastal process studies:** to determine the potential impact of the Revised Proposal marine infrastructure on coastal processes on the beaches adjacent to Town Point and the adjacent near-shore environment.
- **Air quality assessment:** to enable impact assessment of the addition of a third LNG train to the Approved Development Gas Treatment Plant being constructed as part of the Revised Proposal.
- **Carbon dioxide migration or release to the surface or near-surface environment analysis:** to determine if there is significant change to the likelihood and/or consequence of potential failure modes associated with the disposal of reservoir carbon dioxide by underground injection into the Dupuy Formation as a result of the Revised Proposal in comparison with the Approved Development.
- **Physical interaction and physical presence of infrastructure with sea turtles analysis:** to determine baseline sea turtle usage of the beaches near the marine infrastructure with the objective of assessing the significance of the effects the Revised Proposal marine facilities may have on sea turtle population viability.
- **Light assessment study:** to enable an assessment of the potential impacts of the additional light emissions from the Revised Proposal.
- **Noise assessment study:** to enable an assessment of the potential impacts of the additional noise emissions from the Revised Proposal.

Environmental Impact Assessment and Management

The GJVs undertook a risk-based environmental impact assessment for the Approved Development and have adopted a comparative and cumulative approach for the Revised Proposal. The risk-based environmental impact assessment involved the following key steps:

1. Establishing the context; identifying project activities.
2. Identifying environmental aspects (stressors), receptors (environmental factors) and potential environmental impacts.
3. Analysing of risk (likelihood and consequence) after application of familiar management measures; this step determines inherent risk.
4. Applying mitigation measures and reassessing risk to determine the residual risk.

The key environmental factors that have been assessed in the PER utilising the risk-based assessment approach are:

- terrestrial fauna (including short-range endemics)
- subterranean fauna
- flora and vegetation
- marine fauna
- marine physical environment and coastal processes
- marine water and sediment quality
- marine benthic primary producers
- quarantine
- light and noise emissions
- atmospheric environment, specifically:
  - air emissions
  - greenhouse gas emissions and reservoir CO_2 injection.

Matters of NES (specifically terrestrial, subterranean and marine fauna species), as listed under the Commonwealth EPBC Act and as relevant to the Revised Proposal, are addressed in the relevant environmental factor section and a consolidated summary provided in a separate section of the PER (Section 13.0).

Table ES0.2 provides a summary of potential environmental impacts, proposed management and the environmental outcome for each of the environmental factors assessed in the PER.

Key Management Actions and Proposed Environmental Conditions

A number of management plans, programs and systems are being prepared to comply with Western Australian and Commonwealth Environmental Conditions prescribed for the Approved Development (as prescribed in Statement No. 748 and EPBC Reference: 2003:1294 respectively). Given that the risks associated with both the Approved Development and Revised Proposal are very similar, it is proposed that the relevant baseline state reports, management plans, programs and systems are amended/updated, where necessary, to incorporate aspects of the Revised Proposal. The GJVs consider the existing baseline state reports, management plans, programs and systems prescribed for the Approved Development to equally apply, and be adequate to cover, the new and/or additional environmental impacts associated with the Revised Proposal.

Management plans, programs and systems required by the Commonwealth approvals (EPBC Reference: 2003/1294 and Sea Dumping Permit No. SD2004/0030 (as applicable) comprise:

- Terrestrial and Marine Quarantine Management System
- Terrestrial Facilities Baseline State and Environmental Monitoring Program
- Coastal and Marine Baseline Sate Survey Plan and Marine Environmental Monitoring Program
- Terrestrial and Marine Facilities Construction Environment Management Plan(s) (including dredging and spoil disposal)
- Terrestrial and Marine Facilities Operations Environment Management Plan(s)
- Long-Term Marine Turtle Management Plan

- Carbon Dioxide Injection Monitoring Program
- Decommissioning and Closure Plan.

Management plans, programs and systems required by the Western Australian approval (Statement No. 748):

- Terrestrial and Subterranean Baseline State and Environmental Impact Report
- Terrestrial and Subterranean Environment Protection Plan
- Terrestrial and Subterranean Environment Monitoring Program
- Terrestrial and Marine Quarantine Management System
- Short Range Endemics and Subterranean Fauna Monitoring Plan
- Fire Management Plan
- Groundwater Abstraction Management Plan
- Long-Term Marine Turtle Management Plan
- Marine Facilities Construction Environmental Management Plan
- Dredge and Spoil Disposal Management and Monitoring Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Gas Pipeline Installation Management Plans
- Coastal Stability Management and Monitoring Plan
- Greenhouse Gas Abatement Program
- Air Quality Management Plan
- Solid and Liquid Waste Management Plan
- Aboriginal Cultural Heritage Management Plan
- Post-construction Rehabilitation Plan
- Project Site Rehabilitation Plan
- Decommissioning and Closure Plan.

Table 15.2 of the PER details the objectives and key management actions for the above management plans, programs and systems.

In addition to the Environmental Conditions prescribed in Statement No. 748 and EPBC Reference: 2003/1294, the GJVs have agreed to additional environmental undertakings. These are described in the preamble to Statement No. 748 and include:

- North West Shelf Flatback Turtle Conservation Program
  A 30-year North West Shelf Flatback Turtle Conservation Program will be undertaken to increase the protection of the population in areas away from Barrow Island.
- North West Shelf Flatback Turtle Intervention Program
  If the monitoring undertaken as part of the above mentioned program clearly demonstrates that the Gorgon Gas Development is having a significant impact to the flatback turtle population, the GJVs will take or fund further actions to improve recruitment to the turtle population, including establishment of hatcheries.
- Threatened Species Translocation and Reintroduction Program
  A Threatened Species Translocation and Reintroduction Program for selected species from Barrow Island to other Pilbara islands will be undertaken.
- Eradication of Non-indigenous Species

In addition to the quarantine management conditions detailed in Statement No. 748, the GJVs will provide a financial guarantee to cover Western Australian Government costs for eradication of non-indigenous species established on Barrow Island after commencement of the Gorgon Project, other than through natural causes, as determined by the Minister under advice from the Quarantine Expert Panel.

- Dredging
  The GJVs will fund Government costs associated with assessment and surveillance of marine activities during dredging and marine construction, and ongoing auditing of the marine environment response and recovery.

The GJVs do not consider it necessary to prescribe different or additional outcomes for those environmental factors already covered by environmental conditions in Statement No. 748 and EPBC Reference: 2003/1294. The GJVs consider that the existing environmental conditions prescribed for the Approved Development to equally apply and to be adequate to address the new and/or additional environmental impacts associated with the Revised Proposal.

Conclusion

The major environmental issues investigated during the environmental assessment process for the Revised Proposal were:

- additional and/or new impacts to biodiversity and conservation values of Barrow Island and its surrounding waters
- quarantine management
- cumulative air, light and noise emissions
- accelerated rate of disposal of reservoir CO_2 by injection into the Dupuy Formation.

The results of the environmental assessment demonstrate that the Revised Proposal is not expected to pose any significant new or additional risks to the biodiversity and physical environment values of Barrow Island and its waters in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts as a result of the entire Gorgon Gas Development. Table ES0.2 provides more detail of potential impacts of the Revised Proposal, proposed management measures and the predicted environmental outcome for each of the environmental factors assessed in the PER.

Environmental Risk and Manageability

The approach taken in this environmental review has been based on a risk assessment approach to characterise environmental factors, determine potential impacts and develop mitigation measures.

The GJVs have extensive experience in managing the development, operation and environmental compliance of similar projects and this experience is anticipated to lead to a greater certainty in achieving desirable environmental outcomes.

The environmental aspects of the Revised Proposal will be primarily managed through:

- implementation of the various Gorgon Gas Development environmental plans, programs and systems
- Chevron Australia's Operational Excellence Management System (which was designed to be consistent with ISO 14001:2004)
- relevant environmental licences that will be required.

Table ES0.2: Summary of Key Potential Impacts of the Revised Proposal, Proposed Management Measures and Predicted Environmental Outcomes

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
Biophysical					
1. Terrestrial fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	♦ Of the 218 terrestrial fauna species which have been recorded from Barrow Island, 119 are likely to occur within the combined terrestrial areas of the Approved Development and Revised proposal. ♦ Of the 119 species that may occur within the combined terrestrial areas of the Approved Development and Revised Proposal, eight species of conservation significance under the Western Australian Wildlife Act and the Commonwealth EPBC Act; one species of Priority flora, as listed by the DEC, could also occur. ♦ Significant habitats identified on Barrow Island and that occur within the additional area of disturbance associated with the Revised Proposal, are termite mounds. Termite mounds are well represented on Barrow	♦ The additional vegetation clearing associated with the Revised Proposal (but within the 300 ha available on Barrow Island for gas processing activities under the Western Australian *Barrow Island Act 2003*) will result in the direct disturbance of additional fauna habitat. ♦ Additional site excavation requirements, including excavation of additional trenches, foundations and pits, could trap fauna. ♦ The extended construction period and associated vehicle movements could potentially result in the loss of individual fauna, particularly less mobile species. ♦ Additional emissions (e.g. light and hot/cold emissions) associated with the additional infrastructure to be constructed under the Revised Proposal could potentially alter fauna behaviour or result in the loss of individual fauna. ♦ The accelerated rate of reservoir CO_2 injection may	The following key environmental management plans, programs and systems (required under conditions prescribed for the Approved Development in Statement No. 748) will be implemented: ♦ Terrestrial and Subterranean Environment Protection Plan ♦ Terrestrial and Subterranean Environmental Monitoring Program ♦ Short Range Endemics and Subterranean Fauna Monitoring Plan ♦ Fire Management Plan ♦ Terrestrial and Marine Quarantine Management System ♦ Carbon Dioxide Monitoring Program.	♦ The Revised Proposal is not considered to pose any significant new or additional risks to terrestrial fauna in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to terrestrial fauna as a result of the Gorgon Gas Development. ♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development is expected to manage the Revised Proposal impacts to terrestrial fauna at a level consistent with that considered acceptable and therefore approved for the Approved Development. ♦ In the case of Revised Proposal impacts with higher residual risk than the Approved Development (namely habitat loss from site clearing and injury or death of fauna due to attraction to light), the scope of the plans, systems and programs is considered adequate to manage the stressors and meet the EPA objective for terrestrial fauna.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
		Island. No additional boodie warrens will be disturbed as a result of the additional ground disturbance associated with the Revised Proposal.	increase the associated risks of unplanned CO_2 release to the surface or near-surface environment under the Revised Proposal, which could lead to the asphyxiation of terrestrial fauna in shallow-surface habitats.		
2. Subterranean fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	♦ There is evidence that the subterranean (geological) habitat on Barrow Island does not represent an impervious layer to subterranean fauna. While it is possible that certain subterranean taxa are restricted to discrete areas of karst habitat, current hydrogeological data suggest that these taxa are generally not restricted to proposed development areas on Barrow Island. ♦ An estimated 24 stygofauna taxa have been identified on Barrow Island, the dominant taxa being cyclopoid copepods and the amphipods. ♦ Twenty-one taxonomic troglofauna groups have been collected from Barrow Island, however only nine groups are true troglobites.	♦ The additional vegetation clearing associated with the Revised Proposal (but within the 300 ha allowed available on Barrow Island for gas processing activities under the Western Australian *Barrow Island Act 2003*) will result in changes in organic inputs to subterranean habitats. ♦ The additional area of excavation and infrastructure associated with the Revised Proposal will result in the direct disturbance of additional subterranean habitat. ♦ The accelerated rate of reservoir CO_2 injection may increase the associated risks of unplanned CO_2 release to the near-surface environment under the Revised Proposal, which could lead to a localised anoxic environment for stygofauna in the superficial aquifer, or lead to asphyxiation of troglofauna	The following key environmental management plans, programs and systems (required under conditions prescribed for the Approved Development in Statement No. 748) will be implemented: ♦ Terrestrial and Subterranean Environment Protection Plan ♦ Terrestrial and Subterranean Monitoring Program ♦ Short Range Endemics and Subterranean Fauna Monitoring Plan ♦ Carbon Dioxide Monitoring Program.	♦ While the Gorgon Gas Development will have a localised impact to the area within the Gas Treatment Plant footprint, it is unlikely to have any significant impact to any individual species or populations of subterranean fauna. ♦ The Revised Proposal is not considered to pose any significant new or additional risks to terrestrial fauna in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to subterranean fauna as a result of the Gorgon Gas Development. ♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development is expected to manage the Revised Proposal impacts to subterranean fauna to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the EPA objective for subterranean fauna.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
		♦ A number of stygofauna and troglofauna species are yet to be recorded outside the combined Approved Development and Revised Proposal disturbance area.	in subsurface area.		
3. Flora and vegetation	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	♦ No plant communities listed under the Commonwealth EPBC Act or the Western Australian Wildlife Act are known from Barrow Island. ♦ There are some vegetation associations considered to be locally sensitive; some of these communities are within the disturbance footprint of the combined area of the Approved Development and Revised Proposal. ♦ All vegetation associations within the terrestrial disturbance footprint are known to occur elsewhere on Barrow Island. ♦ All the flora species recorded on Barrow Island have been recorded on the mainland. ♦ No Threatened Flora species have been recorded on Barrow	♦ The additional vegetation clearing associated with the Revised Proposal (but within the 300 ha available on Barrow Island for gas processing activities under the Western Australian *Barrow Island Act 2003*) will result in loss or disturbance of flora species and vegetation communities, or a change in vegetation community composition from changes to soil profiles and/or drainage patterns. ♦ The additional infrastructure may pose an increased fire risk, which may result in a loss of vegetation communities, change in the species composition of a vegetation community, reduce the topsoil quality or result in loss of seeds from the topsoil. ♦ The extended construction period and the resultant dust emissions from vehicle movements, clearing and earthworks, could reduce photosynthetic activity of some plants or increase the	The following environmental management plans, programs and systems required under conditions prescribed for the Approved Development in Statement No. 748, will be implemented: ♦ Terrestrial and Subterranean Environment Protection Plan ♦ Terrestrial and Subterranean Environmental Monitoring Program ♦ Fire Management Plan ♦ Air Quality Management Plan ♦ Carbon Dioxide Monitoring Program ♦ Terrestrial and Marine Quarantine Management System.	♦ The Revised Proposal is not considered to pose any significant new or additional risks to terrestrial flora and vegetation in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to flora and vegetation as a result of the Gorgon Gas Development. ♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development is expected to manage the Revised Proposal impacts to flora and vegetation to a level consistent with that considered acceptable and therefore approved for the Approved Development. ♦ In the case of Revised Proposal impacts with higher residual risk than the Approved Development (namely loss of general flora and vegetation from site clearing and loss of vegetation community as a result of fire), the scope of the plans, systems and programs is considered adequate to manage the stressors and meet the EPA objective for terrestrial flora and vegetation.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
		Island. ♦ Three Priority Flora species have been recorded on Barrow Island. One species (*Corchorus congener*) has been recorded within the combined clearing area of the Approved Development and Revised Proposal; this species is not restricted to the disturbance footprint. ♦ Several species of weeds have been recorded on Barrow Island.	absorption of near-infrared radiation by leaves. ♦ The additional area of land disturbance associated with the Revised Proposal could increase the risk associated with the introduction or spread of non-indigenous plant species, which can compete with native species for resources such as water and nutrients.		
4. Marine fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	♦ The marine fauna habitats within the Revised Proposal area include intertidal reef with large rock pools, limestone platform reef, deeper pavement reef covered with sand and a rocky ridge. ♦ The marine fauna of the waters surrounding Barrow Island is diverse, and includes a variety of tropical and subtropical fish, mammals, reptiles, avifauna and invertebrates. ♦ A number of marine fauna species are considered to be of	♦ Change in location of the physical disturbance of the seabed during construction of the revised marine infrastructure may cause loss of and/or disturbance to marine fauna habitat, direct loss of benthic faunal communities, including potential loss of listed pipefish, and a decline in marine water quality (e.g. sedimentation, nutrient increases and/or oxygen depletion) different to that of the Approved Development. ♦ Additional light emissions, associated with the additional infrastructure, may affect turtles and some	The following environmental management plans and programs required under conditions prescribed for the Approved Development in Statement No. 748, will be implemented: ♦ Marine Facilities Construction Environmental Management Plan ♦ Dredge and Spoil Disposal Management and Monitoring Program ♦ Long-term Marine Turtle Management Plan ♦ Solid and Liquid Waste Management Plan.	♦ The Revised Proposal is not considered to pose any significant new or additional risks to marine fauna in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to marine fauna as a result of the entire Gorgon Gas Development. ♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development is expected to manage the Revised Proposal impacts to marine fauna to a level consistent with that considered acceptable and therefore approved for the Approved Development. ♦ In the case of Revised Proposal

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
		conservation significance, listed under the Western Australian Wildlife Act and/or EPBC Act, including species of marine turtles and whales.	seabirds, potentially altering their movements and behaviour. ♦ Accidental leaks and spills associated with the additional movements of marine vessels have the potential to be detrimental to seagrass infauna and most intertidal biota, and may cause irritation and/or harm to marine mammals and sea turtles. ♦ The change in the location of the physical presence of the revised marine infrastructure may disturb marine fauna behavioural patterns (i.e. some obstruction of movement along east coast of Barrow Island) and may potentially lead to increased predation different to that of the Approved Development. ♦ Additional LNG and condensate tanker movements may increase the risk of accidental vessel collision with marine fauna and associated fauna, which is associated with fauna injury or death. ♦ Noise and vibration emissions resulting in potential disturbance and or injury to marine fauna due to underwater drilling, blasting and seismic data acquisition activities.		stressors with higher residual risks than the Approved Development (namely disturbance to marine fauna behavioural patterns), the scope of the plans, programs and systems is considered adequate to manage the stressors and meet the EPA objective for marine fauna.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
5. Marine physical environment and Coastal processes	To maintain the integrity, ecological functions, and environmental values of the soil and landform. To maintain the integrity, ecological functions, and environmental values of the seabed and coast. To protect the environmental values of areas identified as having significant environmental attributes.	♦ The coast in the vicinity of the Revised marine facilities is comprised of several extended, almost linear sandy beaches, separated by short rocky headlands. The beaches are perched upon a gently sloping rock shore platform. ♦ Tropical cyclones potentially create the most dramatic changes to beach profiles as storm surge raises water levels and exposes wave influence to higher parts of the beach not normally vulnerable to waves. ♦ Coastal erosion of the rocky headland and weathering of the intertidal shore platform provides a source of sediment for the beach faces.	♦ Change in location of the physical disturbance of the seabed and physical presence of the revised marine infrastructure may cause a change in seabed profile and type (sand, rock, etc.), and cause smothering of the seabed different to that of the Approved Development.	The following environmental management plans and programs required under conditions prescribed for the Approved Development in Statement No. 748, will be implemented: ♦ Marine Facilities Construction Environmental Management Plan ♦ Dredge and Spoil Disposal Management and Monitoring Program ♦ Coastal Stability and Monitoring Program.	♦ The Revised Proposal is not considered to pose any significant new or additional risks to the marine environment and coastal processes in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to the marine physical environment and coastal processes as a result of the Gorgon Gas Development. ♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development is expected to manage the Revised Proposal impacts to the marine physical environment and coastal processes to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the relevant EPA objectives.
6. Marine water and sediment quality	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards. To maintain the	♦ Background contamination levels of the waters off the east coast of Barrow Island are generally low. ♦ The shallow waters close to Barrow Island are naturally more turbid than deeper offshore waters. ♦ Nutrient levels are often	♦ Change in location of the physical disturbance of the seabed may cause a change in water quality (e.g. turbidity) different to that of the Approved Development.	The following environmental management plans and programs required under conditions prescribed for the Approved Development in Statement No. 748, will be implemented: ♦ Coastal and Marine Baseline State and Environmental Impact Report ♦ Marine Facilities	♦ Although the Revised Proposal seabed disturbance impacts were assessed as higher residual risk than the Approved Development subsequent studies have demonstrated that the risk is no greater (or less) than the Approved Development. ♦ There are no unacceptable cumulative impacts related to marine water and sediment quality as a result of the Gorgon Gas Development.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
	integrity, ecological functions and environmental values of the seabed and coast.	high; given the widespread distribution of such data suggests, this is characteristic of the area. ♦ Nutrient concentrations in the near-shore sediments surrounding Barrow Island are low. ♦ Metal concentrations of the near-shore marine sediments surrounding Barrow Island, except silver, are low. The source of the elevated silver concentrations is unknown.		Construction Environmental Management Plan ♦ Dredge and Spoil Disposal Management and Monitoring Program. ♦ Horizontal Directional Drilling Management and Monitoring Plan ♦ Offshore Gas Pipeline Installation Management Plan	♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development are expected to manage impacts from the Revised Proposal to marine water and sediment quality resulting from seabed disturbance to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the relevant EPA objectives.
7. Marine benthic primary producers	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	♦ Marine benthic primary producers in the vicinity of the marine facilities include macroalgae, seagrasses, and hard and soft corals. ♦ Mangroves on Barrow Island only occur within isolated pockets on the fringes of the southern and eastern coastlines. There are no mangroves in the vicinity of the Gorgon Gas Development east coast marine facilities.	♦ Change in the location of the physical disturbance of the seabed during construction may result in turbidity, light attenuation and reduced photosynthetic potential in dredge plume and decreased water quality different to that of the Approved Development. ♦ Accidental leaks and spills associated with the additional movements of marine vessels may lead to smothering of mangrove pneumatophores and impacts to associated biota; metabolic effects on shallow subtidal coral; metabolic effects on intertidal and shallow subtidal biota; contamination of intertidal	The following environmental management plans and programs required under conditions prescribed for the Approved Development in Statement No. 748, will be implemented: ♦ Coastal and Marine Baseline State and Environmental Impact Report ♦ Marine Facilities Construction Environmental Management Plan ♦ Dredge and Spoil Disposal Management and Monitoring Program. ♦ Offshore Gas Pipeline Installation Management Plan	♦ The Revised Proposal is not considered to pose any significant new or additional risks to benthic primary producers in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to marine benthic primary producers as a result of the Gorgon Gas Development. ♦ The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development are expected to manage impacts from the Revised Proposal to marine benthic primary producers to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the EPA objective for marine benthic primary producers.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
			reef or sediments; and smothering of exposed intertidal biota from contact with slick of hydrocarbons.		♦ The GJVs will be able to manage marine construction, dredging and spoil disposal operations so as not to exceed the 22 ha limit on net coral mortality within the High and Moderate Zones of Impact, as prescribed for the Approved Development under Condition 18 in Statement No. 748 (Appendix A)
Emissions					
8. Air emissions	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.	♦ Air quality in the vicinity of the Revised Proposal is currently influenced by other projects in the region. ♦ The key sources of air emissions identified for the Approved Development were power generation, process area gas turbines. heating medium heaters, flaring of hydrocarbons and shipping. ♦ In comparison to the Approved Development, the Revised Proposal includes four additional sources of air emissions: one additional LNG train, two additional compression turbines, one additional power generation turbine, one additional boil off gas (BOG) elevated flare.	• Cumulative air emissions from the Approved Development and the Revised Proposal may affect vegetation on Barrow Island and the health of the workforce.	The GJVs will implement the following approach for the management of air emissions from the Gorgon Gas Development: ♦ Best practice management in the design and construction of the LNG facilities. ♦ Installation of dry low nitogen oxides (DLN) technology in turbines to minimise oxides of nitrogen (NOx) emissions. ♦ Continuous monitoring of emissions and conditions to ensure design tolerance of DLN technology is achieved. ♦ In addition, air emissions will be addressed by the Air Quality Management Plan required under a condition prescribed for the Approved Development in Statement No. 748.	♦ Based on modelling completed, the emissions arising from the routine operation of the Revised Proposal can be managed to achieve the EPA objective for air quality. ♦ Modelling also indicates that potential impacts during non-routine upset conditions can be adequately managed during these periods. ♦ The addition of the Revised Proposal as a regional emission source will influence ground level concentrations of target species both on Barrow Island and the mainland. However, the relative increase in regional concentrations is not considered significant. ♦ Based on the modelling results, it is considered that the changes associated with the Revised Proposal can be effectively managed under the conditions already prescribed for the Approved Development. ♦ There are no unacceptable cumulative impacts related to air emissions as a result of the Gorgon Gas Development.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
9. Light emissions	To avoid or manage potential impacts from light spill and comply with acceptable standards.	The proposed changes to the Gas Treatment Plant of the Approved Development include the following elements that will contribute to an increase in light spill: ♦ the physical presence of an additional LNG train (module) ♦ additional non-routine flaring associated with the operation of the third LNG train ♦ an increase in LNG and condensate offloading frequency (and light sources associated with marine vessels and operation of the LNG Jetty and MOF).	Light spill and light characteristics (e.g. light colour, intensity, etc.) from the Revised Proposal have the potential to affect the behaviour of the following key fauna receptors: ♦ flatback turtles visiting the beaches either side of Town Point to mate, rest in the near shore waters and lay eggs on the beaches ♦ the bridled tern and wedge tail shearwater colony on Double Island.	The GJVs will implement measures and procedures consistent with commitments made for the Approved Development, which include: ♦ environmental lighting design measures will be incorporated in the lighting design for the Gorgon Gas Development ♦ light emission impact mitigation strategies will be implemented through marine operating procedures during the construction and operations phase of the Gorgon Gas Development.	♦ Light emissions from the Revised Proposal are not expected to extend further or affect new areas that were not identified as being affected by the Approved Development. These emissions are not expected to pose any significant new or additional risks to the terrestrial or marine values of Barrow Island in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to light emissions as a result of the Gorgon Gas Development. ♦ Based on the modelling completed, illumination levels on the adjacent beaches caused by light spill from the Revised Proposal were comparable to illumination levels on clear nights with full or quarter moon. ♦ Furthermore, natural shielding afforded by sand dunes and the additional large structures on the Gas Treatment Plant site are expected to contribute to lower illuminance levels at the adjacent beach (e.g. Terminal and Bivalve beaches) than the levels predicted by the model. ♦ The environmental design measures and operating procedures (developed to be consistent with commitments made in relation to the Approved Development) are expected to manage the increase in light emissions from the Revised Proposal to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the EPA objective for light emissions.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
10. Noise emissions	To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.	• Background noise emissions on Barrow Island are associated with operation of the existing Chevron Camp and natural sources such as wind and wave action at the adjacent beach (e.g. Terminal and Bivalve beaches). ♦ The change in levels of terrestrial noise emissions from the Revised Proposal are linked to the operation of the additional LNG train and the increase in number of non-routine flaring events associated with the operation of the additional train. ♦ Noise emissions from marine activities are also expected to increase due to the increase in LNG and condensate offtake vessel movements.	At Barrow Island, noise emissions from the Revised Proposal have the potential to affect the behaviour of sensitive terrestrial and marine fauna.	The noise control philosophy for the Revised Proposal [refer to full Noise Study Report (KJVG 2008b) (Appendix D) is aligned with the design basis planned for the Approved Development, which include (but are not limited to): ♦ Compressor gas turbine drive and generator gas turbine drive intake/exhaust ducting are to be acoustically insulated with an appropriate acoustic insulation. ♦ Exhaust silencers are required for gas turbine drives of generators. ♦ Use of vibration isolation pads, such as Fabreeka or equivalent, for compressor suction/ discharge pipe supports to reduce the noise radiation from pipe supports. ♦ Low noise type air coolers not to exceed sound pressure level of 85 dB(A) per fan 1 meter below fan centre. ♦ Inlet silencers required for the gas turbines of Mixed Refrigerant and Propane compressors. ♦ These measures aim to define the best practice approach to noise mitigation for this type of Gas Treatment Plant.	♦ Noise emissions from the Revised Proposal are not considered to pose any significant new or additional risks to noise sensitive receptors in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to noise emissions as a result of the Gorgon Gas Development. ♦ Based on the modelling completed, increases in noise levels at the Gorgon Construction Village and the existing Chevron Camp are expected to be minimal in comparison to the Approved Development. ♦ The noise design philosophy (developed to be consistent with commitments made in relation to the Approved Development) is expected to manage the increase in noise emissions from the Revised Proposal to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the EPA objective for noise emissions.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
11. Greenhouse gas emissions	To minimise emissions to levels as low as practicable on an ongoing basis and consider offsets to further reduce cumulative emissions.	♦ Annual greenhouse gas emissions from the Approved Development were estimated to be 4.0 MTPA CO_2e. ♦ The estimated greenhouse gas emissions from the Revised Proposal are estimated to be 5.45 MTPA CO_2e. ♦ The greenhouse emissions intensity for the Revised Proposal (0.348 tonnes CO_2e per tonne of LNG) will not significantly differ from intensity of the Approved Development. ♦ The Approved Development requires the development of a project to inject reservoir CO_2 into the Dupuy Formation.	♦ Increase in greenhouse gas emissions and accelerated rate of reservoir CO_2 injection in to the Dupuy Formation. ♦ The accelerated rate of reservoir CO_2 injection may increase the associated risks of unplanned CO_2 release to the surface or near-surface environment under the Revised Proposal (as described above for terrestrial and subterranean fauna).	♦ The following environmental management systems and programs required under conditions prescribed for the Approved Development in Statement No. 748, will be implemented: ♦ Carbon Dioxide Monitoring Plan ♦ Greenhouse Gas Abatement Program. ♦ Terrestrial and Subterranean Environment Protection Plan ♦ Terrestrial and Subterranean Monitoring Program.	♦ The Gorgon Gas Development represents application of best practice energy efficiency and emissions control. ♦ The proposal to significantly reduce emissions from the Revised Proposal by the underground injection of reservoir CO_2 represents a 'beyond no regrets' action. ♦ The Approved Development is subject to a number of environmental approval conditions that regulate emissions from the Approved Development and address issues such as accidental leakage of injected reservoir CO_2 into the near surface cave systems on Barrow Island. These conditions provide a workable framework by which to manage greenhouse gas emissions resulting from the Revised Proposal, and by which the GJV will meet the EPA objective for greenhouse gas emissions. ♦ There are no unacceptable cumulative impacts related to greenhouse gas emissions as a result of the Gorgon Gas Development.
Other					
12. Quarantine	Note: in absence of specific EPA objective for quarantine, Chevron Australia's objective is: to facilitate the construction and operation of a gas processing facility on	♦ Barrow Island remains relatively free from non-indigenous species. ♦ There are currently 14 weed species recorded from Barrow Island; these are mostly located in areas of disturbance such as along existing	♦ Non-indigenous flora species can compete with native species for resources such as water and nutrients. ♦ Non-indigenous flora species can also change the original vegetation composition and structure. ♦ Non-indigenous fauna (feral)	As required under Statement No. 748, a Terrestrial and Marine Quarantine Management System will be implemented. The specific objectives of the QMS are (as outlined in Statement No. 748): ♦ to prevent the introduction of Non-indigenous Terrestrial	♦ The construction approach for the Revised Proposal relies more heavily on 'modularisation', requiring decreased volumes of construction supplies and raw materials to be shipped to Barrow Island (relative to the Approved Development), and therefore a lower exposure of quarantine risk associated with these commodities.

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
	Barrow Island and simultaneously protect the conservation values of the Island.	tracks. ♦ No non-indigenous flora (weed) species have been recorded from the terrestrial disturbance footprint associated with the Revised Proposal. ♦ There are likely to be several species of non-indigenous invertebrate fauna species on Barrow Island although none have been recorded to date.	species can compete with native species for resources (such as food and habitat), can predate upon native fauna species and introduce diesease.	Species and Marine Pests ♦ to detect Non-indigenous Terrestrial Species (including weed introduction and/or proliferation) and Marine Pests ♦ to control and, unless otherwise determined by the Minister, eradicate detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests ♦ mitigate adverse impacts of any control and eradication actions taken against detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests.	♦ The quarantine barriers developed for pre-fabricated modules in the Approved Development are scalable; that is they apply to modules regardless of size, and continue to result in a low risk of introduction for larger modules in the Revised Proposal. ♦ Similarly, the conditions relating to quarantine management prescribed for the Approved Development are scalable and do not have any diminished effect for the proposed construction of a third LNG Train (or any of the Associated Terrestrial Infrastructure) on Barrow Island. ♦ In addition, the licensed Quarantine Approved Premises (QAP) provide an additional layer of protection to prevent introductions, over and above the barriers adopted in the Approved Development. ♦ The proposed construction approach and quarantine barriers, together with the applicable conditions (outlined above) are considered adequate to manage the associated quarantine risk to acceptable levels. ♦ There are no unacceptable cumulative impacts related to quarantine as a result of the Gorgon Gas Development.
13. Matters of NES	Note: in the absence of specific EPA or DEWHA objectives, Chevron Australia's objective is to avoid and/or mitigate significant impacts to	Matters of NES include terrestrial, subterranean and marine fauna species. See descriptions provided for terrestrial and marine fauna above for these environmental factors.	See descriptions of potential impacts provided for terrestrial and marine fauna above for the relevant environmental factors.	See the descriptions provided for terrestrial and marine fauna above for the relevant environmental factors.	♦ The Revised Proposal is not considered to pose any significant new or additional risks to matters of NES in comparison to the Approved Development. ♦ There are no unacceptable cumulative impacts related to matters of NES as a

Environmental Factor	EPA Objective (EPA 2004a)	Existing Environment	Key Potential Impacts	Proposed Management	Predicted Environmental Outcomes
	matters of NES on Barrow Island and in its waters.				result of the entire Gorgon Gas Development. ♦ Consequently, the Revised Proposal is considered to have an unchanged risk to such species and is unlikely to have a significant impact to these species.

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1.0 INTRODUCTION

This document is the Public Environmental Review (PER) prepared by the Gorgon Joint Venturers (GJVs) for the Gorgon Gas Development Revised and Expanded Proposal (Revised Proposal). It has been prepared in accordance with the Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2002 of the Western Australian *Environmental Protection Act 1986* (EP Act), and to satisfy the requirements for assessment of the Revised Proposal under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In accordance with the Western Australian EP Act requirements, the GJVs prepared an Environmental Scoping Document (Chevron Australia 2008b) that was endorsed by the EPA in July 2008 and which forms the basis for assessment of this PER.

This PER specifically addresses the changes introduced to the Approved Gorgon Gas Development (Approved Development) by the GJVs Revised Proposal.

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

1.1 Proposal Overview

1.1.1 Location

Barrow Island is located approximately 70 km off the north-west coast of Western Australia (Figure 1.1).

The island currently supports a Chevron-operated oil field; this operation has been in place since the 1960s and is expected to continue for another 15 to 20 years.

The Gorgon Gas Development Gas Treatment Plant is part of both the Approved Development and the Revised Proposal. It will be located on the east coast of Barrow Island at Town Point, with related approved terrestrial infrastructure located at a small number of other locations on the Island. The Reservoir Carbon Dioxide Injection System is located north of the Gas Treatment Plant on the east side of Barrow Island. The MOF, which is also part of both the Approved Development and Revised Proposal, will be located within the Port of Barrow Island and extend offshore from Town Point on the east coast of Barrow Island.

1.1.2 Description

The Approved Development was approved by the Western Australian Minister for the Environment on 6 September 2007 by way of Ministerial Implementation Statement (Statement) No. 748 and the then Commonwealth Minister for the Environment and Water Resources on 3 October 2007 (EPBC Reference: 2003/1294) (Appendix A). The Approved Development was assessed at the level of Environmental Impact Statement (EIS – Commonwealth) and Environmental Review and Management Programme (ERMP – Western Australian).

The Commonwealth Minister for the Environment and Water Resources also approved a Sea Dumping Permit (No. SD2004/0030) subject to conditions, on 3 October 2007 for the Approved Development as required under section 19 of the *Environmental Protection (Sea Dumping) Act 1981* (Cth).

In May 2008, under section 45C of the EP Act, the EPA approved some minor changes to the Approved Development (Appendix A) that it considered "not to result in a significant, detrimental, environmental effect in addition to, or different from, the effect of the original proposal".

The Approved Development comprises a range of offshore and onshore components to recover gas from the Gorgon gas field west of Barrow Island and to process gas from the Greater Gorgon gas fields at, and ship it from, a Gas Treatment Plant on Barrow Island.

Since then, the GJVs have determined the need for the following changes to the Approved Development:

- addition of a five million tonnes per annum (MTPA) liquefied natural gas (LNG) train, increasing the number of LNG trains from two to three in order to generate more clean-burning natural gas sooner in a rapidly growing global energy market
- changes to the Reservoir Carbon Dioxide Injection System to allow an increased injection rate associated with the addition of one LNG Train, increasing the number of injection wells and surface drill centre locations
- revision of the Causeway and the Materials Offloading Facility (MOF) designed to access deeper water to avoid hard rock material and the need for an extensive drilling and blasting program. These elements are further described in Section 2.0.

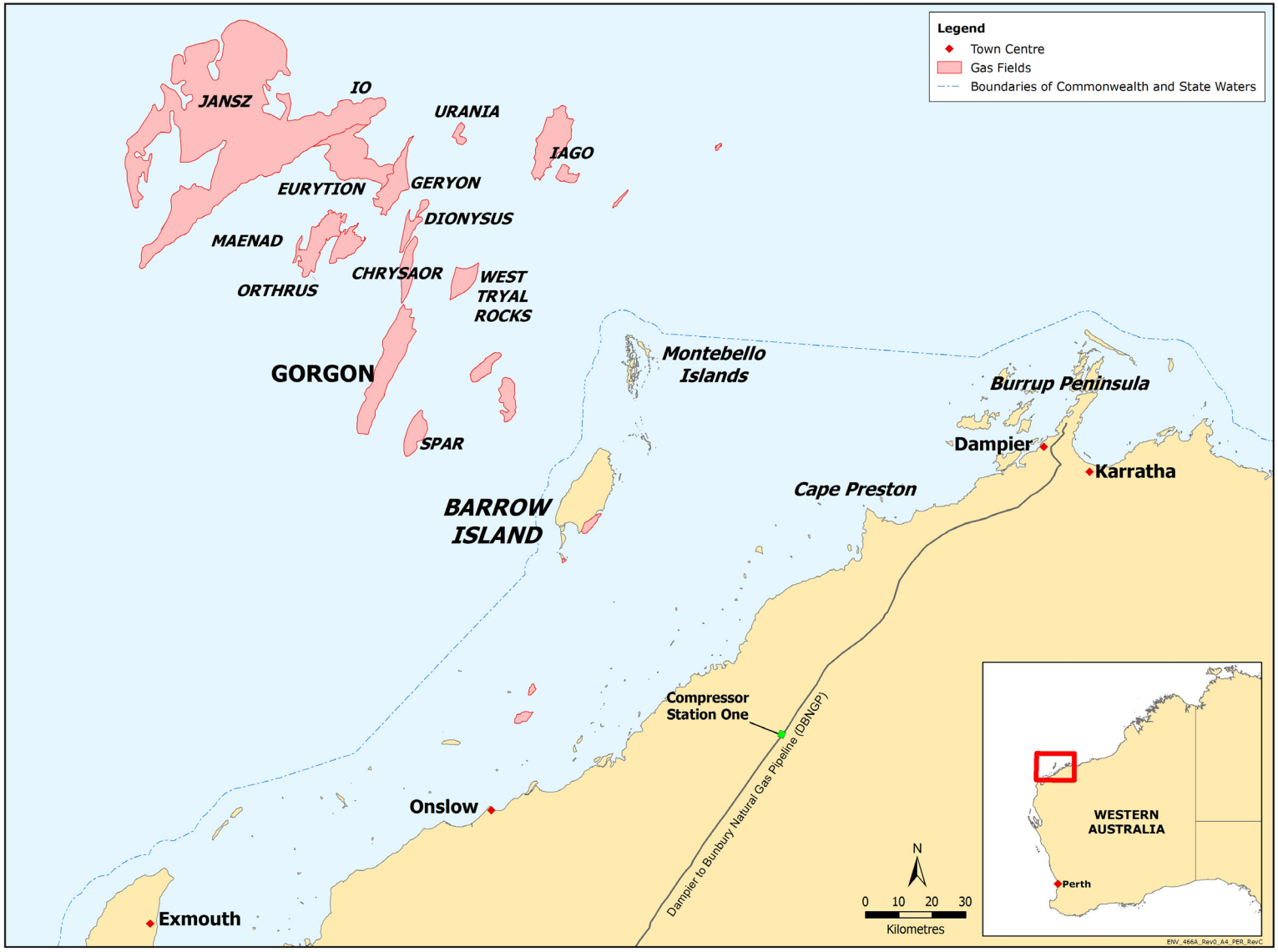

Figure 1.1: Regional Location of Gorgon Gas Development Revised Proposal

1.2 The Proponent

Chevron Australia Pty Ltd (Chevron Australia) is the operator and proponent for both the Approved Development and the Revised Proposal on behalf of the following companies (collectively known as the Gorgon Joint Venturers [GJVs]):

- Chevron Australia Pty Ltd
- Chevron (TAPL) Pty Ltd
- Shell Development (Australia) Proprietary Limited
- Mobil Australia Resources Company Pty Limited.

The contact person at Chevron Australia for the Revised Proposal is:

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1.3 Justification for Proposal

1.3.1 Options Analysis

Barrow Island is the location for the Approved Development. Alternate locations for the Revised Proposal have not been considered due to the requirements of Statement No. 748 to inject reservoir CO_2 as part of the Approved Development. An explanation of the options considered for the Approved Development siting, and the rationale for selecting Barrow Island and the specific sites for the Gorgon Gas Development facilities on, and adjacent to, Barrow Island, are provided in the EIS/ERMP (Chevron Australia 2005a).

1.3.2 Re-evaluation of Design Opportunities

The GJVs have re-evaluated the economics of the Gorgon Gas Development in light of increases in the costs of the materials required to construct the Approved Development. To improve project economics, it is necessary to include one additional LNG train as part of the Development to take advantage of economies of scale. The EIS/ERMP (Chevron Australia 2005a) included information relating to the GJVs' intent to further develop the Gorgon Gas reserves through capacity increases of the processing facilities on Barrow Island in the future, within the 300 ha available on Barrow Island for gas processing under the Western Australian *Barrow Island Act 2003*.

The addition of a third LNG processing train will increase the annual average volume of reservoir CO_2 anticipated to be injected by approximately 25% for the Revised Proposal, however, the total volume of CO_2 to be injected over the life of the project remains the same as for the Approved Development.

The accelerated rate at which reservoir CO_2 is proposed to be injected will require one to two additional injection wells and one to two drill centres, with a corresponding increase in the length of the approved CO_2 pipeline. All land disturbances associated with the injection of reservoir CO_2 will be managed in accordance with the limits imposed by the Gorgon Gas Processing and Infrastructure Project Agreement (*Barrow Island Act 2003* (WA) – Schedule 1).

Marine geophysical and geotechnical information acquired during the Front-End Engineering and Design (FEED) phase of the Gorgon Gas Development has indicated that the rock substrate in the vicinity of the MOF location is significantly harder and more extensive than previous data indicated. This would result in the need to drill and blast approximately 500 000 m^3 of material in coastal waters before mechanical removal for the construction of the MOF access channel and berthing pockets.

Re-evaluation of MOF design opportunities has taken into account environmental impacts (during the construction and operation phases), safety, accessibility and functionality. This has resulted in a revised design including a modified MOF orientation and longer MOF structure, which will reduce the required length of the dredged access channel. The extension of the MOF structure into deeper water reduces the need for significant drilling and blasting of the MOF access channel and berthing pockets in the near-shore marine area off Town Point. Further explanation of this proposed revision and the results of the geophysical surveys appear in Section 2.4.

1.3.3 Market Demand

The GJVs are nominating a change to the Approved Development scope from two 5 MTPA LNG trains to three 5 MTPA LNG trains with several other associated component changes. By developing three LNG production units in quick succession the Gorgon Gas Development will generate more clean-burning natural gas sooner in a rapidly growing global energy market.

1.3.4 Benefits of the Gorgon Gas Development

The Gorgon Gas Development is officially the largest ever resource development undertaken in Australia.

Extensive economic modelling conducted in 2008 by an independent third party (ACIL Tasman 2008) has confirmed that the Gorgon Gas Development is a mega project expected to create its own economic environment and significant life-of-project local content benefits.

As the Development progresses through construction and operation it has the potential to deliver a significant economic boost, creating thousands of jobs and generating billions of dollars in government revenue for use on roads, schools and hospitals.

Independent economic analysis (ACIL Tasman 2008) indicates that the substantial infrastructure and investment required for the Development may provide a stimulus with the potential to transform Western Australia into a regional and global petroleum service hub. The development of new technologies and skills for the project, such as carbon dioxide injection and subsea developments, may also establish Western Australia as a global centre of excellence in new areas of expertise.

Key economic findings of ACIL Tasman (2008), based on the first 30 year operation of a 15 million tonne per annum, three train development, include:

- peak construction employment in Western Australia of around 6000 personnel with more than 3500 direct and indirect jobs sustaining throughout the life of the Gorgon Gas Development
- the Net Present Value of Australia's Gross Domestic Product (GDP) is expected be boosted by A$64.3 billion
- around A$33 billion in today's dollars are expected to flow to locally purchased goods and services (local content)

- anticipated government revenue of about A$39.8 billion in today's dollars.

The GJVs are committed to providing full, fair and reasonable opportunity for Australian industry to supply goods and services.

While developments such as the Gorgon Gas Development require large capital expenditure overseas, local content opportunities for local contractors are being identified and Australian industry will have an opportunity to globally showcase its expertise and its competitiveness, in both cost and quality, in the global energy project market.

All opportunities will be posted on the Industry Capability Network of Western Australia's ProjectConnect website at www.projectconnect.com.au.

1.4 Purpose and Scope of this Document

The purpose of this document is to present a description of the principal components of the Revised Proposal; including environmental impact assessment, mitigation and management measures. It is intended for the consideration of stakeholders; the Western Australian Environmental Protection Authority (EPA), the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) and the community at the level of PER.

The scope of this PER is to assess the significance of those environmental impacts of the Revised Proposal that are in addition to, different from, or cumulative with the Approved Development, and whether and how these impacts will be avoided (where possible), minimised and managed.

1.5 Western Australian Environmental Impact Assessment Process

The Revised Proposal was referred to the Western Australian EPA under section 38 of the EP Act on 22 February 2008. On 17 March 2008, the EPA assigned the Revised Proposal a PER level of assessment with an eight week public review period.

An Environmental Scoping Document was prepared to seek EPA endorsement regarding the scope of the assessment of the Revised Proposal as well as providing an indicative timeline for the assessment process. The Draft Environmental Scoping Document was submitted to the EPA on 1 May 2008. It included a summary of the potential environmental impacts, their significance and possible management responses, proposed scope of work to obtain information for the PER, key legislation, stakeholder consultation program, project and assessment schedule and study team. The Final Environmental Scoping Document was endorsed by the EPA on 10 July 2008, following EPA review and comment (Chevron Australia 2008b).

The Environmental Scoping Document and PER were prepared in accordance with the Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2002 (the Administrative Procedures) for environmental assessment prescribed under the EP Act.

This PER was drafted and submitted to the EPA for review to ensure the document addresses all of the environmental factors and studies identified in the Environmental Scoping Document. The EPA Board authorised this PER for release for public review on 8 September 2008.

The PER document has been released for the eight week public review period during which time members of the public may make submissions on the proposal to the EPA. The submissions will be provided to the GJVs, who formally respond to the issues raised in the submissions. The EPA then undertakes assessment of the PER document, submissions and the GJVs' responses to submissions. The EPA will provide an assessment report (report and recommendations published in an EPA Report) to the Minister for the Environment, who will then decide whether or not the Revised Proposal should be implemented and if so, under what conditions.

Figure 1.2 outlines the procedure for a PER level of assessment under the EP Act and EPBC Act.

1.6 Commonwealth Environmental Impact Assessment Process

The Revised Proposal was referred to the Commonwealth Minister for the Environment, Water, Heritage and the Arts, under the EPBC Act, on 21 April 2008. On 23 May 2008, the Department of Environment, Water, Heritage and the Arts (DEWHA) advised that the action was considered to be a 'controlled action' under the EPBC Act due to the potential significant impacts on the following controlling provisions:

- listed threatened species and communities (sections 18 and 18A)
- listed migratory species (sections 20 and 20A).

As the Revised Proposal will be assessed by the Western Australian Government at the PER level of assessment, the Western Australian/Commonwealth Assessment Bilateral Agreement will apply to the Revised Proposal. The parallel assessment process is shown in Figure 1.2.

Following receipt of public submissions on the PER (via the process described in Section 1.5), the DEWHA will also undertake an assessment of the PER document, submissions and the GJVs' responses to submissions. The DEWHA will deliver their assessment report to the Federal Minister for the Environment, who will then decide whether or not the Revised Proposal should be implemented and if so, under what conditions.

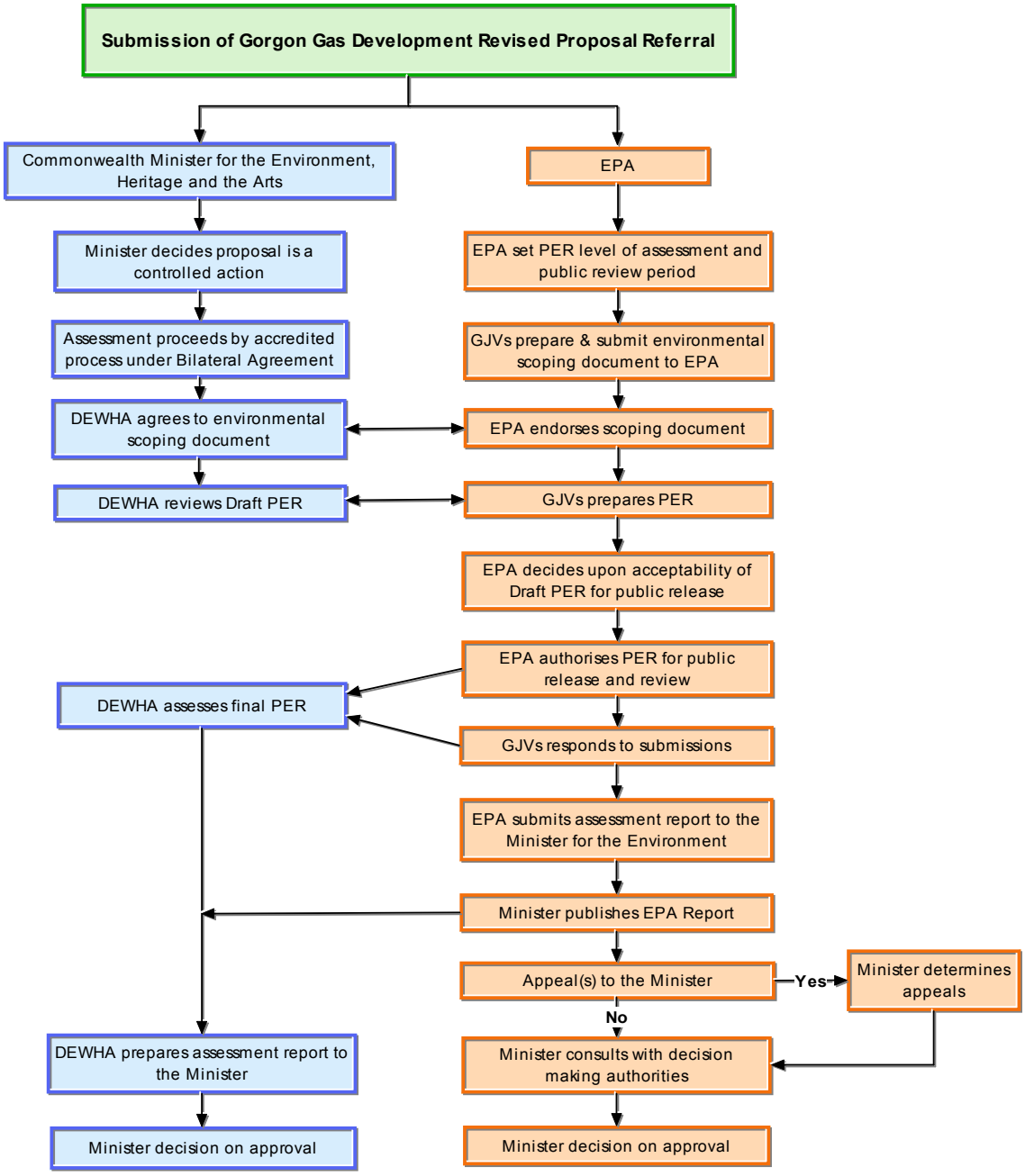

Figure .2: Parallel Processing of EP Act (WA) and EPBC Act (Cth) Approvals Processes for the Gorgon Gas Development Revised Proposal

1.7 Relevant Environmental Legislation and Policy

1.7.1 Commonwealth and Western Australian Legislation

The Revised Proposal must comply with applicable Western Australian and Commonwealth legislation. Current key Western Australian and Commonwealth legislation (with an environmental focus) applicable to the Revised Proposal is outlined in Table 1.1.

Table 1.1: Key Commonwealth and Western Australian Legislation Relevant to the Revised Proposal

Western Australian	Commonwealth
Aboriginal Heritage Act 1972 (WA)	*Aboriginal and Torres Straight Islander Heritage Protection Act 1984* (Cth)
Agricultural and Related Resources Protection Act 1976 (WA)	*Australian Maritime Safety Authority Act 1990* (Cth)
Barrow Island Act 2003 (WA)	*Energy Efficiency Opportunities Act 2006* (Cth)
Conservation and Land Management Act 1984 (WA)	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
Dangerous Goods and Safety Act 2004 (WA)	*Environment Protection (Sea Dumping) Act 1981* (Cth)
Environmental Protection Act 1986 (WA)	*Historic Shipwrecks Act 1976* (Cth)
Fish Resources Management Act 1994 (WA)	*Native Title Act 1993* (Cth)
Heritage of Western Australia Act 1990 (WA)	*National Greenhouse and Energy Reporting Act 2007* (Cth)
Jetties Act 1926 (WA)	*Navigation Act 1912* (Cth)
Land Administration Act 1997 (WA)	*Offshore Petroleum Act 2006* (Cth)
Local Government Act 1995 (WA)	*Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth)
Marine and Harbours Act 1981 (WA)	*Sea Installations Act 1987* (Cth)
Occupational Safety and Health Act 1984 (WA)	
Petroleum Act 1967 (WA)	
Petroleum Pipeline Act 1969 (WA)	
Petroleum Safety Act 2004 (WA)	
Petroleum (Submerged Lands) Act 1982 (WA)	
Planning and Development Act 2005 (WA)	
Pollution of Waters by Oils and Noxious Substances Act 1987 (WA)	
Shipping and Pilotage Act 1967 (WA)	
Soil and Land Conservation Act 1945 (WA)	
Wildlife Conservation Act 1950 (WA)	

1.7.2 Barrow Island Act (WA)

In-principle support for the Gorgon Gas Development was granted by the Western Australian Government in August 2003. This in-principle support is expressed in the Gorgon Gas Processing and Infrastructure Project Agreement and its ratifying Act, the *Barrow Island Act 2003* (WA), which was promulgated on 20 November 2003. The *Barrow Island Act 2003* (WA) sets out the rights and obligations of both the GJVs and the Western Australian Government in regard to the Gorgon Gas Development In particular, it:

- provides a mechanism by which the Western Australian Government may authorise the implementation of the Gorgon Gas Development

- makes provision for land on Barrow Island to be used for gas processing project purposes
- makes provision for underground disposal of reservoir CO_2
- has regard for the need to minimise environmental disturbance on Barrow Island and provide support for conservation programs.

1.7.3 Environmental Protection Act (WA)

The Revised Proposal will be assessed under Part IV of the EP Act (Section 1.5). In addition, Part V of the EP Act provides that Works Approvals and Environmental Licences are required for various listed prescribed premises. No such approvals have yet been sought for the Approved Development.

A Works Approval is required for the construction of some elements of the Approved Development, and there will be no change to this requirement for the Revised Proposal. A Licence will also be required for the operation of some elements of the Approved Development, and there will be no change to this requirement for the Revised Proposal.

1.7.4 Other Applicable Environmental Management Instruments

A number of environmental management instruments are applicable to the Revised Proposal, including:

International

- China Australia Migratory Birds Agreement (CAMBA 1988)
- Convention on Biological Diversity (Secretariat of the Convention on Biological Diversity 1992)
- Convention on the Conservation of Migratory Species of Wild Animals (Secretariat of the Convention for the Conservation of Migratory Species of Wild Animals 1979)
- Convention on Wetlands of International Importance (RAMSAR 1971)
- International Convention for the Prevention of Pollution from Ships 1973, as modified by the protocol of 1978 (MARPOL 73/78) (International Maritime Organization 1973)
- Japan Australia Migratory Birds Agreement (JAMBA 1974)
- Republic of Korea Australia Migratory Birds Agreement (ROKAMBA 2006)
- United Nations Framework Convention on Climate Change (United Nations 1992) and Kyoto Protocol (United Nations 1997)

Commonwealth

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000)
- National Strategy for Ecologically Sustainable Development (Commonwealth Government of Australia 1992a)
- National Water Quality Management Strategy (COAG 1994)
- Intergovernmental Agreement on the Environment (Commonwealth Government of Australia 1992b)
- National Strategy for Conservation of Australia's Biological Diversity (Commonwealth Government of Australia 1996)

State (Western Australia)

- Barrow Island Interim Environmental Quality Criteria (Department of Environment and Conservation 2007)
- Department of Environment and Conservation (DEC) Guidelines for Air Quality Modelling (Department of Environment 2006)
- Indicative Management Plan for the Proposed Montebello/Barrow Islands Marine Conservation Reserves (Department of Conservation and Land Management 2004)
- Environmental Weed Strategy for Western Australia (Department of Conservation and Land Management 1999)
- DEC Guidelines for Ambient Air Quality (Department of Environment 2004)
- Premier's Climate Change Action Statement, "Climate Change: Making Decisions for the Future" (Government of Western Australia 2007)
- State Water Quality Management Strategy (Document No. 6) (Government of Western Australia 2004)
- Western Australia State Sustainability Strategy (Government of Western Australia 2003)
- Western Australia Greenhouse Strategy (Western Australian Greenhouse Task Force 2004)
- Western Australian Planning Policy No. 2.6. – State Coastal Planning (Western Australian Planning Commission 2003)
- State Conservation Strategy (1987)

A number of EPA Guidance and Position Statements are also relevant to the Revised Proposal. These are listed and described in the relevant environmental factor sections of this PER (Section 6.0 through Section 12.0). Key environmental and sustainability principles have also been incorporated in the Revised Proposal, and are discussed in detail in Section 14.3 and Section 14.4 respectively.

2.0 DESCRIPTION OF REVISED PROPOSAL

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

2.1 Key Characteristics of Revised Proposal

The Revised Proposal comprises changes to several elements of the Approved Development (Table 2.1). The key elements of the Revised Proposal are:

- addition of one 5 MTPA LNG train, increasing the number of LNG trains from two to three
- changes to the Reservoir Carbon Dioxide Injection System
- revision of the causeway and the MOF into deeper water.

The addition of one LNG train has arisen as a result of a review of the economics associated with the Gorgon Gas Development and the revision of the engineering design of the Approved Development.

The changes to the Reservoir Carbon Dioxide Injection System are a direct result of the increased production capacity brought about by the additional LNG train.

The changes to the causeway and MOF have arisen as a result of the acquisition of further marine geophysical data during the Gorgon Gas Development FEED phase. This has led to the re-design of the marine facilities to significantly reduce the need for drilling and blasting as explained in Section 1.3.1.

The key elements of the Revised Proposal are further described in Sections 2.2 through 2.4. Figures 2.1 and 2.2 illustrate the layout of terrestrial and marine facilities (respectively) for both the Approved Development and as revised in the Revised Proposal. Figure 2.3 provides a close up of the revised design for the marine facilities.

All other key Approved Development characteristics described in Schedule 1 of Statement No. 748 are either:

- not subject to change
- will change, but have been approved by the EPA under section 45C of the EP Act (EPA 2008) because the changes are not considered to have a significant detrimental effect on the environment in addition to or different from the effect documented for the Approved Development.

Domestic gas will be exported via a domestic gas pipeline from Barrow Island to tie into the Dampier to Bunbury Natural Gas Pipeline on the mainland (as described for the Approved Development). A minor realignment of this pipeline at the Barrow Island end will be required as a result of the changes to the marine infrastructure. As was described in the EIS/ERMP (Chevron Australia 2005a), the route for this pipeline is yet to be finalised but will be modified to avoid sensitive benthic habitat where reasonably practicable.

The description of the Approved Development provided within the EIS/ERMP (Chevron Australia 2005a) identified a number of water supply options (groundwater or seawater via reverse osmosis [RO]) and potential RO brine disposal alternatives (injection or ocean outfall). These options for RO brine disposal were also included in Schedule 1 of Statement No. 748. Further investigation of the alternatives and system design evaluations has recommended seawater, via RO technology, as the water supply source, and ocean outfall as the best practicable brine disposal method. The decisions to pursue a seawater source and brine ocean outfall are not related to the changes described in the Revised Proposal, but were based on detailed water supply options, water treatment technology and liquid waste disposal options evaluation.

The normal maximum water production capacity from the RO facilities will be in the order of 1500 m^3/day with peak brine discharge about 3000 m^3/day. The RO brine is essentially concentrated seawater, which will contain residual low concentrations of chemicals used in the RO process. Operation of the RO plant, the RO brine diffuser design and its location will be optimised to minimise potential environmental impacts.

Pursuant to condition No. 30.2 (ii) of Statement No. 748, which states that:
*"…discharges from any waste water treatment plant, reverse osmosis plant or process water are disposed of via deep well injection, unless otherwise authorized by the Minister; "*the GJVs will seek authorisation from the Western Australian Minister for the Environment for the ocean outfall disposal of RO brine discharge under the process as specified in Statement No. 748. Therefore such authorisation is not being sought through the environmental approval process for the Revised Proposal, i.e. approval for RO brine disposal will be sought via the process set-out in Statement No. 748.

Table 2.1: Summary of Revised Proposal – Proposed Changes to Approved Development

Aspect	Element	Description of Approved Development Elements	Description of Revised Proposal Elements
Terrestrial Infrastructure			
Gas Treatment Plant	Number of LNG trains	2	3
	Gas Processing Drivers	4 x 80 MW dry low NOx (DLN) gas turbines.	6 x 80 MW (nominal) dry low NOx (DLN) gas turbines.
	Power Generation	4 x 116 MW conventional gas turbines without DLN burners.	5 x 117.5 MW (nominal) conventional gas turbines with DLN burners.
	Condensate Production Rate	2,000 m^3/day	Approximately 3,600 m^3/day.
	LNG Tank Size	2 x 165,000 m^3 (net)	2 x 180,000 m^3 (net).
	Condensate Tank Size	2 x 60,000 m^3	4 x 35,000 m^3 (net).
Associated Terrestrial Infrastructure			
	Utilities Area	Located near the Gas Treatment Plant.	Located within the Gas Treatment Plant site.
Carbon Dioxide (CO_2) Injection System	CO_2 pipeline (aboveground)	Length approximately 5 km. Easement approximately 6 ha.	Length approximately 10 km. Easement approximately 8 ha.
	CO_2 injection wells	Approximately 7 injection wells directionally drilled from 2 or 3 surface locations.	Approximately 8 - 9 injection wells directionally drilled from 3 - 4 drill centres. NOTE: The final location of the drill centres and injection wells is subject to ongoing technical assessment.
	Pressure Management wells	Pressure management well (or wells) may be required once injection performance is established.	Approximately 4 pressure management wells (or water production wells) will be required to manage reservoir pressure in the Dupuy formation. NOTE: The final location of the wells is subject to ongoing technical assessment.

Aspect	Element	Description of Approved Development Elements	Description of Revised Proposal Elements
	Pressure Management Water Injection Wells	Not included in Schedule 1 of Statement No. 748.	Approximately 4 pressure management water injection wells for the re-injection of produced water from the pressure management wells. NOTE: The final location of the wells is subject to ongoing technical assessment.
	Anode wells	Not included in Schedule 1 of Statement No. 748.	Four shallow drilled anode wells are required for each CO_2 injection well for the purposes of cathodic protection. Anode wells are also required for cathodic protection of pressure management wells and pressure management water injection wells. NOTE: The final location of the wells is subject to ongoing technical assessment.
Feed Gas Pipelines	Length onshore (Barrow Island)	Approximately 14 km	Approximately 14 km (no change to pipeline length). Minor realignment over a distance of approximately 500 m to accommodate changes to the Gas Treatment Plant footprint.
Marine Facilities			
Marine Offloading Facility (MOF)	Causeway length	Approximately 800 m	Combined length of approximately 2,120 m. (re-alignment and lengthening of the MOF structure [causeway and offloading facilities] by approximately800 m).
	MOF length	Approximately 520 m	
	MOF access	Constructed channel approximately 1.6 km long x 120 m wide, dredged to 6.5 m relative to chart datum.	Constructed channel approximately 750 m long x approximately 165 m wide. Dredge volumes are anticipated to remain consistent with those considered acceptable during the assessment of the Approved Development.
LNG Jetty	LNG jetty length	Approximately 2.7 km	Approximately 2.1 km
	Turning basin and access channel design	Turning basin 1 x 700 m circle (approximately), channel 300 m wide (approximately) Dual berth facility	Shape of turning basin has been revised as shown in **Figure 2.3** (dredging volumes remain the same as for the Approved Development, i.e. 6.5 million m^3). Dual berth facility (redesigned to meet safety requirements).

Aspect	Element	Description of Approved Development Elements	Description of Revised Proposal Elements
Clearing	All elements	Clearing of native vegetation for the purpose of implementing the Proposal.	Clearing of native vegetation for the purpose of implementing the Revised Proposal.

NOTES:

- *Some of the proposed changes described in Table 2.1 are based on investigations that are continuing and as such, may vary as a result of further investigations during detailed design of the Gorgon Gas Development.*
- *All other key Approved Development characteristics described in Schedule 1 of Statement No. 748 are either (a) not subject to change, or (b) will change, but have been approved by the EPA under section 45C of the EP Act (EPA 2008) because the changes are not considered to have a significant detrimental effect on the environment in addition to, or different from, the effect of the Approved Gorgon Gas Development Proposal.*
- *The Approved Development permits processing of domestic gas sourced from the Greater Gorgon Gas Fields. Options to source domestic gas from other gas fields in the Greater Gorgon Area are currently under consideration and approval for extraction from such fields will be obtained separately, although processing has already been approved.*
- *Domestic gas will be exported via a domestic gas pipeline from Barrow Island to tie into the Dampier to Bunbury Natural Gas Pipeline on the mainland (as described in the Approved Development). A minor realignment of this pipeline at the Barrow Island end will be required as a result of the changes to the marine infrastructure. As was described in the EIS/ERMP (Chevron Australia 2005a) the route for this pipeline is yet to be finalised, but will be modified to avoid sensitive benthic habitat where reasonably practicable, as the design develops.*

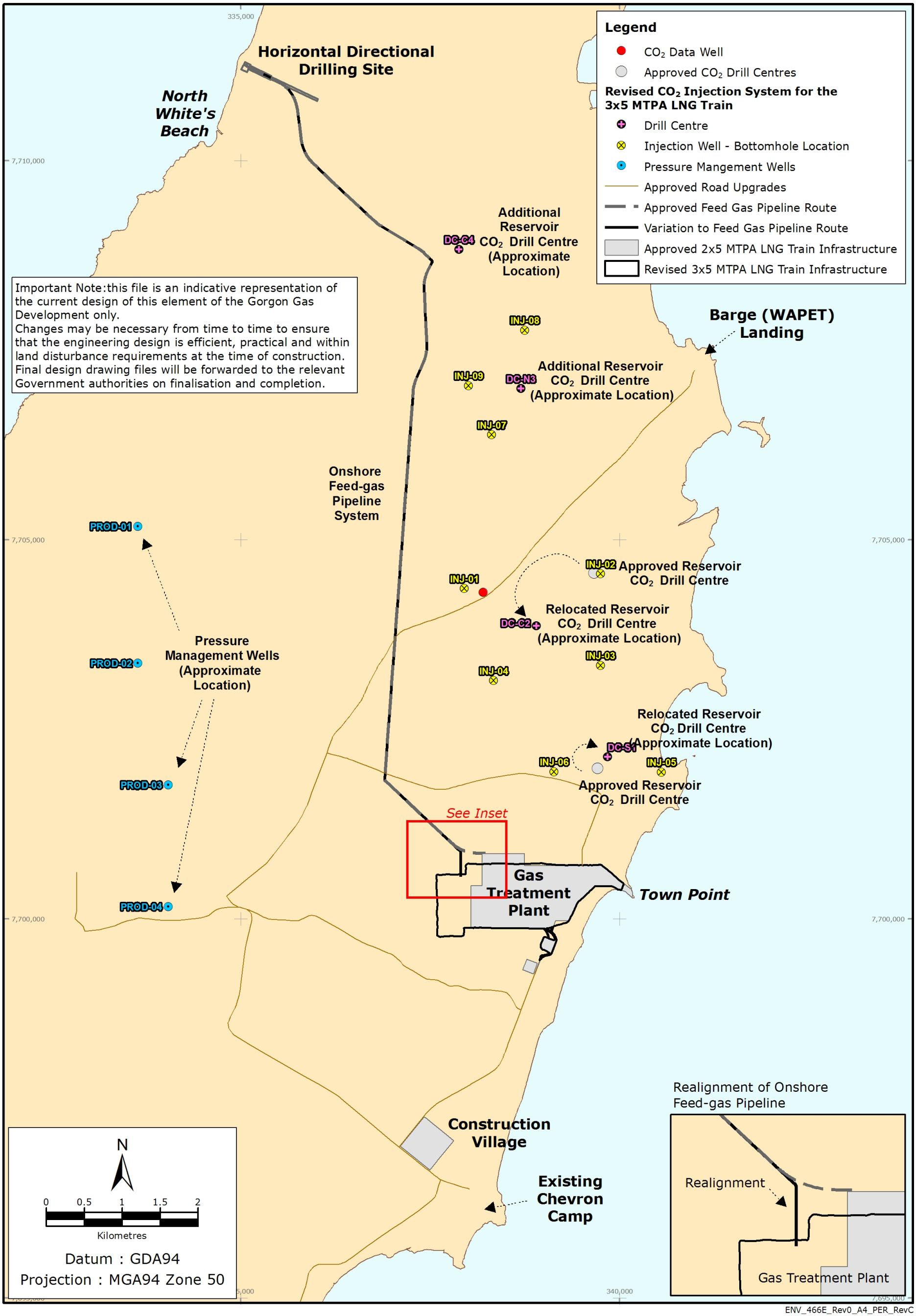

Figure 2.1: Location of the Approved and Revised Terrestrial Facilities on Barrow Island

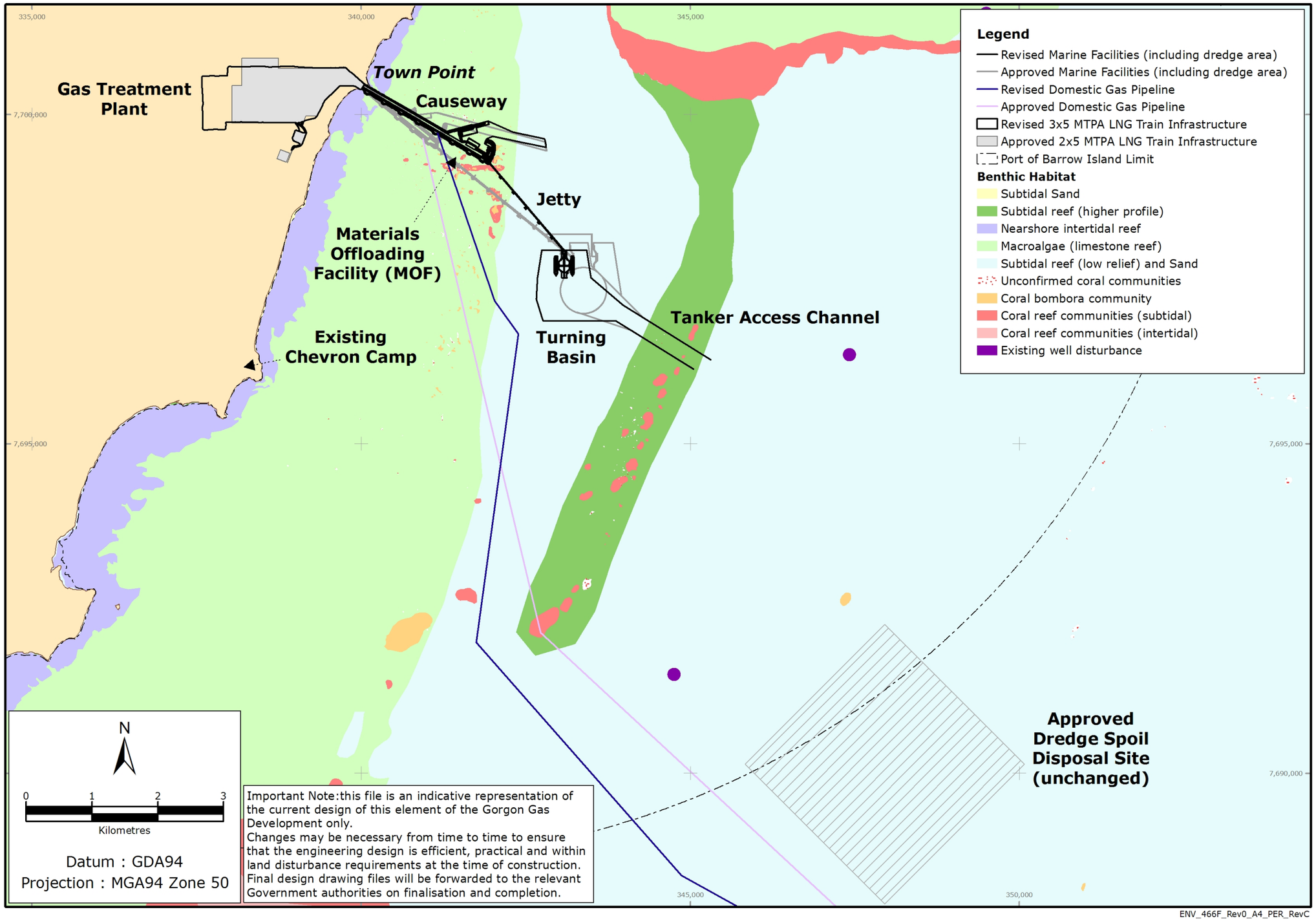

Figure 2.2: Location of Approved and Revised Marine Facilities off East Coast of Barrow Island

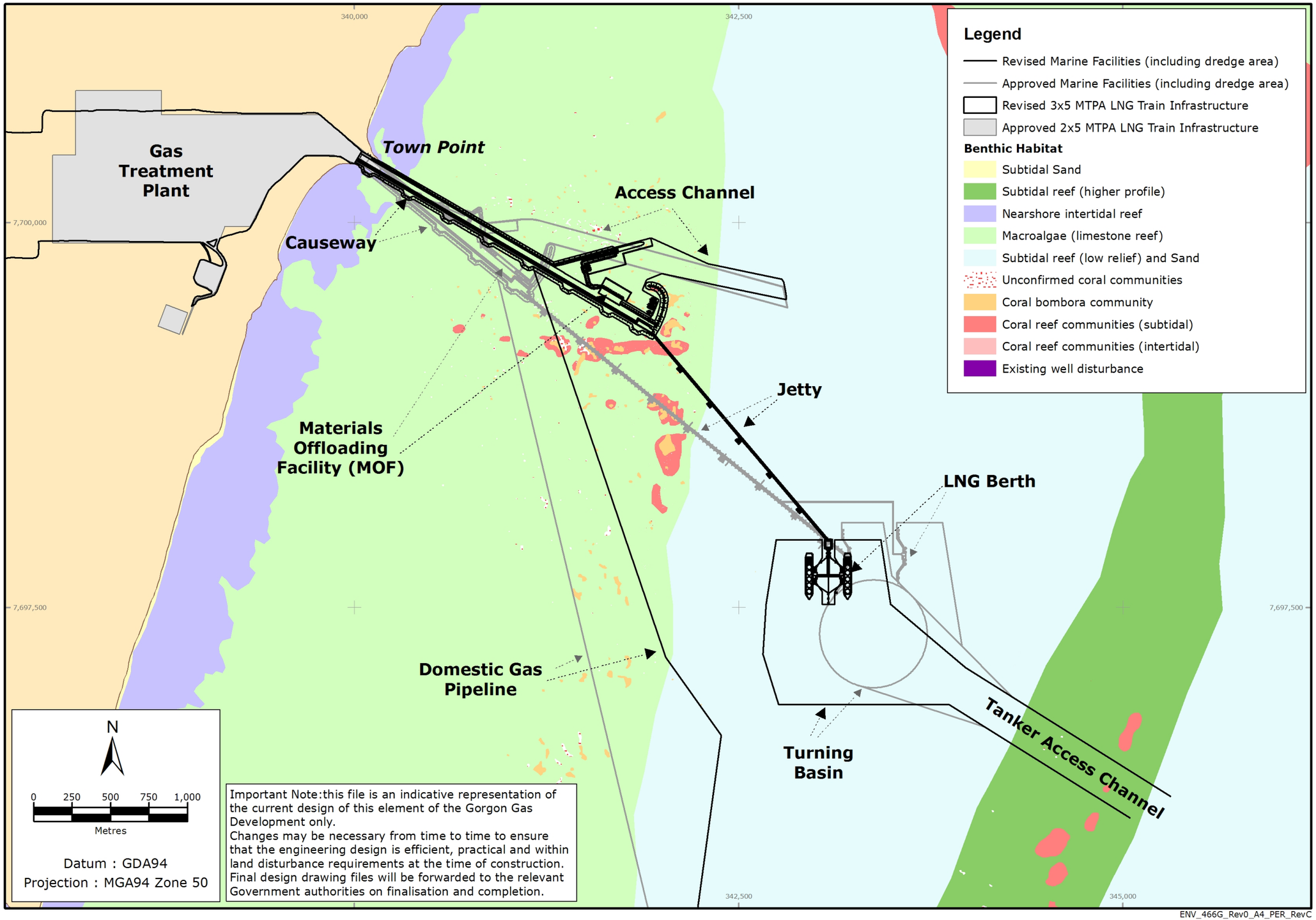

Figure 2.3: Location of Approved and Revised MOF and LNG Jetty

2.2 Revised Proposal Gas Treatment Plant

It is proposed to increase the throughput capacity of the Gas Treatment Plant, which is part of the Approved Development, by installing one additional 5 MTPA LNG train, thereby increasing the number of LNG trains from two to three, and nominal production capacity of LNG from 10 MTPA to 15 MTPA.

The additional LNG processing train will be located in parallel with the two approved LNG trains and will use equivalent components, including two 80 MW gas turbines to drive the refrigeration compressors. This will increase the total number of refrigeration compressor turbines from four (already approved) to six. All six of these turbines will be fitted with Dry Low NOx (DLN) burners and will incorporate waste heat recovery units (WHRUs) to recover heat for the plant heating medium system from the gas turbines exhaust gas streams.

An increase in electrical generation capacity will also be required to support the additional LNG train. The Approved Development incorporated four gas turbine generators without DLN burners. Addition of one 117.5 MW (nominal) gas turbine generator will be required to support the three LNG processing trains. It is proposed to fit all five of these turbines with DLN burners. As the Gas Treatment Plant heat energy needs are satisfied by the heat recovered from the WHRUs fitted to the gas turbines in the LNG processing trains, the power generation plant gas plant turbines will not be fitted with WHRUs.

The Revised Proposal's resultant increase in the production rate of hydrocarbon condensate will be in the order of 80% or an additional 1600 m^3 per day. The total condensate production rate of the Revised Proposal will therefore be approximately 3600 m^3 per day.

Increases in the capacity of the LNG Storage Tanks (up to 2 x approximately 180 000 m^3 [net] tanks) and the Condensate Storage Tanks (up to 4 x 35 000 m^3 [net] tanks) are necessary to safely and effectively manage the increased rate of LNG and condensate production resulting from the addition of the third LNG train. Exact tank volumes will be determined during the procurement process based on consideration of constructability and layout constraints within the nominated Gas Treatment Plant site area.

During the environmental impact assessment for the Approved Development (Chevron Australia 2005a), the full extent of the likely impact to the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA) was considered. Of this 300 ha, the *Barrow Island Act 2003 (WA)* and the related State Agreement allow for 150 ha of uncleared land to be the subject of long-term tenure during the operational phase for the purpose of the Greater Gorgon Area Gas Processing Facilities, carbon dioxide pipelines, control lines and ancillary services. In addition to this 150 ha, another 50 ha would also be utilised for the purpose of petroleum pipelines, control lines and ancillary services. The remaining portion of the 300 ha (i.e. 100 ha) would be utilised for future expansion or alternatively rehabilitated following the completion of construction activities.

The *Barrow Island Act 2003* (WA) and the State Agreement (Clause 6(10)) makes provision for the GJVs to request permission from the Barrow Island Act Minister to bring forward a proposal under the State Agreement in respect to the use of land within the Gas Processing Area beyond that which is reserved for them from time to time, such as the allocation of the remaining 100 ha. The Minister may in his discretion allow this. It is the GJVs' intention to bring forward such a proposal and request the Minister's

permission to allow the GJVs' long-term use of the remaining 100 ha of land for the Gorgon Gas Development.

The Revised Proposal will involve additional long-term utilisation of approximately 40 ha of the remaining 100 ha, over and above the long term land use estimate for the Approved Development. Reconfiguration of the Approved Development Gas Treatment Plant, to incorporate the additional LNG train and associated Gas Treatment Plant infrastructure, will result in the overall Gas Treatment Plant footprint being extended to the west (Figure 2.1). The increase in area of the Gas Treatment Plant site also incorporates the Utilities Area, which was located external to the Gas Treatment Plant site in the Approved Gorgon Gas Development design.

Overall use of uncleared land for the Gorgon Gas Development will not exceed the total area available under the *Barrow Island Act 2003* (WA) (i.e. 300 ha) for gas processing activities on Barrow Island. Furthermore, if approved, the Revised Proposal will rehabilitate 60 ha following completion of construction activities.

As a result of the Revised Proposal changes to the Gas Treatment Plant, minor changes are necessary to the approved feed gas pipeline route to align the pipes as they enter the Plant (i.e. only the last 500 m [approximately] of the pipeline route will change) (Figure 2.1). The area required for the feed gas pipeline easement will not exceed 50 ha, as defined in Schedule 1, Clause 6 (3) of the *Barrow Island Act 2003* (WA)

2.3 Revised Proposal Reservoir Carbon Dioxide Injection System

As part of both the Approved Development and the Revised Proposal, it is proposed that reservoir CO_2 extracted from the reservoir gas feed during gas processing operations will be disposed of via injection into the Dupuy Formation, rather than venting it to the atmosphere. This Revised Proposal will result in an accelerated rate of reservoir CO_2 injection when compared with the Approved Development, however the total volume of reservoir CO_2 injected over the life of the project will remain unchanged.

The addition of a third LNG processing train and a Domestic Gas supply will potentially increase the annual volume of reservoir CO_2 to be injected from approximately 2.72 MTPA as a result of the Approved Development, to a total of approximately 3.36 MTPA (Table 2.2) as a result of the Revised Proposal.

Table 2.2: Increase in Available Reservoir CO_2 and Anticipated Injection Volumes

		Approved Development (10 MTPA LNG) [MTPA CO_2]	Revised Proposal (15 MTPA LNG) [MTPA CO_2]
Reservoir CO_2 available for injection	Domestic gas processing	0.97	0.45
	LNG processing	2.43	3.75
Reservoir CO_2 to be disposed of by injection into the Dupuy Formation.		2.72	3.36
Reservoir CO_2 vented.		0.68	0.84

NOTE:
The Approved Gorgon Gas Development includes the processing of domestic gas sourced from the Gorgon Field. Options to source domestic gas from other gas fields in the Greater Gorgon Area are currently under consideration. Should it be decided to source domestic gas from a field with lower concentrations of carbon dioxide this will reduce the volumes of reservoir carbon dioxide to be injected into the Dupuy Formation.

The accelerated rate at which the reservoir CO_2 will be injected will require additional injection wells and drill centres, with a corresponding increase in the length of the approved CO_2 pipeline and associated land disturbance. Therefore, the number of wellheads will increase from seven wells directionally drilled from two or three drill centres (as part of the Approved Development) to approximately eight to nine wells drilled from three or four drill centres as part of the Revised Proposal. The final number and location of the injection wells and drill pads is subject to ongoing technical studies.

The reservoir CO_2 injection development concept for the Approved Development and the development concept for the Revised Proposal are shown in Figure 2.4.

Modelling studies involving the higher CO_2 injection rates associated with the Revised Proposal have indicated that implementation of a pressure management strategy is likely to be required soon after the commencement of reservoir CO_2 injection (rather than after several years, as was anticipated for the Approved Development). It is anticipated that approximately four pressure management wells will be drilled around the south-western flank of the CO_2 plume. Water produced from these wells will be disposed of into the Barrow Group Reservoir via pressure management water injection wells. It is anticipated that approximately four water injection wells will be required to support the Reservoir Carbon Dioxide Injection System. The location of these wells will be finalised in the next phase of design for the Gorgon Gas Development. Ancillary surface equipment such as pumps, water pipelines, and electrical power and control lines will be required along with road access. The GJVs seek approval for the revisions to the Reservoir Carbon Dioxide Injection System as part of this PER assessment process.

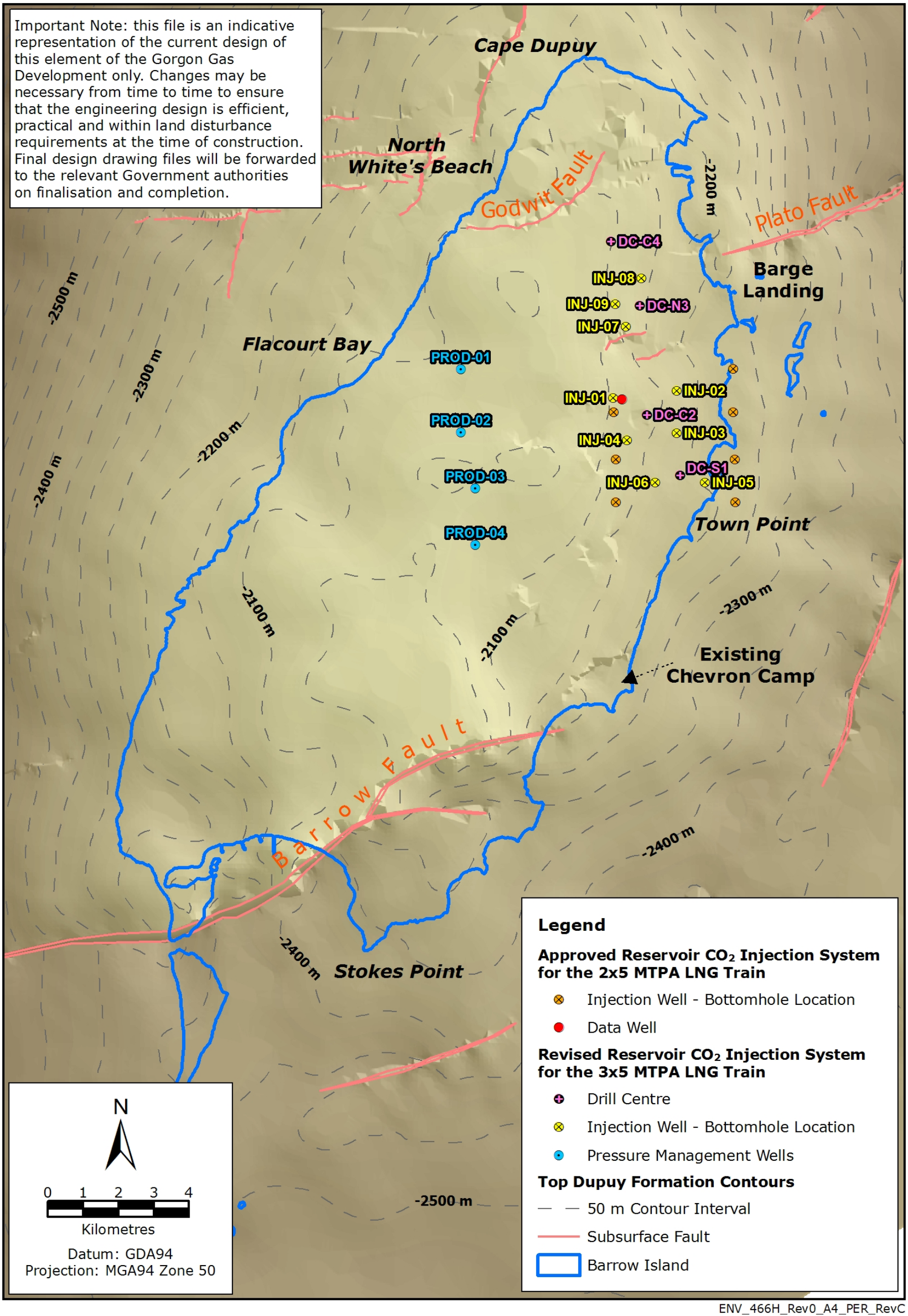

Figure 2.4: Reservoir Carbon Dioxide Injection System Concept for Approved Development and Revised Proposal

A cathodic protection system will be installed where necessary to protect the CO_2 injection wells and the pressure management and water disposal wells. Cathodic protection of all wells on Barrow Island is required to manage corrosion of well surface casing where the well intersects the water table. Cathodic protection of wells is not required once the wells have been decommissioned as the wells are effectively isolated at a distance below the top of the surrounding watertable. The exact locations of these wells and associated land disturbances are yet to be determined, but typically they would be located within approximately 250 – 350 m of the injection well drill centres (which are the surface location from which the CO_2 injection wells are drilled).

2.4 Revised Proposal Marine Facilities

The MOF will be used to receive construction materials during the construction phase and other provisions during the operational phase of the Gorgon Gas Development. For the Approved Development, access to the MOF (from Barrow Island) was approved via an 800 m long causeway from Town Point with the MOF extending a further 520 m from the offshore end of the causeway. To allow marine vessel access to the MOF, an access channel approximately 1.6 km long was approved for dredging.

Condition 17 of Statement No. 748 requires the GJVs to prepare and submit to the Minister a Marine Facilities Construction Environmental Management Plan. Under section 5 (viii) of this Condition, the Plan shall include measures that address "The avoidance of blasting as far as practicable and management measures to be applied if blasting is required". To achieve a reduction in blasting, the GJVs propose to relocate the MOF further offshore to avoid hard rock.

The MOF structure (causeway and offloading facilities) will be lengthened by approximately 800 m to a total length of approximately 2120 m. This will reduce the length of the dredged access channel from 1.6 km to approximately 750 m. The need for drilling and blasting in the near-shore environment will be significantly reduced. The relocation of the MOF as part of the Revised Proposal therefore significantly reduces the need to remove hard rock in near-shore marine waters.

Figure 2.5 displays the results of Geophysical survey work extending along the proposed route of the Approved Causeway and MOF structure. These results clearly show that hard rock is present in the location previously approved for the MOF Access Channel and associated dredging. It is anticipated that this rock may not be dredgeable and would need to be removed using drill and blast techniques.

The drilling and blasting program is anticipated to assist in the removal of up to approximately 50 000m^3 of hard rock at the western end of the revised MOF Access Channel. This volume can not be more accurately predicted for this PER and will ultimately be determined by the Dredge Contractor based on the in-situ findings during dredging.

The Revised Proposal drilling and blasting program will be implemented by adopting best practicable measures to minimise impacts to the environment. This approach will include completion of the drilling and blasting program using controlled methods. Detailed discussion of the potential environmental impacts and proposed management measures associated with the drilling and blasting program is included in Section 7.

As part of the implementation of Statement No. 748, the proponent will submit the following plans:

- Long-term Marine Turtle management Plan (Condition 16)
- Marine Facilities Construction EMP (Condition 17) (this has specific reference to managing blasting, and it will include relevant management within)
- Dredge and Spoil Disposal Management and Monitoring Plan (Condition 20).

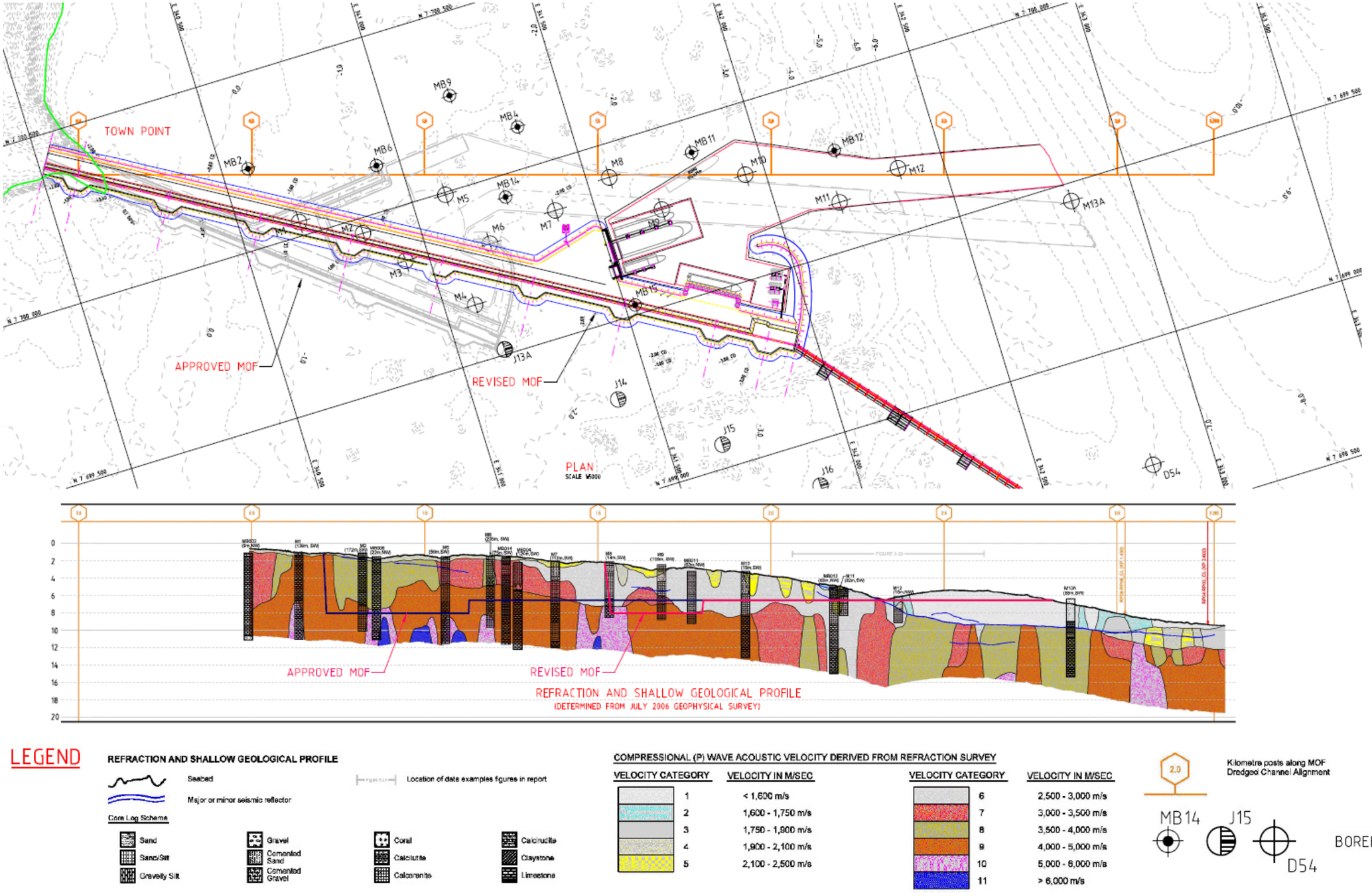

Figure 2.5: Geophysical Investigation Results Indicating Location of Hard Rock in vicinity of Approved Development Causeway and MOF (Velocity = 3000 – 5000 m/sec)

In summary, the advantages associated with the MOF proposed as part of the Revised Proposal when compared to the Approved Development include the following:

- significant reduction in drilling and blasting activity (and associated environmental impacts) required to construct the Approved Development MOF
- reduction in the length of the MOF marine vessel access channel
- minor re-orientation of the adjoining LNG Jetty, which has the benefit of reducing some direct coral impact
- reduction in the total length of the LNG Jetty.

The anticipated additional impacts of these changes are assessed in Section 7.0.

The function of the LNG Jetty will not change under the Revised Proposal. It will still be built with mooring facilities to receive LNG and condensate carriers and will be constructed from the offshore end of the MOF/causeway as indicated in the Approved Development. However, by extending the length of the MOF and causeway as part of the Revised Proposal, the total length of the jetty will be reduced from approximately 2.7 km (as part of the Approved Development) to approximately 2.1 km. The orientation of the jetty will also be modified to align with the revised MOF structure. By realigning the LNG jetty, an area of coral that was within the jetty footprint of the Approved Development will be avoided (Figure 2.3).

The GJVs have also investigated altering the shape of the turning basin, located at the end of the jetty. It is proposed that the shape of the turning basin be changed from the circular shape in the Approved Development, to a polygon for the Revised Proposal (Figure 2.2 and Figure 2.3). The shape of the turning basin may vary as investigations continue during the detailed design phase of the Gorgon Gas Development (e.g. following further Navigation Simulations [NavSim]). The total dredging volumes for the MOF marine vessel access channel and LNG Jetty turning basin as part of the Revised Proposal will remain the same as for the Approved Development.

The Domestic Gas Pipeline (a component of the Gorgon Gas Development infrastructure approved for the Approved Development) will tie into the Revised Proposal's marine facilities at some point along the causeway or LNG jetty and then run to the mainland. The revised routing of the Domestic Gas Pipeline as shown in Figure 2.2 is only indicative at this stage, and the route will be modified to avoid sensitive coral habitat as the design develops. It should be noted that the Domestic Gas component of the Gorgon Gas Development does not form part of the scope of the Revised Proposal.

3.0 OVERVIEW OF EXISTING ENVIRONMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

As the Revised Proposal relates only to changes to the Gorgon Gas Development on Barrow Island and its surrounds, this section of the PER provides a description of the existing environment on Barrow Island and its surrounding marine environment, rather than any mainland environment.

3.1 Social Environment

3.1.1 Socio-Economic Setting

The Revised Proposal is located on Barrow Island and its immediate surrounds, which is within the Shire of Ashburton. The Shire covers an area of approximately 105 650 km^2 (predominantly mainland), the majority of which is pastoral properties (Shire of Ashburton 2007). The mainland resident population of the Shire is approximately 6000 (ABS 2006), primarily being employed in industries including oil and gas, mining, cattle, fishing and tourism (Shire of Ashburton 2007).

There is no resident population on Barrow Island. The Island has been actively used for petroleum exploration and production purposes since 1957 and access to the Island is restricted to personnel associated with oilfield operations and the Department of Environment and Conservation (DEC) activities.

3.1.2 Land and Sea Use and Tenure

Barrow Island is reserved under the *Conservation and Land Management Act 1984* (WA) as a Class A nature reserve for the purposes of 'Conservation of Flora and Fauna' (Figure 3.1). The Island is vested in the Conservation Commission of Western Australia and is managed on its behalf by DEC. DEC is currently in the process of preparing a draft Barrow Island Nature Reserve Management Plan. The nature reserve is also listed on the Commonwealth Register of the National Estate.

Barrow Island is zoned 'Conservation, Recreation and Nature Land' under the Shire of Ashburton Town Planning Scheme No. 7.

The *Barrow Island Act 2003* (WA) authorises the implementation of the Gorgon Gas Development and makes provision for land on Barrow Island to be used for gas processing project purposes.

Petroleum lease L1H extends over the land mass of Barrow Island.

The State waters around Barrow Island are part of the Montebello – Barrow Island Marine Conservation Reserves (Figure 3.1). The majority of the conservation area is zoned as a Marine Management Area. The conservation area also comprises the Barrow Island Marine Park and Bandicoot Bay Conservation Area, located in waters adjoining the west and south coast of Barrow Island respectively. The Barrow Island Marine Area is listed on both the Western Australian Register of Heritage Places and the Commonwealth Register of the National Estate.

The Port of Barrow Island is located on the east coast of the Island. The marine facilities on the eastern side of Barrow Island, as approved in the Approved Development and proposed in the Revised Proposal, are contained entirely within the Barrow Island Port Area, which is excluded from the Marine Management Area.

A number of Western Australian and Commonwealth commercial fisheries operate in the Montebello/Lowendal/Barrow Island region.

3.1.3 Aboriginal Heritage and Native Title

Barrow Island occupies a potentially important position in the indigenous archaeology of north-western and continental Australia. It is located between the Cape Range Peninsula (mainland) and the Montebello Islands, both of which were initially occupied by indigenous people at 34 200 ± 1050 years Before Present (BP) and 27 220 ± 650 years BP respectively. The presence of two areas with such long occupation records either side of Barrow Island strongly suggests that Barrow Island may also contain indigenous archaeological material of great antiquity in both rock shelter and possibly stratified sites in sand dunes.

The Department of Indigenous Affairs (DIA) Register of Aboriginal Sites indicates 13 archaeological and no ethnographic sites are listed for Barrow Island. Archaeologists, anthropologists and indigenous stakeholders examined areas associated with the Approved Development in 2006 and 2007 and no new indigenous cultural sites or materials were discovered in areas likely to be disturbed.

There are no lodged Native Title claims over Barrow Island. In August 2002, the High Court in the Ward Case held that vesting of reserves under the *Land Act 1933* (WA) (now the *Land Administration Act 1997* (WA)) has extinguished Native Title. Accordingly, the vesting of Barrow Island as a Class A nature reserve (Section 3.1.2) will have extinguished Native Title to the Island.

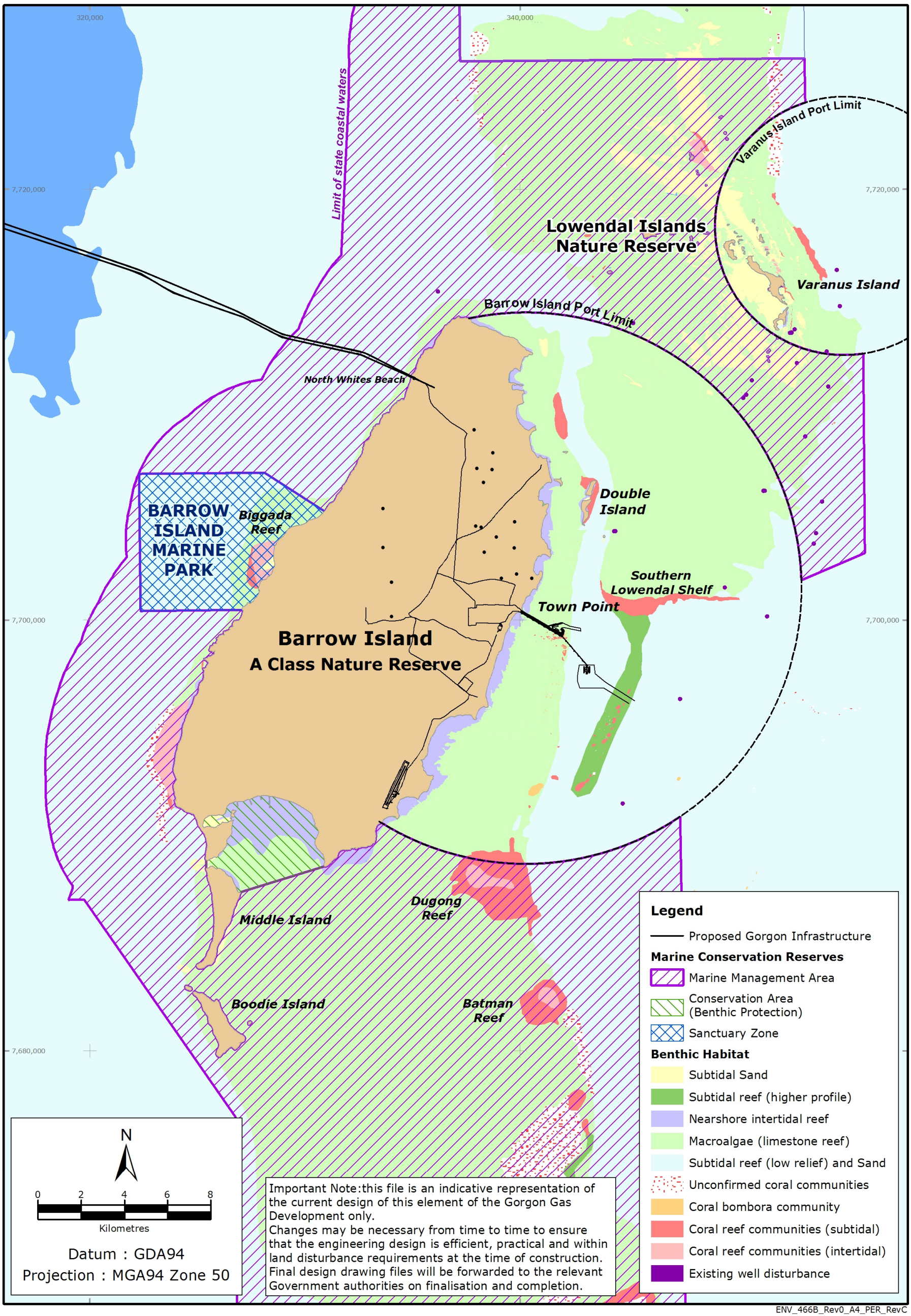

Figure 3.1: Reserves Associated with Barrow Island

3.1.4 European Heritage

Potential European heritage values are limited to maritime heritage, in particular shipwrecks (Section 3.1.5).

3.1.5 Maritime Heritage

Archival sources suggest that a number of significant vessels have been lost in the Onslow/Barrow Island region and there is potential for lugger shipwreck sites to occur in the vicinity of Barrow Island. The existence of any residual wreckage (which would constitute an archaeological site) can only be determined on discovery. The MOF and shore areas adjacent to the Gas Treatment Plant site area, which are part of the Approved Development, have been examined by a marine heritage expert and no shipwreck sites were discovered. Although shipwreck sites most often occur in shallow reef areas, sites may also occur in deep water. Marine underwater video survey work and review of side-scan sonar results have not revealed the presence of any shipwreck material to date.

3.2 Terrestrial Environment

3.2.1 Climate

Barrow Island is characterised by an arid, sub-tropical climate. In summer (October to March), mean daily maximum temperatures reach 34°C with mean daily minimum temperatures averaging 20°C. During winter (June to August), daily maximum temperature reach 26°C (mean) and daily minimum temperatures reach 17°C (mean).

Rainfall on Barrow Island varies significantly from year-to-year and is dependent on rain-bearing low pressure systems, thunderstorm activity and passage of tropical cyclones (which generally occur from November to April). The mean annual rainfall for the area is 320 mm.

The annual mean evaporation rate is approximately 3 500 mm for the region (based on records from the Dampier Salt Weather Station). Daily evaporation rates range from approximately 11 mm/day during the summer months to 7 mm/day during winter months.

Wind patterns on the north-west shelf are dictated by seasonal movement of atmospheric pressure systems. During the summer months, high pressure cells produce south to south-westerly winds which vary between 10 and 13 m/s. During the winter months, high pressure cells over central Australia produce north-westerly to south-easterly winds with average speeds of between 6 and 8 m/s.

3.2.2 Landforms and Topography

Five landscape units have been identified on Barrow Island, specifically:

- **West Coast Complex:** the west coast of Barrow Island is exposed to direct wind and wave action from the Indian Ocean. The coastline topography varies from rocky weathered sheer cliffs to less steep, traversable inclines. Typically narrow sandy beaches occur between weathered rocky headlands. This coastline is a significant feature of Barrow Island.
- **East Coast Complex:** the eastern coastline is protected from wave action and has a slight land gradient to the ocean. This coastline is characterised by vegetated sand dunes and expansive tidal flats.
- **Valley Slopes and Escarpments:** the western half of Barrow Island is characterised by steep formed valleys, escarpments and exposed limestone ridges.

- **Limestone Ridges:** generally occur throughout the central upland plateaus of the Island. The terrain ranges from steeper slopes in the west to flatter more gentle undulations as the ridges continue east.
- **Creek and Seasonal Drainage:** occur generally in the broad valleys and flats of limestone ridges and is located adjacent to the coastal fringes. This landscape has deeper alluvial soil structure.

The Revised Proposal area is located predominantly on the East Coast Complex and the topography of the area is undulating, varying between 24 and 36 m above mean sea level.

3.2.3 Geology and Soils

Barrow Island is a geological extension of the Cape Range Peninsula, which became separated from mainland Australia between 8 000 and 6 000 years ago as a result of rising sea levels.

The Island is composed of coastal deposits overlying tectonically folded limestone.

Three broad geomorphic units have been identified:

- limestone uplands
- near coastal lowlands
- coastal fringe.

The surface geology at the Gas Treatment Plant site consists of limestone (Tamala limestone), floodplain deposits, dune sands and gravels. Investigations near the site of the Gas Treatment Plant encountered up to 10 m of sands and clays overlying limestone.

3.2.4 Seismic Activity

Barrow Island is located within a linear zone of seismicity known as the North West Shelf Zone. The Barrow Fault, located at the southern end of the island, is represented topographically by a low, east-west trending scarp. The surface expression of the fault is marked by occasional clay pans and even fewer deposits of sulphur. Barrow Island occurs in an area of relatively low seismic activity.

3.2.5 Surface Hydrology

The surface hydrology on Barrow Island is characterised by:

- unpredictable, but sometimes very intense rainfall resulting in significant runoff in some areas and short-term ponding
- consistently high rates of evaporation resulting in extremely low soil moisture content
- high infiltration capacities of the surface sands and limestones which is conducive to recharge of relatively deep groundwater aquifer(s).

The hydrological regime of the island is split by a water divide running north to south along a central, elevated ridge. Drainage lines flow along a largely east-west orientation on either side of this divide, but are highly ephemeral and usually dry (Figure 3.2). Permanent surface water sources occur in freshwater seeps, though none of these are located within 5 km of the Gas Treatment Plant site. Other seeps are ephemeral and generally only appear after rain events.

3.2.6 Hydrogeology

There is one shallow unconfined potentially fresh water aquifer on Barrow Island. This fresh water aquifer forms a lens of relatively fresh groundwater at depths typically between 9 m and 53 m floating upon denser, saline ground water located predominantly within the Tertiary Limestone. While beneficial uses of this fresh water aquifer are limited, it is an important environment for the stygofauna identified on Barrow Island.

Salinity of the water in this lens varies considerably across the Island. Recharge to the aquifer is from rainfall and occurs most rapidly in areas of highly permeable soils overlying porous karst limestone. Lower salinities occur in areas where there is more rapid groundwater recharge. Higher salinities occur where recharge is slower, generally in areas where clays and silts are overlying the more porous and permeable limestone. Salinity of the lens is also higher in coastal areas where seawater influx occurs close to the surface of the water table.

A Site Conceptual Model for the geological and hydrogeological conditions beneath the Gas Treatment Plant site has been prepared based on site visit observations and existing drilling records from historical geotechnical and groundwater investigations (Golder Associates 2008). The shallow subsurface consists of three geologic units. Beneath the surficial soil layer which is generally less than 1 m in thickness is a karstic limestone layer believed to be Giralia Calcarenite. This limestone layer is known to contain many cavities and solution tubes and provides habitat for subterranean fauna.

Below this upper limestone layer is a band of siliceous silty sand with a recorded thickness of 6 m to 8 m across the Gas Treatment Plant site area. This sand layer was encountered in all boreholes which were extended through the upper limestone layer, and has been noted at a thickness of 24 m in a borehole located at the terminal tanks site to the north of the Gas Treatment Plant site. This sand layer creates a barrier for subterranean fauna as there are no cavities or large pore spaces to allow movement, it is unlikely to encounter populations of subterranean fauna beneath this layer.

The third geologic unit is a karst limestone layer believed to be Trealla Limestone. This limestone layer is about 30 m thick and is also karst but cavity occurrence decreases sharply approximately 60 m below ground surface.

The halocline boundary between highly saline groundwater and the perched freshwater lens occurs within these shallow subsurface geologic units.

There are several saline ground water systems on Barrow Island:

- Tertiary Limestone extending from the mean sea level down to approximately 300 m below mean sea level.
- Windalia Sand Member of the Muderong Shale, generally at depths between 650 m and 700 m below mean sea level.
- The Barrow Group comprising the Flacourt and Malouet Formations, generally at depths between 1 000 m and 2 000 m below mean sea level.
- The Dupuy Formation, generally at depths between 2 000 m and 2 300 m below mean sea level.
- The Biggada Formation generally at depths greater than 3000 m below mean sea level.

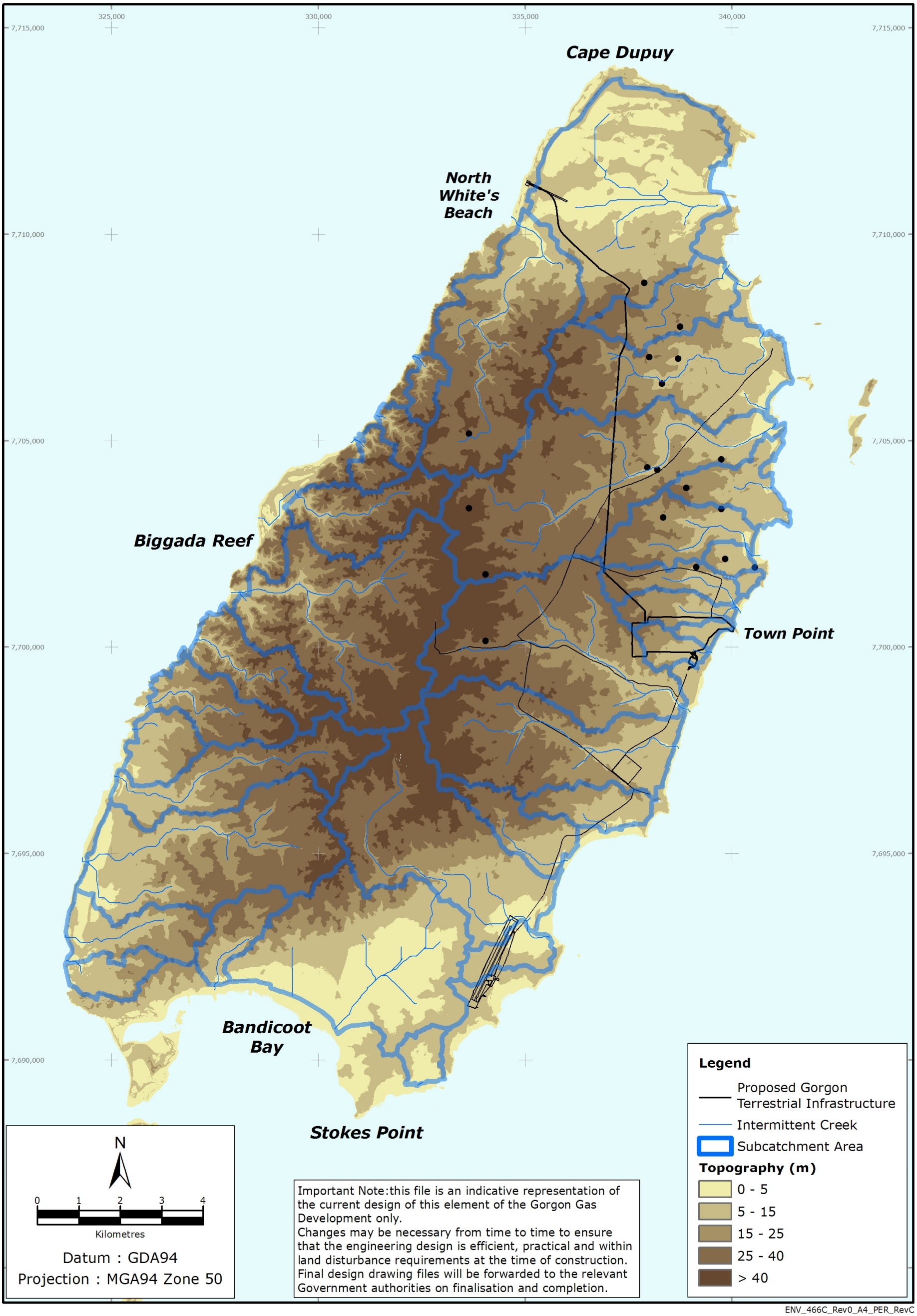

Figure 3.2: Surface Hydrology and Topography of Barrow Island

3.3 Terrestrial Ecology

3.3.1 Vegetation and Flora

3.3.1.1 Flora and Vegetation Investigations

Barrow Island's vegetation was classified into eight major vegetation units by Buckley in 1983. Mattiske and Associates (1993) subsequently refined the classification into 34 communities based on major landforms, soil types and species composition. These have been mapped across the entire island (23 567 ha).

Investigations for EIS/ERMP Reporting

Vegetation surveys were undertaken in 2003 and 2004 by RPS BBG to support the impact assessment of the Approved Development. The results of the surveys were presented in the Draft EIS/ERMP for the Gorgon Gas Development (Chevron Australia 2005a). These surveys were completed in accordance with the EPA Guidance Statement Number 51 (EPA 2004d):

- Vegetation plots (50 x 50 m, divided into 10 x 10 m quadrats) were established within the Approved Development Gas Treatment Plant site and wider survey area in September and October 2003 and January 2004. The Gas Treatment Plant site was re-surveyed in April and May 2004, following cyclonic rains, to collect annual species.
- The onshore feed gas pipeline route was surveyed in April and May 2004, with additional surveys in July 2004. The survey methodology consisted of a continuous transect at least twice the width of the pipeline easement. The entire length of the pipeline easement was surveyed on foot.

As a result of these surveys, the broad scale vegetation communities described by Mattiske and Associates (1993) were further refined to vegetation association level.

Investigations Subsequent to EIS/ERMP Reporting

Further surveys have since been conducted to cover areas of proposed changes to the terrestrial facilities. These surveys were completed by Astron Environmental and RPS BBG applying directly comparable methodologies to the surveys undertaken by Mattiske. The following surveys were undertaken:

- The North White's Beach onshore feed gas pipeline shore crossing area was surveyed in June, November and December 2005 and additional areas of White's Beach were surveyed in 2006 (RPS BBG 2006a). Surveys consisted of vegetation plots (50 x 50 m) and transects (25 m x 10 m) divided into 10 x 10 m quadrats.
- As a result of minor realignments of the onshore feed gas pipeline route, additional areas of vegetation were surveyed in May 2006 (RPS BBG 2006a).
- Vegetation surveys were undertaken at the airport by Astron Environmental in October 2005 and RPS BBG in May 2006 to support the proposed expansion and realignment of the existing airstrip (RPS BBG 2006b). The methodology was similar to previous surveys and used 50 x 50 m vegetation plots, which were supplemented by opportunistic searches.

Compilation of the vegetation surveys undertaken between 2003 and 2006 identifies approximately 2 483 ha of vegetation on Barrow Island as having been mapped for the Gorgon Gas Development. Of the 2 483 ha that have been mapped, 2 400 ha have been classified to the vegetation association level. The remaining 83 ha have been mapped at the broader scale of vegetation community consistent with Mattiske and Associates (1993) classifications. These areas are outside the Gorgon Gas Development clearing area but are still undergoing analysis to further subdivide the vegetation types into vegetation associations.

The abovementioned surveys were undertaken in support of, and subsequent to, those completed for the EIS/ERMP, to cover the additional disturbance area associated with the changes to the terrestrial facilities that form part of the Revised Proposal.

3.3.1.2 Vegetation

Barrow Island is located within the Fortescue Botanical District of the Eremaean Botanical Province (Beard 1980). More recently the area has been categorised in the Cape Range subregion according to the Interim Biogeographic Regionalisation of Australia (Kendrick & Mau 2002).

To date, 170 vegetation associations have been mapped as part of the biological investigations for the Approved Development and the Revised Proposal. As shown in Table 3.1, 51 vegetation associations occur within the combined development area of the Approved Development and Revised Proposal and will be cleared to some extent; however none of these associations occur entirely within the clearing area. That is, no vegetation association will be completely cleared as a result of the Gorgon Gas Development. A description of the vegetation associations detailed in Figure 3.3 is contained in Appendix K.

Table 3.1: Number of Vegetation Communities and Associations on Barrow Island

Vegetation Communities	Number of Vegetation Associations within Survey Area	Number of Vegetation Associations within Combined Development Area of Approved Development and Revised Proposal
Coastal Communities	21	7
Drainage and Creekline Communities	24	6
Flats Communities	36	8
Limestone Communities	64	20
Rock	1	0
Claypan Communities	3	0
Valley Slopes and Escarpment Slopes Communities	21	10
Total	**170**	**51**

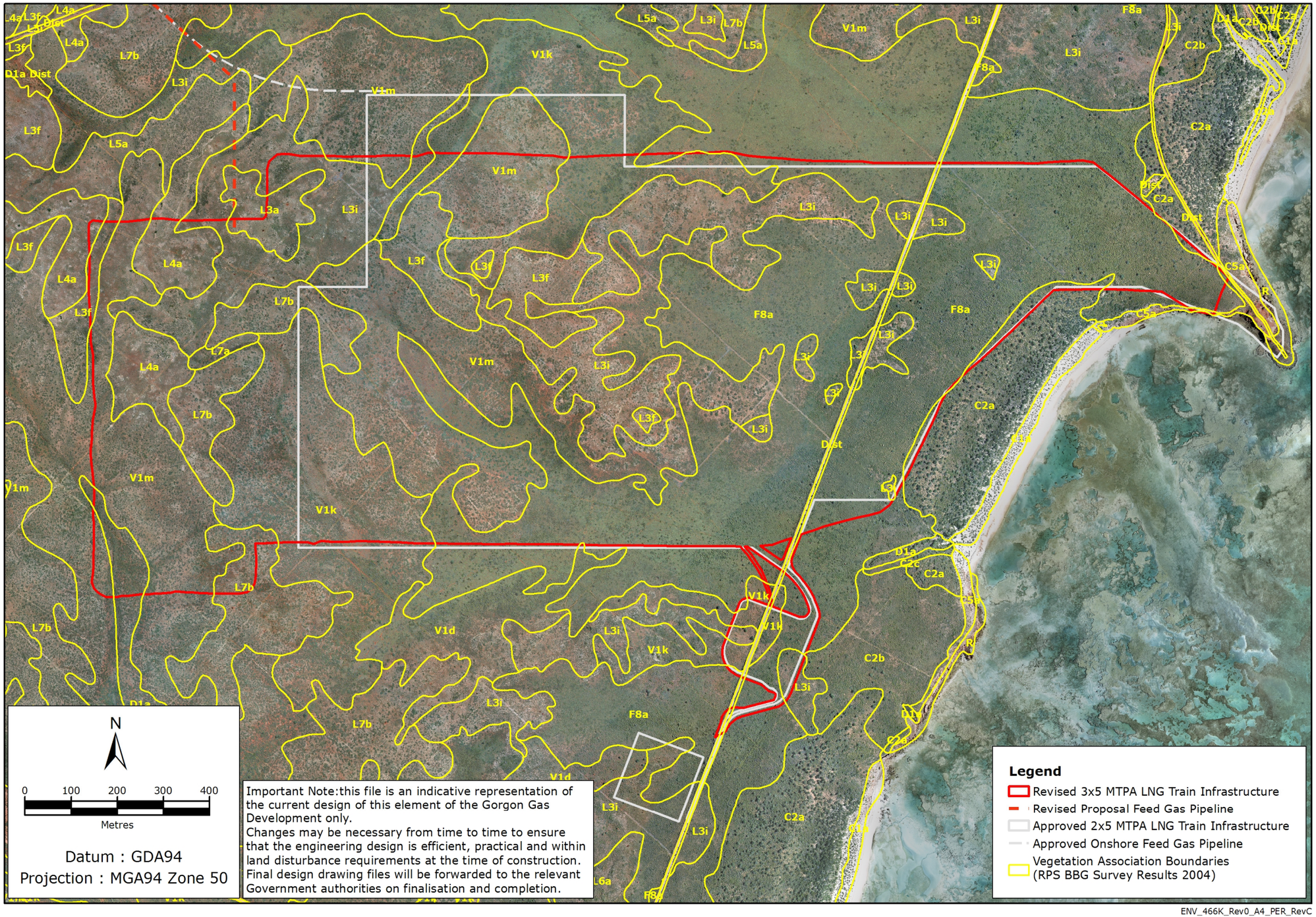

Figure 3.3: Vegetation Associations in the vicinity of the Gorgon Gas Development Gas Treatment Plant Footprint

Vegetation of Conservation Significance

No plant communities listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) have been recorded or are known to occur on Barrow Island. No Threatened Ecological Community (TEC) as listed by DEC's Threatened Ecological Database has been recorded or is known to occur on Barrow Island.

Possible TECs that have not been adequately surveyed or defined are listed as Priority Ecological Communities (PECs) by DEC. PECs are not protected by legislation. There is one vegetation-based PEC listed by the DEC that occurs on Barrow Island; this being:

- Barrow Island Creekline Vegetation and Mangroves – General Cover of *Triodia angusta* with shrubs principally *Hakea suberea, Petalostylis labicheoiodes, Acacia bivenosa* and *Gossypium ribinsonii.* Mangrove thickets (*Avicennia marina*) at the creek mouths.

Barrow Island Creekline Vegetation and Mangroves is a Priority 1 PEC. This, by definition, means that the community is:

- poorly-known with apparently few, small occurrences, all or most occurrences of the community are not actively managed for conservation (e.g. active mineral leases) and for which current threats exist; or
- comparatively well-known from one or more localities, but does not meet adequacy of survey requirements, and/or is not well defined, and appears to be under immediate threat from known threatening processes across its range.

Vegetation associations are considered to be locally sensitive if the vegetation association:

- is part of the Barrow Island Creekline Vegetation and Mangroves PEC
- is part of a broader community that has a restricted distribution on Barrow Island
- is part of a broad-scale coastal community that is vulnerable to erosion due to the nature of the landform and/or soil
- typically contains more than 2% cover of a plant that has low regeneration rates or is restricted within Barrow Island
- represents a relict vegetation unit within an uncharacteristic, isolated landscape position that has resulted from geological processes.

Based on these criteria, 20 of the 51 vegetation associations within the combined development area for the Approved Development and the Revised Proposal on Barrow Island are considered sensitive. These vegetation associations are described in Table 3.2.

Table 3.2: Sensitive Vegetation Associations within the Combined Development Area of Approved Development and Revised Proposal on Barrow Island

Sensitive Vegetation Associations	Reason for Sensitivity
Coastal Communities	
C1e, C2a, C2b, C2f, C2h, C2j	Vulnerable to erosion
Drainage and Creekline Communities	
D1a, D1d, D1e, D1f, D2d, D2f	Restricted Distribution
Flats Communities	
F4b	Restricted Flora Species (*Erythrina vespertilio*)
Limestone Communities	
L6b, L6c, L6d, L7a, L7b	Restricted Flora Species (*Grevillea pyramidalis* subsp. *leucadendron*)
Valley Slopes and Escarpment Slopes Communities	
V1k, V1m	Restricted Flora Species (*Melaleuca cardiophylla)*

Coastal vegetation associations C1e, C2a, C2b, C2f, C2h and C2j are considered sensitive as they are restricted to the near coastal areas and are vulnerable to erosion.

Undisturbed portions of vegetation associations occurring within major drainage lines (including undisturbed portion of D1a, F1d, D1e, D1f, D2d and D2f) are considered to have a restricted areal distribution on Barrow Island, based on the total land area on Barrow Island. These also form part of the Priority One PEC Barrow Island Creekline Vegetation and Mangroves. Note that there are no mangroves within the Gorgon Gas Development clearing area.

Vegetation association F4b has a restricted distribution because it typically contains more than 2% cover of the flora species *Erythrina vespertilio*, which is relatively widespread in Western Australia, but is only found as scattered trees or in small populations on Barrow Island (RPS BBG & Mattiske 2005).

Grevillea pyramidalis subsp. *leucadendron* has a patchy and restricted distribution on Barrow Island and typically covers more than 2% of limestone associations L6b, L6c and L6d, which are consequently considered to be locally sensitive. It also recorded in the Pilbara region of Western Australia.

Limestone associations L7a and L7b and valley slope associations V1k and V1m are considered locally sensitive due to the presence of restricted flora species *Melaleuca cardiophylla*. Whilst *Melaleuca cardiophylla* is not considered to be restricted in distribution on Barrow Island, it is slow to regenerate following disturbance.

3.3.1.3 Flora

The flora of Barrow Island is typical of the arid Pilbara region but has floral affinities with the Cape Range area on the mainland (Trudgen 1989; Mattiske 1997). The floral linkages reflect the diversity of the environments on Barrow Island, as well as the past linkages to the mainland (RPS BBG & Mattiske 2005).

More than 400 vascular plant taxa have been recorded on Barrow Island. The Poaceae (grass) family has the most representation with 57 species recorded to date, followed by 31 species each for the Asteraceae (daisy) and Papilionaceae (pea) families. The Malvaceae (mallow) family is represented by 30 species and the Chenopodiaceae (chenopod) family is represented by 24 species.

The most frequently recorded genera were:

- *Acacia* (Mimosaceae family, 13 species)
- *Sida* (Malvaceae family, 10 species)
- *Heliotropium* (Boraginaceae family, 9 species)
- *Hibiscus* (Malvaceae family, 9 species).

It is estimated that at least 90% of the vascular flora of Barrow Island has been documented. Approximately 20 – 30% of species are expected to be visible only after cyclonic events or fires. None of the flora species found on Barrow Island are unique to the Island; that is, all of the flora species have been recorded on the mainland of Western Australia.

Flora Species of Conservation Significance

No Declared Rare Flora (DRF), pursuant to the *Wildlife Conservation Act 1950* (Wildlife Act) (WA), or Threatened Flora species, pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cth), have been recorded on Barrow Island.

Three Priority flora species have been recorded on Barrow Island:

- *Helichrysum oligochaetum* (Priority 1)
- *Mukia* sp. Barrow Island (Priority 2)
- *Corchorus congener* (Priority 3).

One of these, *Corchorus congener* has been recorded in the combined clearing area for the Approved Development and Revised Proposal. This species is a small shrub with yellow flowers that is found in sand and red sandy loam. This species is known to occur in several areas on Barrow Island, including limestone habitats, coastal areas, flats, drainage lines and creeklines. It has been recorded in more than 40 vegetation associations within the greater survey area. It is also found elsewhere on the island and in the Pilbara and Carnarvon regions of the Western Australian mainland.

Helichrysum oligochaetum and *Mukia* sp. Barrow Island have not been recorded in the Gorgon Gas Development clearing area.

In addition to the Priority Flora species, 37 other flora species that have been recorded on Barrow Island are considered to have conservation significance because they:

- represent a range extension from the Kimberley, Pilbara and Cape Range regions
- have restricted or unknown distribution on Barrow Island
- have low regeneration rates.

Of these 37 species, the ones considered to be at greatest risk from impacts associated with the Gorgon Development are 25 plant taxa that have been identified as having low regeneration rates and/or restricted/unknown distribution on Barrow Island. Only three of the 25 restricted flora species have been recorded as typically occurring within vegetation associations that will be impacted by the combined clearing area for the Approved Development and Revised Proposal:

- *Erythrina vespertilio*
- *Grevillea pyramidalis* subsp. *leucadendron*
- *Melaleuca cardiophylla.*

Erythrina vespertilio is a deciduous tree with orange or red flowers that occurs in a broad range of habitats including sand, clay and loam over limestone or basalt. It is not considered threatened on the mainland of Western Australia, and is found in many regions from the northern Kimberley to the Gascoyne region. *Erythrina vespertilio* is considered to be vulnerable on Barrow Island because it occurs in four main populations on the Island, as well as localised scattered trees in areas away from the main populations.

Grevillea pyramidalis subsp. *leucadendron* is a small tree or shrub with white, yellow or cream flowers that is generally found in loam soils. The stunted form of *Grevillea pyramidalis* subsp. *leucadendron* plants on Barrow Island and the relatively dense populations that occur in some areas of the Island are not considered to be typical of this species' occurrence on the mainland. On the Western Australian mainland, this species is not considered threatened and is found from the Kimberley to the Pilbara. However, it is considered to have restricted distribution on the Island, being mainly found in scattered populations, therefore it is considered to be sensitive to impacts.

Melaleuca cardiophylla is a shrub with white or cream flowers that is found in a range of generally coastal habitats including sand, sand dunes and limestone ridges or outcrops. It mainly has a coastal distribution on the mainland of Western Australia, extending from the Pilbara south to the Wheatbelt region, although some inland populations have been recorded. On Barrow Island, this flora species occurs predominantly on central limestone hillslopes. It is not considered to be threatened on the mainland and it not considered to have a restricted distribution on Barrow Island, but is considered to be sensitive because of its relatively low regeneration rate on the island.

3.3.1.4 Introduced Flora

Historically, 16 introduced flora species have been recorded on Barrow Island. None of the introduced species are listed as Declared Plants under the *Agricultural and Related Resources Protection Act 1976* (WA). Ten of these species are listed as Environmental Weeds under the Environmental Weed Strategy for Western Australia (Department of Conservation and Land Management 1999), as identified in Table 3.3.

Table 3.3: Weed Species Historically Recorded on Barrow Island

Species	Common Name	DEC Environmental Weed Status
Aerva javanica	Kapok	Environmental Weed (High rating)
Arctotheca calendula	Capeweed	Environmental Weed (Moderate rating)
Cenchrus ciliaris	Buffel grass	Environmental Weed (High rating)
Centaurium erythraea	Common century	Environmental Weed (Moderate rating)
Conzya sumatrensis	Tall fleabane	Not Listed
Cynodon dactylon	Couch grass	Environmental Weed (Moderate rating)
Dactyloctenium aegyptium	Coast button grass	Not Listed
Emex australis	Double-gee	Not Listed
Eucalyptus gomphocephala	Tuart	Not Listed
Lycopersicon esculentum	Tomato	Not Listed
Malvastrum americanum	Spiked malvastrum	Environmental Weed (Moderate rating)
Passiflora foetida var *hispida*	Stinking passion flower	Environmental Weed (High rating)
Helichrysum luteoalbum	Jersey cudweed	Environmental Weed (Moderate rating)
Setaria verticillata	Whorled pigeon grass	Not Listed
Solanum nigrum	Blackberry nightshade	Environmental Weed (Moderate rating)
Sonchus oleraceus	Milk thistle	Environmental Weed (Moderate rating)

Ongoing weed monitoring and weed control is undertaken by the existing Chevron operations on Barrow Island. In 2007, weed monitoring recorded buffel grass, milk thistle and blackberry nightshade in locations on the Island that have been or are being used by people such as the airport, old airport site, Terminal Tanks and existing Chevron Camp (WA Oil 2008). Weed control methods including removing weeds by hand and chemical control were used in August, October and November 2007 at locations where weeds were recorded.

Due to high rainfall in early 2008, including three significant rainfall events in January, weed monitoring in March 2008 found new occurrences of buffel grass along existing roads on Barrow Island, as well as reoccurring growth at sites previously known to have weeds such as the airport, old airport and existing Chevron Camp (WA Oil 2008). Weed monitoring programs to date in 2008 have also recorded low occurrences of milk thistle, tall fleabane, blackberry nightshade, whorled pigeon grass and one watermelon plant. The watermelon plant is a new record for Barrow Island; it was recorded at the airport and is believed to have germinated due to the above-average rainfall (WA Oil 2008). Weed control has been carried out in May and June 2008, and further monitoring and weed control will be undertaken in 2008.

3.3.2 Terrestrial Fauna Habitat and Fauna Species

3.3.2.1 Fauna Habitat

Fauna habitat was considered significant in the EIS/ERMP for the Approved Development (Chevron Australia 2005a) if it:

- supports an unusually high species richness or abundance compared with other parts of Barrow Island
- contains fauna habitats that are not well represented in other parts of the island
- contains specialised habitat for fauna with restricted habitat requirements
- is in a location where development impacts may extend beyond the boundaries of the site and the impacts may lead to the disruption of ecological processes.

The habitats identified as significant in the EIS/ERMP for Barrow Island are:

- warrens which are habitat for burrowing bettongs (*Bettongia lesueur*)
- termite mounds which provide habitat (e.g. shelter) for a high diversity of fauna including reptiles and birds
- habitat suitable for the nests of birds of prey (e.g. eagles, osprey), such as coastal cliffs; bird of prey nests are not found on the island in high numbers.

Investigations for EIS/ERMP Reporting

Fauna habitat surveys (Chevron Australia 2005a) targeted sites within the areas of the Approved Development and surrounding areas (including the Revised Proposal area), that either:

- represent unique vegetation associations or
- represent other significant habitats that support high or unusual biodiversity or maintain unique ecological functions such as boodie warrens, termite mounds, and raptor nests.

One active boodie warren was found within the disturbance footprint of the Approved Development, and trapping shows that this warren supports 2–5 animals (F. Donaldson, UWA, pers. comm.). This warren is within the Revised Proposal footprint. Active boodie warrens are widely and evenly dispersed across Barrow Island at low density (approximately 0.43/km^2). There appears to be more suitable habitat for boodies to build warrens on the Island than there are active warrens (Short *et al.* 1989).

Termite mounds were recorded throughout the Approved Development area on Barrow Island, but are also found in large numbers across Barrow Island.

There are no recorded raptor nests within the Approved Development area.

Investigations Subsequent to EIS/ERMP Reporting

Since the studies conducted to support the EIS/ERMP (Chevron Australia 2005a), further surveys for significant fauna habitat have been completed, including surveys for boodie warrens (active and inactive) within the Revised Proposal area. These surveys did not find any additional warrens within the Revised Proposal area.

Termite mounds are spread across Barrow Island and are not restricted to the area in the Revised Proposal. Termite mounds were mapped within 500 m of the Revised Proposal clearing boundary using aerial photography of Barrow Island recorded in 2005. The average density of termite mounds in this area was 1.7 mounds/ha, which is similar to other areas on the Island.

Surveys subsequent to the EIS/ERMP have not recorded any raptor nests (e.g. sea eagle, osprey) within the Gorgon Gas Development area.

Melaleuca cardiophylla shrubland was included in the EIS/ERMP as potentially being critical habitat for the Barrow Island white-winged fairy-wren. This fairy-wren is abundant on Barrow Island, but is not found on mainland Western Australia. Subsequent to the publication of the EIS/ERMP, a field survey of white-winged fairy-wren nest site selection concluded that, while Barrow Island white-winged fairy-wrens favour vegetation associations that include *M. cardiophylla* shrubs, they also occur and breed in vegetation associations where *M. cardiophylla* is not present (RPS BBG 2006d). For example, wrens have been recorded as nesting in tall *Triodia angusta* along existing Barrow Island roads. *M. cardiophylla* shrubland has therefore not been included as significant habitat in this PER.

3.3.2.2 Terrestrial Fauna

Investigations for EIS/ERMP Reporting

Fauna surveys for the Approved Development have been reported in the EIS/ERMP (Chevron Australia 2005a). Surveys included mammal and herpetological (reptile, amphibian) searches (via spotlighting, trapping, litter searches) across a survey area surrounding and including the Approved Development. Surveys were undertaken seasonally and focused on sampling different habitats that may support unique or dependent fauna assemblages in the area.

Terrestrial invertebrate searches including short range endemics (SREs) were conducted during November and December 2003, and in August and September 2004, within and around the Approved Development using pitfall traps, hand searches, and leaf litter collections (Chevron Australia 2005a). Two undescribed species (species which have not yet been given a formal scientific name) were found in the Approved Development area; a large scorpion *Urodacus* sp., and a pseudoscorpion *Synsphronous* sp. nov. 'barrow'. These species were considered to be potential SREs in 2004 because they were not recorded elsewhere on the Island from past surveys.

Investigations Subsequent to EIS/ERMP Reporting

An additional three-month data acquisition survey for shorebirds around the coast of Barrow Island, including the Town Point area, was conducted in October 2005, and in February and March 2006 (RPS BBG 2006c). These surveys confirmed that the south and south-east coastlines of Barrow Island are important resting areas for migratory shorebirds compared to other coastlines on the Island. Bivalve Beach and Terminal Beach, which are located either side of the Revised Proposal MOF, causeway and jetty facilities, do not support large aggregations of shorebirds.

More intensive surveys for terrestrial invertebrates were conducted across 27 sites on Barrow Island from 2005 to 2007 in several vegetation types adjacent to the Approved Development, including vegetation types that are found in the Revised Proposal (Majer *et al.* 2006b; Majer *et al.* 2008a; Majer *et al.* 2008b). These surveys were conducted during the wet and dry seasons to allow for potential seasonal variations in the diversity of terrestrial invertebrates on the Island. The intent of these surveys was to document invertebrates that occur in various vegetation types on the Island, and to report any invertebrates that may be non-indigenous species (NIS).

A pilot study by Majer *et al.* (2006b) was used to develop protocols to ensure comprehensive sampling in terms of sampling period, length of trapping period, pitfall trap diameter, number of pitfall traps and number of vacuum samples. The methods developed during the pilot study were used for subsequent invertebrate surveys.

Several search methods were used to maximise the number of terrestrial invertebrate species collected including:

- litter searches
- beat sampling
- vacuum sampling
- nocturnal hand searches
- light traps (Majer *et al.* 2008a).

Identification of key invertebrate groups involved 26 taxonomists. While full taxonomy of some groups remains to be completed, this survey work has found that there are at least 1 460 species of terrestrial invertebrates on Barrow Island.

Species that were believed to be restricted to the Approved Development area (scorpion, pseudoscorpion) have since been recorded elsewhere on Barrow Island and outside the Revised Proposal area following targeted searches, demonstrating the distribution of these species is less restricted than was previously known (Majer *et al.* 2006a; Majer *et al.* 2008a; Majer *et al.* 2008c). Further surveys on SRE terrestrial invertebrates (snails, scorpions, mygalomorph spiders) have been undertaken in the area related to the Revised Proposal (Majer *et al.* 2008d) using techniques targeted to finding them. Preliminary results suggest there are unlikely to be SRE terrestrial invertebrate species in the Revised Proposal area, although final taxonomy on specimens is being completed by the Western Australian Museum and Curtin University.

Summary of Fauna Diversity

Of the 218 terrestrial vertebrate and terrestrial SRE fauna species that have been recorded from Barrow Island (Chevron Australia 2005a), 119 species (55%) are likely to occur within the combined terrestrial development areas of the Approved Development and Revised Proposal (Table 3.4).

Table 3. Error! Bookmark not defined.**: Terrestrial Fauna Species Recorded on Barrow Island**

Fauna	Total Number of Species on Barrow Island	Number of Species Predicted to Occur Within Approved Development and Revised Proposal Development Areas
Birds	51	16
Mammals	15[2]	12
Amphibians	2	2
Reptiles	44	28
Short Range Endemics[1]	39	39
Total	218	119

NOTES:
[1] SRE refer to terrestrial invertebrates, (minimum numbers recognised as listed in Chevron Australia 2005a).
[2] Includes two species of bats recorded as vagrants to the Island.

3.3.2.3 Terrestrial Birds

To date, 118 bird species have been recorded on Barrow Island including 6 vagrants. The 51 terrestrial bird species are discussed in this section. The 61 marine bird species recorded on or around Barrow Island, including shorebirds and seabirds, are discussed in Section 3.5.2.7.

Of the 51 terrestrial bird species recorded from Barrow Island, only 16 species are residents or regular migrants to the Island (Pruett-Jones and O'Donnell, 2004). It is estimated that 16 of the terrestrial bird species on Barrow Island potentially occur in the Gorgon Gas Development area; however the majority of birds recorded on the Island are migratory species which occur primarily in the south and south-east of Barrow Island.

Terrestrial Birds of Conservation Significance

Of the 51 terrestrial bird species recorded on Barrow Island, 16 are expected to occur within the Gorgon Gas Development area. Only one of these species, the Barrow Island white-winged fairy wren, is of conservation significance; the remainder comprises terrestrial and shore-inhabiting species that are widely distributed around Barrow Island.

The Barrow Island white-winged fairy-wren is listed as Schedule 1 under the Wildlife Act and as Vulnerable under the EPBC Act. An intensive survey was conducted in October 2004 to examine habitat preferences of the Barrow Island white-winged fairy-wren. Further surveys of the nesting habitat preferences of this species were conducted during their breeding season (August-September 2005) (RPS BBG 2006d). Barrow Island white-winged fairy-wrens have been found to nest in a range of plant species including *Melaleuca cardiophylla, Acacia bivenosa, A. coriacea, Hakea lorea, Grevillia pyramidalis* and *Triodia* sp. (RPS BBG 2006d). These studies show that nesting is not restricted to certain flora, and they nest in a variety of vegetation types (including Spinifex *Triodia angusta* along the roadways on Barrow Island in areas without *M. cardiophylla*) (RPS BBG 2006d). The Gorgon Gas Development area is not considered significant habitat for the Barrow Island white-winged fairy-wrens at the island-scale. The Gorgon Gas Development area has no unique features that might constitute crucial white-winged fairy-wren habitat.

3.3.2.4 Mammals

Barrow Island is recognised as an important refuge for native terrestrial mammal species that have either declined in numbers or become extinct on the mainland. Barrow Island supports 13 species of resident terrestrial mammals, with a further two species of bats recorded as occasional visitors to the island.

Mammals of Conservation Significance

As shown in Table 3.5, five terrestrial mammals known from Barrow Island are listed under the EPBC Act and the Wildlife Act. One species is given Priority status by DEC.

Table 3.4: Mammal Species of Conservation Significance

Species	Latin Name	State (WA) Level	Cth Level[1]	Matter of NES	Likely Presence in the Gorgon Gas Development Area
Burrowing Bettong (boodie)	*Bettongia lesueur*	Schedule 1[2]	Vulnerable	Yes	Recorded
Golden Bandicoot	*Isoodon auratus barrowensis*	Schedule 1	Vulnerable	Yes	Recorded
Spectacled Hare-wallaby	*Lagorchestes conspicillatus conspicillatus*	Schedule 1	Vulnerable	Yes	Recorded
Barrow Island Euro	*Macropus robustus isabellinus*	Schedule 1	Vulnerable	Yes	Recorded
Water Rat	*Hydromys chrysogaster*	Priority 4[3]	Not listed	No	Not recorded but likely to be present
Black-Flanked Rock Wallaby	*Petrogale lateralis lateralis*	Schedule 1	Vulnerable	Yes	Unlikely to occur in the Gorgon Gas Development area

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed under the Wildlife Act (WA).
[3] As listed by DEC.

All of the mammal species that are considered to have conservation significance are widespread on the island, with the exception of the black-flanked rock wallaby and the water rat. Both of these are restricted to certain habitat types on Barrow Island. The black-flanked rock wallaby inhabits coastal limestone outcrops and cliffs. There is no suitable habitat for the black-flanked rock wallaby within the Revised Proposal area, therefore this species is not expected to occur in this area. The water rat inhabits coastal beach habitats. While the Revised Proposal area includes some water rat habitat, such habitat is not restricted to the areas affected by the Revised Proposal and is also found elsewhere on Barrow Island.

There is one active boodie warren within the Approved Development site with an estimate of up to five boodies using the warren (F. Donaldson UWA, pers. comm.). These five boodies represent approximately 0.002% of the total Barrow Island population, which is estimated to be in the order of 2 900 individuals (Burbidge *et al.* 2003). The Revised Proposal, which includes this active warren will not disturb any additional boodie warrens. Boodies within the area to be cleared will be translocated as part of an approved translocation program for the Approved Development in consultation with DEC.

3.3.2.5 Amphibians

One frog species (*Cyclorana maini)* has been recorded on Barrow Island and is known to breed in seasonal watercourses in the Town Point area, in Airport Creek to the south of the Approved Development, and in other areas across the island. The Western Australian Museum holds a specimen of a second frog species *(C. platycephela)* that has been collected from the island. The timing and location of the collection of this specimen has yet to be confirmed with the Western Australian Museum. Both species are widespread across the Pilbara region, and neither is listed as having conservation significance under Western Australian or Commonwealth legislation. These species are expected to occur in the Revised Proposal area.

Amphibians of Conservation Significance
There are no amphibians of conservation significance recorded on Barrow Island.

3.3.2.6 Reptiles

Forty four reptile species have been recorded on Barrow Island, of which 24 have been recorded in the vicinity of the Gorgon Gas Development. The reptile fauna of Barrow Island includes a range of species from small sand-dwelling skinks, dragons and snakes up to the large varanid lizards (including the perentie, which is considered to be a top-order predator on the Island). The number of reptiles on Barrow Island is low in comparison to the adjacent mainland.

The skink *Ctenotus pantherinus acripes* is not listed as a conservation significant species, but is believed to be an endemic race, genetically and geographically separated from the nearest mainland populations. It has been found within the Approved Development site, but has also been captured in a wide range of habitats and is distributed across Barrow Island.

Reptiles of Conservation Significance
No reptile species on Barrow Island are listed under the EPBC Act. The subterranean blind snake *(Ramphotyphlops longissimus)* has been found on Barrow Island and is listed by the DEC as a Priority 2 species. Due to its cryptic habit and difficulty in sampling this species, it is not currently known from the areas affected by the Approved Development and Revised Proposal.

3.3.2.7 Terrestrial Invertebrates (Including Short Range Endemics)

To date, 1 460 species of terrestrial invertebrates have been recorded on Barrow Island (Majer *et al.* 2008a, Majer *et al.* 2008b). None of the species found are considered to rely on unique habitats or vegetation assemblages, and all species currently recorded are expected to be widely distributed on the Island because the vegetation associations from which they were collected are also widespread on the island.

The large scorpion (*Urodacus* sp.) and pseudoscorpion (*Synsphronous* sp. nov. 'barrow') that were believed to be restricted to the Approved Development area in 2005 (Chevron Australia 2005a) have since been recorded elsewhere on Barrow Island outside of the Gorgon Gas Development area following targeted searches. This demonstrates that the distribution of these species is less restricted than was previously known (Majer *et al.* 2006a; Majer *et al.* 2008a; Majer *et al.* 2008c).

Further surveys for SRE terrestrial invertebrates (snails, scorpions, mygalomorph spiders) have been undertaken in the area related to the Revised Proposal (Majer *et al.* 2008d). Preliminary results suggest there are unlikely to be any SRE terrestrial invertebrate species restricted to the Revised Proposal area, although final identification to species level is being completed by the Western Australian Museum and Curtin University (Majer *et al.* 2008d).

Terrestrial Invertebrates of Conservation Significance
Whilst complete results and analysis for some groups (e.g., mites, wasps, flies, moths) are outstanding, information to date shows that none of the terrestrial invertebrate identified on the Island are listed as requiring special protection under the EPBC Act, Wildlife Act or DEC Priority species lists.

3.3.2.8 Introduced Fauna

Investigations for EIS/ERMP Reporting

Surveys for terrestrial fauna species have also targeted fauna species that are considered to be non-indigenous species (NIS) to the Island. Surveys previously conducted by Chevron Australia and CALM (now DEC) have reported no evidence of introduced mammals, reptiles or birds to Barrow Island (Burbidge *et al.* 2003, Chevron Australia 2005a).

Investigations Subsequent to EIS/ERMP Reporting

Mammal surveys have been conducted by the DEC on Barrow Island since 2005. Targeted surveys by Chevron have also been completed for geckos (targeting Asian house gecko) (RPS BBG 2006g), and terrestrial invertebrates (Majer *et al.* 2008b). No NIS of mammal or reptile (gecko) has been found to occur on Barrow Island. The baseline invertebrate surveys sampled 16 invertebrate taxa from six Orders that are considered NIS. These were divided into two categories:

- Confirmed NIS – species that have been positively identified as non-indigenous species, and there are no reasons to doubt that they have become naturalised on Barrow Island. These species tend to be associated with human-habitats and display commensal ecologies. There is no evidence they are impacting on the natural environment.
- Cryptic NIS – species that have been identified as possible NIS, although there is a level of doubt concerning either the identity of the organism, the taxonomy, origin, or natural range of the species.

Of the 1 460 species of terrestrial invertebrates collected, twelve taxa were confirmed as NIS (Table 3.6). Investigations are continuing into a number of species that were recorded as part of the baseline invertebrate survey which are considered putative and where confirmation of status is complicated by taxonomic uncertainty.

3.3.3 Subterranean Fauna

Barrow Island is well recognised as being of high conservation significance for subterranean fauna (stygofauna and troglofauna) communities. The subterranean fauna of the Island demonstrates a high level of endemicity and species diversity, with over 20 species known from Barrow Island.

There are two broad categories of fauna that have adapted to subterranean conditions and are generally considered to comprise true subterranean fauna:

- stygofauna – groundwater dwelling aquatic fauna
- troglofauna – obligate cave or karst dwelling terrestrial subterranean fauna occurring above the watertable.

Subterranean fauna are typically strongly adapted to the subterranean environment, with features such as lack of pigment, elongated appendages and reduced or absent eyes.

Subterranean fauna have been studied on Barrow Island since 1991; surveys during that decade were conducted by the Western Australian Museum and focused largely on cave fauna.

Investigations for EIS/ERMP Reporting

Subterranean fauna sampling was undertaken by Chevron Australia in 2002 and 2003. Subsequent to this, Chevron Australia commissioned a 19-month four-phase survey, spanning from 2004 to 2006, to support the assessment of the Approved Development:

- Phase I was undertaken by Biota between 30 November – 2 December 2004
- Phase II was undertaken by Biota from 1 – 4 March 2005
- Phases III and IV were conducted subsequent to EIS/ERMP reporting (see below for details).

The sampling approach adopted for the four-phase survey program was consistent with that outlined in EPA Guidance Statement No. 54a (EPA 2007b). Troglofauna sampling was conducted using troglofauna litter traps suspended within boreholes, and stygofauna sampling using plankton haul nets in groundwater bores. Bores were sampled within the disturbance areas of the Approved Development (including the Gas Treatment Plant and Gorgon Construction Village sites) and at nearby areas outside the disturbance areas (including sites in the vicinity of the existing WA Oil Terminal Tanks and current Chevron Base Camp).

Sampling in Phase I and Phase II collected a total of 14 taxa groups: six stygal groups and eight troglobitic groups.

Investigations Subsequent to EIS/ERMP Reporting

Phases III and IV of the four-phase survey program for subterranean fauna (stygofauna and troglofauna) were undertaken in 2006 (post preparation of the EIS/ERMP):

- Phase III was undertaken by Biota between 6 – 9 March 2006
- Phase IV was undertaken by Biota between 29 May – 2 June 2006.

Sampling in Phase III and Phase IV collected an additional two stygal taxa groups and two troglobitic taxa groups bringing the total for the four-phase survey program to 18 subterranean taxa groups. This increased the total number of subterranean groups known from the Island from 21 to 29 (excluding *Nedsia* sp. due to taxonomic difficulties) (Biota 2007).

For some taxa, positive identification can only be made using adult specimens or individuals of a particular sex as these have key morphological features used to identify them. If suitable specimens are not collected during a survey, species-level identification based on morphology remains ambiguous.

3.3.3.1 Subterranean Fauna Habitat

There is evidence that the subterranean (geological) habitat on Barrow Island does not present any large scale barriers to the distribution of subterranean fauna across the island. While it is possible that certain subterranean taxa are restricted to discrete areas of karst habitat, current hydrogeological data infers that these taxa should not be restricted to the Approved Development or Revised Proposal areas on Barrow Island. A geological review by Campbell and Wedepohl (2005) suggests that the karstic and shallow aquifer habitat is widespread both within and beyond the Revised Proposal footprint. This is further supported by the morphological and genetic species distributional data (UWA 2007). There is no evidence of large caves or other large-scale geomorphological features that might create barriers to gene flow between the Approved Development or Revised Proposal development areas and adjacent habitats on Barrow Island. Most of the stygal and troglobitic species that have been well collected, that have a taxonomic frame of reference, and for whom genetic or morphological work has been

completed, have a wider distribution on Barrow Island (i.e. beyond the Revised Proposal footprtint).

The Revised Proposal area falls within the local geology of the Approved Development where subterranean fauna surveys have been conducted to date (Biota 2007). Given Chevron Australia's current knowledge of the hydrogeology of the island including the area of the Approved Development, it is highly probable that the geology/hydrogeology of the additional area of disturbance associated with the Revised Proposal is contiguous with the geology/hydrogeology of the adjacent area where the sampling bores are located. Therefore, it is also highly probable that the subterranean fauna populations are also contiguous. A geotechnical investigation and geophysical survey is scheduled to commence in late 2008 to further characterise the subterranean fauna habitat in the Revised Proposal area.

3.3.3.2 Stygofauna Species

During the four-phase survey, a total of 19 bores were sampled for stygofauna within the Approved Development disturbance area and 27 bores were sampled in areas outside the Approved Development disturbance areas.

Sampling in Phase I and Phase II collected a total of six stygal taxa groups. Sampling in Phase III and Phase IV collected an additional two stygal taxa groups, bringing the total number of stygofauna fauna recorded for the four-phase survey program to eight taxa groups.

Stygofauna were recorded from 59% of bores during the four-phase survey. Including historical records as well as results from the four phase subterranean fauna survey, 24 stygofauna taxa have been identified on Barrow Island (Table 3.7). The dominant taxa, both numerically and spatially, were the cyclopoid copepods and amphipods. Cyclopoid copepods accounted for approximately 31% of the total collection of stygofauna, and were collected from 35% of the bores sampled. Amphipods made up 30% of the total collection of stygofauna, and were collected from 43% of the bores sampled (Biota 2007). The stygofaunal groups recorded are representative of the stygofaunal groups recorded at Western Australian mainland locations, including Cape Range and the Robe Valley.

A number of the specimens of stygofauna found during the sampling program are awaiting detailed study by a specialist taxonomist for accurate species classification, in particular, specimens of Cyclopoida, Harpacticoida and Bathynellacea (Table 3.6). However, specimens from all three groups have been found within and outside the Revised Proposal area, therefore it is unlikely that any of the species are restricted to the Revised Proposal area.

Future work is planned to further survey for those stygofauna previously only located in the Gas Treatment Plant area, as part of requirements to satisfy conditions of Statement No. 748. Current efforts have confirmed that of four taxa initially only found within the Gorgon Gas Development area, one has a more widespread distribution on Barrow Island.

Table 3.5: Recorded Distribution of Stygofauna Species on Barrow Island

Species	Within Approved Development and Revised Proposal Development Area	Outside Gorgon Gas Development Area	Restricted to Gorgon Gas Development Area
Cyclopoida *Halicyclops rochai*		Yes	
Cyclopoida *Halicyclops longifurcatus*		Yes	
Cyclopoida *Diacyclops humphreysi unispinosus*		Yes	
Cyclopoida *Allocyclops consensus*		Yes	
Cyclopoida[1]	Yes	Yes	
Harpacticoida *Sarsameira* sp.		Yes	
Harpacticoida *Phyllopodopsyllus wellsi*		Yes	
Harpacticoida *Phyllopodopsyllus thiebaudi*		Yes	
Harpacticoida *Inermipes humphreysi*		Yes	
Harpacticoida *Biameiropsis barrowensis*		Yes	
Harpacticoida[1]	Yes	Yes	
Bathynellacea nr. *Chilibathynella* sp.		Yes	
Bathynellacea *Atopobathynella* sp. *nov*.		Yes	
Bathynellacea undescribed sp.[1]	Yes		Yes
Amphipoda *Nedsia sculptilis/macrosculptilis*	Yes	Yes	
Amphipoda *N. humphreysi*		Yes	
Amphipoda unknown sp. 1	Yes		Yes
Amphipoda unknown sp. 2 poss. *Bogidomma* sp.	Yes		Yes
Amphipoda unknown sp. 3		Yes	
Amphipoda *Liagoceradocus subthalassicus*		Yes	
Amphipoda *Bogidomma australis*	Yes	Yes	
Isopoda *Haptolana pholeta*	Yes	Yes	
Isopoda Sub Order *Oniscoidea* undescribed sp.		Yes	
Thermosbaenacea *Halosbaena tulki*		Yes	
Haplotaxida *Enchytraeidae* sp.		Yes	
Decapoda *Stygiocaris stylifera*	Yes	Yes	
Eleotridae *Milyeringa veritas*		Yes	

NOTE:
[1] Specimens have been found both within and outside of the Revised Proposal disturbance areas and are awaiting species level classification to clarify species distribution.

To date, three stygal taxa are yet to be recorded outside the disturbance area associated with the Approved Development Gas Treatment Plant site (Table 3.7); these being two Amphipoda taxa and one Bathynellacea taxon. Subsequent sampling and taxonomic investigations have been conducted in relation to these species.

A mitochondrial deoxyribonucleic acid (DNA) genetic analysis of the collected amphipods was undertaken in 2007 to understand the variation of this Amphipoda taxon across Barrow Island and within the Gas Treatment Plant site of the Approved Development (Finston 2007). This study showed there were five distinct species of amphipods, of which two species belong to the genus *Nedsia*. One species of *Nedsia* is widespread, occurring in all bores sampled. The second species of *Nedsia* is less common, occurring in five bores, all of which are outside the Revised Proposal disturbance areas. The three

other amphipod species have so far only been recorded in single bores; two of these bores (and two of the three amphipod species) occur within the Approved Development Gas Treatment Plant site (UWA 2007). Given the wider distribution of the other species in the same genus, it is likely that these two restricted species will be found elsewhere with further sampling effort, as required by Statement No. 748 conditions.

Two species of *Bathynellacea* have been found in a number of sample bores across Barrow Island. The specimen of *Bathynellacea* sp. found within the Gas Treatment Plant site has not yet been classified to species level and is very likely a specimen of one of these two known species. However, there is still the potential that it is a new species and it must therefore be considered as restricted to the Gas Treatment Plant site pending further information. A taxonomic investigation is currently underway to ascertain the distribution of this species across Barrow Island. It is considered likely that this species will be found elsewhere on the Island with further sampling effort as required by Statement No.748.

3.3.3.3 Troglofauna Species

In Western Australia, troglofauna have historically only been known from cave systems and massive karst such as those found on the Nullarbor, Cape Range and Barrow Island. Recent work has, however, confirmed that troglobitic communities also occur in other fractured and cavernous geology types such as in pisolite mesas in the Pilbara region (Biota 2007).

During the four phase subterranean fauna survey program conducted from 2004 to 2006, a total of 19 bores were sampled for troglofauna within the Approved Development disturbance area on Barrow Island and 27 bores were sampled in areas outside the Approved Development disturbance areas.

Twenty-one taxonomic groups were collected during the four-phase troglofauna fauna surveys undertaken between 2004 and 2006. However, the majority of individuals did not show the morphological adaptations that characterise species that are restricted to the underground environment (i.e. most individuals were not true troglobites). On this basis only nine of the 21 taxonomic groups collected were classified as representing troglobitic taxa. Within the nine taxonomic groups, 10 troglobitic taxa were identified (Table 3.8). Sampling in Phase I and Phase II identified eight of the 10 troglobitic taxa, while sampling in Phase III and Phase IV identified the additional two troglobitic taxa.

Troglofauna were recorded from 46% of bores. Schizomids were the most abundant, accounting for approximately 71% of the total collection of troglobites, and were collected from 50% of the bores sampled (Biota 2007). At the classification level of Order, the troglobite taxa recorded are representative of the troglofaunal taxa recorded at mainland locations, including Cape Range and the Robe Valley.

Table 3.7: Recorded Distribution of Troglobitic Species on Barrow Island

Species	Within Approved Development and Revised Proposal Development Area	Outside Development Area	Restricted to Development Area
Schizomida *Draculoides bramstokeri*	Yes	Yes	
Pseudoscorpionida *Tyrannochthonius garthhumphreysi*		Yes	
Pseudoscorpionida *Ideoblothrus nesotymbus*	Yes	Yes	
Spirobolida *Speleostrophus nesiotes*	Yes	Yes	
Blattodea *Nocticola* sp.	Yes	Yes	
Thysanura *Trinemura* sp. nov	Yes		Yes
Symphyla *Symphyla* sp.		Yes	
Diplura *Japygidae* sp.		Yes	
Araneae *Gnaphosidae* sp.		Yes	
Scolopendrida *Cryptopidae* sp.		Yes	

Two species, a pseudoscorpion *Tyrannochthonius garthhumphreysi* and an undescribed species of gnaphosid spider were collected while sampling for troglofauna; these were not recorded in the Revised Proposal disturbance area.

Current efforts, as part of Statement No. 748, have confirmed that of four taxa initially perceived to be restricted to the Development footprint, three have a more widespread distribution on Barrow Island.

To date, one troglobitic taxon (*Trinemura* sp.) is yet to be located outside the Approved Development Gas Treatment Plant site disturbance area (Table 3.8). Only one specimen of *Trinemura* sp. has been collected and as the specimen was a juvenile it could not be identified beyond the genus level of classification. However, according to the records of the Western Australian Museum, it is the first troglobitic Thysanuran collected from the Island, and appears to be a new species to science, *Trinemura* sp. nov (Biota 2007). In previous reports this specimen was referred to as *Archaeognatha* sp. 1, which was determined with further analysis to belong to the genus *Trinemura*. Given the distribution of the other troglobites collected, it is likely that this restricted species will be found elsewhere with further sampling effort as required by Statement No. 748 conditions.

Subterranean Fauna Species of Conservation Significance

Stygofauna and troglofauna in Western Australia, and in particular Barrow Island and Cape Range, are regarded as geological relicts, descendants from ancient lineages dating back to periods when tropical rainforest covered arid northern Australia (the Miocene; circa 20 million years ago; Humphreys 1993). The stygofauna and troglofauna of Barrow Island represent relict lineages that are closely related to fauna of Gondwana, the Tethys Sea and surface dwelling ancestors that occurred prior to the break-up of Pangaea (Humphreys 1993).

Barrow Island is well recognised as being of high conservation significance for subterranean fauna at state, national and international levels. The subterranean fauna of the Island demonstrates a high level of endemicity and species diversity, with over 20 species known only from Barrow Island (Chevron Australia 2005a).

Eleven species of subterreanean fauna found on Barrow Island are protected by legislation, none of which are restricted to the Revised Proposal footprint (Table 3.8).

Table 3.6: Subterranean Fauna Species of Conservation Significance

Species	Scientific Name	State (WA) level	Cth[1] level	Matter of NES	Likely Presence in Area Related to the Revised Proposal Project Area
No common name	*Draculoides bramstokeri*	Schedule 1[2]	Not Listed	No	Not recorded but likely to be present
No common name	*Speleostrophus nesiotes*	Schedule 1	Not Listed	No	Not recorded but likely to be present
Blind Gudgeon	*Milyeringa veritas*	Schedule 1	Vulnerable	Yes	Not recorded but likely to be present (has been recorded 6km southwest of Revised Proposal disturbance area)
No common name	*Nedsia fragilis*	Schedule 1	Not Listed	No	Not recorded but likely to be present
No common name	*Nedsia humphreysi*	Schedule 1	Not Listed	No	Not recorded but likely to be present
No common name	*Nedsia hurlberti*	Schedule 1	Not Listed	No	Not recorded but likely to be present
No common name	*Nedsia macrosculptilis*	Schedule 1	Not Listed	No	Not recorded but likely to be present
No common name	*Nedsia sculptilis*	Schedule 1	Not Listed	No	Not recorded but likely to be present
No common name	*Nedsia straskraba*	Schedule 1	Not Listed	No	Not recorded but likely to be present
No common name	*Nedsia urifimbriata*	Schedule 1	Not Listed	No	Not recorded but likely to be present

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed under the Wildlife Act (WA).

3.4 Marine Environment

3.4.1 Meteorology

The mean wind speed around Barrow Island during the summer period (October through March) is 6.6 m/s and the mean maximum summer wind speed is 16.2 m/s. The dominant direction is from the southwest and west. During winter, April through September, winds approach from the east, south and south-west and have a mean speed of 5.8 m/s and mean maximum speed of 19.4 m/s. Easterly gales occur between May and August with speeds in the range of 12.5 to 20 m/s (see Appendix F).

Barrow Island is located in a region of high tropical cyclone frequency. Between 1960 and 2003 on average 3.84 cyclones passed within 400 nautical miles of Barrow Island each year (MetOcean 2006). Tropical cyclones usually form in the Timor and Arafura seas between November and April. They initially travel in a generally south-westerly direction; as they travel further south the tracks become more variable.

3.4.2 Bathymetry

Barrow Island lies on the continental shelf, with water depths increasing rapidly to the west of the Island (Figure 3.3). Water depths between the east coast of the island and the mainland generally do not exceed 20 m; however depth varies immediately adjacent to the coast due to seabed outcrops and the presence of numerous pinnacles. The water depth in the vicinity of the Revised MOF, LNG jetty and turning basin ranges from approximately 12 m depth up to approximately 5 m depth, and shallower on the nearshore limestone pavement areas. Detailed bathymetry has recently been collected for the MOF, the LNG shipping channel and jetty areas (Fugro Survey Pty Ltd 2007).

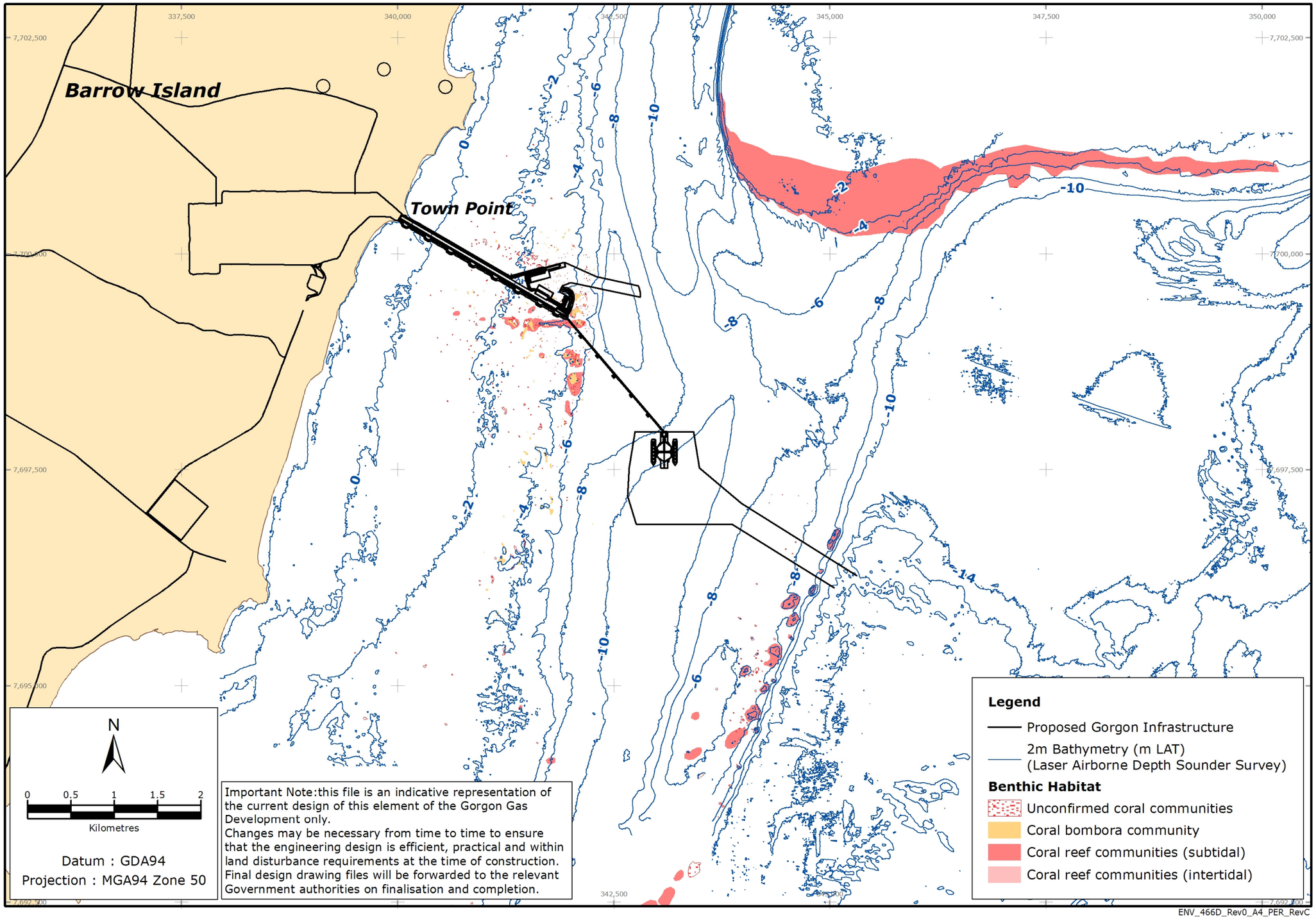

Figure 3.4: Bathymetry of Revised Proposal Area on the East Coast of Barrow Island

3.4.3 Oceanography

Surface water temperatures around Barrow Island typically vary between 21°C during July and August to 30°C in late summer (ChevronTexaco Australia 2003a). The seawater is generally well mixed with uniform temperatures throughout the water column.

3.4.3.1 Circulation and Currents

The prevailing oceanographic conditions in the Barrow Island area are governed by a combination of sea and swell waves. On the east coast of Barrow Island, periods of greatest wave activity correspond to periods of strong easterly winds during winter (ChevronTexaco Australia 2003a). The mean significant wave height at the MOF is 0.47 m, with a mean maximum wave height of 2.11 m. Town Point is largely sheltered from westerly swell by Barrow Island and the shallow reef system to the south. Maximum wave heights will result from tropical cyclones, but the maximum wave heights at the MOF location will be limited by the shallow bathymetry (Kellogg Joint Venture Gorgon 2008).

The west coast of Barrow Island is affected by the Southern Ocean swell which refracts around the northern and southern ends of the Island. On the east coast, periods of greatest wave activity correspond to periods of strong easterly winds (ChevronTexaco Australia 2003a).

Currents are principally driven by semi-diurnal tidal forcing. Near the Revised Proposal marine area, tidal currents run strongly parallel to the eastern shore and funnel through the offshore channel north of the Town Point site. Current measurements at the tanker mooring confirm the tidal nature of these currents, reflecting a distinct spring-neap (14-day) tidal cycle and a semi-diurnal pattern. The maximum current measured at this point was 0.62 m/s. The direction of the tidal currents (for both spring and neap) was a flood flow towards the south-west and an ebb flow towards the north-east (ChevronTexaco Australia 2003a). The marine waters adjacent to the Island are generally well-mixed throughout the water column. As the eastern side of Barrow Island is protected from ocean swells, the greatest wave activity on the eastern shoreline occurs during periods of strong easterly winds (Chevron Australia 2005a).

3.4.3.2 Tides

Tides in the Barrow Island region are semi-diurnal, comprising two high tides and two low tides per day. The tidal gradients are strong and aligned in a north-south direction. The combination of moderate tidal ranges, and shallow bathymetry, results in large areas of exposed seabed along the east coast at low tide (West Australian Petroleum 1989).

3.4.3.3 Coastal Geomorphology and Processes

On the east coast of Barrow Island, intertidal reef flats and shallow pavements progress to deeper sands offshore. Nearshore limestone or calcarenite pavements are covered by sand, gravel and coral. Bare sands overlay limestone pavements in many parts of the area with increased quantities of rubble on exposed pavement where strong water currents are present.

The coast in the vicinity of the Revised Proposal MOF is comprised of several extended, almost linear sandy beaches, separated by short rocky headlands. The headland at Town Point extends approximately 400 m from the beaches. The beaches are perched upon a gently sloping rock shore platform which extends almost 3 km from the shoreline (Kellogg Joint Venture Gorgon 2008).

The coastal morphology at Town Point has resulted from marine erosion and solution weathering of low sub-vertical limestone cliffs, up to 5 m in height, creating an unstable environment. Typical coastal erosion features include:

- unstable cliffs with rock fall debris
- coastal sea cut caves and stacks
- tension cracks.

Wave shoaling and breaking processes occur over the intertidal reef flat and shallow pavement and the wave energy on the beach faces is low. Waves typically only reach the foredune during spring high tide conditions. Tropical cyclones potentially create the most dramatic changes to beach profiles as storm surge raises water levels and exposes wave influence to higher parts of the beach not normally vulnerable to waves. Tropical cyclones passing east of Barrow Island will have the most significant impact on beach profiles and sedimentation at Town Point as this track direction results in maximum storm surge on the east coast.

Longshore sediment transport on the east coast is broken up by the rocky headlands. Coastal erosion of the rocky headland and weathering of the intertidal shore platform provides a source of sediment for the beach faces (Kellogg Joint Venture Gorgon 2008).

Aerial photographs of Town Point taken between 1991 and 2001 demonstrate the shoreline is not susceptible to change; there is no net erosion or accretion of the beaches to the north and south of Town Point or around the headland features (Kellogg Joint Venture Gorgon 2008).

3.4.3.4 Coastal Processes Studies

A series of engineering design optimisations undertaken in 2007 resulted in a revised design for the MOF. Under the Revised Proposal, the causeway and MOF now extend 2 120 m to the east of Town Point. Additional numerical modelling was undertaken to determine the impact of the longer MOF structure on the marine environment. The additional analysis included wind, wave, hydrodynamic and sediment transport modelling (Kellogg Joint Venture Gorgon 2008). The potential impacts of the Revised Proposal in terms of coastal processes, as predicted by the modelling, are discussed in detail in Section 7.2.2.

3.4.4 Water and Sediment Quality

Marine water circulation and benthic sediments provide the medium for the conveyance and/or cycling of the resources required by marine biota for growth and reproduction. A decrease in either water or sediment quality may alter the availability of those resources, with potential consequences for the diversity, distribution and abundance of marine biota.

The marine waters and sediments of the Pilbara region and the North West Shelf in general are recognised as generally being of very high quality and the concentrations of most contaminants in the waters and sediments of existing coastal ports have been found to be acceptable for waters assigned a High Level of Ecological Protection (McAlpine *et al.* 2006; Wenziker *et al.* 2004).

3.4.4.1 Water Quality

Preliminary studies for the Gorgon EIS/ERMP have been augmented by ongoing water and sediment quality studies conducted in the waters surrounding Barrow Island and on the Lowendal Shelf, to establish a pre-construction baseline.

Background contaminant concentrations detected in samples collected from this area are generally low, although nutrient levels often exceed the ANZECC and ARMCANZ (2000) default trigger values. Higher turbidity levels and light attenuation coefficients indicate that the shallow waters close to Barrow Island are naturally more turbid than deeper offshore waters. Recorded Light Attenuation Coefficients (LAC) were generally slightly higher in the shallow waters, particularly on the east coast where both higher turbidity and TSS readings have been recorded (RPS 2007).

The light profile of the waters along the east coast of Barrow Island is dominated by tidal changes in water level. Reductions in light at the seabed are also caused by increases in suspended sediment in the water column, which result from seabed disturbance and the re-suspension of sediment by cyclones and terrestrial run-off. These events are infrequent, and in all but the shallowest areas, are associated with wave re-suspension of the sediments rather than by tidal flow (RPS BBG 2006h).

Generally, temperature stratification of nearshore waters surrounding Barrow Island is infrequent and there is little evidence of salinity stratification at any of the nearshore sites monitored on the east or west coasts of the island. Hydrocarbons, BTEX (benzene, toluene, ethylbenzene and xylene), oils and grease, phenol and organotin concentrations detected in samples collected from this area were below the laboratory reporting limits at the majority of sampling sites (RPS 2007). Recorded concentrations of all trace metals other than cadmium were below laboratory reporting limits. Cadmium levels were on average, double the ANZECC and ARMCANZ (2000) 99% level of protection trigger levels for this metal (0.7 µg/L). However, the concentrations of cadmium were relatively consistent across both the east and west coast samples, ranging only from 1.2 to 1.6 µg/L. This may reflect normal background concentrations, rather than contamination (RPS 2007).

Chlorophyll pigment levels in near-shore waters are low, however recorded concentrations of nitrate and nitrite, Total Nitrogen (TN) and Total Phosphorus (TP) slightly exceeded the default triggers levels in the ANZECC and ARMCANZ (2000) guidelines (RPS 2007). The widespread distribution of these data suggests that these nutrient concentrations may be characteristic of the area. Concentrations of inorganic compounds were consistent, but slightly elevated levels of radionuclides have been detected north of Barrow Island, suggesting the possibility of some contamination from either produced or natural seeps of formation water. No pesticides were detected in any of the seawater samples.

3.4.4.2 Sediment Quality

Preliminary sediment quality data indicate that nutrient concentrations in the near-shore sediments surrounding Barrow Island are low and that concentrations of all metals other than silver are below ANZECC and ARMCANZ (2000) Interim Sediment Quality Guideline (ISQG) Low trigger values. The source of the elevated silver concentrations is unknown. Hydrocarbons and BTEX were below laboratory detection limits in all sediments sampled around Barrow Island (RPS 2007; URS 2006).

Monobutyl tin and dibutyl tin concentrations were below laboratory detection limits. Tributyl tin (TBT) was detected but the measured concentrations were well below the ANZECC and ARMCANZ ISQG trigger value (RPS 2007). The presence of TBT in the marine sediments suggests historical contamination from antifouling paints on vessel hulls, however an international convention prohibiting the TBT paints on ships came into full effect on 1 January 2008 (IMO 2001), and as such, ongoing contribution of TBT contamination is considered unlikely.

3.5 Marine Ecology

3.5.1 Marine Benthic Primary Producers

3.5.1.1 Investigations for EIS/ERMP Reporting

Marine benthic habitat surveys along the east and west coasts of Barrow Island were conducted between 2001 and 2004 for the Approved Development (Chevron Australia 2005a). Surveys included review of existing marine mapping data, camera tow surveys and snorkelling surveys using specialist marine scientists. Intertidal areas were surveyed on foot by specialist marine scientists during extreme low spring tides. The survey area included the Approved Development footprint and surrounding areas on the east and west coasts of Barrow Island.

3.5.1.2 Investigations Subsequent to EIS/ERMP Reporting

Further comprehensive benthic surveys targeting the Revised Proposal layout for the causeway, MOF and LNG jetty on the east coast of the island were undertaken in 2007 and 2008 and are ongoing. Survey techniques include video camera tows and snorkel diving to ground-truth benthic features identified from satellite imagery and Laser Airborne Depth Surveys. Particular attention during the benthic habitat surveys was paid to sensitive coral habitats and identifying *Porites* bombora communities within the Revised Proposal marine footprint.

3.5.1.3 Description of Marine Benthic Primary Producers

Marine benthic primary producers (BPP) are photosynthetic organisms that are attached to marine intertidal and subtidal substrates and contribute to the productivity of marine ecosystems. BPP are restricted to the photic zone where light is sufficient to support photosynthesis. Seagrasses, macroalgae, corals and mangroves are the most important BPP in the tropical marine ecosystems surrounding Barrow Island and on the mainland coast. Corals are considered to be primary producers due to photosynthesis of microalgae (zooxanthellae) living in their cells.

Benthic primary producer habitats (BPPH) have a complex structure that provides substrate for the growth of a diverse suite of sessile organisms and shelter for juveniles and adults of mobile biota (EPA 2004a). In addition, BPP can assist in stabilising soft sediments and shorelines and in consolidating mobile substrates such as rubble.

The marine macrophyte and coral assemblages in the waters surrounding Barrow Island are dominated by tropical and sub-tropical species that are widely distributed within the Montebello/Lowendal/Barrow Island region and across the Rowley Shelf. Mainland taxa are similarly widespread along the Pilbara coast and throughout the Pilbara Inshore Bioregion.

In general, Barrow Island is almost entirely surrounded by limestone pavement reef that extends to the subtidal zone. Broad intertidal reef platforms with scattered mud and sand flats are widespread along the east coast of Barrow Island. Sandy beaches are widespread around both the east and west coasts of Barrow Island and typically form above the intertidal reef between rocky headlands.

Coral reefs and bombara are restricted to the photic zone and vary greatly in structure and in ecology in response to physical disturbance, water clarity and exposure to swell. Corals are abundant around Barrow Island, growing as high profile reefs and on pavement on both the west and east coasts. The most significant coral reefs around Barrow Island are Biggada Reef on the west coast, Dugong Reef and Batman Reef off the south-east coast and along the southern edge of the Lowendal Shelf on the east side of Barrow Island.

Within the Revised Proposal disturbance area, the nearshore area where the causeway is proposed comprises an intertidal reef with large rock pools. These reefs support algal turf, while the rock pools support macroalgae and sparse seagrass. The eastern end of the causeway, MOF and part of the LNG jetty cover an area of limestone platform reef. This reef is covered in macroalgae (*Sargassum*), scattered hard and soft corals and thin sand veneers.

The offshore areas of the Revised Proposal MOF access channel and LNG jetty, the tanker turning basin and the western end of the tanker access channel cover deeper pavement reef covered with sand. The sediments in these areas support sparse ephemeral seagrass of the genus *Halophila*, seapens, seawhips and gorgonians.

The offshore area of the proposed tanker access channel intersects a rocky ridge running southward from the Lowendal Shelf (Figure 3.4). This ridge rises several metres above the surrounding seabed and comprises pavement reef scattered with rocky lumps. There is variable cover of macroalgae, soft corals and hard corals.

3.5.1.4 BPP in the Revised Proposal Area

The elements of the Revised Proposal that will affect BPP and their habitats are the:

- causeway and MOF
- jetty
- change to footprint of dredge areas.

3.5.1.5 Causeway and MOF

The Revised Proposal Town Point causeway occupies the same footprint at the shore-crossing as the Approved Development causeway (Figure 3.4). As the causeway extends seaward it deviates north from the original design, but covers equivalent intertidal habitats. The revised causeway extends from the rocky headland at Town Point, through the rocky upper intertidal zone and across the intertidal part of the platform reef fringing the east coast of the island. The limestone pavement reef at Town Point slopes gently into the lower intertidal and subtidal zones approximately 200 m seaward from the boulder zone. There is a large shallow lagoon surrounding Town Point with a narrow break in the platform open to the sea (RPS BBG 2005a).

The marine macrophyte assemblages within the footprint of the Revised Proposal causeway vary from sparse communities on almost bare exposed rock, to low turf, to dense macroalgae in the rock pools and the lower intertidal pavement. The upper intertidal pavement is covered in sediment veneers of varying thickness and is mostly bare of macrophytes, apart from low turfing red algae in areas free from sediment. Rock pools support the growth of macroalgae (*Sargassum* and *Cystoseira*) and seagrass in varying densities ranging from occasional plants to small meadows. Seagrasses include *Halophila*, *Halodule* and *Thalassia* (RPS BBG 2005a).

The lower intertidal rock platform has less sediment cover and supports the growth of macroalgae and seagrass, as well as scleractinian corals (stony corals) and octocorals (soft corals). The coral assemblage is dominated by various species of *Goniastrea*, some specimens exceeding 80 cm in diameter. Less common corals include *Porites*, *Euphyllia*, *Lobophyllia*, *Plesiastrea*, *Favia*, *Favites*, *Turbinaria*, *Platygyra* and *Acanthastrea* (RPS BBG 2005a).

Mangroves on Barrow Island only occur within isolated pockets on the fringes of the southern and eastern coastlines. They are generally the white mangrove (*Avicennia*

marina) and only form a narrow band of stunted trees in most locations. A major mangrove community of *Avicennia marina* is growing in Bandicoot Bay on the south coast of Barrow Island away from the Revised Proposal area. There are no mangroves in the immediate vicinity of Town Point; however, there are small stands of *Avicennia marina* mangroves to the north and south of Town Point.

The intertidal habitats represented at Town Point are widespread along the east coast of Barrow Island and are of low conservation significance.

The subtidal pavement reef surrounding Town Point and the deeper, more offshore sections of the revised causeway is overlain by a thin veneer of sediment and is generally dominated by *Sargassum*, with other macroalgae such as *Cystoseira* and *Dictyopterus*, very conspicuous members of the macroalgal community. Subtidal coral communities vary from almost exclusively coral-dominated assemblages to areas dominated by macroalgae but with scattered small hard corals (*Acropora* and *Turbinaria*) and soft corals (*Rumpbella*). *Porites* bombora up to 1 m high are either interspersed as isolated elements throughout the subtidal reef areas or grouped together to form bombora communities.

The Revised Proposal causeway and MOF extend approximately 800 m further to the east (offshore) of the Approved Development footprint. The benthic habitats associated with this area consist of *Sargassum*-dominated subtidal pavement, limestone pavement with scattered corals including *Porites* bombora. The Revised Proposal MOF location has been chosen to avoid coral habitats where possible; however at its eastern end it is close to well developed coral habitat (Figure 3.4). This habitat is considered to be of local significance, but not of regional conservation significance because it is generally very widespread throughout the Pilbara region (CALM 2004). The location of the Revised Proposal causeway and MOF also takes into account the prevailing wave direction. The proposed angle of extension into deeper water largely negates the impacts of the infrastructure on wave direction in the receiving beaches either side of Town Point (Appendix F). The chosen angle of extension also allows the required dredging to occur in a location that reduces the likelihood of sedimentation and turbidity to the regionally significant corals of the Southern Lowendal Shelf.

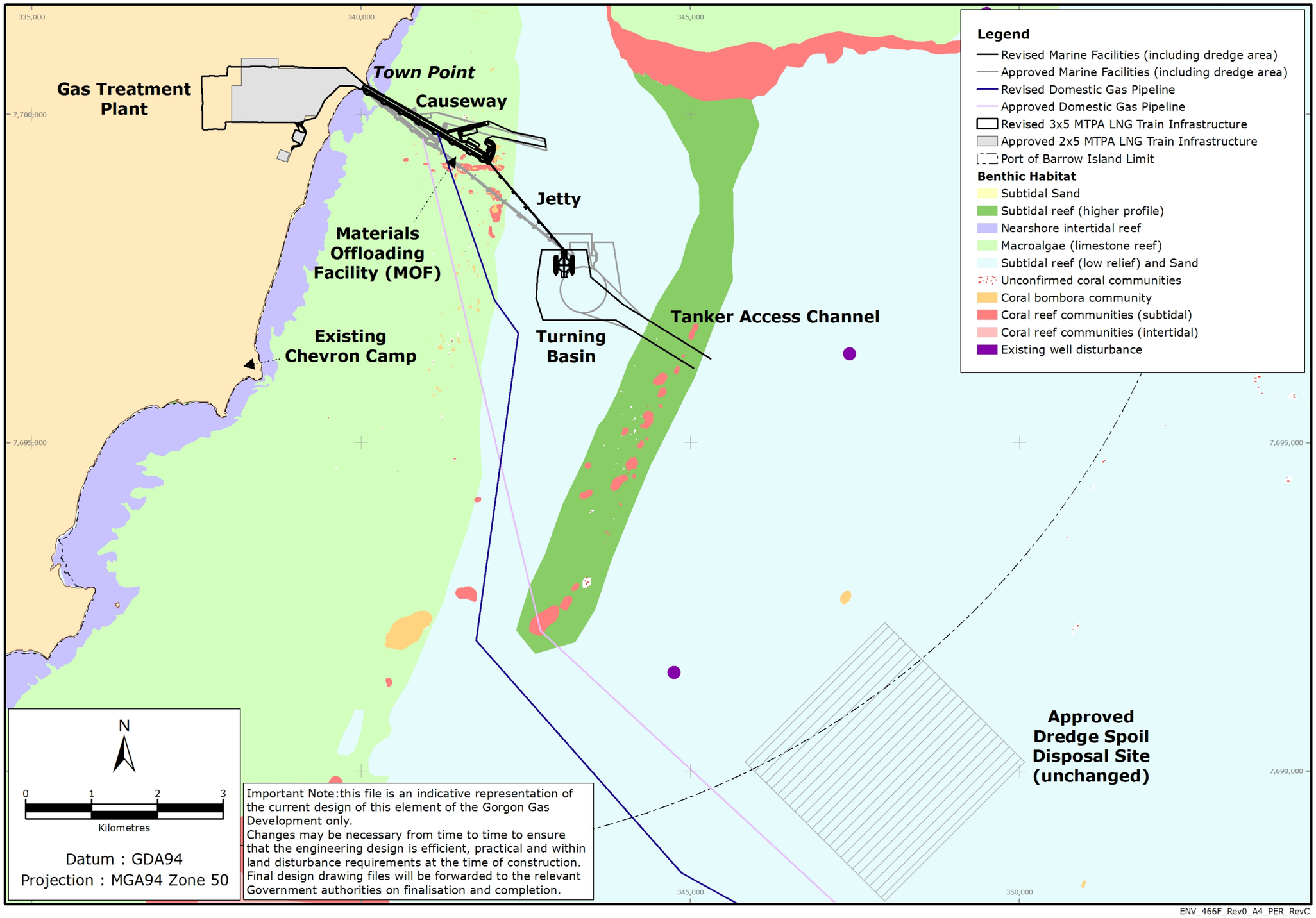

Figure 3.5: Benthic Habitats in the Vicinity of the Revised Proposal Marine Facilities

3.5.1.6 Jetty

The revised jetty is approximately 600 m shorter than the Approved design and runs south-east from the MOF to the proposed tanker loading facility. The jetty crosses macroalgal dominated subtidal pavement with scattered corals and *Porites* bombora and bare sand with sparse seagrass before terminating in the deeper soft sediments off the edge of the limestone platform. The re-alignment of the jetty as per the Revised Proposal avoids some well developed coral communities on the sub-tidal pavement. The coral reef communities within the jetty footprint comprise scattered *Porites* bombora and are of local, but not regional, conservation significance.

3.5.1.7 Dredge Areas

The Revised Proposal footprint of the MOF access channel is smaller in overall length, but similar in orientation to the Approved Development channel footprint. The eastern end of the channel begins at the same point as the Approved Development, but is reduced in length by approximately 850 m because of the revision of the causeway and MOF to extend further offshore into deeper waters. The channel footprint covers essentially the same benthic habitats as the Approved Development, but less dredging and blasting of the shallower subtidal pavement will be required.

The Revised Proposal tanker loading facility and turning basin lies to the east of the platform reef. The footprint of the revised layout for the turning basin is offset to the south-west of the Approved Development. The realignment places the turning basin in a natural depression in the seafloor, covered by the same benthic habitats as the turning basin under the Approved Development. The benthic habitats in this area comprise pavement reefs with sand veneers in approximately 10 m water depth. The sand in some areas supports relatively dense stands of seapens, but overall is mostly bare (RPS BBG 2005b).

There is no change in the location of the dredge spoil ground from the Approved Development proposal.

3.5.2 Marine Fauna

3.5.2.1 Investigations for EIS/ERMP Reporting

The majority of marine fish species have a pelagic egg and larval phase that promotes dispersal over large distances. Consequently, most species found in the vicinity of Barrow Island are widespread throughout the Indo-West Pacific region. The likely distribution of fish species of significance, within the Approved Development area and broader region (as reported in Chevron Australia 2005a), was derived from available scientific literature.

The suite of marine mammal species likely to occur in the Approved Development area was derived from a desktop review of available literature on marine species, consultation with Western Australian and federal government departments, consultation with research personnel, a review of information from previous surveys and opportunistic observations during field surveys.

Marine turtle nesting activity on beaches around Barrow Island was surveyed by beach monitoring and track identification during the 2003 – 2004 and 2004 – 2005 breeding seasons (Chevron Australia 2005a). The likely distribution of seasnakes and kraits was determined from available scientific literature.

Shorebird surveys reported in the EIS/ERMP (Chevron Australia 2005a) involved monthly counts around Barrow Island and detailed observations on the coastline north and south of Town Point. Surveys were carried out on foot by experienced observers

and birds were identified using binoculars and spotting telescopes. Shorebird assemblages expected to occur in the general vicinity of any shore crossings for the Approved Development were determined from Birds Australia listing for these areas (Birds Australia 2004).

3.5.2.2 Investigations Subsequent to EIS/ERMP Reporting

Marine fauna surveys have continued beyond those conducted for the EIS/ERMP and are ongoing. Fish, marine mammal and marine reptile habitat has been identified during general marine benthic habitat surveys and any opportunistic sightings of species of significance including fish, sharks, marine mammals and reptiles have been recorded.

Since the EIS/ERMP for the Approved Development (Chevron Australia 2005a) was completed, there has been an annual sea turtle research and monitoring program conducted in the region for Chevron Australia.

Systematic surveys undertaken for the Gorgon Gas Development over the 2005/2006 to 2007/2008 seasons have included the following seven projects that help to improve our understanding of flatback turtle population ecology on Barrow Island:

- Turtle populations nesting on beaches (Pendoley Environmental 2008a)
- Track counts on a monthly basis across the nesting season (Pendoley Environmental 2008b)
- Nest emergences including hatchling orientation to the sea (Pendoley Environmental 2008b)
- Nest (clutch) success (Pendoley Environmental 2008c)
- Satellite tracking (Pendoley Environmental 2006a, 2006b, 2008d)
- Beach sand characteristics (Pendoley Environmental 2008e)
- Light experiments (Pendoley Environmental 2007, 2008f).

Turtle Tagging

A systematic turtle tagging program over three nesting seasons from 2005 to 2008 on Barrow Island, and at Mundabullangana (on the mainland), has been undertaken to understand the numbers of flatback turtles nesting at these locations. A total of 2979 flatbacks at Barrow Island and 1060 flatbacks at Mundabullangana have been tagged while nesting during this period of time. If the number of turtles recorded is adjusted for tagging effort, Mundabullangana has a significantly higher number and density of flatback turtles nesting on beaches compared to Barrow Island. Tagging shows that flatback turtle nesting on Barrow Island is focused on central east coast beaches, which include: Mushroom, Bivalve, Terminal, and Yacht Club North and South beaches. The locations of nests on the beach at Barrow Island were recorded during the tagging program. The majority of nests were deposited on the beach flat. Flatback turtles prefer deep sandy beaches to nest in, with peak nesting occurring in the December and January period, and hatchling emergence occurring from mid-January to late-March. Few green turtles (23 recorded) and hawksbill turtles (9 recorded) were recorded from the main flatback nesting beaches over the 3-year tagging period, suggesting these beaches are not used frequently by these two species for nesting.

Track Counts on a Monthly Basis across the Nesting Season

Beach track surveys have shown that flatback turtles prefer the sheltered low energy beaches along the east coast of Barrow Island. The turtles nesting adjacent to the beaches of the marine infrastructure area proposed for the Gorgon Development are almost exclusively flatback turtles. Track counts show that flatback turtle nesting is focused on central east coast beaches which include: Mushroom, Bivalve, Terminal, and Yacht Club North and South beaches. Track counts confirmed the peak of nesting occurred during the December – January periods.

Nest Emergences including Hatchling Orientation to the Sea
This project aimed to collect a baseline data set of flatback hatchling fan metrics that could be used at a later date as a monitoring tool during the gas plant operations. These results showed the average spread angle of flatback hatchling fans (spread of footprints of all hatchlings from nest to water) significantly differed between the six beaches and ranged between 40.2° - 51.2°, while the average offset angle (angle from nest to water taken by hatchlings), values were not significantly different between beaches.

Nesting Success
The number of eggs laid during nesting was counted during 26 nesting events on Barrow Island during the 2007/2008 breeding season. Clutch size was variable (egg range between clutches = 11-72 eggs). Between nest comparisons did not find any relationship between hatching success rates and clutch size, nest depth or distance to the high tide line. Nor was there any statistical difference between the success rate of nests on Yacht Club North versus Yacht Club South nests, or between beach flat and dune nests.

Satellite Tracking
Satellite tracking of at least some adult (females) flatback turtles shows they use a variety of inshore and offshore marine areas off the east, and to some degree west, coasts of Barrow Island. Internesting habitat at Barrow Island has been inferred from satellite tracking data. Females inter-nest close to their nesting beaches, typically in 0 – 10 m of water, however, flatback turtles also travel approximately 70 km and inter-nest in shallow nearshore water off the adjacent mainland coast, before returning to Barrow Island to lay another clutch of eggs. Average internesting period is 13-16 days.

Following the nesting period, females have been shown to migrate up to 1500 km away from Barrow Island, with many individuals migrating to waters off the Kimberley coastline. The analysis shows that non-breeding flatback turtles spend most of their time in water 25 - 100 m deep. The information on the migratory routes and (presumed) foraging ground locations indicate that flatback turtles do not favour the near shore shallow water near the mainland coast as suggested by the literature and in fact may spend more time in deep clear water than was previously thought. The results also suggest that flatback turtles may not travel to a single (presumed) foraging ground at the end of their breeding migration and that some may in fact forage in a range of areas before returning to Barrow Island to nest the following season.

Beach Sand Characteristics
Beach sand characteristics have been assessed on the basis of parameters (pH, Total Organic Carbon, Moisture, particle size distribution) that are indicative of sands where a nest chamber is located (Pendoley Environmental 2008e). The parameters of pH, grain size and TOC were similar across all sampled beaches and sampled depths, although grain size in sub-surface sand at Bivalve Beach was higher than at subsurface locations at other beaches.

Light Experiments
The results of the wavelength discrimination study are important as this data can be used to identify the specific light wavelengths that flatback sea turtles are most, and least, sensitive to. Operationally these results will provide guidance to the design engineer when selecting specific lights for the Gorgon plant and jetty. This work has shown that flatback hatchlings will select short wavelength light over longer wavelength light statistically more often, and they do not discriminate well between long wavelength lights (reds/oranges) vs. dark.

In a separate field experiment in 2007, a project was designed to investigate the impacts of light glow from shielded light sources using sodium vapour, fluorescent and metal halide light types on flatback sea turtle hatchlings at three different light intensities (500W, 1000 W and 1300 W). Further aims were to investigate the effect of changing light horizon elevation on flatback sea turtle hatchlings, and to test the effects of vibrations on hatchling orientation. This study has shown for the first time that flatback hatchlings are able to both see and to respond to sky glow resulting from high pressure sodium, metal halide and fluorescent luminaires at intensities ranging from 500 W – 1300 W (with the single exception of 500 W HPS) when these lights are positioned 150 m distant to hatchlings, and when glow is positioned at an elevation of 1° above the dune. The management implication of this is that lights must be screened from nesting beaches, light intensity should be reduced as much as possible, luminaire types should exclude short wavelength emissions (Low Pressure Sodium preferred over High Pressure Sodium) and all lights containing short wavelength emissions (e.g. High Pressure Sodium, metal halide, fluorescent) should be filtered to further reduce short wavelength light.

In addition to these studies, marine turtle occurrence in the Approved Development MOF and LNG approach channels was surveyed in August 2006 to quantify marine turtle use of the benthic areas during the non-breeding times of the year; no turtles were found in this area (RPS BBG 2006h). The locations of the approach channels for the Revised Proposal have not changed from the Approved Development.

An additional three months of survey for shorebirds around the coast of Barrow Island, including the Town Point area, was conducted in October 2005, and in February and March 2006 (RPS BBG 2006c). These surveys confirmed that the south and south-east coastline of Barrow Island are important resting areas for migratory shorebirds compared to other coastlines on the island. Bivalve Beach and Terminal Beach, which are located either side of the Revised Proposal MOF, causeway and jetty facilities, do not support large aggregations of shorebirds.

3.5.2.3 Description of Marine Fauna

The marine fauna of Barrow Island is highly diverse, and includes a wide variety of tropical and subtropical fish, mammals, reptiles, avifauna and invertebrates.

A number of species of marine fauna that occur in the areas covered by the Revised Proposal are listed as threatened and/or migratory under the EPBC Act and are thus considered to be matters of NES. Additionally, there are species or biological communities that are not considered to be matters of NES, but are recognised as 'key receptor species'. These species were originally identified for the Approved Development to represent species and biological communities that occupy similar ecological niches. These matters of NES and the key receptor species are also used for the Revised Proposal. There are no additional species known to be affected by the Revised Proposal.

Marine fauna that are matters of NES, and/or recognised as key receptor species, that are likely to occur within the Revised Proposal area include fish, mammals, reptiles, avifauna and general marine taxa. These are described in the following sections.

3.5.2.4 Fish

The majority of fish species found around Barrow Island are widespread throughout the Indo-West Pacific region, however, some species are protected by legislation as they are migratory, endangered or subject to fishing pressure.

No areas of regional importance to fish were identified during seabed surveys of the development area associated with the Revised Proposal.

Fish likely to inhabit waters near the Revised Proposal marine facilities include Sygnathids (pipefish, pipehorses and sea horses), sharks and reef fish. The same species were also identified for the Approved Development. The key receptors representing fish taxa for the Revised Proposal are listed in Table 3.9.

Table 3.7: Fish Likely to be in Vicinity of the Revised Proposal Marine Facilities

Species	Scientific Name	EPBC Act (Cth) Listing Status[1]	State (WA) Level Protection [2, 3]	Matters of NES	Key Receptor	Likely to be Found in Revised Proposal Area
Whale shark	*Rhincodon typus*	Vulnerable Listed migratory	Part 2[2]	Yes	Yes	Yes
Great white shark	*Carcharodon carcharias*	Vulnerable Listed migratory	Schedule 1[3] Part 2[2]	Yes		
Grey nurse shark	*Carcharias taurus*	Vulnerable	Schedule 1[3] Part 1[2]	Yes		
Rock pipefish	*Phoxocampus belcheri*	Listed marine	Not listed		Yes	Yes
Potato cod	*Epinephelus tukula*	Not listed	Part 2[2]		Yes	Yes

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed in Schedule 2 of the Fish Resources Management Act 1994 (WA).
[3] As listed under the Wildlife Act (WA).

Sygnathids are widely distributed in Western Australian waters, but there is limited information on the distribution of individual species within the region. Approximately 30 species of pipefish and seahorse occur in the Barrow Island area. These species are expected to be widespread through the shallower benthic areas of the Revised Proposal area (i.e. in the nearshore areas of the causeway). The rock pipefish (*Phoxocampus belcheri*) is known to occupy shallow rock pools along the east coast of Barrow Island. This species was selected as the key receptor for all Sygnathids and is protected under the EPBC Act as a listed marine species.

Numerous species of shark are likely to be present in the Revised Proposal area, including three that are matters of NES: the whale shark (*Rhincodon typus*), great white shark (*Carcharodon carcharias*) and grey nurse shark (*Carcharias taurus*). Grey nurse sharks are expected off the west coast of Barrow Island and great white sharks may rarely be encountered around the Island.

The whale shark was selected as the key receptor for sharks. Whale sharks are listed as Vulnerable and Migratory under the EPBC Act and are protected under the Wildlife Act and the *Fisheries Resource Management Act 1994* (WA). Whale sharks occur periodically along the northern Western Australian coast, including the Montebello/Lowendal/Barrow Island region. Whale sharks congregate each year between March and April off Ningaloo Reef, approximately 150 km south-west of Barrow Island, and are expected to occasionally visit the deeper areas of the Revised Proposal, particularly the areas around the tanker access channel and tanker turning basin.

A wide variety of reef fish are known to occur in the Revised Proposal marine footprint. The potato cod (*Epinephelus tukula*) was selected as the key receptor to represent reef

fish. Potato cod are likely to occur in deeper areas of coral reef within the Revised Proposal and are protected under the Wildlife Act and the *Fisheries Resource Management Act 1994* (WA).

3.5.2.5 Marine Mammals

The region supports migratory, transient and resident marine mammals such as whales, dolphins and dugong. The regional distribution of many whale species is not well understood and while many species may occur in the Pilbara region, most are likely to be transients or occasional visitors.

Marine mammals that are likely to be found in the vicinity of the Revised Proposal marine facilities are baleen whales, toothed whales, inshore dolphins, offshore dolphins and dugongs. The same species were also identified for the Approved Development.

The key receptors representing marine mammal taxa for the Revised Proposal are listed in Table 3.10.

Table 3.8: Marine Mammals Likely to be in Vicinity of the Revised Proposal Marine Facilities

Species	Scientific Name	EPBC Act (Cth) Listing Status[1]	State (WA) Level Protection[2]	Matters of NES	Key Receptor	Likely to be Found in Revised Proposal Area
Humpback whale	*Megaptera novaeangliae*	Vulnerable Listed migratory Listed cetacean	Schedule 1[2]	Yes	Yes	Yes
Southern right whale	*Eubalaena australis*	Endangered Listed migratory Listed cetacean	Schedule	Yes		
Blue whale	*Balaenoptera musculus*	Endangered Listed migratory Listed cetacean	Schedule 1	Yes		
Bryde's whale	*Balaenoptera edeni*	Listed migratory Listed cetacean		Yes		
Fin whale	*Balaenoptera physalus*	Vulnerable Listed migratory Listed cetacean	Schedule 1	Yes		
Sei whale	*Balaenoptera borealis*	Vulnerable Listed migratory Listed cetacean	Schedule 1	Yes		
Sperm whale	*Physeter macrocephalus*	Listed migratory Listed cetacean		Yes	Yes	
Orca	*Orcinus orca*	Listed migratory Listed cetacean		Yes		
Common dolphin	*Delphinus delphis*	Listed cetacean			Yes	
Bottlenose dolphin	*Tursiops truncatus*	Listed cetacean			Yes	Yes
Dusky dolphin	*Lagenorhynchus obscurus*	Listed migratory Listed cetacean		Yes		Yes
Irrawaddy dolphin	*Orcaella heinsohni*	Listed migratory Listed cetacean		Yes		Yes
Indo-Pacific humpack	*Sousa chinensis*	Listed migratory Listed cetacean		Yes		Yes

Species	Scientific Name	EPBC Act (Cth) Listing Status[1]	State (WA) Level Protection[2]	Matters of NES	Key Receptor	Likely to be Found in Revised Proposal Area
dolphin						
Dugong	*Dugong dugon*	Listed migratory Listed marine	Schedule 4	Yes	Yes	Yes

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed under the Wildlife Act (WA).

There are a number of whale species that may occasionally visit the region, though humpback whales are considered to be regular visitors. Most whales are more abundant in deeper waters and are expected to be rare visitors to the waters close to the western shore of Barrow Island. They are unlikely to visit the shallow, inshore waters in the vicinity of the east coast facilities. All whales are protected as listed cetaceans under the EPBC Act.

The key receptor for baleen whales is the humpback whale (*Megaptera novaeangliae*). Humpback whales are considered Vulnerable and Migratory under the EPBC Act and are also protected under the Wildlife Act. Humpback whales pass through the Montebello/Lowendal/Barrow Island region between June and October on their annual migration between their feeding grounds in Antarctic waters and their calving grounds in Pilbara/Kimberley waters. Humpback whales are more common in waters west of Barrow Island but may occasionally visit the tanker access channel and tanker turning basin.

The key receptor for toothed whales is the sperm whale (*Physeter macrocephalus*). Sperm whales are listed as a Migratory species under the EPBC Act. Sperm whales tend to be found in offshore waters (Reeves *et al.* 2002) and are unlikely to be present within the waters of the Revised Proposal.

Dolphins can be expected to occasionally visit all subtidal marine areas of the Revised Proposal. The regional distribution of most dolphin species is poorly known and while many species may occur in the Pilbara region, most are likely to be transients or occasional visitors. All dolphins are protected as listed cetaceans under the EPBC Act.

The key receptor species for inshore dolphins is the bottlenose dolphin (*Tursiops truncatus*) and the key receptor for offshore dolphins is the common dolphin (*Delphinus delphis*). Bottlenose dolphins and Indo-Pacific humpback dolphins (*Sousa chinensis*) have resident populations within the shallow waters of the inner Rowley Shelf, including Barrow Island. Common dolphins, spinner dolphins (*Stenella longiostris*) and striped dolphins (*Stenella coeruleoalba*) are also abundant in the waters around Barrow Island, but these are generally oceanic species and are more likely occur on the west coast of the Island rather than near the Revised Proposal.

Dugongs occur throughout the shallow waters between the Pilbara offshore islands and the mainland. Dugongs are generally associated with shallow seagrass meadows on which they feed and have been observed in the shallow waters over the Barrow Shoals, along the east coast of Barrow Island and over the Lowendal Shelf. Dugongs are protected under the Wildlife Act and are listed as Vulnerable under the EPBC Act. They are likely to be occasional visitors to any area of subtidal seagrass in the vicinity of the Revised Proposal.

3.5.2.6 Marine Reptiles

Six species of sea turtle are known from the Montebello/Lowendal/Barrow Island region, all of which are protected under the International Bonn Convention, EPBC Act and the Wildlife Act. Barrow Island is also a regionally important nesting area for green turtles and flatback turtles. Sea turtles in the region generally migrate over large distances and return to the same area to breed. The region also supports foraging grounds for turtles that nest elsewhere in Western Australia.

The key receptors representing marine reptile taxa for the Revised Proposal are listed in Table 3.11.

Table 3.9: Marine Reptiles in Vicinity of Revised Proposal Marine Facilities

Species	Scientific Name	EPBC Act (Cth) Listing Status[1]	State (WA) Level Protection [2]	Matters of NES	Key Receptor	Likely to be Found in Revised Proposal Area
Green turtle	*Chelonia mydas*	Vulnerable Listed migratory Listed marine	Schedule 1	Yes	Yes	Yes
Flatback turtle	*Natator depressus*	Vulnerable Listed migratory Listed marine	Schedule 1	Yes	Yes	Yes
Olive Ridley turtle	*Lepidochelys olivacea*	Endangered Listed migratory Listed marine	Schedule 1	Yes		
Loggerhead turtle	*Caretta caretta*	Endangered Listed migratory Listed marine	Schedule 1	Yes		
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable Listed migratory Listed marine	Schedule 1	Yes		Yes
Leatherback turtle	*Dermochelys coriacea*	Vulnerable Listed migratory Listed marine	Schedule 1	Yes		
Olive sea snake	*Aipysurus laeivs*	Listed marine			Yes	Yes

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed under the Wildlife Act (WA).

Hawksbill turtles nest at low densities around the Island and loggerhead turtles have been only occasionally recorded from the Island. The key receptors for marine reptiles are the green turtle (*Chelonia mydas*), flatback turtle (*Natator depressus*) and olive sea snake (*Aipysurus laevis)*. The green turtle and flatback turtle are listed as Vulnerable, Migratory and Marine under the EPBC Act. Olive sea snakes are a listed Marine species under the EPBC Act. Both sea turtle species and the olive sea snake are likely to be observed near the revised marine facilities. This is consistent with the description for the Approved Development (Chevron Australia 2005a).

The flatback turtle (*Natator depressus*) is the second most abundant species of sea turtle in northern Western Australia (Pendoley 1997). Regionally important flatback turtle rookeries in Western Australia include Cape Thouin/Mundabullangana Station, Barrow Island, the Lacepede Islands, Dampier Archipelago, Port Hedland, the Montebello Island and the Lowendal Islands (Limpus 2004a).

Town Point Beach is an important rookery for flatback turtles. Flatback turtles nest typically at Barrow Island between November and February (Pendoley 2005) and female flatback turtles are present on the beaches and in the nearshore waters around Town Point during this period.

Flatback turtle hatchlings emerge from their nests six to eight weeks after egg-laying and the hatchlings are present on the beaches and in the waters around the Revised Proposal marine facilities at Town Point between December and April.

Flatback turtles are a key receptor species for sea turtles that nest on the east coast of Barrow Island (i.e. flatback and hawksbill turtles). Flatback turtles are protected under the Wildlife Act and are listed as Vulnerable and Migratory under the EPBC Act.

Resident foraging green and flatback turtles also occupy the waters around the Revised Proposal marine facilities and others areas around Barrow Island throughout the year. Green turtles are herbivorous and graze on algae and seagrass, whereas flatback turtles are carnivorous and forage primarily on soft-bodied invertebrates such as soft corals, sea pens and holothurians. Macroalgae are abundant on the subtidal limestone pavement around the Revised Proposal marine facilities and throughout the nearshore waters of Barrow Island, whereas seagrass meadows are generally sparse and not extensive near the Revised Proposal marine facilities. Soft corals are widespread on the subtidal limestone pavement and there are limited areas of seapens within the area designated for the Revised Proposal turning basin.

Storr *et al* (1986) estimate nine genera and 22 species of sea snakes and kraits occur in Western Australian waters. Sea snakes are highly mobile and are likely to occasionally visit all of the deep offshore, shallow offshore and mainland development areas. Sea snakes are common inhabitants of the waters around Barrow Island and the shallow Rowley Shelf (Chevron Australia 2005a). Sea snakes do not appear to be territorial or migratory and are not generally found in association with specific habitats. Little is known of the distribution of individual species along the east coast of Barrow Island.

The olive sea snake (*Aipysurus laeivs*) is common on the east coast Barrow Island and is the key receptor for sea snakes for the Revised Proposal. The olive sea snake is a Listed Marine species under the EPBC Act.

3.5.2.7 Marine Avifauna

Barrow Island supports numerous species of migratory shorebirds as well as resident shorebirds. Many of these species are protected under International treaties (e.g. JAMBA, CAMBA, ROKAMBA). Barrow Island is both a staging site and an important non-breeding site for migratory shorebirds. The highest abundance of shorebirds on Barrow Island, with over two-thirds of records for most species, is associated with the south-eastern and southern coasts of the Island.

Marine avifauna that is likely to be observed near the Revised Proposal marine facilities includes migratory shorebirds, migratory seabirds and littoral raptors. The same marine avifauna was described for the Approved Development Chevron Australia 2005a).

The key receptors representing marine avifauna taxa for the Revised Proposal are listed in Table 3.12.

Table 3.10: Marina Avifauna in Vicinity of the Revised Proposal Marine Facilities

Species	Scientific Name	EPBC Act (Cth) Listing Status[1]	State (WA) Level Protection[2]	Matters of NES	Key Receptor	Likely to be Found in Revised Proposal Area
Osprey	*Pandion haliaetus*	Listed migratory Listed marine		Yes	Yes	Yes
White-bellied sea eagle	*Haliaeetus leucogaster*	Listed migratory Listed marine		Yes		Yes
Greater sand plover	*Charadrius lescheriaultii*	Listed migratory Listed marine		Yes	Yes	Yes
Lesser sand plover	*Charadrius mongolus*	Listed migratory Listed marine		Yes		Yes
Ruddy turnstone	*Arenaria interpres*	Listed migratory Listed marine		Yes		Yes
Grey-tailed tattler	*Heteroscelus brevipes*	Listed migratory Listed marine		Yes		Yes
Red-necked stint	*Calidris ruficollis*	Listed migratory Listed marine		Yes		Yes
Wedge-tailed shearwater	*Puffinus pacificus*	Listed migratory Listed marine		Yes	Yes	Yes
Bridled tern	*Sterna anaethtus*	Listed migratory Listed marine		Yes		Yes
Eastern reef egret	*Egretta sacra*	Listed migratory Listed marine		Yes		Yes
Bar-tailed godwit	*Limosa lapponica*	Listed migratory Listed marine		Yes		Yes
Eastern reef egret	*Egretta sacra*	Listed migratory Listed marine		Yes		Yes
Whimbrel	*Numenius phaeopus*	Listed migratory Listed marine		Yes		Yes
Common greenshank	*Tringa nebularia*	Listed migratory Listed marine		Yes		Yes
Common sandpiper	*Actitis hypoleucos*	Listed migratory Listed marine		Yes		Yes
Grey plover	*Pluvialis squatarola*	Listed migratory Listed marine		Yes		Yes
Caspian tern	*Sterna caspia*	Listed migratory Listed marine		Yes		Yes
Common tern	*Sterna hirundo*	Listed migratory Listed marine		Yes		Yes
Lesser crested tern	*Sterna bengalensis*	Listed migratory Listed marine		Yes		Yes

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed under the Wildlife Act (WA).

Migratory species visit coastal regions in the Pilbara from the northern hemisphere or close to the equator, and pass through the region to feed and rest during the southern and northern migrations along the East Asian-Australasian Flyway. Some species stay in the Pilbara region until ready to journey north to breed. The southern migration occurs in August-September and the northern migration in April-May. Resident species remain in the Pilbara region throughout the year, but may move around within the region.

Barrow Island is an internationally important site for migratory shorebirds because it meets the RAMSAR criterion of supporting >1 % of a species population for several

shorebird species. However, the area surrounding the Revised Proposal marine facilities at Town Point is of low importance to migratory shorebirds, compared with other parts of Barrow Island.

Studies have shown only 1% of shorebirds recorded on Barrow Island foraged on the intertidal reef platforms near the causeway of the Revised Proposal. The Town Point area is not considered of local importance to any EPBC Act listed shorebird species.

The greater sand plover is one of the most abundant species that forage at Town Point, along with the red-necked stint (*Calidris ruficollis*), grey-tailed tattler (*Heteroscelus brevipes*), ruddy turnstone (*Arenaria interpres*), bar-tailed godwit (*Limosa lapponica*), lesser sand plover (*Charadrius mongolus*), silver gull (*Chroicocephalus novaehollandiae*), common tern (*Sterna hirundo*) and the fairy tern (*Sterna nereis*) (Chevron Australia 2005a).

Cormorants (*Phalocrocorax varius*), eastern reef egrets (*Egretta sacra*), silver gulls and pied oystercatchers (*Haematopus longirostris*) roost on the rocks at Town Point. The large-eyed northern race of the sooty oystercatcher (*Haematopus fuliginosus ophthalmicus*) nests on the headland. Barrow Island is an important site for the northern race of sooty oystercatchers, with approximately 1% of the known world population. This subspecies has not been surveyed thoroughly across northern Australia and is likely to be more abundant than the current estimate indicates. With approximately 30–40 breeding pairs of this subspecies on the island, the nesting pair at Town Point represents approximately 2.5–3.3% of the northern race on Barrow Island. The pied oystercatcher, Caspian tern (*Sterna caspia*) and red-capped plover (*Charadrius ruficapillus*) may also nest in the general area surrounding Town Point.

The greater sand plover (*Charadrius leschenaultii*) is the key receptor for migratory shorebirds and is listed as Migratory under the EPBC Act.

Double Island, located approximately 5 km north of Town Point (Figure 3.1), is a regionally significant rookery for bridled terns (*Sterna anaethetus*) and a locally significant rookery for wedge-tailed shearwaters (*Puffinus pacificus*). The wedge-tailed shearwater rookery is small in comparison with other rookeries in the immediate region.

The wedge-tailed shearwater is the key receptor for migratory seabirds in the Revised Proposal area. This species is listed as Migratory under the EPBC Act.

Three species of littoral raptor have been recorded in the vicinity of the Revised Proposal, the osprey (*Pandion haliaetus*), white-breasted sea eagle (*Haliaeetus leucogaster*) and brahminy kite (*Haliastur indus*). The key receptor for littoral raptors is the osprey; it is listed as Migratory under the EPBC Act.

3.5.2.8 General Marine Taxa and Communities

The key receptors representing general marine taxa and communities for the Approved Development and Revised Proposal are infauna communities on soft sediments and invertebrate filter-feeding communities from hard substrates.

The key receptors representing general marine taxa for the Revised Proposal are listed in Table 3.13.

Table 3.11: Marine Fauna of National Environmental Significance and/or Key Receptor Species that may occur in the Revised Development Area

Marine Fauna	Scientific Name	EPBC Act (Cth) Listing Status[1]	State (WA) Level Protection [2]	Matters of NES	Key Receptor	Likely to be Found in Revised Proposal Area
Infauna communities	N/A	N/A	N/A	N/A	Yes	Yes
Filter-feeding communities	N/A	N/A	N/A	N/A	Yes	Yes

NOTES:
[1] As listed under the EPBC Act (Cth).
[2] As listed under the Wildlife Act (WA).

The broad intertidal reef platform and large rock pools adjacent to Town Point support diverse invertebrate assemblages typical of the east coast platform reefs. The invertebrate assemblages of the upper intertidal zone are dominated by barnacles, limpets, turbinid snails (*Turbo*), littorine (*Nodlittorina)* snails and rock oysters (*Saccostrea*). The large rock pools support a diverse assemblage of very small corals (*Turbinaria*), branching, encrusting and vasiform sponges, holothurians, hermit and portunid crabs, squid, *Octopus*, muricid clams (*Australium*, *Tridacna*), chitons, cerith snails, nudibranchs and other molluscs.

The deeper parts of the pavement reef support soft corals (*Sarcophyton*, *Lobophyton*, *Dendronephthya* and *Sinularia*) and hard corals (G*oniastrea*, *Euphyllia*, *Porites*, *Lobophyllia*, *Pleaseastrea*, *Favia*, *Favites*, *Turbinaria*, *Platygyra* and *Acanthastrea*). These taxa are all widespread along the east coast of Barrow Island.

The dense algal (*Sargassum*) bed covering the platform supports a diverse assemblage of epifauna dominated by crustaceans, molluscs, small fish and worms. No significant invertebrate assemblages occur along the Revised Proposal causeway route or within the Revised Proposal access channels.

The soft sediments within the Revised Proposal tanker-turning basin are largely bare of epifauna, with sometimes dense patches of seapens and occasional branching gorgonians. Outcropping rock on the ridge running south from Lowendal Shelf supports soft corals (*Rumphella*), seawhips (*Junceella*), gorgonians, fans, hydroids and small hard corals.

The infaunal assemblages of the Revised Proposal dredged shipping channel are expected to be similar to those in the turning basin. Epifaunal assemblages on soft sediments in the turning basin and along the access channel are dominated by seapens and echinoderms (heart urchins, seastars, crinoids and holothurians) with seapens, sponges, hydroids and occasional gorgonians on exposed hard substrates.

4.0 STAKEHOLDER CONSULTATION

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

As part of the PER process, the GJVs have actively engaged and informed a range of government and community stakeholders. This interaction allows stakeholders to develop an awareness of the Revised Proposal, and contribute to the public review process.

4.1 Identification of Stakeholders

Key stakeholders identified and consulted during the preparation of the PER document included:

Key Government agencies

- Environmental Protection Authority Service Unit (EPA SU) (WA)
- Department of Environment and Conservation (DEC) (WA)
- Department of Environment, Water, Heritage and the Arts (DEWHA) (Commonwealth)
- Department of Industry and Resources (DoIR) (WA)
- Department for Planning and Infrastructure (DPI) (WA)
- Department of Resources, Energy and Tourism (DRET) (Commonwealth)
- Department of Fisheries (WA)
- Conservation Commission of Western Australia (WA)
- Office of Development Approvals Coordination (ODAC) (WA)

Local Government Authorities

- Shire of Ashburton
- Shire of Roebourne

Community and Non-government Organisations (NGOs)

- Conservation Council of WA
- Worldwide Fund for Nature
- Australian Conservation Foundation
- Greenpeace

- Marine and Coastal Communities Network
- Waterbird Conservation Group
- Wildflower Society of Western Australia
- Australian Marine Conservation Society
- Western Australian Naturalists' Club
- Western Australian Weeds Committee
- Royal Society of Western Australia
- Pilbara Wildlife Carers Association
- Western Australian Speleological Group
- Wilderness Society of WA
- Environmental Weeds Action Network of WA
- Birds Australia (Western Australia Group)
- Care for Hedland Environmental Association
- Cape Conservation Group
- Nickol Bay Naturalists Club
- Humane Society International
- Chamber of Commerce and Industry WA
- Chamber of Minerals and Energy Western Australia
- Australian Petroleum Production and Exploration Association
- Chevron Onslow Community Reference Group

4.2 Form and Timing of Consultation

The Revised Proposal is not expected to pose any significant new or additional risks to the biodiversity and physical environment values of Barrow Island and its waters over that already approved. Consequently, relevant issues raised during the GJVs stakeholder consultation program undertaken during the Approved Development EIS/ERMP process (which commenced in 2002) have been taken into consideration in the formulation of the environmental investigations, and the scope of the assessment and preparation of the PER for the Revised Proposal.

A broad range of engagement methods were employed for the EIS/ERMP consultation process to ensure the process was inclusive and comprehensive. Engagement methods included: technical workshops; briefings and meetings; Barrow Island site visits; conferences and forums; media announcements; newsletters; and the Gorgon Project website. Stakeholders engaged included: Western Australian and Commonwealth Ministers, their advisors and agencies; regional government agencies and authorities; conservation organisations; industrial interests and organisations; and academic and scientific organisations. Key matters raised by stakeholders during the EIS/ERMP consultation process were addressed in the EIS/ERMP document.

In addition, various forms of consultation were employed to ensure broad awareness and opportunity for stakeholders to contribute to the PER process. The Referral and Environmental Scoping Documents have been made available on the Gorgon Project's website (www.gorgon.com.au) and details of the PER process have been featured in the Gorgon Project's newsletter, which is emailed to over 700 recipients each quarter.

During the preparation of the PER document (August 2008), a letter was sent to those environmental NGOs and interest groups consulted during the EIS/ERMP preparation and assessment process for the Approved Development, The letter offered to discuss the PER process with any of the groups. This communication ensured that these groups had opportunity to prepare for the proposed PER public review period in September – October 2008.

A toll-free telephone enquiry line (1800 782 957) and email address (gorgon.info@chevron.com) were established during the preparation of the PER document to allow feedback and queries to be raised directly with Gorgon Project team.

A summary of the consultation undertaken to date for the PER process is contained in Table 4.1.

Table 4.1: Summary of Community and NGO Consultation Undertaken to August 2008

Date	Stakeholder	Purpose
31 July 2008	Conservation Council of WA	Contact to highlight referral and PER process; currently awaiting meeting time to suit Conservation Council.
4 August 2008	Conservation Commission of WA	Contact to highlight referral and PER process, meeting in September.
5 August 2008	Worldwide Fund for Nature	Contact to highlight referral and PER process, currently awaiting meeting time to suit WWF.
6 August 2008	Australian Conservation Foundation (WA)	Correspondence to inform the organisation of the PER process and seek any feedback or enquiries
6 August 2008	Greenpeace	Correspondence to inform the organisation of the PER process and seek any feedback or enquiries
6 August 2008	Marine and Coastal Communities Network Waterbird Conservation Group Wildflower Society of Western Australia Australian Marine Conservation Society Western Australian Naturalists' Club Western Australian Weeds Committee Royal Society of Western Australia Pilbara Wildlife Carers Association Western Australian Speleological Group Wilderness Society of WA Environmental Weeds Action Network of WA Birds Australia (Western Australia Group) Care for Hedland Environmental Association Cape Conservation Group Nickol Bay Naturalists Club Humane Society International Chamber of Commerce and Industry WA	Correspondence to inform the organisation of the PER process and seek any feedback or enquiries

Date	Stakeholder	Purpose
	Chamber of Minerals and Energy Western Australia Australian Petroleum Production and Exploration Association	

4.3 Stakeholder Comments and Responses of Proponent

Issues raised by the various stakeholders during the Approved Development EIS/ERMP process that are relevant to the Revised Proposal have also been addressed in this PER, and specifically, the following studies investigated key areas of concern:

- **Dredge plume modelling study:** to determine the changes that may occur as a result of the revision of the dredging program.
- **Coastal process studies:** to determine the potential impact of the Revised Proposal marine infrastructure on coastal processes on the beaches adjacent to Town Point and the adjacent near-shore environment.
- **Air quality assessment:** to enable impact assessment of the addition of a third train to the Approved Development Gas Treatment Plant being constructed as part of the Revised Proposal.
- **Carbon dioxide migration or release to the surface or near-surface environment analysis:** to determine if there is any significant change to the likelihood and/or consequence of potential failure modes associated with the disposal of reservoir carbon dioxide by underground injection into the Dupuy Formation as a result of the Revised Proposal in comparison with the Approved Development.
- **Physical interaction and physical presence of infrastructure with sea turtles analysis:** to determine baseline sea turtle usage of the beaches near the marine infrastructure with the objective of assessing the significance of any effects the Revised Proposal marine facilities may have on sea turtle population viability.
- **Light assessment study:** to enable an assessment of the potential impacts of the additional light emissions from the Revised Proposal.
- **Noise assessment study:** to enable an assessment of the potential impacts of the additional noise emissions from the Revised Proposal.

4.4 Ongoing Consultation

The GJVs will continue to inform stakeholders through the remainder of the environmental assessment/approval process and also post-approval as the Project progresses. The Gorgon Project's newsletter will continue to feature updates on progress with regard to PER commitments, and the website will feature documents and content to inform the community of project-related activities.

5.0 RISK-BASED ASSESSMENT APPROACH TO ENVIRONMENTAL IMPACT ASSESSMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

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5.1 Environmental Risk Assessment Methodology for the Revised Proposal

5.1.1 Overview

Environmental risk assessment is a process that evaluates the likelihood and consequence of environmental impacts occurring as a result of exposure to one or more stressors. One of the advantages of this process is that it allows potential environmental aspects or threats to be considered on the basis of the level of potential risk to the environment. This subsequently assists in prioritising the development of management measures to achieve an overall acceptable level of risk.

The GJVs undertook a risk assessment to support the environmental impact assessment for the Approved Development. For comparative purposes, the risk assessment process for the Revised Proposal followed the same methodology that was utilised for the Approved Development and presented in the EIS/ERMP (Chevron Australia 2005a).

For both the EIS/ERMP and the PER, the environmental risk assessment was undertaken in accordance with the principles and guidelines contained in the following:

- AS/NZS 4360:2004, Risk Management
- SAA Handbook 203:2004, Environmental Risk Management – Principles And Process
- AS/NZS 3931:1998, Risk Analysis of Technological Systems – Application Guide.

The environmental risk assessment process is depicted in Figure 5.1, and is described in the following sections.

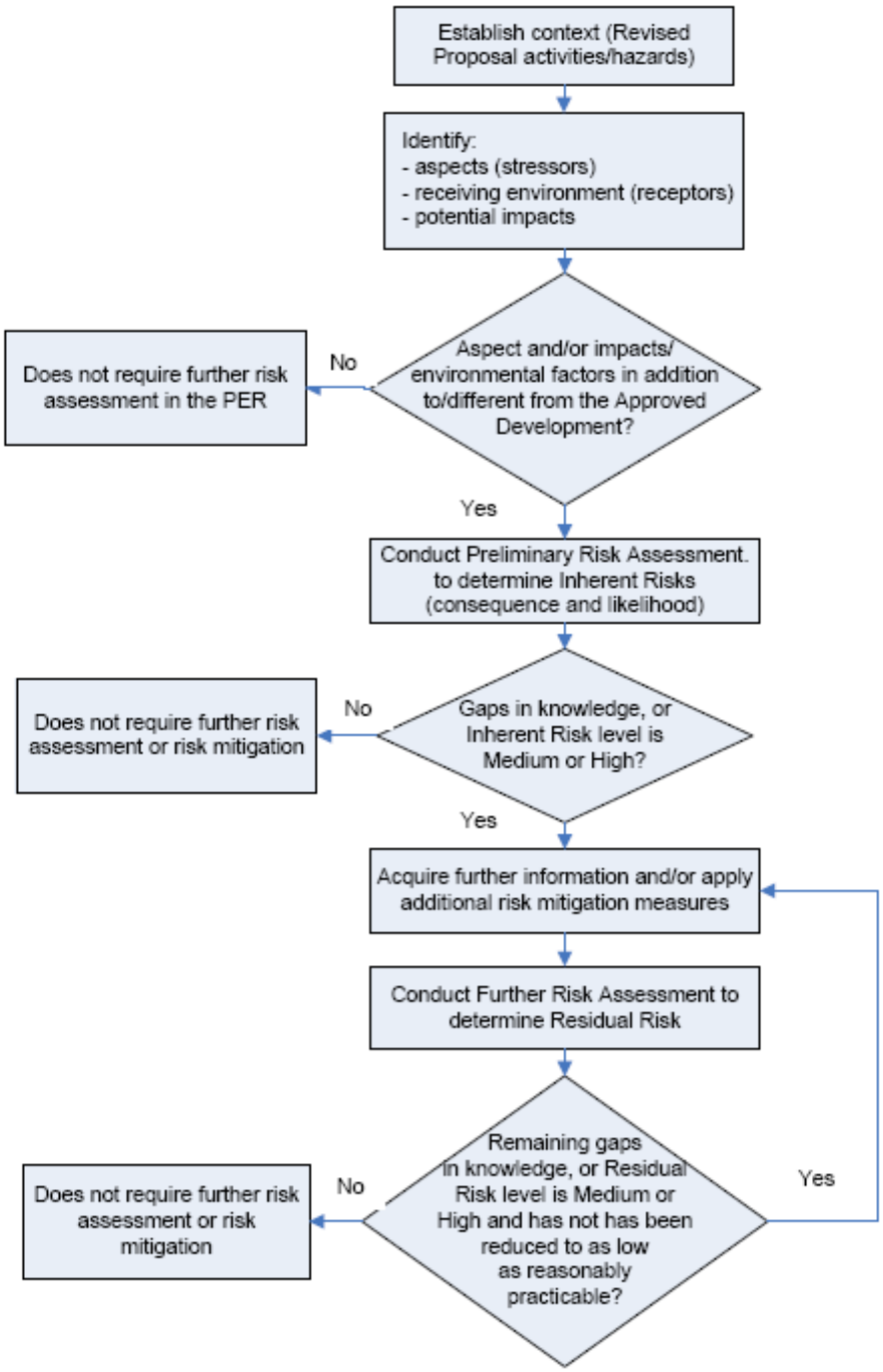

Figure 5.1: Steps in the Environmental Risk Assessment Process

5.1.2 Establishment of Risk Assessment Framework for the Revised Proposal

5.1.2.1 Identification of Activities Associated with the Revised Proposal

Activities for the Revised Proposal were grouped into key project phases:

- construction
- commissioning
- operation
- unplanned events

- non-routine operations.

5.1.2.2 Identification of Additional or Different Environmental Aspects and Impacts

A preliminary risk-based analysis was undertaken during the development of the Revised Proposal Environmental Scoping Document to identify:

- potential aspects and/or impacts that were in addition to, or different from, the Approved Development and/or may pose a significant environmental risk
- aspects and potential impacts (and the associated environmental factors) differing from those identified for the Approved Development and therefore requiring assessment in the PER (and where further data acquisition to support the assessment may be required)
- aspects and potential impacts (and the associated environmental factors) that remained unchanged from those identified for the Approved Development and therefore did not require further assessment in the PER.

During preparation of the Environmental Scoping Document for the Revised Proposal, a one day workshop was conducted on 11 April 2008, to consultatively identify the aspects, receptors and potential impacts of the Revised Proposal. This workshop was attended by officers of the Western Australian Environmental Protection Authority Service Unit (EPA SU) (as observers) and the Western Australian Department of Environment and Conservation (DEC) (as observers), specialist consultants and relevant Gorgon Project personnel.

In summary, it was determined that:

- most of the aspects and impacts associated with the Approved Development also apply to the Revised Proposal
- the Revised Proposal would result in primarily incremental environmental impacts and only a comparatively small number of different impacts when compared with the Approved Development.

A number of environmental factors were identified in the scoping phase (and presented in the Environmental Scoping Document) as not requiring further assessment in this PER because the Revised Proposal will not result in any additional or different impact to the environmental factor(s) when compared with the Approved Development. These environmental factors being:

- soils and landforms
- surface water
- groundwater.

The results from the preliminary risk-based analysis are presented in Appendix C of this PER.

5.1.2.3 Definition of Likelihood, Consequences and Risk Matrix

The risk assessment for the Revised Proposal was undertaken using the same processes and format as were used for the Approved Development. That is, the risk matrix and its defining measures of likelihood and consequence were the same as those used for the Approved Development allowing the results from the two assessments to be directly compared. These measures of likelihood and consequences and the risk matrix are presented in Table 5.1, Table 5.2, Table 5.3 and Table 5.4.

Table 5.1: Measures of Likelihood

Likelihood Category	Description
1 – Almost certain	Very likely to occur on an annual basis, includes planned activities. Socio-economic description includes the period during construction.
2 – Likely	Likely to occur more than once during the life of the proposed development.
3 – Possible	May occur within the life of the proposed development.
4 – Unlikely	Not likely to occur within the life of the proposed development.
5 – Remote	Highly unlikely and unheard of in industry, but theoretically possible.

Table 5.2: Measures of Consequence – Terrestrial

	1	2	3	4	5
	Critical	**Major**	**Serious**	**Moderate**	**Minor**
Soils and Landform	Widespread contamination that cannot be readily remediated and/or; Major changes in regional recharge patterns and/or; Regional loss of a unique landform.	Widespread contamination requiring a significant probability of the event occurring, the receptor being present and the resultant long-term remediation effort and/or; Widespread, long-term change in soil characteristics and/or; Minor changes in regional recharge patterns and/or; Widespread loss of a unique landform habitat.	Local contamination that cannot be readily remediated and/or; Local, long-term, or widespread, short-term change in soil characteristics and/or; Major, widespread changes in sub-catchment recharge patterns and/or; Widespread loss of well-represented landform habitats and/or; Local loss of a unique landform habitat.	Local contamination requiring a long-term remediation effort and/or; Local, short-term change in soil characteristics and/or; Local and major change in recharge patterns within sub-catchments and/or; Widespread and minor changes in recharge patterns and/or; Local loss of well-represented landform habitats.	Local contamination that can be readily remediated and/or; Negligible impact to soil characteristics and/or; Local and minor change in recharge patterns within sub-catchments and/or; Disturbance of well-represented landform habitats.
Restricted Flora and Vegetation	Widespread and long-term decrease in abundance of flora or impact to community structure and/or; Extinction on Barrow Island, or reduced viability in the immediate region.	Widespread and long-term decrease in abundance of flora or impact to community structure and/or; Reduction in viability of taxon or community on Barrow Island.	Widespread, short-term or local, long-term decrease in abundance of flora or impact to community structure and/or; Reduced viability of community taxon in local area, no reduction in viability on Barrow Island.	Widespread, short-term or local, long-term decrease in abundance of flora or impact to community structure and/or; No reduction in community/taxon viability in local area.	Local and short-term decrease in abundance of flora or impact on community structure and/or; Sub-lethal physiological impacts.
General Flora and Vegetation	Widespread and long-term decrease in abundance of flora or impact to community structure and/or; Extinction in immediate area.	Widespread and long-term decrease in abundance of flora or impact to community structure and/or; Extinction on Barrow Island, or reduced viability in the immediate region.	Widespread and long-term decrease in abundance or flora or impact to community structure and/or; Reduced viability of taxon or community on Barrow Island.	Widespread, short-term or local, long-term decrease in abundance of flora or impact to community structure and/or; Reduced viability of community or taxon in local areas, no reduction in viability on Barrow Island.	Widespread, short-term or local, long-term decrease in abundance of flora or impact to community structure and/or; Sub-lethal physiological impacts and/or; No reduction in community or taxon viability in local area.

	1	2	3	4	5
	Critical	**Major**	**Serious**	**Moderate**	**Minor**
Listed Terrestrial Fauna	Widespread, long-term impact to population and/or; Extinction of Barrow Island race.	Local, long-term or widespread, short-term impact leads to loss of local population/s and reduced viability of the race on Barrow Island.	Widespread, long-term behavioural impact and/or; Local, long-term or widespread short-term decrease in abundance and/or; Loss of individuals leads to reduction in viability of local population and/or; No reduction in viability of race on Barrow Island.	Local, long-term or widespread, short-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Loss of small number of individuals without reduction in local population viability.	Local, short-term behavioural impact and/or; Local, short-term decrease in abundance and/or; No lasting effects on local population.
General Terrestrial Fauna	Loss from immediate region.	Widespread, long-term impact on population and/or; Extinction on Barrow Island.	Local, long-term or widespread, short-term impact leads to loss of local population/s and reduced viability on Barrow Island.	Widespread, long-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Loss of individuals leads to reduction in viability of local population and/or; No reduction in viability on Barrow Island.	Local, long-term or widespread, short-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Loss of small number of individuals without reduction in local population viability.
Subterranean Fauna	Loss from immediate region.	Widespread, long-term impact on population and/or; Extinction on Barrow Island.	Local, long-term or widespread, short-term impact leads to loss of local population/s and reduced viability on Barrow Island.	Widespread, long-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Loss of individuals leads to reduction in viability of local population and/or; No reduction in viability on Barrow Island.	Local, long-term or widespread, short-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Loss of small number of individuals without reduction in local population viability.

	1	2	3	4	5
	Critical	**Major**	**Serious**	**Moderate**	**Minor**
Surface Water	Regional, long-term reduction in water quality.	Regional, short-term reduction in water quality.	Widespread, long-term reduction in water quality.	Minor reduction in water quality which is widespread, short-term or local, long-term and/or; Major reduction in water quality which is local, short-term.	Local, short-term or minor reduction in water quality.
Groundwater	Regional, long-term reduction in water quality.	Regional, short-term reduction in water quality.	Widespread, long-term reduction in water quality.	Minor reduction in water quality which is widespread, short-term or local, long-term and/or; Major reduction in water quality which is local, short-term.	Local, short-term or minor reduction in water quality.
Air Quality	Regional, long-term change in air quality.	Regional, short-term change in air quality.	Widespread, long-term exceeding of standards.	Minor exceeding of standards that is widespread, short-term or local, long-term and/or; Major exceeding of standards which is local, short-term.	Local, short-term or minor exceeding of standards.

Table 5.3: Measures of Consequence – Marine

	1	2	3	4	5
	Critical	**Major**	**Serious**	**Moderate**	**Minor**
Restricted and Significant Marine Benthic Primary Producer Communities	Widespread and long-term decrease in abundance or impact to a community and/or; Extinction on Barrow Island, within mainland management unit, or in surrounding waters or reduced viability in the immediate region.	Widespread and long-term decrease in abundance or impact to a community and/or; Reduced viability of taxon or community in waters surrounding Barrow Island.	Widespread, short-term or local, long-term decrease in abundance or impact to a community and/or; Reduced viability in a local area and/or; No reduction in community or taxon viability in waters surrounding Barrow Island.	Widespread, short-term or local, long-term decrease in abundance or impact to a community and/or; No reduction in community or taxon viability in local area.	Local and short-term decrease in abundance or impact to a community.
General Benthic Primary Producer Taxa and Communities	Widespread and long-term decrease in abundance or impact to a community and/or; Extinction in immediate region.	Widespread and long-term decrease in abundance or impact on a community and/or; Extinction on Barrow Island, within mainland management unit, or in surrounding waters or reduced viability in the immediate region.	Widespread and long-term decrease in abundance or impact to a community and/or; Reduced viability of taxon or community in waters surrounding Barrow Island.	Widespread, short-term or local, long-term decrease in abundance or impact to a community and/or; Reduced viability in local area and/or; No reduction in community or taxon viability in waters surrounding Barrow Island.	Widespread, short-term or local, long-term decrease in abundance or impact to a community and/or; No reduction in community or taxon viability in local area.
Listed Marine Fauna and Benthic Communities or Evolutionary Significant Units	Widespread, long-term impact to population and/or; Extinction on Barrow Island or reduced viability in the immediate region.	Local, long-term or widespread, short-term impact to population and/or; Reduced population viability on Barrow Island or in surrounding waters.	Widespread and long-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Reduced local population viability and/or; No reduction in population viability on Barrow Island or in surrounding waters.	Widespread, short-term or local, long-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; No reduction in local population viability.	Local and short-term behavioural impact and/or; Local and short-term decrease in abundance.

	1	2	3	4	5
	Critical	**Major**	**Serious**	**Moderate**	**Minor**
General Marine Fauna and Benthic Communities	Extinction in the immediate region.	Widespread, long-term impact to population and/or; Extinction on Barrow Island or reduced viability in the immediate region.	Widespread, long-term or widespread, short-term impact to population and/or; Reduced population viability on Barrow Island or in surrounding waters.	Widespread and long-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; Reduced local population viability and/or; No reduction in population viability on Barrow Island or in surrounding waters.	Widespread, short-term or local, long-term behavioural impact and/or; Local, long-term or widespread, short-term decrease in abundance and/or; No reduction in local population viability.
Marine Water Quality	Regional, long-term reduction in water quality.	Regional, short-term reduction in water quality.	Widespread, long-term reduction in water quality.	Small reduction in water quality which is widespread, short-term or local, long-term and/or; Large reduction in water quality which is local, short-term.	Local, short-term or small reduction in water quality.
Seabed (Subtidal and Intertidal) and Foreshore	Widespread contamination or disturbance that cannot be readily rectified and/or; Regional loss of a unique landform habitat.	Widespread contamination or disturbance requiring a significant long-term restoration effort and/or; Widespread, long-term change in benthic substrate characteristics and/or; Widespread loss of a unique landform habitat.	Localised contamination or disturbance that cannot be readily rectified and/or; Local, long-term, or widespread, short-term change in benthic substrate characteristics and/or; Widespread loss of well-represented landform habitats and/or; Local loss of a unique landform habitat.	Localised contamination or disturbance requiring a long-term restoration effort and/or; Local, short-term change in benthic substrate characteristics and/or; Local loss of well-represented landform habitats.	Localised contamination of low metabolic effect, or disturbance that can be readily rectified and/or; Negligible impact to benthic substrate characteristics and/or; Disturbance of well-represented landform habitats.

Table 5.4: Risk Matrix

Likelihood Category	Consequence Category: 5 Minor	4 Moderate	3 Serious	2 Major	1 Critical
1 Almost certain					
2 Likely					
3 Possible					
4 Unlikely					
5 Remote					

Low risk | Medium risk | High risk

5.1.3 Preliminary Environmental Risk Assessment to Determine Inherent Risk

Subsequent to the identification of environmental aspects, receptors and potential impacts of the Revised Proposal (undertaken during the scoping phase – Section 5.1.2.2), a Preliminary Environmental Risk Assessment was conducted to determine the inherent level of risk associated with the impacts identified for the Revised Proposal that were in addition to or different from the Approved Development. This process involved assessing the environmental risk posed by aspects of the proposal to the receptor (e.g. environmental factor) and assumed familiar management practices were applied. This preliminary environmental risk assessment was undertaken by relevant Gorgon Project subject matter experts and the results are presented in Appendix C.

Following this Preliminary Environmental Risk Assessment process, some potential impacts were found to be of a low level of risk, and therefore did not warrant further assessment in the PER. Potential impacts that were considered to be low risk are presented in Appendix C of this PER, but are not assessed in detail in this document.

5.1.4 Further Assessment of Potentially Significant Impacts and Determination of Residual Risk

Those aspects that were assessed as having potentially significant impacts (i.e. determined in the Preliminary Environmental Risk Assessment as being of Medium to High level of Inherent Risk) were further assessed by Gorgon Project subject matter experts during preparation of the PER in order to determine the extent of environmental impact(s). This assessment drew on existing data and/or specific investigations and/or modelling that was conducted to support the impact assessment. The assessment considered:

- the additional or different impacts associated with the Revised Proposal (compared to the Approved Development), as well as
- cumulative impact/s of the Gorgon Development as a whole (i.e. Approved Development and the Revised Proposal).

A Further Assessment of Residual Environmental Risk was then conducted based on:

- the impact assessment undertaken
- the application of environmental management measures and/or environmental offsets proposed.

The level of Residual Risk was assessed via workshops held on 19 and 20 June 2008 and attended by officers of the Commonwealth DEWHA, the Western Australian EPA Service Unit (as observers) and DEC (as observers), and Gorgon Project subject matter experts. The 'Predicted Environmental Risk' sections in each of the environmental factor sections of the PER (Sections 6.1.5, 6.2.5, 6.3.5, 7.1.5, 7.2.4, 7.3.4, 7.4.4) contains a discussion of the predicted Residual Risks.

The results of the workshops can be put into two categories:

1. Aspects requiring no further assessment - A number of additional environmental aspects were assessed as requiring no further assessment or discussion in the environmental factor sections of the PER. These were aspects that resulted in a Residual Risk ranking of Low and were assessed by the workshop attendees (including DEC, EPA SU and DEWHA observers) as requiring no further discussion in this PER. Aspects which fell into this category are listed in Table 5.5. Appendix C contains the Risk Assessment Tables that were used to record the findings of the workshops.

2. Aspects requiring further assessment - A number of environmental aspects were considered to require further analysis as the initial assessment suggested an increase in the Residual Risk ranking when compared to the Approved Development. However, as the assessment was conducted pending completion of studies or modelling that were still in progress at that time, the assessed Residual Risk levels were considered to be *tentative* until such time as the studies and modelling were completed. The Gorgon Project team (including subject matter experts) subsequently used the results of the studies and modelling to re-assess the accuracy of the Residual Risk rankings. Accordingly, the level of impact (consequence) for some Residual Risk levels discussed in the following sections of the PER, differ from the perceived impact (consequence) levels as they were recorded at the Residual Risk assessment workshops held on 19 and 20 June 2008 and presented in Appendix C. Explanation of these specific differences is provided in the relevant sections of this PER. These updated Residual Risk rankings (if required) are referred to in the PER Risk Assessment Tables as *Completed Residual Risk*.

Table 5.5: Summary of Aspects and Associated Environmental Factors (Residual Risk Assessment)

Aspect	Associated Environmental Factors	Conclusion Following Residual Risk Assessment Workshops	How Dealt with in PER
Aspects and associated environmental factors requiring further data acquisition and assessment in the PER (As listed in PER Environmental Scoping Document)			
Air emissions (other than dust)	Air quality and greenhouse gas emissions	The Revised Proposal may result in additional impacts to this environmental factor in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further data acquisition and shall be assessed/discussed in the PER.	Section 9 – Air Emissions – Risks and Management
	Flora and vegetation	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. These aspects and associated environmental factors will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
	Soils and landform		
	Terrestrial fauna		
CO_2 migration or release to the surface or near-surface environment	Terrestrial fauna	The Revised Proposal is not anticipated to result in any additional impacts to these environmental factors from the Approved Gorgon Gas Development (based on continuing research into CO_2 behaviour within the Dupuy Reservoir). There is likely to be community/public interest in this component of the development, and so this aspect and associated environmental factors shall be subject to further assessment/discussion in the PER utilising existing data/information	Section 12 – Greenhouse Gas Emissions – Risks and Management
	Subterranean fauna		
	Flora and vegetation		
	Soils and landform	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. These aspects and associated environmental factors will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
Physical disturbance of seabed	Marine primary producers	The Revised Proposal may result in additional impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further data acquisition and shall be assessed/discussed in the PER.	Section 7 – Marine and Coastal Environment – Risks and Management
	Physical environment – seabed (subtidal and intertidal) and foreshore)		
	Marine water quality		
Physical presence of infrastructure	Marine primary producers	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.

Aspect	Associated Environmental Factors	Conclusion Following Residual Risk Assessment Workshops	How Dealt with in PER
		This aspect and associated environmental factor will not be further assessed in the PER.	
	Marine fauna	The Revised Proposal may result in incremental additional impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. These aspects and associated environmental factor shall be subject to further data acquisition and shall be assessed/discussed in the PER	Section 7 – Marine and Coastal Environment – Risks and Management
	Physical marine environment (including intertidal environment)		
	Beach environment		
Physical interaction	Marine fauna		
Aspects and associated environmental factors not requiring further data acquisition but will be addressed or analysed in the PER (As listed in PER Environmental Scoping Document)			
Vegetation clearing	Flora and vegetation	The Revised Proposal may result in incremental additional impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. There is likely to be community/public interest in vegetation clearing, and so this aspect and associated environmental factors shall be further assessed in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
	Terrestrial fauna		Section 6 – Terrestrial Environment – Risks and Management
Site disturbance/ excavation	Terrestrial fauna	The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factors shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
	Subterranean fauna		Section 6 – Terrestrial Environment – Risks and Management
Fire	Flora and vegetation	The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factors shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
	Terrestrial fauna		Section 6 – Terrestrial Environment – Risks and Management
Liquid and solid waste disposal	Terrestrial fauna	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factor will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
Spills and leaks	Soils and landform	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factors will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
	Surface water		
	Groundwater		
	Flora and vegetation		
	Terrestrial fauna		
	Water and sediment quality		
	Subterranean fauna	The Revised Proposal may result in some	Section 6 – Terrestrial

Aspect	Associated Environmental Factors	Conclusion Following Residual Risk Assessment Workshops	How Dealt with in PER
		incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factors shall be subject to further assessment in the PER utilising existing data/information.	Environment – Risks and Management
	Marine primary producers		Section 7 – Marine and Coastal Environment – Risks and Management
	Marine fauna		Section 7 – Marine and Coastal Environment – Risks and Management
Dust emissions	Flora and vegetation	The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factors shall be subject to further assessment in the PER utilising existing data/information.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
	Air quality		
	Terrestrial fauna	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factor will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
Physical presence of infrastructure	Terrestrial fauna	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factor will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
Physical interaction	Terrestrial fauna	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
Creation of shade	Terrestrial fauna	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factor will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.

Aspect	Associated Environmental Factors	Conclusion Following Residual Risk Assessment Workshops	How Dealt with in PER
Hot and/or cold emissions	Terrestrial fauna	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
Noise and vibration emissions	Terrestrial fauna	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. .	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information. Section 11 contains an assessment of the predicted residual environmental risk associated with noise emissions.
	Marine fauna		Section 7 – Marine and Coastal Environment – Risks and Management
	Subterranean fauna	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
Light emissions	Terrestrial fauna	The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factors shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
	Marine fauna		Section 7 – Marine and Coastal Environment – Risks and Management
Introduction and/or spread of non-indigenous species (quarantine)	Terrestrial fauna Marine fauna Marine primary producers	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. .	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information. Section 8 contains information on Quarantine Management and Risks.
	Flora and vegetation	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in	Section 8 - Quarantine Management and

Aspect	Associated Environmental Factors	Conclusion Following Residual Risk Assessment Workshops	How Dealt with in PER
		comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further assessment in the PER utilising existing data/information.	Risks
Physical disturbance of seabed	Marine fauna	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further assessment in the PER utilising existing data/information.	Section 7 – Marine and Coastal Environment – Risks and Management
Air emissions	Water and sediment quality	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factor will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
CO_2 migration or release to the marine environment	Water and sediment quality Marine primary producers	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factors will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
Aspects and associated environmental factors not requiring further assessment in the PER (As listed in PER Environmental Scoping Document)			
Vegetation clearing	Subterranean fauna	The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development. This aspect and associated environmental factor shall be subject to further assessment in the PER utilising existing data/information.	Section 6 – Terrestrial Environment – Risks and Management
	Soils and landform	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to this environmental factor in comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. This aspect and associated environmental factor will not be further assessed in the PER.	No additional discussion considered necessary in PER. Refer to Appendix C for Risk Assessment information.
Site disturbance/ excavation	Soils and landform Surface water	Assessed as Low Risk. The Revised Proposal may result in some incremental additional and/or different impacts to these environmental factors in	No additional discussion considered necessary in PER. Refer to
Runoff	Surface water		

Aspect	Associated Environmental Factors	Conclusion Following Residual Risk Assessment Workshops	How Dealt with in PER
	Subterranean fauna	comparison to the Approved Gorgon Gas Development, but these impacts are not predicted to be significantly additional and/or different. These aspects and associated environmental factors will not be further assessed in the PER.	Appendix C for Risk Assessment information.
Liquid and solid waste disposal	Soils and landform		
	Surface water		
	Groundwater		
	Subterranean fauna		
	Flora and vegetation		
Physical presence of infrastructure	Surface water		
	Groundwater		
	Subterranean fauna		

5.2 Assessment of Relevant Environmental Factors

In summary, the following key environmental factors were determined in the PER scoping phase as requiring detailed assessment in the PER:

1. Terrestrial Environment:
   - fauna (including quarantine)
   - subterranean fauna
   - vegetation and flora (including quarantine)
   - light
   - noise.

2. Marine Environment:
   - fauna (including quarantine)
   - coastal processes
   - marine water and sediment quality
   - marine primary producers
   - light
   - noise.

3. Atmospheric Environment:
   - air quality – air emissions and greenhouse gas emissions (including reservoir CO_2 injection).

The above key environmental factors associated with the Revised Proposal are addressed in the following sections (Sections 6.0 through 13.0) of the PER in the following format:

- **Assessment Framework or Policy**: details the relevant EPA objective/s, key statutory requirements and environmental policy relevant to the environmental factor.
- **Detailed Assessment of Potentially Significant Impacts**: contains the detailed assessment of the aspects and potential impacts that were identified in the preliminary environmental risk assessment as having a medium to high inherent risk level.
- **Assessment of Potential Impacts to Matters of NES:** provides an impact assessment specifically relating to relevant matters of NES. As the Revised Proposal requires assessment under the Commonwealth EPBC Act, this PER needs to assess potential impacts to matters of NES, specifically listed threatened species and communities (sections 18 and 18A) and listed migratory species (sections 20 and 20A).
- **Proposed Management Actions**: lists those key management plans, programs and systems that will be implemented.

- **Predicted Environmental Risk**: provides a summary description of residual level of risk and includes consideration of the environmental acceptability of the Revised Proposal (and consistency with relevant EPA objectives/policies) and cumulative risk to the environmental factor.

6.0 TERRESTRIAL ENVIRONMENT – RISKS AND MANAGEMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

6.1 Terrestrial Fauna

6.1.1 Assessment Framework or Policy

6.1.1.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvement of knowledge (EPA 2004b).

6.1.1.2 Commonwealth Policy

The National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth Government of Australia 1996) addresses the conservation of Australia's biological diversity by defining guiding principles. Proposals need to demonstrate application of the principles listed in this Strategy; the key principles being:

- protection of biological diversity *in situ*
- maintenance of ecological systems and processes
- actively managing at source the causes of significant reduction or loss of biological diversity.

6.1.1.3 State (WA) Policy

EPA Position Statement No. 3 – Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002b)

This Position Statement requires proposals to demonstrate the following:

- Proponent has demonstrated that all reasonable measures have been undertaken to avoid impacts to biodiversity. Where impact on biodiversity is unavoidable, proponent has demonstrated that the impact will not result in unacceptable loss.
- Information gathered for environmental impact assessment meets state, national and international agreements, legislation and policy in regard to biodiversity conservation.
- Quality of information and scope of field surveys meets the standards, requirements and protocols of the EPA.
- Proponent has ensured that terrestrial biological surveys provide sufficient information to address both biodiversity conservation and ecological function values

within the context of the type of proposal being considered and the relevant EPA objectives for protection of the environment.

- Terrestrial biological surveys will be made publicly available and will contribute to the bank of data available for the particular region.

EPA Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004e)
This guidance statement requires proposals to demonstrate that terrestrial fauna surveys undertaken to support environmental impact assessments have been undertaken at the appropriate level for the scale of the proposal and in accordance with the provisions of the Guidance Statement.

DEC Priority Fauna List
Priority species are those listed by DEC as being potentially threatened; priority species are ranked from Priority 1 to 5. Priority species are not afforded additional legal protection; however, given the lack of scientific knowledge about their behaviour or distribution, they should be protected and conserved wherever possible.

6.1.2 Further Assessment of Potentially Significant Impacts

Potential stressors that may affect terrestrial fauna due to the Revised Proposal have been identified and risk determined through an assessment of consequences and likelihood. The risk assessment methods, and levels of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia 2005a). The full results of the risk assessment are presented in Appendix C.

Environmental stressors with the potential for Low risk impacts and/or those stressors that have not changed in character or magnitude from the Approved Development, are listed below; these are not assessed further in this PER:

- site clearing activities
- effects of habitat fragmentation
- unnatural fire regimes (i.e. no fires)
- waste release/disposal
- spills of liquids/leaks
- presence of infrastructure and people
- creation of shade
- noise and vibrations
- release of CO_2 from facility well heads
- the introduction or spread of NIS (discussion of the Quarantine Management System is provided in Section 8).

The Revised Proposal is expected to alter the following stressors, resulting in Medium-High risk to terrestrial fauna:

1. **Loss of habitat** will result from the additional vegetation clearing associated with the Revised Proposal (Note: clearing will still remain within the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA)).
2. **Site excavations and associated activities**, which include additional trenches, foundations and pits for construction.
3. **Vehicle movements** could potentially result in the loss of individual fauna, particularly of less mobile species.

4. **Emissions** associated with the additional infrastructure to be constructed under the Revised Proposal could potentially alter fauna behaviour or result in the loss of individual fauna.

Unplanned CO_2 release to the surface or near-surface environment from surface facilities or unplanned migration of CO_2 from deep faults is considered to result in a Low risk to fauna. However, discussion of unplanned CO_2 release has also been included in this PER due to community interest in this topic. Unplanned CO_2 release to the surface or near-surface environment from unplanned migration of CO_2 from deep faults could potentially lead to the localised asphyxiation of terrestrial fauna in shallow-surface habitats (e.g. burrows).

Changes to the potential environmental impacts identified for the Approved Development, resulting from the stressors associated with the Revised Proposal are shown in Table 6.1.

Table 6.1: Comparison of Approved Development and Revised Proposal Stressors for Terrestrial Fauna

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Loss of habitat	Clearing of Gas Treatment Plant site. Fire (planned and unplanned)	Clearing of Gas Treatment Plant site. Fire (planned and unplanned)	The total area of clearing (i.e. 300 ha) is not increasing however there will be an increase in area of long-term land use within that 300 ha by approximately 40 ha (which means less of the total clearing area will be rehabilitated in the short-term/prior to facilities decommissioning) (see explanation in section 6.1.2.1).
Site excavations	Trenches, foundations and pits for construction	Trenches, foundations and pits for construction	Some additional excavations within the revised Gas Treatment Plant footprint will be required. No additional excavations are associated with the feed gas pipeline deviation (overall length remains the same).
Vehicle movements	Injury or death of fauna from vehicles	Injury or death of fauna from vehicles	No additional vehicles are required for the Revised Proposal; however the construction schedule is approximately three to six months longer.
Emissions	Light emissions from construction sites. Light emissions from the Gas Treatment Plant. Hot and cold emissions from Gas Treatment Plant.	Light emissions from construction sites. Light emissions from the Gas Treatment Plant. Hot and cold emissions from Gas Treatment Plant.	Addition of one LNG train (module) and associated lighting.
Unplanned CO_2 release	Unplanned migration of CO_2	Unplanned migration of CO_2	The addition of a third LNG processing train will increase the annual volume of reservoir CO_2 to be injected by 0.92 MTPA from approximately 2.72 MTPA (Approved Development) to approximately 3.64 MTPA (Revised Proposal). The total volume of CO_2 injected over the life of the project remains the same.

It should be noted that the combined footprint of the Approved Development and future development areas (i.e. the 300 ha available for gas processing activities under the *Barrow Island Act 2003* (WA)) was assessed for impacts to fauna for the Approved Development. As the Revised Proposal will remain within the 300 ha, there is no difference between the Approved Development and the Revised Proposal in terms of total clearing area.

6.1.2.1 Loss of Habitat

Site Clearing

Clearing of vegetation will result in the loss of habitat (native vegetation, termite mounds), and potentially a reduction in the overall carrying capacity for fauna on the Island.

The areas to be cleared for the Revised Proposal differ slightly from those for the Approved Development. Nonetheless, the risks of fragmenting habitat surrounding the Revised Proposal is low because Barrow Island vertebrates are generally highly mobile and can move through habitat that will remain around the boundary of the land cleared for the Gas Treatment Plant site. Similar barriers already exist on Barrow Island (current airport and infrastructure buildings) and these show no evidence for restricting fauna movements. The feed gas pipeline will be below-ground and will not pose a barrier to wide-ranging fauna. Habitat fragmentation has the potential to influence the densities of SRE species which have poor dispersal abilities, however no terrestrial fauna (including fauna listed as matters of NES, terrestrial invertebrates and SREs) have been found to be unique to the habitat proposed for clearing. Therefore it is unlikely that terrestrial fauna will suffer the effects of habitat fragmentation due to site clearing.

There is a risk that fauna moving from cleared areas into adjacent habitat (including fauna listed as matters of NES) will experience increased resource competition among species within already occupied habitats. Displacement and competition may lead to the local loss of individuals through competition or mortality. Abundances of terrestrial vertebrates estimated in the EIS/ERMP (Chevron Australia 2005a) indicate the loss of individuals is unlikely to compromise the population size of each species on the Island.

There is no evidence that fauna are restricted in distribution to the area nominated for clearing in the Revised Proposal and there is no evidence to suggest that the populations within the Revised Proposal area depend on this area of the Island as a refuge. Loss of habitat within the Revised Proposal area is therefore not considered to result in different impacts to the Approved Development.

Current measures to mitigate impacts associated with site clearing, as committed to in the EIS/ERMP and that are applicable to the Approved Development, include the establishment of vegetation clearing audit procedures, translocation of boodies and established procedures to manage fauna from cleared areas (including procedures for vouchering specimens required by the Western Australian Museum, and for managing animal welfare). These measures are considered adequate to manage the potential impacts of the Revised Proposal and it is deemed that no additional measures are required for the Revised Proposal.

The cumulative clearing for the Revised Proposal will not exceed the 300 ha available for gas processing activities under the *Barrow Island Act 2003* (WA). However, within that total clearing area of 300 ha, the Revised Proposal will require an additional (approximately) 40 ha of land for long term use (i.e. for the operational life of the Gas Treatment Plant and associated facilities), relative to the long-term land use needs of the Approved Development. In other words, this 40 ha of land that was allocated for

temporary use (construction phase) for the Approved Development, will remain in use for the operational life of the Revised Proposal, and therefore will not be rehabilitated until the facilities decommissioning phase of the Gorgon Project. The cumulative impact of site clearing on conservation-significant species is not considered to be significantly different from the impacts associated with the Approved Development.

The impacts (consequences) to fauna as a result of site clearing for the Revised Proposal are considered to be Moderate, as clearing will result in local loss of habitat within the designated clearing area for the Revised Proposal, but will not result in the loss of habitats elsewhere on Barrow Island. Site clearing is not expected to result in the reduction of viability of any fauna species on Barrow Island.

It is considered that the Revised Proposal does not represent significant additional or different environmental risk than the Approved Development regarding the loss of habitat from site clearing.

Fire

The Revised Proposal will result in a longer construction time (approximately three to six months longer than that for the Approved Development). However, the Revised Proposal does not present any significant new or additional fire ignition sources than those for the Approved Development.

Fire may be used to burn vegetation that has been cleared from the Gas Treatment Plant site. If this method is utilised it will only be carried out in favourable climatic conditions and in a controlled manner with appropriate firebreaks and fire fighting resources on-hand.

Any fire that escapes the proposed area for construction, while unplanned, would cause a loss of native vegetation. Fauna, including listed fauna, which remain within vegetation exposed to fire, would be at risk of being injured or killed. The severity of the risk would depend on the extent of the area through which a fire passes and the climatic conditions at the time. Secondary effects to fauna of fire in adjacent habitat include increased competition due to loss of habitat, exposure and increased predation. It is considered that the Revised Proposal does not have the potential to result in more intense fires than the Approved Development if an unplanned fire was to occur.

Current measures to mitigate risks associated with fire, as committed to in the EIS/ERMP, and as required under the Approved Development Statement No. 748, include a Fire Management Plan and established procedures to manage injured fauna.

The fire-related impacts to fauna associated with the Revised Development are not significantly different to the impacts identified for the Approved Development as there are no new ignition sources and no significantly different activities associated with the Revised Proposal. Construction of the Revised Proposal will be approximately three to six months longer than for the Approved Development; however this additional construction time is not considered to be significant. The cumulative impacts of fire on conservation-significant species are not considered by the Proponent to be significantly different from the cumulative fire-related impacts of the Approved Development.

The impacts to fauna as a result of fire (unplanned event) caused by Revised Proposal activities are considered to be Serious within the immediate area of a fire; that is if a fire was to occur it would have the potential to result in localised temporary loss of fauna habitat and individuals within the immediate area would move on or be lost. However, a fire is highly unlikely to result in the loss of overall viability of fauna species on Barrow Island and fauna habitat is expected to recover in burnt areas in the near-term.

It is considered that the Revised Proposal does not represent significant additional or different environmental risk than the Approved Development regarding the loss of habitat from fire.

6.1.2.2 Site Excavations

Open pits and trenches will be used to develop the foundations for building structures, and to lay the feed gas pipelines below ground. While construction activities, including noise, will help to deter animals from the area, excavations have the potential to trap fauna (including fauna listed as matters of NES) that enter them. Without the proper management activities to prevent access to the open trench, or assist the egress of fauna from excavations, entrapment in excavations could potentially lead to fauna fatality by starvation, dehydration, drowning or injuries sustained when entering the excavation. Fauna trapped in excavations are also more susceptible to predation.

The Revised Proposal will result in a minor realignment of the feed gas pipeline over a distance of approximately 500 m to accommodate changes to the Gas Treatment Plant footprint, but the total length of the feed gas pipeline associated with the Revised Proposal will not change from the Approved Development; therefore the pipeline deviation is not considered to be a different or new stressor. The Revised Proposal will also result in some additional excavations to accommodate changes in the foundations and structure of the Gas Treatment Plant. However, the overall length of time that excavations will be open for the Revised Proposal will not change from that for the Approved Development, and those located in the cleared footprint are less prone to significant animal activity.

Current measures to mitigate risks associated with site excavations, as committed to in the EIS/ERMP and required under the Approved Development Statement No. 748, include the execution of construction environmental management plans and Fauna Handling and Management Procedures.

The impacts to fauna from excavations associated with the Revised Development are not significantly different to the impacts identified for the Approved Development. While there are some additional excavations within the revised Gas Treatment Plant footprint, these will be managed to reduce impacts to fauna in the same way as those for the Approved Development. There will be no additional excavations associated with the feed gas pipeline deviation (overall length remains the same). The cumulative impacts of site excavations on conservation significant species are not considered to be significantly different from the impacts of the Approved Development. The additional residual risk posed by site excavations associated with the Revised Proposal (compared to the Approved Development) to conservation significant species is considered by the GJVs to be Medium, which is the same as the residual risk level for the Approved Development (Chevron Australia 2005a).

The residual risk to fauna as a result of site excavations caused by Revised Proposal activities is considered to be Medium within the localised area of the Revised Proposal, with the potential loss of small numbers of individuals. However, the Revised Proposal is not expected to lead to a reduction in the local population viability on Barrow Island of any fauna species.

For the injury or death of fauna from site excavations, it is considered that the Revised Proposal does not represent significant additional or different environmental risk relative to the Approved Development.

6.1.2.3 Vehicle Movements

No new roads are proposed for the Revised Proposal as compared to the Approved Development. The Revised Proposal will result in an increase in construction time on the Island by approximately three to six months. This will increase the period of time that construction vehicles travel from the construction accommodation village to the Gas Treatment Plant site along designated roads, which in turn could increase the possibility of injury or death of fauna from vehicle strikes. The abundance of terrestrial fauna, including matters of NES and fauna specially listed by the *Wildlife Conservation Act* (WA) is unlikely to be affected by the impact from vehicle movements because fauna distributions extend across Barrow Island, and fauna are not restricted to habitats along roadside edges.

Current measures to mitigate risks associated with vehicle movements, as committed to in the EIS/ERMP and as required under the Approved Development Statement No. 748, include restricting vehicles and equipment to designated areas/roads, appropriate day-time speed (60 km/hr) and night-time speed (40 km/hr) limits for all vehicles, sign-posting of speed limits and the use of buses to transport people to/from the accommodation area to the construction village to reduce the number of vehicle movements.

The impacts to fauna associated with the Revised Development area are not significantly different to the impacts related to the Approved Development area. While the time period for construction is extended by three to six months, road traffic will be managed to reduce impacts to fauna in the same way as those for the Approved Development. The number of vehicles and the size of the workforce are not expected to increase on the island as a result of an extended construction period. The cumulative impacts of vehicle movement on conservation significant species are not considered to be significantly different from the impacts of the Approved Development.

The residual risk to fauna as a result of vehicle movements caused by Revised Proposal activities is considered to be Medium within the localised area of the Revised Proposal, with the potential loss of small numbers of individuals without reduction in the local population viability on Barrow Island of any fauna species.

The injury or death of fauna due to vehicle movements related to the Revised Proposal is not considered to present significant additional or different environmental risk relative to the Approved Development.

6.1.2.4 Emissions

Emissions from the Gas Treatment Plant and associated infrastructure typically include light, hot or cold air and hot or cold water. Noise emissions are not considered here as the Revised Proposal (like the Approved Development) poses a Low risk to fauna from noise (Appendix C). See Section 11 for an assessment of the changes to noise emissions under the Revised Proposal.

Light spill or glow from artificial lighting and gas flares pose a potential risk to seabirds that frequent the coastline at night. Seabirds can become disorientated by artificial lighting resulting in injury or death; for example disorientated birds can be injured by flying into lights or construction equipment/facilities. In particular, wedge-tailed shearwaters that nest on nearby islands may be at risk, as could birds of prey that may build nests on flare towers. Lights at night can attract large numbers of invertebrates such as moths, which in turn may attract animals that feed on invertebrates. See Section 10 for an assessment of the changes to light emissions under the Revised Proposal.

Hot emissions from the Revised Proposal facilities may attract reptiles and insects to heat or warm equipment during cooler weather. Cold emissions may attract mammals or birds during hot weather. Water emissions offer a source of free water to fauna. Depending on the temperature, hot emissions have the potential to cause injuries or deaths to individuals from burns and heat. Alternatively, animals that are attracted to heat or cold may congregate around facilities and potentially could be exposed to predators that learn to hunt in these areas of high prey density.

The proposed changes to the Gas Treatment Plant under the Revised Proposal include:

- the physical presence of an additional LNG train
- additional non-routine flaring associated with the operation of the third LNG train
- an increase in LNG and condensate offloading frequency.

These changes will result in additional sources of emissions, particularly light. However, while there are additional lights associated with having a third LNG train, light emissions studies conducted for the Revised Proposal (Section 10 and Appendix D) demonstrate little variation in lux estimates towards the coastline compared with the Approved Development. This indicates that the additional LNG train and changes in the offshore infrastructure for the Revised Proposal will result in only a minor increase in overall lighting compared to the Approved Development. Furthermore, lights will be managed through a lighting basis of design. Identified management actions include measures that will be implemented in the design of the facility, as well as impact mitigation strategies that will be implemented through marine and operating procedures during the construction and operations phases of the project.

Nevertheless, it is recognised that the frequency of condensate and LNG tanker movement at the jetty loading facilities will increase as a result of the Revised Proposal. Intermittent use of the Boil-off Gas (BOG) flare may also increase proportional to the number of 'warm' tankers that require cool down prior to cargo loading. Therefore the GJVs have conservatively assessed the cumulative risks of emissions on conservation significant species to increase from Low (Approved Development) to Medium (Revised Proposal), in recognition of the additional lighting sources associated with the third LNG train operations.

The cumulative risks to fauna as a result of emissions caused by Revised Proposal activities are considered to be Medium within the localised area of the Revised Proposal, with the potential loss of small numbers of individuals without reduction in local population viability on Barrow Island.

6.1.2.5 Unplanned CO_2 Migration or Release

The residual risk of unplanned migration or release of CO_2 impact to fauna associated with the Revised Development is not significantly different from the impacts identified for the Approved Development. The addition of a third LNG processing train will increase the annual volume of reservoir CO_2 injected by 0.92 MTPA. This will require additional CO_2 injection wells and an additional 3 km length of CO_2 pipeline; however the method of reservoir CO_2 injection will not differ from the Approved Development.

Unplanned migration or release of CO_2 to the surface or near-surface environment could potentially lead to the asphyxiation of fauna in caves or fauna that use shallow surface areas such as burrows as day-time refuges (e.g. boodies) if sufficient quantities or concentrations of CO_2 are released.

Given the current measures to mitigate risks associated with unplanned CO_2 migration, it is considered highly unlikely that such a situation would eventuate over the life of the

project. As committed to in the EIS/ERMP and as required under the Approved Development Statement No. 748, mitigation measures include:

- selection of the Dupuy Formation for injection of reservoir CO_2 which provides multiple baffles and barriers to contain the injected CO_2 and prevent/slow CO_2 migration
- selection of the injection location such that the CO_2 plume is not anticipated to approach faults
- existing decommissioned wells completed in the Dupuy Formation will be worked over to ensure suitability for CO_2 service.

See Section 12 for more information relating to the assessment and management of risks associated with the injection of reservoir CO_2.

The cumulative impacts of unplanned migration or release of CO_2 on conservation-significant species for the Revised Proposal at the island-wide scale of impact are not considered to be significantly different from the impacts of the Approved Development.

The residual risk to fauna as a result of unplanned migration or release of CO_2 caused by Revised Proposal activities is considered to be Low within a localised area, with the potential loss of small numbers of individuals within a short-term, without reduction in the local population viability on Barrow Island.

It is considered that reservoir CO_2 injection associated with the Revised Proposal does not represent significant additional or different environmental risk relative to the Approved Development.

6.1.3 Assessment of Potential Impacts to Matters of NES

Species of conservation significance, as listed under the EPBC Act, which are likely to occur in, and be potentially affected by, the Revised Proposal, are discussed below:

Barrow Island White-Winged Fairy Wren

This subspecies is not restricted to the Revised Proposal or Approved Development areas. The EIS/ERMP (Chevron Australia 2005a) stated that this species' preferred habitat is vegetation communities with emergent shrubs such as *Melaleuca cardiophylla* and *Acacia bivenosa*. Subsequent to the EIS/ERMP, Barrow Island white-winged fairy wrens have been found to occur and breed in a range of plant species on Barrow Island, including *Melaleuca cardiophylla*, *Acacia bivenosa, Acacia coriacea, Hakea lorea, Grevillia pyramidalis* and *Triodia* sp. (including *Triodia angusta* along the roadways on Barrow Island) (RPS BBG 2006d).

Site clearing for the Revised Proposal will lead to the loss of some white-winged fairy wren habitat. However, as the birds are now known to forage and nest widely over a range of habitats, on the Island as noted above, the Revised Proposal will have minimal impact to this species versus the Approved Development. This species is not expected to be significantly affected by unplanned fire, site excavations, road traffic, emissions or unplanned CO_2 release to the surface. Compared to the Approved Development, the Revised Proposal is considered to present an unchanged risk to the matter of NES and is therefore unlikely to have a significant impact on this particular species.

Burrowing Bettong (Boodie)
This species occupies warrens that are widely distributed across Barrow Island, and are not restricted to the area described by the Revised Proposal or the Approved Development. The Approved Development will impact one active boodie warren, but the additional clearing for the Revised Proposal will not impact any additional warrens. Unplanned fires are unlikely to impact animals which can shelter below-ground. Unplanned release of CO_2 from faults may lead to localised risks to animals occupying warrens near the release location; however this risk is considered to be unchanged from that for the Approved Development. Artificial light and hot/cold emissions associated with the Revised Proposal or Approved Development are not expected to affect boodies differently.

Vehicles on the island for a longer period of time during construction (Revised Proposal) may increase the likelihood of injuries or deaths of boodies from vehicle strikes. Road traffic will be managed for speed and volume on the Island's roads, with limited night driving. The additional pits and excavations required for the Revised Proposal may increase the risk of animals entering them. A procedure will be established to guide the handling and management of fauna that become trapped in pits or trenches. With these mitigation measures in place, it is considered that the Revised Proposal presents an unchanged risk to this matter of NES in comparison to the Approved Development. The Revised Proposal is therefore unlikely to have a significant impact on this particular species.

Barrow Island Euro, Golden Bandicoot and Spectacled Hare-wallaby
These species are distributed across Barrow Island and are not restricted to the area of the Revised Proposal or the Approved Development. Site clearing for the Revised Proposal is expected to remove some of their habitat. Vehicles on the island for a longer period of time (revised Proposal) may increase the risks associated with vehicle strikes. Pits and excavations may increase risks of animals falling inside. Road traffic will be managed for speed and volume on the island's roads, with limited night driving. A procedure will be established to guide the handling and management of fauna that become trapped in pits or trenches. With these mitigation measures in place, it is considered that the Revised Proposal presents an unchanged risk to the Barrow Island euro, golden bandicoot and spectacles hare-wallaby populations in comparison to the Approved Development. The Revised Proposal is therefore unlikely to have a significant impact on this particular species.

Osprey and White-bellied Sea Eagle
These birds of prey occur and nest in a variety of locations around Barrow Island, and are not restricted to the areas described by the Revised Proposal or the Approved Development.

Intermittent operation of the upright BOG flares pose a risk to birds of prey that may build nests on flare towers when gas is not being flared. Mitigations to discourage birds from nesting on these towers include structural features that make it physically difficult to construct a nest.

These species are not expected to be affected by site clearing, road traffic, unplanned release of CO_2 or excavations. Therefore, the Revised Proposal is unlikely to have a significant impact on these particular species.

Wedge-tailed Shearwater
This species feeds in open water away from land, and returns to islands during the day, particularly during the breeding season when shearwaters nest underground. This species nests in colonies along the Western Australian coastline including a variety of

locations across the Pilbara Region, including (but not restricted to) North and South Double Islands off the east coast of Barrow Island. However, the wedge-tailed shearwater does not breed or nest on Barrow Island and is not found within the area to be directly disturbed by the Revised Proposal or the Approved Development.

Lights and gas flares pose a risk to seabirds that frequent the coastline at night. Wedge-tailed shearwaters that nest on nearby islands may be attracted to the light spill or glow from artificial lighting and flares, however light spill studies undertaken for the Revised Proposal demonstrate that light is not expected to significantly increase towards the coast with a third LNG train, as compared to the Approved Development (Section 10). Current measures to mitigate emissions, as committed to in the EIS/ERMP and as required under the Approved Development Statement No. 748, include the management of lights to reduce light spill, minimise the use of lights and the management of their point-source intensity. Compared to the Approved Development, the Revised Proposal is considered to present a Medium risk to this matter of NES in recognition of the additional third train, with the potential loss of small numbers of individuals without reduction in the local population viability.

6.1.4 Proposed Management Actions

The Revised Proposal will be implemented by adopting best practicable measures to minimise impacts on terrestrial fauna and SREs.

Impacts to terrestrial fauna values of Barrow Island, including matters of NES, will be addressed by several EMPs that are consistent with the requirements of conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294. As part of the implementation of Statement No. 748, the Proponent will develop and implement the following management plans and systems, which will include mitigation and management measures for terrestrial fauna and SRE:

- Terrestrial and Subterranean Environment Protection Plan
- Fauna handling and management procedures
- Vegetation clearing and audit procedures
- Traffic Management procedures
- Solid and Liquid Waste Management Plan
- Terrestrial and Marine Quarantine Management System
- Fire Management Plan
- Carbon Dioxide Monitoring Program
- Post-construction Rehabilitation Plan
- Project Site Rehabilitation Plan.

The objectives and management measures for each of these plans, procedures and systems are outlined in Table 15.2.

Environmental monitoring programs are being developed and will be implemented as required by Statement No. 748. These programs will collect data to monitor the condition of the environment on Barrow Island and can be readily adapted to include monitoring for the Revised Proposal. In particular, the following programs are considered to apply to the monitoring of terrestrial fauna and SRE impacts as a result of the Revised Proposal:

- Terrestrial and Subterranean Environment Monitoring Program

- Short Range Endemics and Subterranean Fauna Monitoring Plan

The proponent will also submit a Terrestrial and Subterranean Baseline State and Environmental Impact Report in accordance with Statement No. 748, which includes a discussion of the key terrestrial fauna and invertebrates related to the areas of disturbance.

Construction and operations phase EMPs will also be developed and implemented, consistent with the requirements for EMPs prescribed in EPBC Reference: 2003/1294, to address stressors to terrestrial fauna.

A review of the EMPs, plans, systems and programs required under the conditions of approval for the Approved Development in terms of their applicability to the Revised Proposal has been undertaken. As a result of this review, it is considered that impacts to terrestrial fauna and SREs due to the Revised Proposal can be adequately addressed by the EMPs, programs, procedures and systems required for the Approved Development.

6.1.5 Predicted Residual Environmental Risk

The Revised Proposal is not considered to pose any significant new or additional risks to terrestrial fauna in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts on terrestrial fauna as a result of the Gorgon Gas Development.

The implementation of various plans, procedures, systems and programs that are required under conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294 is expected to manage the following Revised Proposal impacts to a level consistent with that considered acceptable and therefore approved for the Approved Development:

- increased competition for resources due to site clearing
- habitat loss from site clearing
- fauna entrapment in excavations
- fauna injury or death from vehicle strikes
- loss of habitat and injury or death from fire
- fauna impact from unplanned CO_2 release on fauna.

In the case of Revised Proposal aspects with higher residual risk than for the Approved Development (namely injury or death of fauna due to attraction to light), the scope of the Approved Development's plans, systems and programs is considered to be adequate to manage the stressors and meet the EPA objectives for terrestrial fauna.

The residual risks for stressors with potential Medium and High risks are summarised in Table 6.2. Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk, Low risk stressors are presented in Appendix C.

Table 6.2: Residual Environmental Risk Assessment – Terrestrial Fauna

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Residual Risk For Revised Proposal (Approved and Revised Footprint)		
			L	C	RR	L	C	RR
Site clearing (vegetation clearing)	Increased resource competition in adjacent areas	Terrestrial and subterranean environment protection plan including: ♦ Vegetation clearing and audit procedures ♦ Fauna handling and management procedures	1	4	M	2	4	M
Site clearing (vegetation clearing)	Habitat loss in cleared area	Relocation/translocation of boodies from warrens. Terrestrial and subterranean environment protection plan including: ♦ Vegetation clearing and audit procedures ♦ Fauna handling and management procedures	1	4	M	1	4	M
Site disturbance/ excavation	Entrapment in pipeline trenches and other open holes/pit excavated	Terrestrial and subterranean environment protection plan including: ♦ Fauna handling and management procedures ♦ Management protocols for the risk of flooding an open trench	1	4	M	1	4	M
Fire	Unplanned large industrial fire that spreads beyond plant boundary	Fire Management Plan Emergency Response Plan	4	3	M	4	3	M
Physical interaction	Injury or fatality (i.e. road kill)	Fauna handling and management procedures Traffic common user procedure	1	4	M	1	4	M
Light emissions	Plant lighting during operations. Attraction of insects to lights, predation by silver gulls. Increase in silver gull population, competing with shore birds. Change in movement/behavio ur of seabirds	Lighting basis of design	1	5	L	3	4	M
Unplanned CO_2 migration or release to	Accidental release of CO_2 from surface faults, resulting in asphixiant in low-	Selection of the Dupuy Formation to receive injected CO_2 Selection of the injection	5	3	L	3	5	L

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Residual Risk For Revised Proposal (Approved and Revised Footprint)		
			L	C	RR	L	C	RR
the surface or near surface environment	lying areas near release.	location such that the CO_2 plume is not anticipated to approach faults. Existing decommissioned wells will be worked over to ensure suitability for CO_2 injection service. Plans to manage well penetrations to ensure they are fit for service have been developed. A wellhead maintenance program and monitoring of annular pressures will be implemented. CO_2 injection and monitoring wells will be designed for CO_2 service. Future hydrocarbon wells will be designed for CO_2 service. Carbon Dioxide Monitoring Program.						

6.2 Subterranean Fauna

6.2.1 Assessment Framework or Policy

6.2.1.1 EPA Objective

To maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvements in knowledge (EPA 2004b).

6.2.1.2 Commonwealth Policy

The National Strategy for the Conservation of Australia's Biological Diversity is also applicable to subterranean fauna; see Section 6.1.1.2 for a discussion relating to this Strategy.

6.2.1.3 State (WA) Policy

EPA Guidance Statements No. 54 and 54a – Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment; Sampling Methods and Survey Considerations for Subterranean Fauna (EPA 2003c; 2007b)

These Guidance Statements require proposals to demonstrate the following:

- Protection of important habitats for subterranean fauna species is adequate.
- The proposal does not potentially threaten the viability of any subterranean species.
- As a consequence of the proposal and sampling, there would be a low likelihood that a subterranean fauna species would meet the criteria for special legal protection as a threatened species under the *Wildlife Conservation Act* (WA).

- If the fauna species is already specially protected under the *Wildlife Conservation Act* (WA), the EPA has approved the proposal and sampling.
- Sampling for subterranean fauna has been undertaken in accordance with Guidance Statement No. 54a.

6.2.2 Detailed Assessment of Potentially Significant Impacts

Potential stressors that may affect subterranean fauna due to the Revised Proposal have been identified and risks have been determined using an assessment of consequences and likelihood. The risk assessment methods, and levels of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia 2005a) and as described in Section 5 of this PER. The full results of the risk assessment are presented in Appendix C.

Environmental stressors with the potential for Low risk impacts and/or those stressors which have not changed in character or magnitude from the Approved Development are listed below and are outlined in Appendix C. These are not assessed further in this PER:

- waste release
- smothering or metabolic effects
- presence of infrastructure
- release of CO_2 from equipment or infrastructure failure.

The Revised Proposal is expected to result in a Medium-High risk to subterranean fauna due to the following stressors:

1. **Vegetation clearing** activities that will lead to changes in organic inputs.
2. **Site excavations** (including additional trenches, foundations and pits for construction) which will lead to loss of habitats, increase the potential for subsurface soil compaction, sedimentation and altered groundwater levels. The extension of the Gas Treatment Plant footprint to the west for the Revised Proposal covers an area of slightly higher elevation and will therefore require more excavation to match the finish level of the Approved Development. This will result in an increase in the volume of habitat removed for the Revised Proposal.
3. **Spills and leaks** may lead to contamination or nutrient loading of the subsurface environment.
4. **Noise and Vibration emissions** may exacerbate damage to surrounding karst areas causing rock fractures or collapse.

Unplanned CO_2 release to the surface or near-surface environment from surface facilities or unplanned migration of CO_2 from deep faults is considered to result in a Low risk to subterranean fauna. However, discussion of unplanned CO_2 release has also been included in this PER due to community interest in this topic. Unplanned CO_2 release to the surface or near-surface environment from unplanned migration of CO_2 from deep faults could potentially lead to a localised anoxic environment for stygofauna in the superficial aquifer, or could potentially lead to the asphyxiation of troglofauna in subsurface areas.

Changes to the potential environmental impacts identified for the Approved Development resulting from the stressors associated with the Revised Proposal are shown in Table 6.3.

Table 6.3: Comparison of Approved Development and Revised Proposal Stressors for Subterranean Fauna

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Vegetation clearing	Clearing of Gas Treatment Plant site	Clearing of Gas Treatment Plant site	The total area of clearing (ie, 300 ha) is not increasing as a result of the Revised Proposal, however there will be an increase in area of long-term land use within that 300ha by approximately 40 ha (see explanation in section 6.1.2.1).
Site excavations	Trenches, foundations and pits for construction. Subsurface soil compaction. Altered groundwater levels.	Trenches, foundations and pits for construction. Subsurface soil compaction. Altered groundwater levels. More volume of habitat removed due to higher (inland) elevation of excavation site.	Increase in area of long-term land use by approximately 40 ha Increased volume of habitat removed beneath site.
Spills and leaks	Spills and leaks Surface water runoff	Spills and leaks Surface water runoff	No change from Approved Development.
Vibration Emissions	Damage to surrounding karst areas	Damage to surrounding karst areas	No change from Approved Development.
Unplanned CO_2 release	Unplanned migration of CO_2	Unplanned migration of CO_2	The addition of a third LNG processing train will increase the annual volume of reservoir CO_2 to be injected from approximately 2.72 MTPA as a result of the Approved Development, to a total of approximately 3.64 MTPA (increase of 0.92 MTPA or 34%). The total overall volume of CO_2 to be injected over the life of the project will however remain the same.

6.2.2.1 Vegetation Clearing

Clearing of vegetation will not have a direct impact on subterranean fauna; however surface vegetation provides the input of organic material into the subterranean habitat which provides nutrients and food for subterranean fauna. Clearing vegetation for the Revised Proposal (similar to the Approved Development) therefore has the potential to reduce the organic inputs to the underlying subterranean habitat, leading to a potential reduction of nutrients available to subterranean fauna.

Minimising clearing requirements has been a key consideration in the reconfiguration of the Gas Treatment Plant site, and the Revised Proposal design has taken this into account when incorporating the additional LNG train into the layout. In addition, management measures will be developed and implemented to control site clearing, including the clear demarcation of all areas to be cleared to ensure that clearing of

vegetation (and the subsequent removal of organic material) does not occur beyond the designated disturbance areas.

The cumulative clearing for the Revised Proposal will not exceed the 300 ha available for gas processing activities under the *Barrow Island Act 2003* (WA). However, within that total clearing area of 300 ha, the Revised Proposal will require an additional approximately 40 ha of land for long term use. In other words, this approximate 40 ha of land allocated for temporary use for the Approved Development will not be rehabilitated under the Revised Proposal, but will remain in use. However, the cumulative impacts of changes in organic input to the subterranean habitat due to site clearing for the Revised are not considered to be significantly different to the impacts associated with the Approved Development.

The risk to subterranean fauna as a result of changes to organic inputs for the Revised Proposal are consistent with the risks identified for the Approved Development, although impacts will be localised within the designated clearing area for the Revised Proposal and will not result in changes to organic inputs elsewhere on Barrow Island. Site clearing associated with the Approved Development or Revised Proposal is not expected to result in the reduction of viability of subterranean fauna species on Barrow Island.

The change in organic input to subterranean habitat from clearing of vegetation for the Revised Proposal is not considered to present significant additional or different environmental risk than for the Approved Development.

6.2.2.2 Site Excavation

Ground disturbance involving blasting and excavation will directly remove areas of troglofauna habitat and may potentially alter the pore spaces available to subterranean fauna and potentially fill open karst spaces underneath or adjacent to the ground disturbance areas. The Revised Proposal will require a larger volume of soil and rock excavation than the Approved Development because it requires a more uniform elevation for the Gas Treatment Plant. Given that most of the subterranean species in question are slow-moving and occur in microhabitats that have been relatively stable for an extended period, troglofauna located in any direct disturbance area will have a higher probability of being lost.

There is one species of troglofauna (*Trinemura* sp. *nov.*) that is yet to be collected from outside the disturbance area associated with the Proposed Gas Treatment Plant site (Table 3.8). It is expected that the ongoing Subterranean Fauna Monitoring Plan (required under Condition 11 of Statement No. 748 for the Approved Development) will confirm a wider distribution of this currently restricted subterranean fauna species.

The additional blasting and excavation required for the Revised Proposal compared to the Approved Development is not expected to significantly affect the subterranean fauna community on Barrow Island, because the nature of the blasting and excavation operations is unchanged compared to those proposed for the Approved Development. The geotechnical characteristics of the Revised Proposal are the same as the Approved Development and the Revised Proposal blasting and excavations will mainly be undertaken in the same area as for the Approved Development with additional blasting/excavations occurring immediately west of the Approved Development area. The overall land take for the Gorgon Gas Development (Approved Development and Revised Proposal) will remain within the 300 ha available for gas processing activities on Barrow Island under the *Barrow Island Act 2003* (WA).

The risks to subterranean fauna as a result of excavations and blasting for the Revised Proposal are consistent with the risks identified for the Approved Development, although impacts will be localised within the designated clearing area for the Revised Proposal and will not result in changes to habitat elsewhere on Barrow Island. Blasting and excavation for the Revised Proposal is not expected to result in the reduction of viability of subterranean fauna species on Barrow Island.

For the loss of subterranean habitat from site excavation it is considered that the Revised Proposal does not present significant additional or different environmental risk than the Approved Development.

6.2.2.3 Vibration

Vibration from blasting and construction may cause damage to surrounding karst areas causing rock fractures or collapse which may lead to localised fracturing or impact to subterranean habitat. Although damage to karst areas is difficult to quantify, the GJVs will manage blasting procedures to reduce blast impacts to the surrounding habitat to the extent reasonably practicable. Site excavation will be managed to utilise mechanical soil and rock removal methodologies to the extent reasonably practicable and reduce the need for high intensity blasting. Controlled blasting will be used to reduce total blasting requirements and to minimise disturbance beyond the footprint area. The Revised Proposal blasting requirements will differ from those for the Approved Development in that the Gas Treatment Plant footprint will be extended to the west; therefore there is a need for some additional blasting. However the majority of the overall area on the site to be blasted will remain the same as the Approved Development.

The level of risk to subterranean fauna as a result of karst habitat loss from vibration associated with construction of the Revised Proposal is considered to be the same as the Approved Development (i.e. High) within the localised area underneath and adjacent to the clearing area. Habitat loss from vibration emissions associated with the Revised Proposal is not anticipated to result in damage to karst habitat or the loss of populations elsewhere on Barrow Island as was the case for the Approved Development. Vibration emissions are not expected to result in the reduction of viability of subterranean fauna species on Barrow Island for either the Revised Proposal or the Approved Development.

For the loss of subterranean habitat from vibration it is considered that the Revised Proposal does not present significant additional or different environmental risk than the Approved Development.

6.2.2.4 Spills and Leaks

The potential exists for the subterranean habitat to be degraded by hazardous materials (e.g. hydrocarbons or contaminated wastewater) from accidental spills or leaks and if construction or operations are not properly managed. This can potentially result in reduced health or loss of troglofauna or stygofauna individuals.

Hydrocarbons and other hazardous materials will be used on a routine basis during the construction and operation of the Gorgon Gas Development. The quantities of some hazardous material are expected to increase for the Revised Proposal compared to the Approved Development. For example, some vehicles will remain on the Island longer, and therefore more fuel, grease and oil will be required for their extended operation. There will be some additional structures associated with the Revised Proposal's third LNG train which will result in more maintenance materials (e.g. paint, grease) being needed. However, the Revised Proposal does not require significantly larger volumes of hazardous materials versus the Approved Development.

All hazardous substances will be handled and stored in accordance with the relevant Material Safety Data Sheets (MSDS), Australian Standards and project plans and procedures. Management measures will be included to minimise the risk of contamination of subterranean fauna habitats from spills or leaks and to undertake spill response and cleanup actions in a timely manner to reduce the likelihood of spills reaching the subsurface.

There will be an increase in the volume of wastewater produced from construction activities as a result of the Revised Proposal because construction will require three to six months longer than for the Approved Development. There will also be an incremental increase in the volume of wastewater produced due to operation of a third LNG train; however the wastewater handling, storage and treatment methods will not vary as compared to the Approved Development.

A groundwater monitoring program will monitor groundwater quality at the Gas Treatment Plant site. The cumulative impacts of contamination due to hazardous materials and wastewater spills and leaks associated with the Revised Proposal are not considered to be significantly different to the impacts associated with the Approved Development.

The risks to subterranean fauna as a result of contamination due to spills and leaks associated with the Revised Proposal are considered to be Medium and would result in a localised impact within the area for the Revised Proposal. Contamination due to spills and leaks is not expected to result in the reduction of viability of subterranean fauna species on Barrow Island.

It is considered that the Revised Proposal does not present significant additional or different environmental risk in relation to the impact from spills and leaks on subterranean fauna than the Approved Development.

6.2.2.5 Unplanned CO_2 Migration or Release

Unplanned migration or release of CO_2 to the surface or near-surface environment could potentially lead to an anoxic environment for stygofauna in the superficial aquifer, or could potentially lead to the asphyxiation of troglofauna in subsurface areas.

Given the current measures to mitigate risks associated with unplanned CO_2 migration, it is considered highly unlikely that such a situation would eventuate over the life of the project. As committed to in the EIS/ERMP and as required under the Approved Development Statement No. 748, mitigation measures include:

- selection of the Dupuy Formation for injection of reservoir CO_2 which provides multiple baffles and barriers to prevent/slow CO_2 migration
- selection of the injection location such that CO_2 plume is not anticipated to approach faults
- existing decommissioned wells will be worked over to ensure suitability for CO_2 service

See Section 12 for more information relating to the assessment and management of risks associated with the injection of reservoir CO_2.

All current mitigation measures remain as they were proposed in the Approved Development, including the integration of Subsurface Uncertainty Management, which relates to monitoring for reservoir performance outcomes that deviate from the

anticipated case. However, one management action that has been improved is the development of a Pressure Management Strategy to ensure reservoir pressures resulting from the higher injection rates remain below acceptable levels. With this in mind, the impacts of unplanned migration or release of CO_2 to subterranean fauna associated with the Revised Development (i.e. Approved and Revised) have been assessed as lower than those of the Approved Development. While the addition of a third LNG processing train will potentially increase the annual volume of reservoir CO_2 available for injection by approximately 0.92 MTPA, the cumulative impacts of unplanned migration or release of CO_2 on subterranean fauna for the Gorgon Gas Development at the Island-wide scale of impact are considered to be less than the impacts of the Approved Development.

The impacts (consequences) to subterranean fauna as a result of unplanned migration or release of CO_2 caused by Revised Proposal activities are considered to be Minor within a localised area, with the potential loss of small numbers of individuals within a short-term, without reduction in the local population viability on Barrow Island. The assessed residual risk is Low.

6.2.3 Assessment of Potential Impacts to Matters of NES

One stygofauna species, the blind gudgeon *(Milyeringa veritas)*, is listed as Vulnerable under the EPBC Act. Two individuals have been collected during the stygofauna surveys undertaken in 2002–2003 (Chevron Australia 2005a). Both specimens were collected from the same bore which is approximately 6 km south-west of the Gas Treatment Plant site. There are no known cave systems beneath the area of the Revised Proposal and therefore no direct impact to this species is expected from the Development. There is a remote chance that unplanned CO_2 migration through the Barrow Fault may result in an impact to stygal species by increasing CO_2 levels in shallow-surface groundwater aquifers (Section 12); however, the bore where the blind gudgeon has been found is at least 3 km from the Barrow Fault and therefore it is highly unlikely that any unplanned escape of CO_2 would migrate such a distance. The Revised Proposal is therefore unlikely to have a significant impact on this species.

Compared to the Approved Development, the Revised Proposal is considered to present unchanged risk to this matter of NES and is unlikely to have a significant impact on the blind gudgeon.

See also Section 13 for a summary of potential environmental impacts to matters of NES.

6.2.4 Proposed Management Actions

The Revised Proposal will be implemented by adopting best practicable measures to reduce impacts on subterranean fauna.

Impacts to subterranean fauna values of Barrow Island, including matters of NES, will be addressed by several plans, systems and programs that are required under the conditions prescribed for the Approved Development in Statement No. 748, including a Terrestrial and Subterranean Baseline State and Environmental Impact Report which includes discussion of the subterranean fauna related to the areas of disturbance. In addition, mitigation measures to minimize impacts to subterranean fauna from the Revised Proposal will be addressed with the following plans and systems:

- Terrestrial and Subterranean Environment Protection Plan including vegetation clearing and audit procedures
- Solid and Liquid Waste Management Plan

- Reservoir Carbon Dioxide Injection System

The objectives and key management actions for each of these plans and systems are detailed in Table 15.2.

Environmental monitoring programs are being developed and will be implemented as required by Statement No. 748. These programs will collect data to monitor the condition of the baseline environment and can be adapted to include monitoring for the Revised Proposal. In particular, the following programs are considered to apply to the monitoring of terrestrial fauna impacts:

- Terrestrial and Subterranean Environment Monitoring Program
- Short Range Endemics and Subterranean Fauna Monitoring Plan

Construction and operation EMPs will also be developed and implemented, consistent with the requirements for EMPs prescribed in EPBC Reference: 2003/1294, to address stressors to terrestrial fauna.

The plans, programs and systems required under the conditions of approval for the Approved Development have been reviewed. It is considered that the impacts and risks of the Revised Proposal can be effectively managed under the same Ministerial Conditions already set by the Western Australian Minister for the Environment (and described in Statement No. 748) for the Approved Development. No additional measures or controls are therefore anticipated to be necessary to manage the potential subterranean fauna impacts.

6.2.5 Predicted Environmental Risk

While the site preparation work for the Gorgon Gas Development is expected to remove troglofauna habitat and inhabitants from the Gas Treatment Plant footprint, and may locally impact stygofauna, it is unlikely to have any significant impact on any species of subterranean fauna.

The Revised Proposal is not considered to pose any significant new or additional risks to subterranean fauna in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts on subterranean fauna as a result of the Gorgon Gas Development.

The implementation of various plans, systems and programs that are consistent with those required under conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294 is expected to manage the following Revised Proposal impacts to a level consistent with that considered acceptable and therefore approved for the Approved Development:

- reduced input of organic material into the subterranean habitat
- habitat loss from blasting and excavations
- damage to karst areas from vibration (including blasting) resulting in localised fracturing or destruction of troglofauna habitat
- contamination of subterranean habitat from inappropriate liquid and solid waste management
- anoxic environment or asphyxiation of subterranean fauna from the release of CO_2.

In doing so, the GJV will meet the EPA objective for subterranean fauna (section 6.2.1.1).

The residual risks for stressors with potential Medium and High risks are summarised in Table 6.4. Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk,

Table 6.4: Residual Environmental Risk Assessment – Subterranean Fauna

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Residual Risk For Revised Proposal (Approved and Revised Footprint)		
			L	C	RR	L	C	RR
Vegetation clearing	Reduced input of organic material into the subterranean habitat	Terrestrial and subterranean environment protection plan Vegetation clearing and audit procedures Short range endemics and subterranean fauna monitoring plan	1	3	H	1	3	H
Site excavation	Habitat loss	Terrestrial and subterranean environment protection plan Vegetation clearing and audit procedures Short range endemics and subterranean fauna monitoring plan	1	3	H	1	3	H
Vibration	Damage to surrounding karst areas causing rock fractures or collapse which may lead to localised fracturing or destruction of troglofauna habitat.	Site excavation will be managed to maximise mechanical soil and rock removal and minimise the need for high intensity blasting. Directional blasting will be used to reduce total blasting requirements and to minimise disturbance beyond footprint area.	1	4	H	2	3	H
Spills and leaks	Liquid and solid waste disposal into subterranean habitat	Solid and Liquid Waste Management Plan Remediation and response protocols to reduce infiltration of fluids into substrate.	4	3	M	3	4	M
Unplanned CO_2 migration or release to the surface or near surface environment	Anoxic environment for stygofauna in the superficial aquifer, or asphyxiation of troglofauna in subsurface areas.	Selection of a Dupuy Formation for injection of reservoir CO_2 (continued zone). Selection of the injection location such that CO_2 plume is not anticipated to approach faults Existing decommissioned wells will be worked over to ensure suitability for CO_2 service. Plans to manage well penetrations and ensure they are fit for service have been developed. A wellhead maintenance program and monitoring of annular pressures will be implemented. CO_2 injection and monitoring wells are designed for CO_2 service. Future hydrocarbon wells will be ensured to be designed for CO_2 service. Carbon Dioxide Monitoring Program.	5	1	M	3	5	L

NOTES:
1. Stressors on subterranean fauna that were assessed as potentially Medium-High risk.
2. Impacts are precautionary as they are based on specimens that have yet to be taxonomically identified with certainty.

6.3 Flora and Vegetation

6.3.1 Assessment Framework or Policy

6.3.1.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvements in knowledge (EPA 2004b).

6.3.1.2 Commonwealth Policy

The National Strategy for the Conservation of Australia's Biological Diversity is also applicable to flora and vegetation; see Section 6.1.1.2 for a discussion relating to this Strategy.

6.3.1.3 State (WA) Policy

EPA Position Statement No. 2 – Environmental Protection of Native Vegetation (EPA 2000b)
This Position Statement requires proposals to demonstrate that proposed clearing in non-agricultural areas of Western Australia will not adversely affect biological diversity and that the actions will be in compliance with the National Strategy for the Conservation of Australia's Biological Diversity.

EPA Position Statement No. 3 – Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002b)

As described in Section 6.1.1.3.

EPA Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004d)
This Guidance Statement requires proposals to demonstrate that terrestrial flora and vegetation surveys undertaken to support environmental impact assessments have been undertaken at the appropriate level for the scale of the proposal and in accordance with the provisions of the Guidance Statement.

6.3.2 Detailed Assessment of Potentially Significant Impacts

Potential stressors that may affect flora and vegetation due to Revised Proposal have been identified and risks have been determined through an assessment of consequences and likelihood. The risk assessment methods, and levels of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia 2005a) and are described in Section 5 of this PER. The full results of the risk assessment are presented in Appendix C.

Environmental stressors with the potential for Low risk and/or those stressors which have not changed in character or magnitude from the Approved Development are listed below. These are not assessed further in this PER:

- spills or leaks
- physiological effects of deposition of pollutants

- dust deposition
- unplanned migration of CO_2 from well leaks
- fire used as a vegetation clearing method.

The Revised Proposal may alter the following stressors resulting in Medium-High risk to:

1. **Vegetation clearing and earthworks** for the construction of the onshore feed gas pipeline, Gas Treatment Plant and associated facilities/infrastructure (for example, laydown areas, access roads), resulting in loss or disturbance of flora species and vegetation communities or a change in vegetation community composition from changes to soil profiles and/or drainage patterns.
2. **Fire**, which may result in a loss of vegetation communities, change in the species composition of a vegetation community, reduce the topsoil quality or result in loss of seeds from the topsoil.

Unplanned reservoir CO_2 release to the surface or near-surface environment from surface facilities or unplanned migration of CO_2 from deep faults is considered to result in Low risk to flora and vegetation. However, discussion of unplanned CO_2 release has also been included in this PER due to community interest in this topic. Unplanned CO_2 release to the surface or near-surface environment from unplanned migration of CO_2, from deep faults and well leaks, which may increase the level of CO_2 in soil profiles, may result in changes to soil chemistry and potential metabolic effects on plant roots.

The spread or introduction of non-indigenous plant species (weeds) is considered to result in Low risk to flora and vegetation. However, discussion of weeds has also been included in this PER due to community interest in this topic. Weeds can compete with native species for resources such as water and nutrients. Non-indigenous plant species can also change the original vegetation composition and structure. Further discussion of the project Quarantine Management System is provided in Section 8.

Changes to the potential environmental impacts of the Approved Development resulting from the changed attributes of the stressors associated with the Revised Proposal, are shown in Table 6.5.

Table 6.5: Comparison of Approved Development and Revised Proposal Stressors for Flora and Vegetation

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Vegetation clearing and earthworks	Loss or disturbance of flora species and vegetation communities Change in vegetation community composition from changes to soil profiles and/or drainage patterns	Loss or disturbance of flora species and vegetation communities Change in vegetation community composition from changes to soil profiles and/or drainage patterns	The total area of clearing (i.e. 300 ha) is not increasing, however there will be an increase in area of long-term land use within that 300 ha by approximately 40 ha (which means less of the total clearing area will be rehabilitated) (see explanation in section 6.1.2.1).
Fire	Loss of vegetation communities Change in the species composition Reduction in topsoil quality or loss of seeds from the topsoil	Loss of vegetation communities Change in the species composition Reduction in topsoil quality or loss of seeds from the topsoil	No additional or new ignition sources are required for the Revised Proposal however the construction schedule is three to six months longer.
Unplanned CO_2 release	Unplanned migration of CO_2	Unplanned migration of CO_2	Number of wells reservoir CO_2 injection increases from approximately seven injection wells directionally drilled from 2–3 locations (Approved Development) to approximately 8–9 injection wells directionally drilled from 3–4 locations (Revised Proposal). CO_2 pipeline length increases from 5 km (Approved Development) to 8 km (Revised Proposal).
Introduction or Spread of Non-Indigenous Plant Species (Weeds)	Competition with native species for resources Changes in vegetation community composition.	Competition with native species for resources Changes in vegetation community composition.	No additional or new pathways to introduce or spread weeds have been identified for the Revised Proposal however the construction schedule is three to six months longer.

6.3.2.1 Vegetation Clearing and Earthworks

Vegetation

The Approved Development was expected to disturb 300 ha on Barrow Island during the construction phase. The *Barrow Island Act 2003* (WA) and related State Agreement divide the maximum 300 ha available for gas processing activities into 200 ha of long term tenure and 100 ha to be utilised for future expansion or alternatively rehabilitated. The 200ha of long-term tenure involved:

- clearing of 150 ha for the Gas Processing Facilities, CO_2 pipeline, control lines and ancillary services
- clearing of 50 ha for the feed gas pipeline, control lines and ancillary services.

Within the 300 ha total available allocation for gas processing facilities, the Revised Proposal will involve long-term use of approximately 40 ha of the 100 ha allocated for future expansion or rehabilitation. The overall 300 ha land take required for vegetation clearing will not change as a result of the Revised Proposal.

The combined Approved Development and Revised Proposal will impact upon 51 vegetation associations. The majority of the Revised Proposal clearing area is the same as the Approved Development; therefore there is no change in impact to 36 of the 51 vegetation associations. Figure 6.1 presents the change in infrastructure layout and resulting changes in impacts to vegetation associations. Descriptions of the vegetation associations are contained in Appendix K.

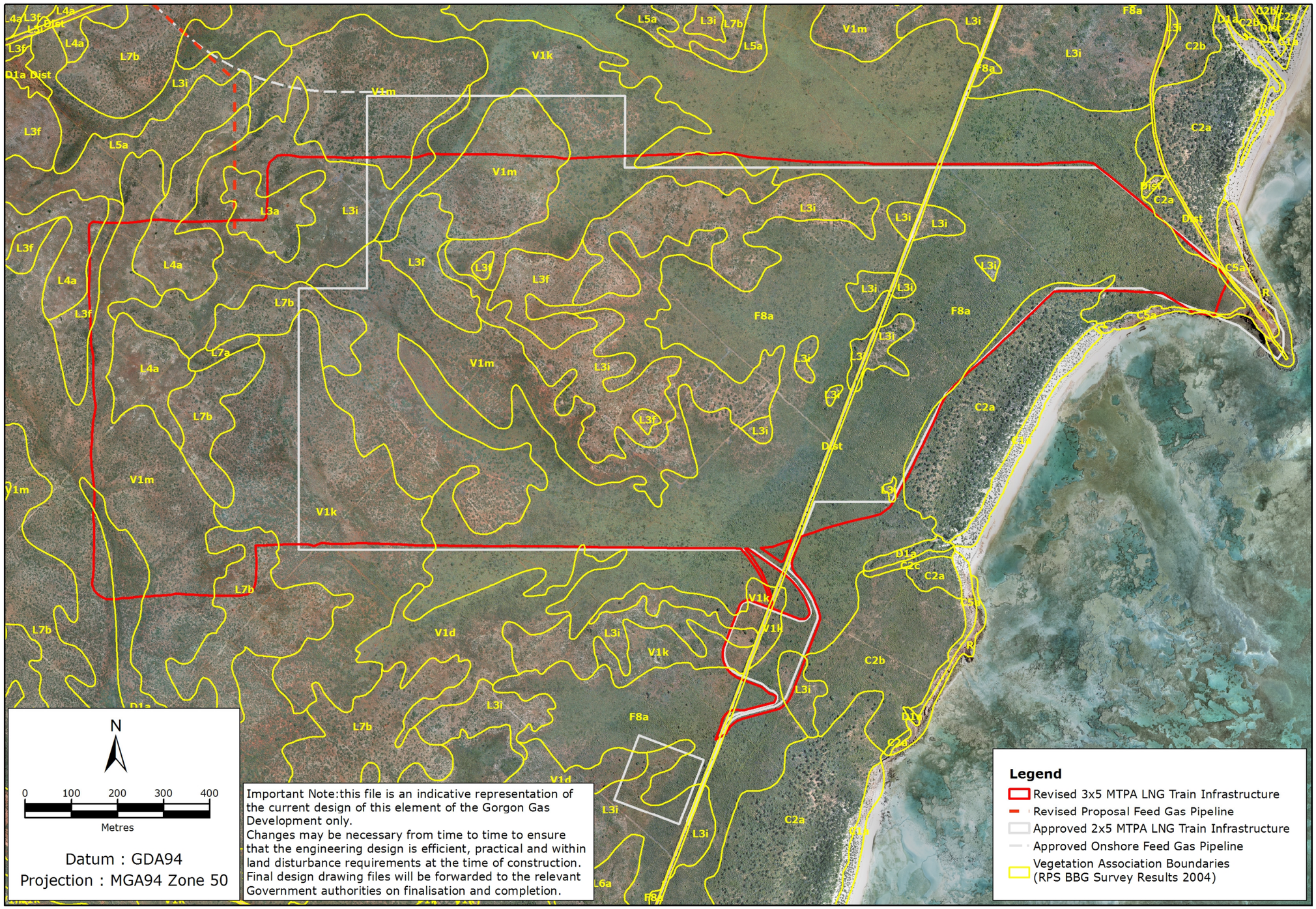

Figure 6.1: Vegetation Associations in the vicinity of the Revised Proposal Gas Treatment Plant Footprint

While there is no change in clearing requirements for 36 of the 51 vegetation associations, the change in the shape of the Gas Treatment Plant plot plan for the Revised Proposal will result in a decrease in clearing requirements for four of the 51 vegetation associations (presented in Table 6.6) and an increase in 13 of the 51 vegetation associations (presented in Table 6.7). There are two vegetation associations that do not now require clearing under the Revised Proposal (when compared with the Approved Development), these are the disturbed drainage line D1a (0.1 ha) and rocky areas (R) (0.2 ha).

Table 6.6: Decrease in Vegetation Clearing Associated with the Revised Proposal

Vegetation Association	Total Area of Vegetation Association within Area Mapped[1] (ha)	Approved Development		Revised Proposal		Decrease in Clearing of Area Mapped[1]
		Area to be Cleared (ha)	Proportion of Area Mapped[1] to be Cleared	Total Area to be Cleared (ha)	Proportion of Area Mapped[1] to be Cleared	
C5a	8.9	0.6	6.2%	0.06	0.6%	5.6%
D1a (Disturbed)	39.8	0.1	0.4%	0	0	0.4%
R	4.7	0.2	4.0%	0	0	4.0%
V1d	9.4	0.2	2.5%	0.003	0.04%	2.5%

NOTE:
[1] 'Area Mapped' is the total area of Barrow Island that has currently been surveyed and vegetation mapped by Chevron Australia. Currently 2 483 ha of vegetation has been mapped, which represents just over 10% of the total area of Barrow Island (23 567 ha). Therefore, it is important to note that the proportions of clearing presented are relative the 'Area Mapped' and not to the total area of Barrow Island.

The increase in clearing of 13 of the 51 vegetation associations is mainly due to the reconfiguration of the Gas Treatment Plant, which requires the extension of the clearing area to the west, as well as the relocation of the Administration and Operations Complex. Table 6.7 shows that the clearing increase is minimal, with the clearing increasing by 5% or less of each vegetation association (relative to the area of vegetation mapped on Barrow Island not the total area of Barrow Island). The exception being vegetation association L3a, for which clearing requirements has increased by 10.5% (relative to the area of vegetation mapped on Barrow Island not the total area of Barrow Island). Currently, Chevron Australia has mapped 2 483 ha of vegetation on Barrow Island, which represents just over 10% of the total area of Barrow Island (23 567 ha). Therefore, it is likely that vegetation associations have a greater extent on Barrow Island and actual clearing requirements of specific vegetation associations are less than those presented in Table 6.7.

Table 6.7: Increase in Vegetation Clearing Associated with the Revised Proposal

Vegetation Association	Total Area of Vegetation Association within Area Mapped[2] (ha)	Approved Development		Revised Proposal		Increase in Clearing of Area Mapped[2]
		Area to be Cleared (ha)	Proportion of Area Mapped[2] to be Cleared	Total Area to be Cleared (ha)	Proportion of Area Mapped[2] to be Cleared	
C2a[1]	53.3	1.0	1.8%	1.1	2.2%	0.3%
C2b[1]	31.0	0	0	0.001	0.004%	0.004%
D1a[1]	68.1	0.1	0.2%	1.4	2.0%	1.8%
F8a	190.0	58.3	30.7%	59.1	31.1%	0.4%
L3a	18.3	0	0	1.9	10.5%	10.5%
L3f	42.8	6.4	15.0%	6.9	16.2%	1.2%
L3i	118.9	20.7	17.4%	26.8	22.5%	5.1%
L4a	174.1	3.8	2.2%	9.3	5.4%	3.2%
L5a	29.0	0.04	0.2%	0.2	0.6%	0.4%
L7a[1]	10.9	0.3	2.5%	0.8	7.0%	4.5%
L7b[1]	203.1	1.7	0.8%	7.8	3.8%	3.0%
V1k[1]	119.0	18.4	15.5%	21.9	18.4%	2.9%
V1m[1]	191.4	32.8	17.1%	39.8	20.8%	3.7%

NOTES:
[1] Denotes vegetation associations considered to be restricted.
[2] 'Area Mapped' is the total area of Barrow Island that has currently been surveyed and vegetation mapped by Chevron Australia. Currently 2 483 ha of vegetation has been mapped, which represents just over 10% of the total area of Barrow Island (23 567 ha). Therefore, it is important to note that the proportions of clearing presented are relative the 'Area Mapped' and not to the total area of Barrow Island.

Due to the change in clearing area, two vegetation associations will be cleared for the Revised Proposal that were not affected by for the Approved Development; these being C2b and L3a. Large proportions of these two vegetation associations occur outside of the clearing area and will not be impacted upon by the Revised Proposal.

Of the 20 locally sensitive vegetation associations being affected by the combined clearing for the Approved Development and Revised Proposal footprint, impacts have only increased from the Approved Development for seven sensitive vegetation associations; these being coastal associations C2a and C2b, drainage line association D1a, limestone associations L7a and L7b and valley slope associations V1k and V1m. The Revised Proposal does not present any change in impact to the other sensitive vegetation associations compared to the Approved Development.

The extent of clearing presented in Tables 6.6 and 6.7 is indicative only, as it is based on the preliminary design of the onshore feed gas pipeline easement, Gas Treatment Plant and ancillary facilities. Some minor modifications are expected as detailed design progresses, for example vehicle turning circles within the feed gas pipeline easement have not been accounted for as the spatial location of these (and therefore the vegetation associations that will be impacted upon) are currently unknown. However, all modifications to clearing will be contained within the 300 ha available for use. Investigations and engineering design are being undertaken with consideration to the spatial extent of the clearing area and minimising impacts to vegetation to as low as practicably possible, with special emphasis being placed on the avoidance or reduction of clearing of sensitive vegetation associations where reasonably practicable.

The sites for the additional wells and pipeline associated with the change to the Reservoir Carbon Dioxide Injection System for the Revised Proposal have not been finalised. When the spatial extent of the system is better defined, vegetation and flora surveys will be completed to assist with the selection of the well and CO_2 pipeline locations. Vegetation and flora surveys will also assist with the route selection for access tracks. There is sufficient flexibility in the selection of locations for wells, pipeline and access track to avoid sensitive vegetation associations where reasonably practicable. Information from the surveys will be used to avoid or reduce disturbance to sensitive flora populations or vegetation associations to as low as reasonably practicable.

The cumulative clearing for the Revised Proposal (i.e. combined Approved Development and Revised Proposal) will not exceed the 300 ha available under the *Barrow Island Act 2003* (WA). However, within that total clearing area of 300 ha, the Revised Proposal will require an approximate additional 40 ha of land for long term use. In other words, this 40 ha of land that was allocated for temporary use by the Approved Development would not be rehabilitated following completion of the construction phase of the Revised Proposal, but instead would remain in use until the end of the operational life of the facilities.

The total area of Barrow Island is 23 567 ha of which approximately 1 222 ha (5.2%) has been cleared for the development of infrastructure for existing oilfield operations and seismic data acquisition. Total clearing for the combined Approved Development and Revised Proposal represents a cumulative increase of cleared land from the existing operations on Barrow Island (5.2%) to approximately 6.5% of the Island. The cumulative impacts of clearing associated with the Revised Proposal do not differ from the cumulative impacts presented for the Approved Gorgon Gas Development (Chevron Australia 2005a), which would also impact on 6.5% of the island.

The impacts (consequences) to vegetation as a result of clearing for the Revised Proposal are considered to be Moderate to Serious at a local scale as it results in localised loss of vegetation within the designated clearing area. However, site clearing is not expected to result in the loss of vegetation elsewhere on Barrow Island, nor is it expected to change the structure of vegetation associations or the viability of vegetation on Barrow Island.

The residual risk associated with clearing has increased from Low (general vegetation associations) and Medium (restricted vegetation associations) for the Approved Development, to Medium (general vegetation associations) and High (restricted vegetation associations) residual risk for the Revised Proposal. This change is in recognition that an approximate additional 40 ha will be allocated for long-term use, and consequences from clearing will be localised rather than widespread at an island-scale (refer to Table 5.2 for consequence descriptors to see how the definitions differ between consequence levels to reflect local and regional scale impacts).

Flora

No DRF or EPBC Act (Cth) listed species have been recorded on Barrow Island.

The Priority 3 species *Conchorus congener* has been recorded in varying densities in several vegetation associations within the combined clearing area for Approved Development and the Revised Proposal. It has also been recorded in 19 vegetation associations within the greater survey area that do not occur within the Revised Proposal clearing area. The changes associated with the Revised Proposal result in an additional 2% of the area covered by vegetation associations that support *Conchorus congener* within the greater survey area being cleared. This is a slight increase from the Approved Development which would result in 11% being cleared. Therefore the overall impact to

Conchorus congener habitat associated with the Revised Proposal is not considered to be significantly different to the Approved Development.

To date, three restricted flora species have been recorded in densities greater than 2% in vegetation associations in the combined clearing area for the Approved Development and Revised Proposal; *Erythrina vespertilio*, *Grevillea pyramidalis* subsp. *leucadendron* and *Melaleuca cardiophylla*. These species are not protected by legislation, but are considered to be of conservation interest because they are either restricted in distribution on Barrow Island or have low regeneration rates after disturbance. Table 6.8 describes the changes in impacts to vegetation associations within the Revised Proposal clearing area that support restricted flora species.

Table 6.8 Revised Proposal Impacts to Restricted Flora

Restricted Flora Species	Vegetation Association with Restricted Flora Species Density >2%	Revised Proposal Footprint	Total Area of Vegetation Associations within Area Mapped[1]
Erythrina vespertilio	F4b	No Change from Approved Development	
Grevillea pyramidalis subsp. *leucadendron*	L6b	No Change from Approved Development	
Grevillea pyramidalis subsp. *leucadendron*	L6c	No Change from Approved Development	
Grevillea pyramidalis subsp. *leucadendron*	L6d	No Change from Approved Development	
Melaleuca cardiophylla	L7a, L7b, V1d, V1k	Increase from 35.0 ha to 48.4 ha	414.8 ha

NOTE:
[1] 'Area Mapped' is the total area of Barrow Island that has currently been surveyed and vegetation mapped by Chevron Australia. Currently 2 483 ha of vegetation has been mapped, which represents just over 10% of the total area of Barrow Island (23 567 ha). Therefore, it is important to note that the proportions of clearing presented are relative the 'Area Mapped' and not to the total area of Barrow Island.

As demonstrated in Table 6.8, there is no change in clearing of associations that are characterised by *Erythrina vespertilio* or *Grevillea pyramidalis* subsp. *leucadendron*. Impacts to these species from the Revised Proposal are therefore considered the same as impacts from the Approved Development. All three species are recorded in other areas of Barrow Island that will not be disturbed by the Revised Proposal clearing area.

Increases in clearing of vegetation associations that support more than 2% coverage of *Melaleuca cardiophylla* are considered relatively small, increasing from approximately 8.5% of the total survey area (Approved Development) to 11.5% of the total survey area (Revised Proposal). Approximately 366 ha of these vegetation associations will remain undisturbed in the total survey area. The total survey area comprises just over 10% of Barrow Island (23 567 ha).

The impacts (consequences) to flora as a result of clearing caused by Revised Proposal activities are considered to be Moderate to Serious within the designated clearing area as it results in localised loss of flora. However, impacts to flora species at the wider scale of Barrow Island are not considered to result in the loss of abundance on flora on the Island or reduced viability of flora.

The residual risk associated with clearing has increased from Low (general flora species) and Medium (restricted flora species) for the Approved Development, to Medium (general flora species) and High (restricted flora species) residual risk for the Revised Proposal. The determinant for the change in risk level is the duration of clearing impact in consequence descriptor, i.e. an approximate additional 40 ha will be allocated for long-term operational use, rather than short-term construction phase use. Refer to Table 5.2 for consequence descriptors to see how the definitions differ between consequence levels to reflect time scale impacts).

6.3.2.2 Fire

The flora of Barrow Island is typical of the arid Pilbara region and has evolved within a regime of sporadic natural fires. Consequently Barrow Island flora is expected to regenerate or recolonise following fire.

The Revised Proposal will result in a longer construction time (approximately three to six months longer then the Approved Development). However, the Revised Proposal is not considered to present any significant additional or different risk in terms of fire impacts to flora and vegetation of Barrow Island in comparison to the Approved Development. The Revised Proposal does not entail any change in clearing method, types of machinery to be used on the island or any significant new ignition sources. Examples of ignition sources during construction and operations include hot works (welding and grinding) and vehicle exhausts.

Fire may be used to burn vegetation that has been cleared from the Gas Treatment Plant site to assist with the clearing process. If this method is undertaken it will only be carried out in favourable weather conditions and in a controlled manner with appropriate firebreaks and fire fighting resources. This is unchanged from the Approved Development. Other management measures for the Revised Proposal include the development and implementation of a Fire Management Plan (as required by Statement No. 748) and deployment of fire-fighting resources on Barrow Island during the construction and operation of the Revised Proposal.

The impacts of fire on flora and vegetation associated with the Revised Proposal are not considered to be significantly different to the impacts of the Approved Development as there are no new ignition sources and no significantly different activities resulting from the Revised Proposal. There is an increase in the overall area that will be allocated for long term use rather than being rehabilitated (approximately 40 ha), and construction will take approximately three to six months longer than the Approved Development schedule. The cumulative impacts of fire on conservation significant species for the Gorgon Gas Development as a whole at the island-wide scale of impact are considered by the Proponent to be the same as the cumulative impacts of the Approved Development.

The impacts (consequences) to flora and vegetation as a result of fire caused by Revised Proposal activities are considered to be Moderate within the immediate area of a fire; that is if a fire was to occur it would have the potential to result in localised loss of flora species or vegetation. However, a fire is highly unlikely to result in the loss of viability of flora and vegetation communities on Barrow Island as a whole.

The residual risk associated with fire has increased from Medium for the Approved Development to Medium-High residual risk for the Revised Proposal, in recognition that construction period will be approximately three to six months longer for the Revised Proposal.

6.3.2.3 Introduction or Spread of Non-Indigenous Species

Based on vegetation and flora surveys undertaken between 2003 and 2006, no introduced flora species have been located within the Revised Proposal clearing area. However, historical records and more recent weed monitoring undertaken by Chevron Australia (as operator for the Barrow Island oilfield) in 2007 and 2008 demonstrate that introduced flora species have occurred elsewhere on the Island; therefore clearing and earthworks will be managed during construction to minimise the introduction and spread of non-indigenous flora species.

The Revised Proposal is seeking to use approximately 40 ha of the 100 ha allocated for future expansion or rehabilitation for long term tenure. The overall Revised Proposal clearing area will not exceed the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA). The Revised Proposal represents a minor change in the location of some land clearing due to the extension of the Gas Treatment Plant, the diversion of the feed gas pipeline route and relocation of the

Administration and Operations Complex, although the majority of the clearing area is in the same location as the Approved Development.

The Revised Proposal is proposing to utilise the same clearing methods and equipment as the Approved Development, in generally the same area as the Approved Development.

It is considered that the introduction or spread of non-indigenous species from the Revised Proposal (and resultant impacts such as competition for resources with native species and change in vegetation) does not present significant additional or different environmental risk than the Approved Development, and that this residual risk is Low.

See also discussion of Quarantine Management System provided in Section 8.

6.3.3 Assessment of Potential Impacts to Matters of NES

There are no flora species or listed vegetation communities that require to be assessed or managed as matters of NES under the EPBC Act.

6.3.4 Proposed Management Actions

The Revised Proposal will be implemented by adopting best practicable measures to minimise impacts to the environment.

Impacts to the terrestrial flora and vegetation values of Barrow Island will be addressed by several plans, procedures, systems and programs that consistent with the requirements of the conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294.

As part of the implementation of Statement No. 748, the GJVs will submit (as applicable) the following plans and systems which include measures to mitigate and manage impacts to flora and vegetation:

- Terrestrial and Subterranean Environment Protection Plan
- Terrestrial and Marine Quarantine Management System
- Fire Management Plan
- Groundwater Abstraction Management Plan
- Solid and Liquid Waste Management Plan
- Post-construction Rehabilitation Plan
- Project Site Rehabilitation Plan.

The objectives and key management actions for each of these plans and systems are detailed in Table 15.2.

Environmental monitoring programs are being developed and will be implemented as required by Statement No. 748 for the Approved Development. These programs will collect data to monitor the condition of the baseline environment and can be adapted to include monitoring for the Revised Proposal. In particular, the Terrestrial and Subterranean Environment Monitoring Program is applicable to the monitoring of flora and vegetation impacts as a result of the Revised Proposal.

The GJVs will also submit a Terrestrial and Subterranean Baseline State and Environmental Impact Report in accordance with Statement No. 748 which includes discussion of the key flora and vegetation issues.

Construction and operation environmental management plans for the Revised Proposal will also be developed to be consistent with the requirements of EPBC Ref. 2003/1294, to address stressors to flora and vegetation.

The purpose, scope and objectives of the EMPs, programs and systems required under the conditions of approval for the Approved Development have been reviewed. It is considered that the impacts and risks of the Revised Proposal can be effectively managed under Ministerial Conditions consistent with those already set by the Western Australian Minister for the Environment (described in Statement No. 748) and Commonwealth Minister (described in EPBC Reference: 2003/1294). No additional measures or controls are anticipated to be necessary to manage the potential terrestrial flora and vegetation impacts (associated with the Revised Proposal).

6.3.5 Predicted Residual Environmental Risk

The Revised Proposal is not considered to pose any significant new or additional risks to terrestrial flora and vegetation in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts on terrestrial flora and vegetation as a result of the Gorgon Gas Development.

The implementation of the various plans, systems and programs that are consistent with the requirements of the conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294 is expected to manage the following Revised Proposal flora and vegetation impacts to a level consistent with that considered acceptable and therefore approved for the Approved Development:

- loss and/or disturbance of restricted flora species and sensitive vegetation associations
- change in vegetation community composition as a result of fire
- reduction of topsoil quality/ loss of seed bank as a result of fire
- smothering of vegetation and changes in the soil conditions along road verges due to dust deposition
- increase in the level of CO_2 in soil profiles from unplanned CO_2 release to the surface or near-surface environment
- competition for resources with native species and change in vegetation from the introduction or spread of non-indigenous plant species (weeds).

In the case of Revised Proposal impacts with higher residual risk than the Approved Development (namely loss of general flora and vegetation from site clearing and loss of vegetation community as a result of fire), the scope of the plans, systems and programs is considered adequate to manage the stressors and meet the EPA objective for terrestrial flora and vegetation. A comparison of the environmental risks for the Approved Development and Revised Proposal is presented in Table 6.9. Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk,

Table 6.9: Residual Environmental Risk Assessment – Flora and Vegetation

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Residual Risk For Revised Proposal (Approved and Revised Footprint)		
			L	C	RR	L	C	RR
Vegetation Clearing and Earthworks	Loss and/or disturbance of restricted flora species and sensitive vegetation associations	Terrestrial and Subterranean Environment Protection Plan Post-construction Rehabilitation Plan Project Site Rehabilitation Plan.	1	3	H	1	3	H
Vegetation Clearing and Earthworks	Loss and/or disturbance of non-restricted flora species and vegetation associations	Terrestrial and Subterranean Environment Protection Plan Post-construction Rehabilitation Plan Project Site Rehabilitation Plan.	1	5	L	1	4	M
Fire	Loss of vegetation community as a result of accidental fire	Fire Management Plan	3	3	M	2	3	H
Fire	Change in vegetation community composition as a result of accidental fire	Fire Management Plan	3	3	M	4	3	M
Fire	Reduction of topsoil quality/ loss of seed bank as a result of accidental fire	Fire Management Plan	3	3	M	3	3	M
Unplanned CO_2 migration or release to the surface or near surface environment	Change in vegetation community composition	Selection of a Dupuy Formation for injection of reservoir CO_2 Selection of the injection location such that CO_2 plume is not anticipated to approach faults Existing decommissioned wells will be worked over to ensure suitability for CO_2 service. Plans to manage well penetrations and ensure they are fit for service have been developed. A wellhead maintenance program and monitoring of annular pressures will be implemented. CO_2 injection and monitoring wells are designed for CO_2 service. Future hydrocarbon wells will be ensured to be designed for CO_2 service. Carbon Dioxide Monitoring Program.	5	4	L	1	5	L

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Residual Risk For Revised Proposal (Approved and Revised Footprint)		
			L	C	RR	L	C	RR
Introduction or Spread of Non-Indigenous Plant Species (Weeds)	Loss of native species due to competition from introduced species	Terrestrial and Marine Quarantine Management System	NA	NA	NA	1	5	L

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7.0 MARINE AND COASTAL ENVIRONMENT – RISKS AND MANAGEMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

7.1 Marine Fauna

7.1.1 Assessment Framework or Policy

7.1.1.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvement of knowledge (EPA 2004b).

7.1.1.2 Commonwealth Policy

Australia's Ocean Policy (Commonwealth Government of Australia 1998) sets in place the framework for integrated and ecosystem-based planning and management for Australia's marine jurisdictions. The key principles of the Policy which need to be considered in the development and implementation of marine-based proposals include:

- Ecologically sustainable development (ESD): all Australian governments have agreed to pursue ESD through their policies and regulations.
- Ecosystem-based management: where understanding and minimising the consequences of human activities on ecosystem integrity should be a primary consideration in making management decisions.
- Integrated oceans planning and management for multiple ocean use: considered necessary as marine-based activities may overlap or interact, needing consideration of all uses and values, and an understanding of cumulative impacts on the ecosystem.

7.1.1.3 State (WA) Policy

Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-20017 (DEC, 2007)
Vision for the Montebello/Barrow islands marine conservation reserves:

"*To conserve the marine flora and fauna, habitats and water quality of the Montebello/Barrow islands area. The area will support commercial and recreational activities that are compatible with the maintenance of environmental quality and be*

valued as an important ecological, economic and social asset by the community." (DEC, 2007)

The Revised Proposal does not increase the risk of exceeding the Key Performance Indicators outlined in this Management Plan beyond that risk already considered for the Approved Development.

There will be no impacts on the Key Performance Indicators for this Management Plan from planned operational activities. The only impacts are likely to result from the dredge program. The majority of the marine disturbance footprint and the Zones of High and Moderate Impact for the Revised Proposal are within the Barrow Island Port Area, which is excluded from the Barrow Island Marine Management Area and all associated Key Performance Indicators. The Zone of Influence extends into un-zoned areas of the Barrow Island Marine Management Area, as was predicted for the Approved Development. However, the Zone of Influence is the visible dredge plume and there are no predicted impacts to benthic primary producers within this area.

The dredge spoil ground is partly within the Port Area, the Marine Management Area and an un-zoned area, however this site location and size is unchanged from the Approved Development and does not require any further assessment for the PER.

7.1.2 Further Assessment of Potentially Significant Impacts

Potential stressors that may affect marine fauna as a result of the Revised Proposal have been identified and risk has been determined through an assessment of consequences and likelihood. The risk assessment methods, and definitions of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia, 2005a). A comprehensive description of the risk assessment process for the Revised Proposal is described in Section 5 of this PER. Section 5 describes the iterative process through which the GJVs have come to the conclusions discussed within this Section of the PER. It is recommended that readers refer to Section 5 of the PER before further examining the content of this Section. The results of the risk assessment workshops are presented in Appendix C.

The environmental stressor for which the likelihood of impact has been reduced in comparison with the Approved Development is listed below. This is not assessed further in this PER:

- Wastewater discharges.

  When wastewater discharges were assessed for the Approved Development, the assumed scenario included the release of tributyltin (TBT) (an organotin compound used in antifoulant paint on marine vessels). This substance has since been prohibited from use by international law, thus reducing the likelihood of occurrence and the risk associated with this stressor.

Aspects of the Revised Proposal with a potentially increased level of risk in comparison to the Approved Development (as determined during Preliminary Risk Assessments), or aspects with a perceived risk score of Medium or High have been further assessed as part of this section. The aspects (or stressors) for Marine Fauna that require the presentation of additional information are:

1. **Seabed disturbance** resulting in marine fauna habitat loss or loss of benthic fauna communities
2. **Light spill** resulting in potential reduction in turtle nesting from light spill and changes in seabird community composition due to increased availability of food

3. **Leaks and spills** resulting in metabolic effects on intertidal and shallow subtidal biota, smothering of exposed intertidal biota or mobile fauna, metabolic effects on sensitive habitats from oil, metabolic effects on foraging shorebirds, metabolic effects on emergent turtle hatchling, and physiological effects on listed marine fauna
4. **Physical presence of infrastructure** resulting in disturbance to marine fauna behaviour patterns
5. **Physical interaction** resulting in accidental vessel collision with listed marine fauna
6. **Noise and vibration emissions** resulting in potential disturbance and or injury to marine fauna due to underwater drilling, blasting and seismic data acquisition activities.

The potential impacts of the introduction and/or spread of non-indigenous species (i.e. quarantine stressor) are addressed in the Quarantine Management section (Section 8) of this PER.

Changes to the potential environmental impacts of the Approved Development resulting from the stressors associated with the Revised Proposal, are shown in Table 7.1. These were subject to further detailed study following the preliminary risk assessment and are discussed in detail in following sub sections. Where these studies indicate that the risk level assigned during the risk assessment workshops were incorrect, the risk levels have been re-assessed. The results from the Completed Risk Assessment are presented in Table 7.2, and are discussed in concluding statements specific to each stressor.

Table 7.1: Comparison of Approved Development and Revised Proposal Stressors for Marine Fauna

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Physical Disturbance of the Seabed	Marine fauna habitat loss Loss of benthic fauna communities	Marine fauna habitat loss Loss of benthic fauna communities	Marine footprint has changed (increase by approximately 6.5 ha or 3.2%). MOF Access Channel area of disturbance reduced. Causeway extended MOF relocated, design modified. LNG Jetty shortened.
Light Spill	Potential reduction in turtle nesting from light spill Changes in seabird community composition due to increased availability of food (i.e. insects and small fish)	Potential reduction in turtle nesting from light spill Changes in seabird community composition due to increased availability of food (i.e. insects and small fish)	East Coast Marine Facilities construction only during dayshift (resulting in reduced lighting requirements). Additional flaring associated with commissioning of 3rd LNG Train. Increase in light from additional LNG vessels.
Accidental Leaks and Spills	Metabolic effects on intertidal and shallow subtidal biota Smothering of exposed intertidal biota or mobile fauna Metabolic effects on	Metabolic effects on intertidal and shallow subtidal biota Smothering of exposed intertidal biota or mobile fauna Metabolic effects on	Increased LNG/Condensate vessel traffic.

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
	sensitive habitats from oil Metabolic effects on foraging shorebirds Metabolic effects on emergent sea turtle hatchling Physiological effects on listed marine fauna	sensitive habitats from oil Metabolic effects on foraging shorebirds Metabolic effects on emergent turtle hatchling Physiological effects on listed marine fauna	
Physical Presence of Infrastructure	Disturbance to marine fauna behavioural patterns	Disturbance to marine fauna behavioural patterns	Less drilling and blasting required. Causeway extended MOF relocated, design modified. LNG Jetty shortened.
Physical Interaction	Accidental vessel collision with listed marine fauna	Accidental vessel collision with listed marine fauna	Increased LNG/Condensate vessel traffic.
Noise and Vibration Emissions	Potential disturbance and or injury to marine fauna due to underwater blasting and drilling, seismic activities	Potential disturbance and or injury to marine fauna due to underwater drilling, blasting and seismic data acquisition activities	Drilling and blasting may be required during construction of the MOF Access Channel. Less drilling required due to shorter jetty. No change to CO_2 seismic monitoring program.

7.1.2.1 Seabed Disturbance

The major impacts to marine fauna from seabed disturbance during construction are habitat loss for flatback turtles and green turtles, and direct loss of habitat and listed benthic fauna such as pipefish.

Seabed disturbance and direct loss of listed benthic fauna will occur during construction of the causeway and MOF, dredging of the MOF access channel, construction of the LNG jetty and dredging of the LNG berth, turning basin and tanker access channel. The Revised causeway has been extended approximately 800 m to the east of the Approved causeway. The size of the MOF is unchanged from the Approved Development, but the location has moved east to deeper water near the edge of the subtidal pavement.

The total area of seabed disturbance on the macroalgae limestone reef from the Revised Proposal's causeway and MOF has increased by approximately 3.2% (Table 7.4). However, the reorientation of the MOF has resulted in a shorter access channel and less drilling and blasting through subtidal pavement (which lies beneath the macroalgae limestone reef habitat).

Loss and modification of the macroalgae limestone reef from dredging the MOF access channel and rock dumping for the causeway under the Revised Proposal will directly impact on the potential habitat of Sygnathid fishes, such as the rock pipefish (*Phoxocampus belcheri*). Although the revision of the causeway will remove an area of existing habitat, it may also encourage colonisation along the causeway wall over time. A local long-term decrease in abundance may occur at that site, but this is not predicted to result in reduced local population viability, particularly if the causeway and MOF structures provide suitable alternate habitat for these species. Pipefish habitats are widespread along the east coast of Barrow Island and the construction of the causeway is not likely to significantly impact important habitat. Some displacement of pipefish to adjacent undisturbed areas may also occur.

Flatback turtles have been observed in the general area of the Revised Proposal's MOF, and nest at beaches either side of Town Point (Pendoley Environmental 2008a). To a lesser extent, hawksbill and green turtles have also been observed in the nearshore areas, although nesting activity by these species on the beaches near Town Point is low (Pendoley Environmental 2008a). The loss of the macroalgae dominant limestone reef area from the construction of the revised causeway and MOF will not significantly reduce the feeding and pre-nesting areas for turtles as this habitat type is extensive in the region. In addition, while there is some evidence of resident flatback turtles in the area, the majority that have been satellite tracked to date move away from Barrow Island waters during the non-breeding season to forage (Pendoley Environmental 2006a, 2006b, 2008d).

There is a concern that the construction of the causeway may result in nesting female flatback turtles being displaced from their naturally selected nesting beach and forced to nest on a different beach. Displacement of nesting females may cause overcrowding of nests on other beaches. However, this is considered unlikely as tagging results show that an individual turtle will naturally use different beaches to haul out and nest (Pendoley Environmental, 2008a). Overall, the impact on nesting activity is not predicted to be different from the Approved Development.

The realignment of the LNG berth and turning basin under the Revised Proposal will result in additional disturbance of subtidal reef (low relief) and sand benthic habitat. Some areas of this habitat support the growth of seapens, part of the preferred diet of the flatback turtle. However, this habitat type is widespread across the east coast of Barrow Island and the region in general (DEC, 2007).

Based on the additional information that has been acquired since the Risk Assessment Workshop (i.e. seabed disturbance footprint calculations (Table 7.4) and benthic primary producer habitat calculations (Table 7.11)) it is considered that the Revised Proposal does not present different environmental risk to marine fauna or their habitat from seabed disturbance in comparison to the Approved Development (refer to Table 7.2, Completed Residual Risk Assessment).

7.1.2.2 Light Spill

Light associated with construction and operation of the Revised Proposal has the potential to impact on sea turtles and some seabirds (e.g. shearwaters and seagulls).

The main sources of light spill to the marine environment will be from lighting on the MOF, dredge vessels operating at night time and LNG vessels berthing or mooring at night time. These sources are unchanged from the Approved Development; however there are some changes to the quantity and duration of lighting requirements for the Revised Proposal. These are summarised below:

- Construction of east coast marine facilities (with the exception of dredging) will be restricted to dayshift resulting in a significant reduction in the magnitude and duration of lighting requirements during construction.
- There may be an increase in periods of operational lighting along the jetty to facilitate the approximately 25% increase in LNG vessel movements.
- Terrestrial light sources during construction and operation are not expected to significantly change.

The effects on marine fauna from artificial lighting are mainly dependent on the duration, intensity and wavelength of the light. Location and timing of the light spill relative to

breeding and foraging activity is also particularly important, as is the resilience of the fauna populations subjected to light.

Town Point beaches adjacent to the proposed causeway primarily support nesting flatback turtles during summer months (November to February). Nesting turtles can potentially be disturbed by artificial light and may be displaced to nearby beaches (Witherington and Martin 2000). Although there is a tendency for nesting turtles to prefer dark beaches, some will nest on artificially lit beaches, thereby exposing emerging hatchlings to the effects of artificial light.

Turtle hatchlings are known to use visual cues to navigate to the water from the nest (Lohmann *et al*. 1996). Intense artificial light sources, such as fluorescent and metal halide lights, can attract hatchlings causing them to become disorientated (Witherington and Martin 2000). Once in the water hatchlings primarily orientate by using the direction of incoming waves, therefore light spill onto the ocean (e.g. from vessels or permanent marine infrastructure) is unlikely to disorientate hatchlings swimming offshore. Coastal Process Modelling (Appendix F) indicates that the ocean currents and water circulation in the vicinity of the Causeway and MOF will tend to disperse hatchlings.

Light experiments on flatback hatchlings emerging from nests (Pendoley Environmental 2008f) have shown that flatback hatchlings will select short wavelength light (blues) over longer wavelength light (oranges/yellows) and they do not discriminate between long wavelength lights (reds/oranges) and a dark background. These findings, together with results of additional light studies conducted in the field (Pendoley Environmental 2007), support the use of low pressure sodium lights on the causeway, MOF and LNG Jetty to minimise disorientation to flatback hatchlings.

Lighting impacts on turtles due to the Gorgon Gas Development are not likely to result in a reduction in local population viability. The significant distance of the MOF and LNG Jetty from the majority of beaches where emergence occurs (Pendoley Environmental 2008b) will allow hatchlings to disperse offshore and will diminish the effect of additional land-based light sources on the turtles (Appendix D).

It is considered that the Revised Proposal does not present significant additional or different environmental risk to the artificial lighting impact on sea turtles in comparison to the Approved Development.

Light spill onto the ocean can also alter foraging behaviour in some shorebirds, such as silver gulls. Increased food availability such as insects and small fish attracted to the lights, is likely to benefit the health of the silver gull population, where gull numbers may increase and additional nesting space may be required. This can result in gulls out-competing other seabirds for nesting space, such as terns on nearby Double Islands, leading to reductions in local tern numbers or displacement of terns to other islands. However, the planned measure to minimise lighting of the marine facilities and minimised lightspill will ensure that this likelihood is minimised.

The impacts to marine fauna from light spill are not expected to extend further or affect new areas beyond those already identified as being affected by the Approved Development.

7.1.2.3 Accidental Leaks and Spills

The potential for significant impact to marine fauna from a leak or spill incident associated with the Revised Proposal mainly relates to condensate or liquid hydrocarbons from work vessels, LNG and condensate tankers and work barges that have bunkers of diesel and possibly other liquid fuels on board.

LNG is not toxic and rapidly evaporates and has been recognised as having little impact on the environment (ABS Consulting 2004). Fresh condensate could be expected to be acutely toxic to seagrass, infauna and most intertidal biota, and may cause irritation and damage to more sensitive membranes of the eyes and mouth in marine mammals and turtles. Release of oil or bunker fuels could potentially cause surface slicks or become entrained in the nearshore sediments resulting in slow release into the marine environment over time.

It is considered that the Revised Proposal presents a reduced environmental risk to marine fauna from hydrocarbon leaks and spill, relative to the Approved Development (Refer to the Risk Assessment Workshop Tables in Appendix C). The risk has been reduced in recognition of strict marine operations and traffic management measures that will be in place within the controlled port area to prevent vessel collisions.

7.1.2.4 Physical Presence of Infrastructure

The major impact to marine fauna from the physical presence of Gorgon Gas Development infrastructure may be disturbance to the behavioural patterns of sea turtles, with disturbance to dugongs and dolphins also possible. The revised causeway extends an additional 800 m offshore from Town Point. This extension may hinder movement of sea turtles along the east coast of Barrow Island by obstructing north–south access of the nearshore waters. The nearshore waters around the Revised Proposal marine facilities support gravid flatback turtles during the nesting season (Pendoley Environmental and RPSBBG 2005, Pendoley Environmental 2008a) and these turtles are known to travel along the coastline in the shallow water searching for places to nest (Pendoley Environmental 2008d).

The GJVs have considered the potential risk that the causeway/MOF structure will provide a barrier to nesting flatback turtles; potentially restricting access to the nesting beaches north and south of Town Point. However, turtles are excellent swimmers and satellite tracking of a number of flatback turtles following nesting on beaches near Town Point indicate habitat ranges in the order of 1500 km and daily ranges up to 40–50 km (http://www.seaturtle.org). This is based on satellite tracking results and the resultant calculation that flatback turtles are able to swim comfortably at 2- 2.5 km per hour (Pendoley, K. 2008. personal communication.). This indicates that the additional 800 m of causeway and MOF is unlikely to limit the accessibility to either the northern or southern beaches for flatback turtles. The revised MOF is expected to act like a natural headland, which turtles will need to navigate around and is not expected to be a significant impediment.

There was also concern raised at the Risk Assessment Workshop that Marine fauna moving between the nearshore areas north and south of the causeway will need to travel through deeper waters to travel past the MOF and potentially be subject to increased predation. The water depth at the head of the MOF (the furthest point of the solid marine infrastructure) for the Approved Development ranged between 2.5 m (low tide) and 7.5 m (high tide). The additional 800 m in length of the MOF results in the water depth at the head of the MOF ranging between 4.5 m and 9.5 m. Figure 7.1 indicates and compares the predicted water depths at the head of the MOF for the Approved Development and the Revised Proposal. As the increase in water depth is minimal, it is not anticipated that this will significantly alter predation rates.

Consideration was given to providing bridge or culvert structures in the causeway to enable turtle movement through the causeway as well as around the structure. The purpose of the causeway is to provide road access to the MOF and LNG Jetty. The causeway also supports the export pipelines and provides a haul road for importing

prefabricated modules units from the MOF to Barrow Island. These modules will have a mass of up to 7000 T. The width of the causeway will vary with water depth but will average around 100m wide.

Bridge or culvert structures would need to include sufficiently wide openings to reduce the tidal flow inside the structure to below velocities that would potentially harm the marine fauna. The structures would need to have sufficient freeboard to eliminate tidal differentials either side of the causeway and be secured to the seabed to withstand cyclonic forces. This would also require the module unit haul road to be elevated several metres above the current level, necessitating a significant increase in the volume of construction material along the majority of the length of the structure.

Incorporating suitable bridge or culvert structures in the causeway would be a major component of infrastructure and would require a more complex mode of construction. Thus adding significant safety implications (associated with additional man-hours during construction involving working at height over water) and additional cost and schedule impacts associated with the required construction methods. Furthermore, it is not known if the sea turtles would actually choose to use the culverts as a preferred conduit. Therefore, given the impacts on cost, structure footprint size, causeway operability and the uncertainty in environmental benefit derived, this option is not considered to be reasonably practicable.

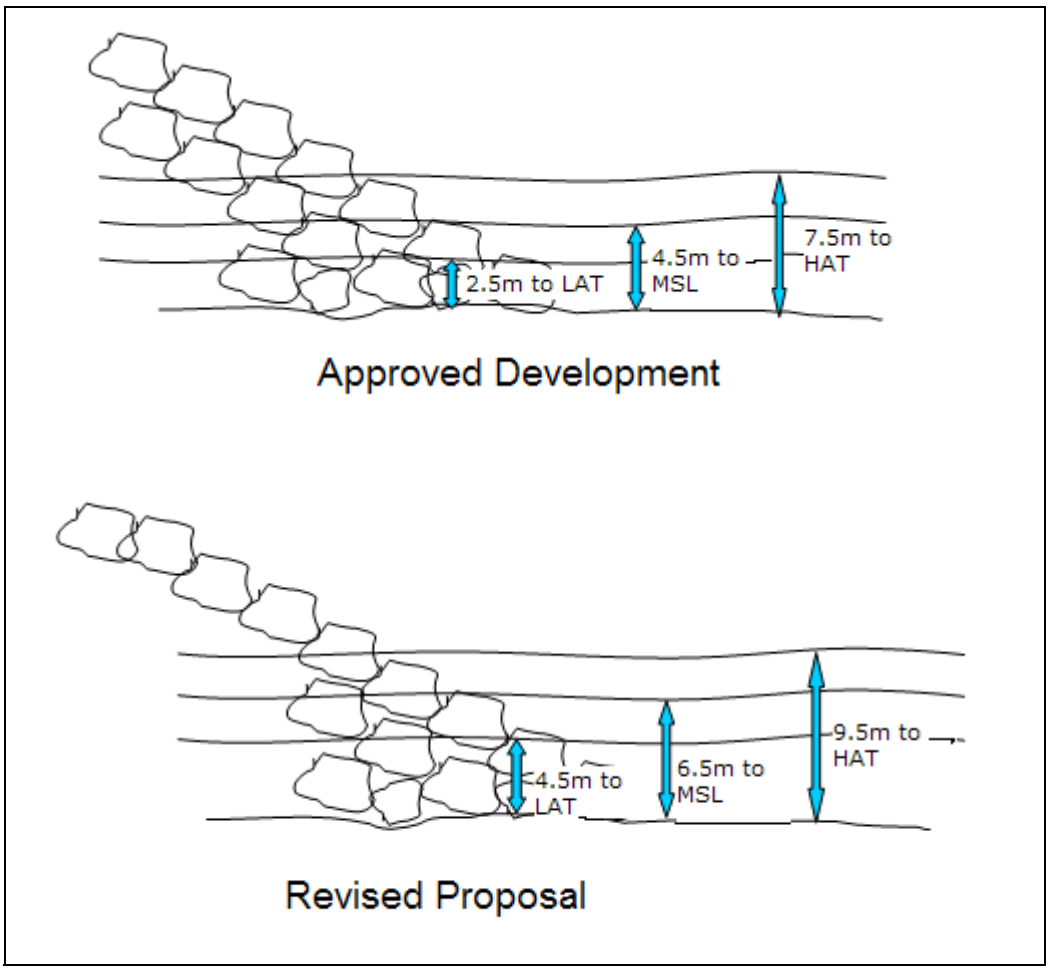


Figure 7.1: Comparison of Water Depth at the Head of the MOF for the Approved Development and the Revised Proposal

The causeway structure has the potential to affect the natural wave direction and disrupt turtle hatchlings as they attempt to move offshore. Once in the water, turtle hatchlings may use the wave direction as one of the directional cues to move offshore. At Town Point the shallow rock platform aligns the wavefront parallel to the shore. The potential impact of the proposed causeway is reduced as it is orientated perpendicular to the wave front and the armour protection will act to absorb the wave energy.

As the hatchlings move offshore, the surface currents become more significant and will tend to disperse the hatchlings beyond the MOF area. These currents are described in Appendix F, which contains the Coastal Process Modelling Report and additional time series plots comparing scenarios with and without the causeway / MOF structure.

The benthic habitats used by marine turtles, in the Revised Proposal area, are well represented around Barrow Island and in the broader region (DEC, 2007). The division of Town Point Beach by the Revised Proposal causeway is considered unlikely to have an increased risk of impacts to the inter-nesting behaviour for nesting flatback and hawksbill turtles in comparison to the Approved Development. This conclusion is based on a better understanding of the seabed profile (including water depth), the coastal processes and analysis of data relating to marine turtle behavioural patterns.

Not withstanding the previous assessment, it is possible that the additional 800 m of the Revised Proposal causeway may increase the risk of disruptions to adult turtle behaviour, beyond predicted disruptions from the Approved Development causeway. Therefore the risk of impacts to turtles from the physical presence of the Revised Proposal Causeway was conservatively assessed as Medium as compared with the Low risk rating given for the Approved Development (Table 7.2).

The natural protection afforded by several hundred metres of limestone rock platform (Appendix F) and the confinement of the beach areas between rocky headlands, results in a relatively low energy coastal environment. Coastal process modelling shows the revised causeway and MOF structures will have little impact on longshore sediment transport (Appendix F). The Town Point foreshore area is a typically stable environment (Appendix F). There may be some additional sedimentation on the beaches either side of the causeway and a minor increase in current strength around the end of the MOF associated with the additional length of the causeway, but this will cause insignificant effects on the marine environment. In general the causeway will provide some protection to the beaches near Town Point during severe weather events potentially reducing periodic erosion associated with these events (Appendix F). Overall, the risk of changes to the foreshore is low and the disturbances to the seabed only affect very well represented landforms.

The risk of impacts to the foreshore associated with the presence of infrastructure can be appropriately monitored and managed (e.g. Statement No. 748 Condition 25, Coastal Stability Management and Monitoring Plan). Construction of the revised marine facilities is not anticipated to affect the ecological integrity of the surrounding physical habitats or the structural integrity of flatback turtle nesting beaches.

7.1.2.5 Physical Interaction

As is the case for other operation ports, whales, turtles and dugongs are at a low risk of vessel collision, potentially resulting in injury or death. The potential impact is greater during the operational phase of the Revised Proposal due to the increase in LNG and Condensate tanker movements from approximately 240 vessels per year to approximately 300 vessels per year. It was not considered that the minor increase in likelihood was sufficient to increase the likelihood descriptor in the risk assessment from ‘likely’ to ‘almost certain’, so the risk remains the same as for the Approved Development. The consequence of vessel strikes will not increase as a result of the Revised Proposal. The results of the risk assessment are presented in Table 7.2.

7.1.2.6 Noise and Vibration Emissions

The marine construction activities with the potential to emit high levels of noise and vibration are blasting and drilling. Activities such as dredging and general shipping emit lower levels of noise and vibration into the marine environment. Seismic monitoring of the subterranean CO_2 plume will emit noise and vibration periodically during the operational phase of the development.

The impacts to marine fauna from noise and vibration emissions are predicted to be limited to behavioural disturbances. Physiological impacts to marine fauna will be restricted to fauna within close proximity of the source and management of the noise producing activities will ensure that marine megafauna are kept out of the immediate vicinity of the activities.

There is no Australian legislation or guidance documentation that defines permissible levels for underwater noise associated with blasting or drilling. The EPBC Act Policy

Statement 2.1 outlines procedures for managing interactions between seismic surveys and cetaceans.

The relocation of the MOF further offshore and the shortening of the LNG Jetty under the Revised Proposal, results in a reduction of drilling and blasting activities in comparison to that ultimately required for the Approved Development (following results of geophysical surveys during Front End Engineering Design). While the impact to marine fauna is anticipated to be less for the Revised Proposal compared to the Approved Development, this stressor will be discussed further in this section due to the importance of this issue.

Figure 2.5 displays the results of Geophysical survey work extending along the proposed route of both the Approved and Revised Causeway and MOF structures. These results clearly show that hard rock is present in the location previously approved for the MOF Access Channel and associated dredging. It is anticipated that this rock may not be dredgeable and would likely need to be removed using drill and blast techniques.

Potential Impacts to Marine Fauna

The efficiency of sound propagation in water allows marine mammals to use sound as a primary method of communication and to sense the presence and location of objects (Richardson et al. 1995). Underwater noise created by ships and other survey and construction activities can be detected many kilometres from the source and can potentially have a negative effect on marine mammals and fish (RPS Energy, 2006). This could interfere with the animal's ability to detect calls from conspecifics, echolocation pulses or other natural sounds. Another potential effect is the influence that these man-made sounds could have on behaviour. Behavioural effects could range from brief interruptions of resting, feeding or social behaviour, to short or long-term displacement from important foraging, shelter or mating habitats (Richardson et al, 1995). Behavioural responses to constant sources of noise, such as drilling, are generally temporary and short range (McCauley 1998). Marine mammals tend to alter direction and swim away from the noise source. However, impacts on other behaviours are difficult to quantify because marine mammals generally feed and socialise underwater (Stone 2003). The difference in behavioural response is largely dependent on whether the noise is an acute or a chronic stressor. The principal effects of intense noise and vibration, such as marine blasting on marine mammals and fish are physiological impacts. These can only occur when marine fauna are close to the blasting source. When fauna are more distant from the source of the marine blasting, behavioural responses (such as avoidance) can occur.

Physiological impacts to marine fauna from intense noise and vibration may include physical injury, permanent hearing loss, temporary hearing loss or mortality. The greatest potential for injuries is associated with blasting and seismic detonation and the fauna most likely to be affected are proximal fauna with gas-filled swim bladders or lungs, for example fish, turtles and marine mammals and animals with well developed auditory systems. These impacts can be minimised by shepherding marine megafauna out of the area prior to discharge, the use of small, warning detonations to scare fauna out of the area and other measures outlined in the ***Management Procedures and Mitigation Strategies*** Section below.

While intense noise has been shown to adversely affect some marine fauna, especially at close range, the studies are ambiguous and the current level of understanding is far from conclusive (Gordon *et al*. 2004; Dolman and Simmonds, 2006). The relationship between the sources of marine noise, sound propagation through the underwater environment and likely impacts on marine receptors is complex and difficult to quantify. In predicting impacts, it is important to consider the duration and frequency of the impulse, the depth of the water, the proximity to the source, water temperature and

salinity, proximity to land masses and even a species' individual perception to given sound frequencies or previous exposure to noise (Richardson et al, 1995; RPS Energy, 2006).

The effects of the noise and vibration emissions from activities on the east coast of Barrow Island will be restricted to the local area. The coast of Barrow Island and the shallow reef systems along the east coast will act as a natural barrier to noise and vibration, greatly limiting the spread of the sound waves and consequently the potential for impacts to marine fauna. Sound transmission in shallow water is highly variable due to the numerous boundary interactions and sound attenuates much more rapidly in shallow than in deeper water (Richardson et al, 1995; Parvin et al, 2006). Marine construction activities along the east coast of Barrow Island for the Revised Proposal will generally be restricted to water less than 15 m deep. Land masses and shallow reef systems naturally inhibit the spread of the sound waves, largely reducing the area of impact from noise in shallow water (Parvin et al. 2006).

Dugongs and dolphins, while not common on the east coast of Barrow Island are the marine mammals most likely to be encountered along the east coast of Barrow Island and are therefore most likely to be affected by noise and vibration emissions associated with the Revised Proposal. Migrating whales are rare visitors to the east coast and unlikely to be affected in general, because most of the migrating whales occur along the west coast of the island where they will be sheltered from noise and vibrations by the island. The marine habitats along the east coast of the island do not represent regionally important areas for these taxa.

It is considered that noise and vibration emissions from Revised Proposal work activities do not present additional risk, or different types of environmental risk, to marine fauna beyond those assessed for the Approved Development.

Potential Impacts to Marine Turtles

The effects of explosive discharges on sea turtles are thought to range from acoustic harassment or disorientation through to death (Viada *et al*., 2008), with animals close to the detonation generally sustaining mortal injuries (Lutcavage *et al*., 1996). A suitable exclusion zone will be set to manage impacts to marine turtles when blast size requirements are known.

Published studies have found anthropogenic noise has a significant effect on sea turtle behaviour, particularly by altering their submerging patterns and displacing them from dependable feeding grounds, migratory routes and nurseries (Geraci & Aubin, 1980; Samuel *et al*., 2005). Impulse noise can lead to startle responses, while ongoing background noise may interfere with communications and cause stress (Samuel *et al*., 2005) which can lead to problems such as lowered resistance to disease, increased vulnerability to environmental disturbances, and endocrine imbalances, which may in turn affect reproduction (Geraci & Aubin, 1980).

Marine Turtle life stages potentially at risk from blasting associated with the Gorgon Gas Development include breeding adults, resident foraging adults, hatchlings and juveniles. Species at risk are predominantly flatback turtles on the east coast. Internesting females of all species are particularly sensitive to disturbance. This is particularly critical for the flatback females since these animals nest on average every two years (Pendoley-Environmental, 2008). Killing or injuring breeding females may potentially have an impact on the breeding population.

It is considered that the Revised Proposal does not present significant additional or different environmental risk to marine turtles from noise and vibration emissions in comparison to the Approved Development.

Management Procedures and Mitigation Strategies (Noise and Vibration Emissions)

The Revised Proposal will be implemented by adopting best practicable measures to minimise impacts to the environment.

Impacts to marine fauna, including matters of NES, will be addressed by several Environmental Management Plans, systems and programs that are consistent with those required under conditions prescribed for the Approved Development in Statement No. 748 and Commonwealth Approval EPBC Reference: 2003/1294.

As part of the implementation of Statement No. 748, the proponent will submit the following plans for Ministerial approval:

- Marine Facilities Construction EMP (Condition 17) (this has specific reference to managing blasting and it will include relevant management within)

Other mitigation measures will include the preparation of the following strategies:

- Offshore Fauna Interaction Impact Mitigation Strategy
- Offshore Noise And Vibration Impact Mitigation Strategy
- Sea Turtle Noise guidance
- Sea Turtle Blasting guidance.

Additional measures to be taken during marine construction and operations activities to reduce the impacts of noise and vibration emissions to marine fauna may include the following where reasonably practicable:

- establishing and managing an exclusion zone appropriate to the activity
- applying best practice industry standards for individual explosive weights
- using sequential explosive charges, staggered to minimise cumulative effects of the explosions
- using smaller, more frequent blasts, as opposed to less frequent, larger blasts
- explosive material; the lethality of an explosion is determined by the rise and fall time of the pulse. Some explosives have slower rise and fall times than others. Explosives with a slower rise and fall time may be used if reasonably practicable.
- considering marine fauna activities (e.g. nesting, turtle nest emergence, migration) when planning drilling, piling, seismic, blasting and dredging operations, and avoiding blasting work during these periods where reasonably practicable
- visual monitoring before detonation; it is recommended that lookouts be posted before blasting and that a small patrol vessel be deployed to determine if there are any turtles or marine mammals inside the safety range of the explosion.
- scheduling blasts for daylight hours only, avoiding dawn and dusk to allow for effective visual monitoring
- consideration of physical removal of marine turtles in consultation with DEC
- consideration of collecting and removing fish kills between blasts to avoid subsequent blast exposure to scavenging marine fauna
- reporting all incidents and assess corrective measures implemented

- reduce noise through vessel speed restrictions

Note: Setting off warning shots prior to marine blasting has been considered. Potential exists for this practice to attract larger fish and dolphins to scavenge on dead baitfish in between the warning shot and the blast proper, potentially resulting in more significant impacts to these species; therefore, this practice will not be used.

7.1.3 Assessment of Potential Impacts to Matters of NES

Some species of marine fauna that occur in the areas covered by the Revised Proposal are listed as threatened and/or migratory under the EPBC Act and are thus considered to be species of National Environmental Significance (NES). Additionally, there are species or biological communities that are not considered to be of NES, but are recognised as 'key receptor species'. These species were originally identified for the Approved Development to represent biological communities that occupy similar ecological niches. These species of NES and the key receptor species are also discussed for the Revised Proposal. There are no additional species affected by the Revised Proposal.

Forty marine fauna species listed as Matters of NES may be impacted by the construction and operation activities of the Revised Proposal. These species include green turtles, flatback turtles, hawksbill turtles and dugongs, as well as a variety of dolphin and seabird species.

The potential impacts of seabed disturbance on green, flatback and hawksbill turtles are discussed in Section 7.1.2.1.

The impacts to sea turtles and seabirds from light spill are discussed in Section 7.1.2.2.

The impacts to sea turtles and seabirds from accidental leaks and spills are discussed in Section 7.1.2.3.

The impacts from the physical presence of the infrastructure on listed marine fauna are described in Section 7.1.2.4.

Several species listed as Matters of NES may be susceptible to vessel collision. This risk is discussed in Section 7.1.2.5.

Several species listed as Matters of NES may be susceptible to impacts caused by noise and vibration emissions. This risk is discussed in Section 7.1.2.6.

7.1.4 Proposed Management Actions

The Revised Proposal will be implemented adopting best practicable measures to minimise impacts to the environment.

Impacts to marine fauna, including matters of NES, will be addressed by several EMPs, systems and programs that are required under conditions prescribed for the Approved Development in Statement No. 748 and Commonwealth Approval Decision EPBC Reference: 2003/1294, including:

- Dredge and Spoil Disposal Management and Monitoring Plan
- Long-term Marine Turtle Management Plan
- Marine Facilities Construction Environmental Management Plan.

The objectives, targets and management measures for each of these plans are detailed in Section 15. In addition to the above plans, the conditions prescribed in Statement No. 748 include the requirement for the GJVs to establish a Marine Turtle Expert Panel and a Construction Dredging Environmental Expert Panel to provide advice to both the Minister and the GJVs on the development and implementation of these plans. Furthermore, the Chevron Australia Oil Spill Contingency Plan will be implemented to fulfil the requirements of AMSA, DoIR and NATPLAN.

Construction and operation environmental management plans for the Revised Proposal will also be developed to be consistent with Commonwealth Approval EPBC Reference: 2003/1294 to address stressors to marine fauna.

It is considered that the impacts and risks of the Revised Proposal can be effectively managed under conditions the same or consistent with those already set by the Western Australian Minister for the Environment in Statement No. 748. No additional measures or controls are anticipated to be necessary to manage the potential marine fauna impacts associated with the Revised Proposal.

7.1.5 Predicted Residual Environmental Risk

The Revised Proposal is not considered to pose any significant new or additional risks to marine fauna in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts on marine fauna as a result of the Gorgon Gas Development. The implementation of various EMPs, programs and systems is expected to manage the potential impacts to marine fauna to a level consistent with that considered acceptable and therefore approved for the Approved Development.

In the case of Revised Proposal stressors with higher residual risks than the Approved Development, the scope of the EMPs, programs and systems is considered adequate to manage the stressors and meet the EPA's objective for marine fauna.

The residual risks for stressors with potential Medium and High risks is summarised in Table 7.2. (Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk),

Table 7.2: Environmental Risk Assessment (with Management Mitigation Practices) to Identify those Impacts on Marine Fauna

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
			L	C	RR	L	C	RR	L	C	RR
CONSTRUCTION											
Seabed disturbance	Loss and/or disturbance of marine fauna habitat	Marine Facilities Construction Environmental Management Plan Dredge and Spoil Disposal Management and Monitoring Program Long-term Marine Turtle Management Plan	2	4	M	1	4	M	1	4	M
	Direct loss of benthic faunal communities		2	4	M	1	4	M	1	4	M
Light spill	Reduced turtle nesting,	Long-term Marine Turtle Management Plan	1	4	M	2	4	M	2	4	M
Noise and Vibration Emissions	Potential disturbance to marine fauna and or injury due to underwater blasting and drilling	Marine Facilities Construction Environmental Management Plan	2	5	L	Noise and Vibration Emissions were not considered during the Risk Assessment Workshop due to the perceived reduction in estimated required blast volume.			2	5	L

			Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
OPERATION											
Leaks and spills	Metabolic effects on intertidal and shallow subtidal biota (60 T spill)	Oil Spill Contingency Plan Long-term Turtle Management Plan	4	3	M	4	4	L	4	4	L
	Smothering of exposed intertidal biota or mobile fauna		4	3	M	4	4	L	4	4	L
	Metabolic effects on sensitive habitats		4	3	M	4	4	L	4	4	L
	Metabolic effects on turtle hatchlings		4	3	M	4	4	L	4	4	L
	Physiological effects on listed marine fauna		4	3	M	4	4	L	4	4	L
Physical presence of infrastructure	Disturbance to marine fauna behavioural patterns	Long-term Turtle Management Plan	2	5	L	3	3	M*	3	4	M
Physical interaction	Vessel collision	Long-term Turtle Management Plan	2	5	L	-	-	M	2	5	L
Light spill	Increased predation of turtle hatchlings	Lighting Strategy	1	5	L**	3	3	M	3	3	M
	Change in gull and tern community		1	5	L**	4	4	L	4	4	L

			Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
	composition										

NOTES:
** Risk Analysis conducted by Pendoley Environmental used as Residual Risk score (Likelihood and Consequence scores not supplied).*
*** Residual Risk score incorrectly listed in EIS/ERMP (Chevron Australia 2005a) as Medium.*

7.2 Marine Physical Environment and Coastal Processes

7.2.1 Assessment Framework or Policy

7.2.1.1 EPA Objective

To maintain the integrity, ecological functions, and values of the seabed and coast (EPA 2004b).

7.2.1.2 State (WA) Policy

Western Australian Planning Policy No. 2.6 – State Coastal Planning (Western Australian Planning Commission 2003)
State Planning Policy No. 2.6 applies to the coasts throughout Western Australia, including offshore islands. The Policy prescribes several objectives which need to be considered in coastal planning process, those relevant to development on Barrow Island being:

- The proposal provides for the protection, conservation and enhancement of coastal values, particularly in areas of landscape, nature conservation, indigenous, and cultural significance.
- The proposed location of coastal development and facilities takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria.

Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-20017 (DEC, 2007)
Vision for the Montebello/Barrow islands marine conservation reserves:
"*To conserve the marine flora and fauna, habitats and water quality of the Montebello/Barrow islands area. The area will support commercial and recreational activities that are compatible with the maintenance of environmental quality and be valued as an important ecological, economic and social asset by the community*." (DEC, 2007)

The Revised Proposal does not increase the risk of exceeding the Key Performance Indicators outlined in this Management Plan beyond that risk already considered for the Approved Development.

The majority of the marine disturbance footprint and Zones of High and Moderate Impact for the Revised Proposal are within the Barrow Island Port Area, which is excluded from the Barrow Island Marine Management Area and all associated key performance indicators. The Zone of Influence extends into un-zoned areas of the Barrow Island Marine Management Area, as was predicted for the Approved Development. However, the Zone of Influence is the visible plume and there are no predicted impacts to benthic primary producers within this area.

The dredge spoil ground is partly within the Port Area, the Marine Management Area and an un-zoned area however, this site location and size is unchanged from the Approved Development and does not require any further assessment for the PER.

7.2.2 Further Assessment of Potentially Significant Impacts

Potential stressors that may affect the marine physical environment and coastal processes as a result of the Revised Proposal have been identified and risk has been determined through an assessment of consequences and likelihood. The risk assessment methods, and definitions of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia, 2005a). A comprehensive description of the risk assessment process for the Revised Proposal is

described in Section 5 of this PER. Section 5 describes the iterative process through which the GJVs have come to the conclusions discussed within this Section of the PER. It is recommended that readers refer to Section 5 of the PER before further examining the content of this Section. The results of the risk assessment workshops are presented in Appendix C.

Aspects of the Revised Proposal with a potentially increased level of risk in comparison to the Approved Development (as determined during Preliminary Risk Assessments), or aspects with a perceived risk score of Medium or High have been further assessed as part of this section. The aspects (or stressors) for the Marine Physical Environment and Coastal Processes that require the presentation of additional information are:

1. **Physical disturbance of the seabed** potentially resulting in change in seabed profile, change in seabed type, smothering of seabed (construction phase).
2. **Physical presence of infrastructure** resulting in change to seabed profile (operation phase). Physical presence of infrastructure will also change the seabed type and smother the seabed. These impacts are covered by Physical disturbance of the seabed.

Changes to the potential environmental impacts of the Approved Development resulting from the changed attributes of the stressors associated with the Revised Proposal are shown in Table 7.3.

Table 7.3: Comparison of Approved Development and Revised Proposal Stressors for Marine Physical Environment and Coastal Processes

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Physical Disturbance of Seabed	Change in seabed profile Change in seabed type Smothering of the seabed	Change in seabed profile Change in seabed type Smothering of the seabed	Marine footprint has changed (increase by approximately 6.5 ha). Less drilling and blasting required. Causeway extended MOF relocated, design modified. LNG Jetty shortened.
Physical Presence of Infrastructure	Change in seabed profile	Change in seabed profile	Causeway extended MOF relocated, design modified. LNG Jetty shortened

7.2.2.1 Physical Disturbance of the Seabed

Construction of the causeway, MOF, jetty, dredged access channels and the turning basin off the east coast of Barrow Island, along with associated dredge sediment disposal, will involve direct disturbance to the seabed.

The following marine components of the Revised Proposal will alter disturbance to the subtidal and intertidal seabed during construction and operation in comparison to the Approved Development (Figure 3.2):

- revision of the causeway and MOF design
- reduced length of the LNG jetty
- dredged vessel access channel to the MOF reduced in length
- tanker offloading facility (including turning basin) altered in size and minor change to orientation.

Approximately 6.5 ha of additional seabed disturbance is associated with construction of the Revised Proposal marine infrastructure in comparison to the Approved Development (Table 7.4).

The LNG jetty is shorter by approximately 600 m under the Revised Proposal, reducing the disturbance to the seabed by direct placement of infrastructure by approximately 15.5 ha for this infrastructure element in comparison with the Approved Development (Table 7.4). It covers approximately the same amount of subtidal reef (low relief) with sand veneers, but less of the macroalgae limestone reef at the MOF end of the LNG Jetty.

The dredging required to create the channels and berth areas for the Revised Proposal will result in physical disruption to localised areas of the seabed at both the dredging and disposal sites, as was the case for the Approved Development. This will modify the hard substrate of the existing seabed to a soft substrate through the accumulation of sediment within the dredged depressions.

The area of dredging required for the Revised Proposal's MOF access channel is reduced by approximately 6.3 ha in comparison to the Approved Development (Table 7.4). However the configuration of the Revised Proposal channel has changed which will result in less blasting though the subtidal pavement (which lies beneath the macroalgae limestone reef habitat) and, therefore, less disruption to the seabed in that area. The dredge volume for the Revised Proposal is unchanged.

The shape of the Revised LNG berth turning basin has changed and its overall footprint, (including the access channel) has increased by approximately 18.8 ha. The seabed type that will be impacted (subtidal reef (low relief) and sand) remains the same. The location of the turning basin has been altered to suit the natural bathymetry of the area, resulting in an unchanged dredge volume for the Revised Proposal.

As the dredge spoil volumes and disposal location for the Revised Proposal remain the same, the area of seabed impacted by smothering also remains unchanged.

Due to the reduced length of the Revised LNG jetty, the requirement for anchoring of construction vessels and other support vessels that will disturb the seabed is reduced. It is expected this will result in approximately 30% decrease in anchor drops and their associated impact during jetty construction.

The consequences of the seabed impacts associated with the Gorgon Gas Development are restricted to local short-term changes in benthic substrate characteristics as a result of dredging and sedimentation or local loss of well-represented landform habitats as a result of the construction and/or dredged areas.

The extra length of the Revised Proposal's causeway will result in additional impacts to the seabed profile and structure, however the seabed in this area is a well represented marine landform around Barrow Island and in the broader region and does not include any structures of high conservation significance. The seabed losses will be partially offset by creation of new substrates that provide increased availability of habitat (e.g. causeway and channel substrates).

The risk of impact to the marine physical environment from physical disturbance of the seabed associated with the Revised Proposal at the Risk Assessment Workshop was assessed as Medium. This is a change from the Low risk category assigned within the EIS/ERMP for the Approved Development. However, following the assessment of the

additional information pertaining to the area of seabed affected presented in the PER (an additional 6.5 ha only) and the fact that this additional disturbance affects well represented seabed type within the regional context, the GJVs are not of the opinion that the consequences of the minor increase in footprint are sufficient to increase the consequence rating. Therefore the risk ratings associated with the physical disturbance of the seabed are not considered to be greater in comparison to the Approved Development (see Table 7.5).

Figure 7.2 gives a visual representation of the infrastructure and locations taken into account for the measured areas presented in Table 7.4 for the Approved Development.

Figure 7.3 gives a visual representation of the infrastructure and locations taken into account for the measured areas presented in Table 7.4 for the Revised Proposal.

Table 7.4: Proposed Permanent Disturbance to Seabed from Infrastructure

	Facility	Approximate Area of Disturbance (ha)		Approximate Volume of Dredged Material (M m3)		Substrate Type	Dominant Benthic Habitat Types
		AD	RP	AD	RP		
Dredging	MOF Access Channel	32.0	25.7 (reduced by 6.3 ha)	1.1	1.1	Calcareous silty sands with shells and shell fragments. Occasional rocky outcrops and limestone reef platform.	Subtidal Reef (low relief) and sand Macroalgae (limestone reef)
	LNG Access Channel & Turning Basin	123.2	142.0 (increased by 18.8 ha)	6.5	6.5	Calcareous silty sands with shells and shell fragments. Occasional rocky outcrops and limestone reef platform.	Subtidal Reef (higher profile) Subtidal Reef (low relief) and sand
Infrastructure	Causeway & MOF	21.1	30.6 (increased by 9.5 ha)	N/A	N/A	Calcareous silty sands with shells and shell fragments. Occasional rocky outcrops and limestone reef platform.	Macroalgae (limestone reef) Nearshore Intertidal Reef Coral Communities
	LNG Jetty (30m buffer)	29.1	13.6 (reduced by 15.5)	N/A	N/A	Calcareous silty sands with shells and shell fragments. Occasional rocky outcrops and limestone reef platform.	Subtidal Reef (low relief) and sand Macroalgae (limestone reef) Coral Communities
Totals		**205.4**	**211.9 (increase of 6.5 ha)**	**7.6**	**7.6**		

NOTES:
***AD**: Approved Development*
***RP**: Revised Proposal*

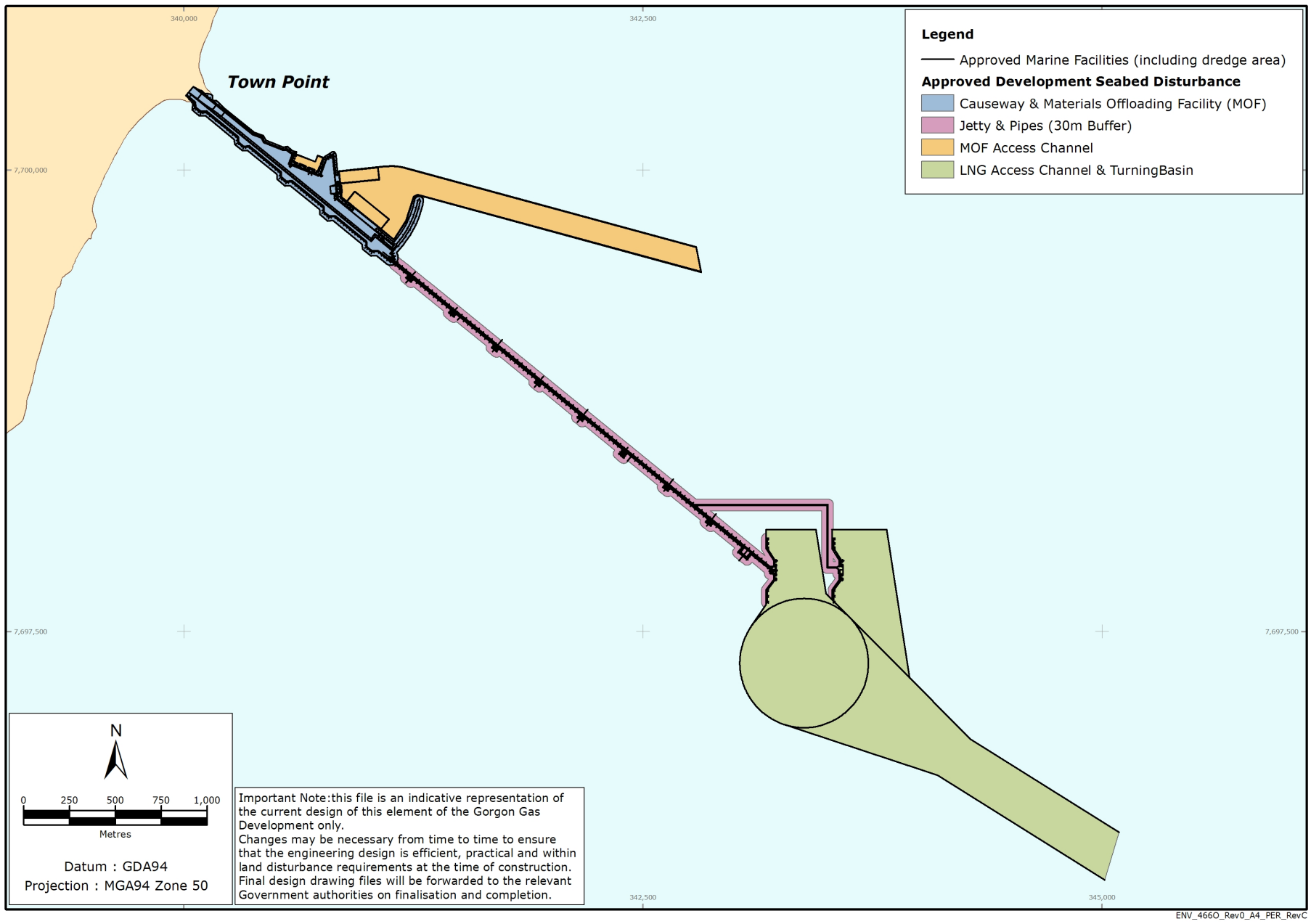


Figure 7.2: Seabed Disturbance Associated with the Approved Development Marine Infrastructure

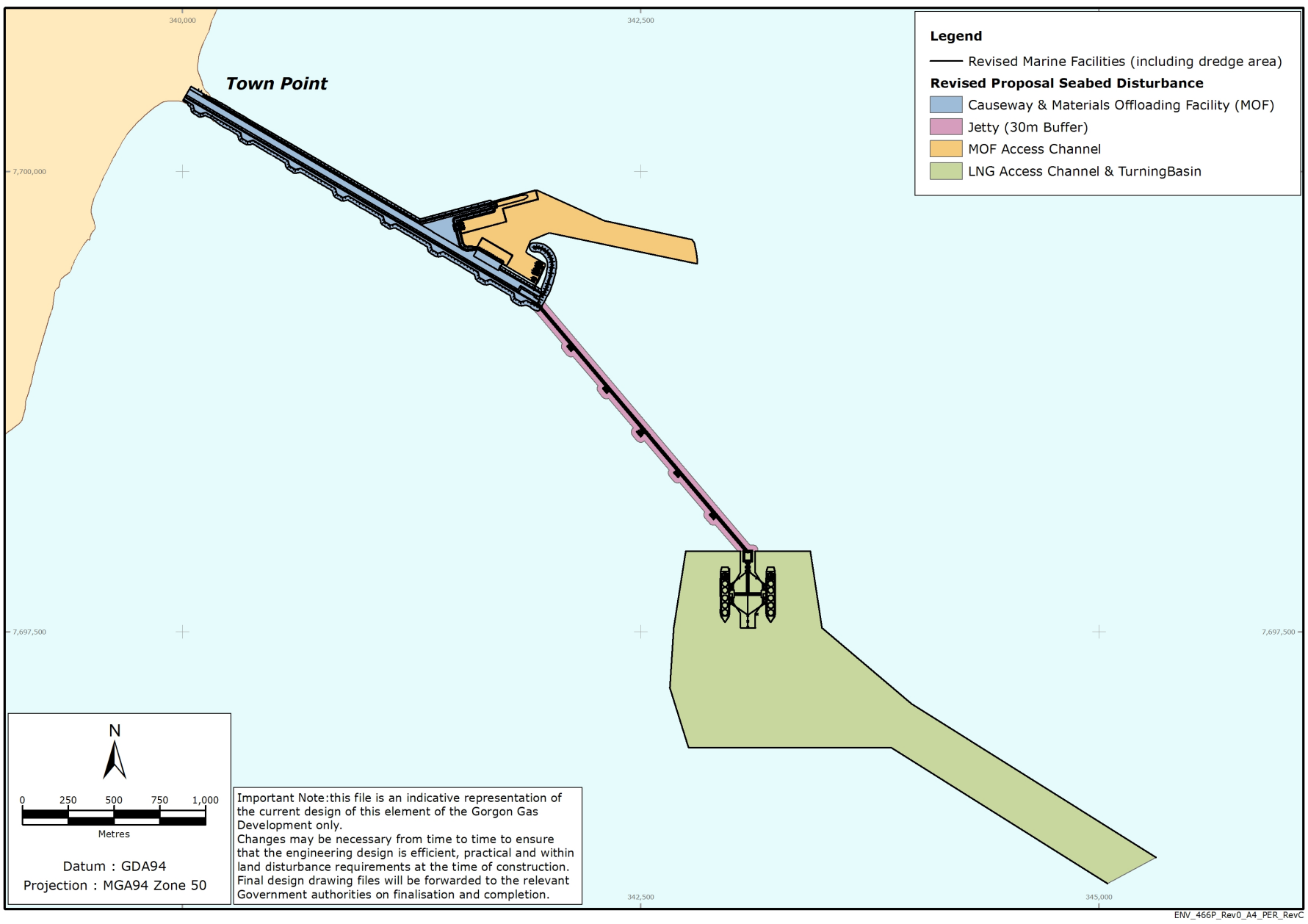


Figure 7.3: Seabed Disturbance Associated with the Revised Proposal Marine Infrastructure

7.2.2.2 Physical Presence of Infrastructure

The revised causeway and MOF are the principal components of the Revised Proposal that has the potential to impact the marine physical environment and coastal processes. The LNG jetty is to be built on piles and will not impact on coastal processes. Other aspects of the proposal, including the LNG jetty, dredge spoil disposal area and access channels will result in permanent changes to the seabed profile but carry a Low level of environmental risk.

The Revised Proposal causeway and MOF are in essentially the same location as that of the Approved Development. For the Revised Proposal, the seaward end of the causeway and MOF has shifted slightly to the north and the length increased from approximately 1 300 m to approximately 2 100 m.

The area covered by the Revised Proposal's causeway and MOF is the same substrate type as that covered by the causeway and MOF for the Approved Development, and is classified as subtidal limestone pavement reef. An additional 9.5 ha (approximately) of this substrate will be affected by the extension of the revised causeway and MOF. The distribution of this substrate type on the east coast of Barrow Island and in the broader Montebello/Lowendal/Barrow Islands region is extensive. It must also be noted that the area impacted by the dredging of the MOF Access Channel has been reduced by approximately 6.3 ha for the Revised Proposal, resulting in a net increase in disturbance in this area of approximately 3.2 ha.

The Revised Proposal's causeway will be perpendicular to the shoreline and prevailing waves, which will minimise wave refraction. The construction of the causeway armour units will provide a permeable surface, which will absorb wave energy resulting in little or no reflection off the causeway.

The natural protection afforded by several hundred metres of limestone rock platform (Appendix F) and the confinement of the beach areas between rocky headlands, results in a relatively low energy coastal environment. Due to the relatively sheltered nature of this zone and the alignment of the causeway with respect to the beach and the waves, the risk that the presence of the causeway results in significant detrimental impact on coastal processes is Low.

Coastal process modelling shows the revised causeway and MOF structures will have little impact on longshore sediment transport (Appendix F). The Town Point foreshore area is a typically stable environment (Appendix F). There may be some additional sedimentation on the beaches either side of the causeway and a minor increase in current strength around the end of the MOF associated with the additional length of the causeway, but this will cause insignificant effects on the marine environment. In general the causeway will provide some protection to the beaches near Town Point during severe weather events potentially reducing periodic erosion associated with these events (Appendix F). Overall, the risk of changes to the foreshore is low, and the disturbances to the seabed only affect very well represented landforms.

The risk of impacts to the foreshore associated with the presence of infrastructure can be appropriately managed and monitored. Construction of the revised marine facilities will not affect the ecological integrity of the surrounding physical habitats.

The risk of impact to the marine physical environment and coastal processes from the physical presence of the marine infrastructure for the Revised Proposal is restricted to a change in seabed profile. During the risk assessment this was assessed as Medium, which is an increase from Low-Medium for the Approved Development, however subsequent studies have quantified the scale of impact and demonstrated that the

impact on the marine environment coastal processes is not significantly different from the Approved Development (Appendix F). Given this additional information, the Completed Residual Risk Assessment as shown in Table 7.5 has been ranked as Low-Medium, as for the Approved Development.

7.2.3 Proposed Management Actions

The Revised Proposal will be implemented by adopting best practicable measures to minimise impacts to the environment.

Impacts to marine physical environment and coastal processes, including matters of NES, will be addressed by several EMPs, systems and programs that are consistent with those required under conditions prescribed for the Approved Development in Statement No. 748 and Commonwealth Approval EPBC Reference: 2003/1294.

As part of the implementation of Statement No. 748, the proponent will submit the following plans, including discussion of the physical impacts of the Revised Proposal on the marine physical environment and coastal processes:

- Marine Facilities Construction Environmental Management Plan
- Coastal Stability Management and Monitoring Plan
- Dredge and Spoil Disposal Management and Monitoring Plan.

The purpose, scope and objectives of the Environmental Management Plans, programs and systems required under the conditions of approval for the Approved Development have been reviewed. It is considered that the impacts and risks of the Revised Proposal can be effectively managed under the approval conditions (described in Statement No. 748 and Commonwealth Approval Decision EPBC Reference: 2003/1294) for the Approved Development. No additional measures or controls are anticipated to be necessary to manage the potential factor impacts to the marine physical environment and coastal processes associated with the Revised Proposal.

The objectives and key management actions for these management plans are detailed in Section 15.

7.2.4 Predicted Residual Environmental Risk

The Revised Proposal is not considered to pose any significant new or additional risks to the marine environment and coastal processes in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts on the marine environment and coastal processes as a result of the Gorgon Gas Development. The implementation of various plans, systems and programs consistent with those required under conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294, is expected to manage the following Revised Proposal marine physical environment and coastal processes impacts to a level consistent with that considered acceptable and therefore approved for the Approved Development:

- Physical disturbance of the seabed impacting to seabed profile, type and smothering of seabed
- Physical presence of infrastructure impacting seabed profile.

The plans, systems and programs required in Statement No. 748 and EPBC Reference: 2003/1294 must be approved by the Western Australian and Commonwealth Government Agencies prior to implementation. The implementation of these plans,

systems and programs will also meet the EPA objectives relevant to the marine physical environment and coastal processes (Table ES0.2).

The residual risks for stressors with potential Medium and High risks are summarised in Table 7.5. Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk,

Table 7.5: Environmental Risk Assessment for Marine Physical Environment and Coastal Processes

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
			L	C	RR	L	C	RR	L	C	RR
CONSTRUCTION											
Physical disturbance of the seabed	Change in seabed profile	Marine Facilities Construction Environmental Management Plan Dredge and Spoil Disposal Management and Monitoring Program Areas for mooring of vessels adjacent to construction area and control of vessels in sensitive operating locations to minimize disturbance and encroachment on coral communities.	1	5-4	L-M	1	4	M	1	5-4	L-M
	Change in seabed type (e.g. sand to rock)		1	5-4	L-M	1	4	M	1	5-4	L-M
	Smothering of seabed		1	5-4	L-M	1	4	M	1	5-4	L-M

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
OPERATION											
Physical Presence of Infrastructure	Change in seabed profile	Coastal Stability and Monitoring Program Causeway design has considered minimizing reflection of wave energy, and negligible increase in current activity at the end of the MOF.	1	5	L	1	4	M	1	5	L

7.3 Marine Water and Sediment Quality

7.3.1 Assessment Framework or Policy

7.3.1.1 EPA Objectives

To maintain the quality of water so that existing and potential environmental values, including ecosystem function, are protected (EPA 2004b).

To maintain the ecological functions and environmental values of marine benthic habitats and the subtidal and intertidal zones.

7.3.1.2 Commonwealth Policy

***National Water Quality Management Strategy* (Commonwealth Government of Australia 1992c)**
The National Water Quality Management Strategy is a framework for water and sediment quality management that is applied within Western Australia through implementation of the State Water Quality Management Strategy (SWQMS) Document No. 6, which was endorsed by Western Australian Government Cabinet in 2004.

Consistent with SWQMS Document No. 6, the former Department of Environment collaboratively developed environmental values and objectives for State marine waters off the Pilbara coast, including waters surrounding Barrow Island. The recommended environmental values, environmental objectives and Levels of Ecological Protection (DoE 2006a) have been endorsed by the EPA as 'interim', pending development of a formal policy under the *Environmental Protection Act 1986* (WA).

As the waters surrounding Barrow Island are largely within an area covered by the Montebello/Barrow Islands Marine Conservation Reserves (DEC 2007), the interim environmental values, environmental objectives and levels of ecological protection endorsed by the EPA have also been incorporated into the recently gazetted Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves (DEC 2007).

7.3.1.3 State (WA) Policy

Barrow Island Interim Environmental Quality Criteria (DEC 2007)
Marine waters on the east coast of Barrow Island (including the gazetted Barrow Island Port Area), within the area covered by the Revised Proposal, are assigned a *High* Level of Ecological Protection.

Waters having a *High* Level of Ecological Protection should maintain very low concentrations of contaminants, and biological indicators should not vary beyond natural variation (DoE 2006a).

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) recommend development of site-specific Environmental Quality Criteria (EQC). It is therefore necessary to acquire a baseline to establish natural concentration ranges against which to assess possible future contamination.

Investigations have been commissioned by the GJVs to quantify background contaminant concentrations in the waters and sediments off the east coast of Barrow Island. Data collected during these investigations in accordance with the ANZECC & ARMCANZ Guidelines (2000), will be used to develop water and sediment quality criteria appropriate to the area.

Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-20017 (DEC, 2007)
Vision for the Montebello/Barrow islands marine conservation reserves:
"*To conserve the marine flora and fauna, habitats and water quality of the Montebello/Barrow islands area. The area will support commercial and recreational activities that are compatible with the maintenance of environmental quality and be valued as an important ecological, economic and social asset by the community*." (DEC, 2007)

The Revised Proposal does not increase the risk of exceeding the Key Performance Indicators outlined in this Management Plan beyond that risk already considered for the Approved Development.

The majority of the marine disturbance footprint and Zones of High and Moderate Impact for the Revised Proposal are within the Barrow Island Port Area, which is excluded from the Barrow Island Marine Management Area and all associated key performance indicators. The Zone of Influence extends into un-zoned areas of the Barrow Island Marine Management Area, as was predicted for the Approved Development. However, the Zone of Influence is the visible plume and there are no predicted impacts to benthic primary producers within this area.

The dredge spoil ground is partly within the Port Area, the Marine Management Area and an un-zoned area however, this site location and size is unchanged from the Approved Development and does not require any further assessment for the PER.

7.3.2 Further Assessment of Potentially Significant Impacts

Potential stressors that may affect water and sediment quality as a result of the Revised Proposal have been identified and risk has been determined through an assessment of consequences and likelihood. Risk assessment methods, and definitions of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia, 2005a). A comprehensive description of the risk assessment process for the Revised Proposal is described in Section 5 of this PER. Section 5 describes the iterative process through which the GJVs have come to the conclusions discussed within this Section of the PER. It is recommended that readers refer to Section 5 of the PER before further examining the content of this Section. The results of the risk assessment workshops are presented in Appendix C.

Environmental stressors with the potential for low risk impacts and those stressors which have not changed in character or magnitude from the Approved Development are listed below. These are not assessed further in this PER:

- leaks and spills
- wastewater discharge
- air emissions
- reservoir CO_2 migration or release to the marine environment
- seabed disturbance resulting in changes to sediment quality.

Aspects of the Revised Proposal with a potentially increased level of risk in comparison to the Approved Development (as determined during Preliminary Risk Assessments), or aspects with a perceived risk score of Medium or High have been further assessed as part of this section. The aspect (or stressor) for Marine Water and Sediment Quality that require the presentation of additional information is:

1. **Physical Disturbance of the Seabed** from dredging, dredge spoil disposal, vessel propeller wash and earthworks associated with the construction of the causeway, MOF, shipping channel, open piled jetty and tanker load-out facility. These activities have the potential to impact water quality in terms of turbidity, nutrients and oxygen depletion.

Changes to the potential environmental impacts of the Approved Development resulting from the changed attributes of the stressors associated with the Revised Proposal, are shown in Table 7.6.

Table 7.6: Comparison of Approved Development and Revised Proposal Stressors for Marine Water and Sediment Quality

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Physical Disturbance of Seabed during Construction	Change in water quality (nutrients, turbidity, oxygen depletion)	Change in water quality (nutrients, turbidity, oxygen depletion)	The orientation of the dredge plume has changed but its magnitude has not.

7.3.2.1 Physical Disturbance of the Seabed

The physical disturbance of the seabed has the potential to have a significant impact on water quality due to dredging, dredge spoil disposal, causeway rock dumping, jetty pile drilling and vessel propeller-wash. These activities are expected to directly increase turbidity and suspended sediment loads, thereby reducing the transmission of light through the water column.

These activities and their impacts are similar in character to those identified and considered during the assessment of the Approved Development. The Revised Proposal has however changed the footprint and orientation of the marine facilities to the extent to warrant a revision of the risk assessment. Furthermore, the potential impacts of this stressor have been re-modelled to provide a quantitative assessment of likely impacts and zones of influence to assist the Risk Assessment (Dredge Plume Modelling, Appendix E).

Preliminary results from marine baseline monitoring suggest that disturbance of the seabed is unlikely to result in a flux of contaminants or nutrients into the water column. Baseline monitoring is continuing, but there is presently no existing data to suggest that the Revised Proposal poses a nutrient contamination or oxygen depletion risk to water quality any different to the Approved Development.

The assessed risk of impact to water and sediment quality for the Revised Proposal is Medium, which has changed from Low for the Approved Development. The impacts from construction dredging for the Gorgon Gas Development will result in a reduction in water quality, but over a localised area and for a limited duration. The tentative residual risk ranking of Medium is indicative of the re-assessed consequence of the impact being deemed to be *moderate* (as assessed in the Risk Assessment Workshop) rather than *minor* as it was deemed to be during the assessment process for the Approved

Development (see Table 7.7 and Appendix C). This consequence score assumed that the impact would be *widespread* as opposed to *local* for a *minor* consequence score. Subsequent to the risk assessment, a dredge plume modelling study was completed (Appendix E), which indicated that under normal meteorological conditions the area of reduced water quality and sedimentation from dredging and spoil disposal operations is anticipated to be localised and similar to that estimated for the Approved Development. Therefore, the risk posed by physical disturbance to the seabed has been ranked as Low in the Completed Residual Risk Assessment (Table 7.7).

7.3.3 Proposed Management Actions

The Revised Proposal will be implemented adopting best practicable measures to minimise impacts to the environment.

Impacts to marine water and sediment quality will be addressed by several EMPs, systems and programs that are consistent with those required under conditions prescribed for the Approved Development in Statement No. 748 and Commonwealth Approval EPBC Reference: 2003/1294.

As part of the implementation of Statement No. 748, the GJVs will submit the following plans which include discussion of the key marine water and sediment quality stressors:

- Marine Facilities Construction Environmental Management Plan
- Dredge and Spoil Disposal Management and Monitoring Plan
- Coastal Stability Management and Monitoring Plan.

The above plans will contain both universal and specific management actions for protecting water and sediment quality.

Furthermore, the Chevron Australia Oil Spill Contingency Plan will be implemented to fulfil the requirements of AMSA, DoIR and NATPLAN.

The proponent will also submit a Coastal and Marine Baseline State and Environmental Impact Report in accordance with Statement No. 748 which includes discussion of the key impacts on marine water and sediment quality resulting from disturbance activities.

Construction and operations environmental management plans for the Revised Proposal will also be developed to be consistent with Commonwealth Approval Decision EPBC Reference: 2003/1294 to address stressors to marine water and sediment quality.

The purpose, scope and objectives of the Environmental Management Plans, programs and systems required under the conditions of approval for the Approved Development have been reviewed. It is considered that the impacts and risks of the Revised Proposal can be effectively managed under the approval conditions (described in Statement No. 748 and Commonwealth Approval Decision EPBC Reference: 2003/1294 for the Approved Development). No additional measures or controls are anticipated to be necessary to manage the potential impacts to marine water and sediment quality associated with the Revised Proposal.

The objectives, targets and key management actions for these management plans are detailed in Section 15.

7.3.4 Predicted Residual Environmental Risk

Although the Revised Proposal seabed disturbance impacts were assessed as higher residual risk than the Approved Development, subsequent dredge plume modelling

studies (Appendix E) have demonstrated that the impact is no greater than for the Approved Development (Table 7.7). Furthermore, there are no unacceptable cumulative impacts on marine water and sediment quality as a result of the Gorgon Gas Development. The scope of the plans, systems and programs is considered adequate to manage the stressors and meet the EPA objective for marine water and sediment quality.

The plans, systems and programs required in Statement No. 748 and EPBC Reference: 2003/1294 (or those plans, systems and programs required under a future approval) must be approved by the Western Australian and Commonwealth Government Environment Ministers prior to implementation.

The residual risks for stressors with potential medium and high risks is summarised in Table 7.7. Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk,

Table 7.7: Environmental Risk Assessment for Marine Water and Sediment Quality

Aspect	Impact	Mitigation	Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
			L	C	RR	L	C	RR	L	C	RR
CONSTRUCTION											
Physical disturbance of the seabed	Change in water quality (nutrients, turbidity, oxygen depletion)	Marine Facilities Construction Environmental Management Plan Dredge and Spoil Disposal Management and Monitoring Program	1	5	L	1	4	M	1	5	L

7.4 Marine Benthic Primary Producers

7.4.1 Assessment Framework or Policy

7.4.1.1 EPA Objectives

The EPA Objectives are:

- To maintain the abundance, diversity, geographic distribution, and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvements in knowledge (EPA 2004b).
- To maintain the abundance, diversity, geographic distribution, and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvements in knowledge (EPA 2004b).

7.4.1.2 State (WA) Policy

EPA Guidance Statement No. 1 – Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2001)
This Guidance Statement requires proposals to demonstrate that the proposal will not adversely affect the mangrove habitat, ecological function of these areas, or the maintenance of ecological processes which sustain the mangrove habitats.

EPA Guidance Statement No. 29 – Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment (EPA 2004a)
This Guidance Statement requires proposals to demonstrate the following:

- Consideration of options to avoid damage or loss of benthic primary producer habitat.
- Design should aim to minimise damage or loss of benthic primary producer habitat, and the need for damage or loss of benthic primary producer habitat should be justified wherever avoidance of benthic primary producer habitat is not possible.
- Best practice in design, construction methods, and environmental management aimed at minimising further damage or loss of benthic primary producer habitat through indirect impacts.
- Consideration of an environmental offset where substantial cumulative losses of benthic primary producer habitat have already occurred.
- Risk to ecosystem integrity within a management unit is not substantial.

Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-20017 (DEC, 2007)
Vision for the Montebello/Barrow islands marine conservation reserves:
"*To conserve the marine flora and fauna, habitats and water quality of the Montebello/Barrow islands area. The area will support commercial and recreational activities that are compatible with the maintenance of environmental quality and be valued as an important ecological, economic and social asset by the community*." (DEC, 2007)

The Revised Proposal does not increase the risk of exceeding the Key Performance Indicators outlined in this Management Plan beyond that risk already considered for the Approved Development.

The majority of the marine disturbance footprint and Zones of High and Moderate Impact for the Revised Proposal are within the Barrow Island Port Area, which is excluded from the Barrow Island Marine Management Area and all associated key performance indicators. The Zone of Influence extends into un-zoned areas of the Barrow Island Marine Management Area, as was predicted for the Approved Development. However,

the Zone of Influence is the visible plume and there are no predicted impacts to benthic primary producers within this area.

The dredge spoil ground is partly within the Port Area, the Marine Management Area and an un-zoned area however, this site location and size is unchanged from the Approved Development and does not require any further assessment for the PER.

7.4.2 Further Assessment of Potentially Significant Impacts

Potential stressors that may affect marine benthic primary producers as a result of the Revised Proposal have been identified, and risk has been determined through an assessment of consequences and likelihood. Risk assessment methods, and definitions of likelihood and consequence, are the same as those used for the Approved Development (Chevron Australia, 2005a). A comprehensive description of the risk assessment process for the Revised Proposal is described in Section 5 of this PER. Section 5 describes the iterative process through which the GJVs have come to the conclusions discussed within this Section of the PER. It is recommended that readers refer to Section 5 of the PER before further examining the content of this Section. The results of the risk assessment workshops are presented in Appendix C.

Environmental stressors with the potential for low risk impacts and those stressors which have not changed in character or magnitude from the Approved Development are listed below. These are not assessed further in this PER:

- physical presence of infrastructure
- wastewater discharge
- unplanned reservoir CO_2 migration or release to the surface or near surface environment.

The potential impacts of the introduction and/or spread of non-indigenous species (ie quarantine stressor) is assessed in the Quarantine Management section (Section 8) of this PER.

Aspects of the Revised Proposal with a potentially increased level of risk in comparison to the Approved Development (as determined during Preliminary Risk Assessments), or aspects with a perceived risk score of Medium or High have been further assessed as part of this section. The aspects (or stressors) for Marine Benthic Primary Producers that require the presentation of additional information are:

1. **Physical disturbance of the seabed** resulting in turbidity, sedimentation, light attenuation and reduced photosynthetic potential in dredge plume and decreased water quality.
2. **Leaks and spills** leading to smothering of mangrove pneumatophores and impacts to associated biota, metabolic effects on shallow subtidal coral, and intertidal and shallow subtidal biota, and smothering of exposed intertidal biota from contact with slick of hydrocarbons.

Changes to the potential environmental impacts of the Approved Development resulting from the changed attributes of the stressors associated with the Revised Proposal, are shown in Table 7.8.

Table 7.8: Comparison of Approved Development and Revised Proposal Stressors for Benthic Primary Producers

Stressor	Impacts Related to Approved Development	Impacts Related to Revised Proposal	Change in Impacts (Approved Development versus Revised Proposal)
Physical Disturbance of the Seabed	Turbidity, light attenuation and reduced photosynthetic potential in dredge plume Decreased water quality (nutrients and oxygen depletion)	Turbidity, light attenuation and reduced photosynthetic potential in dredge plume Decreased water quality (nutrients and oxygen depletion)	The dredge footprint and plume has changed orientation but remains a similar magnitude to that predicted for the Approved Development. Permanent coral loss is essentially unchanged at approximately 22 ha.
Leaks and Spills	Impact to mangroves and associated fauna Metabolic effects on shallow subtidal coral Smothering of exposed intertidal biota from contact with slick of hydrocarbons	Impact to mangroves and associated fauna Metabolic effects on shallow subtidal coral Smothering of exposed intertidal biota from contact with slick of hydrocarbons	Increase in vessel traffic during operations increases the duration that vessels are within the proposal area.

Benthic primary producers (BPP) are potentially impacted during implementation of the Revised Proposal by direct removal, burial under infrastructure, smothering by deposited sediments, shading by fine sediments suspended in the water and hydrocarbons contamination.

The main activities for the Revised Proposal (including non-routine operations) that have the potential to impact BPP are:

- dredging and earthworks for the causeway, MOF, and access channels
- dredge spoil disposal
- construction of the open piled LNG jetty and tanker loadout facility
- maintenance dredging during operations
- hydrocarbon leaks and spills from vessels.

Benthic habitat mapping is a component of the Coastal and Marine Baseline State and Environment Impact Report (CMBSEIR) under Condition 14 of Statement No. 748. The CMBSEIR will be finalised prior to the start of construction and will contain the final pre-construction benthic habitat maps against which actual loss of BPPH will be ultimately assessed.

Current data from the CMBSEIR baseline studies has been used to update the benthic habitat maps presented in Figures 7.5 – 7.7 below. Appendix E contains figures at a larger scale.

For the purposes of BPPH loss calculations, all habitat units dominated by coral were classified as “coral habitats”. The only bare substrate included in the calculations was the “subtidal sand”. Other areas of bare substrate were assumed to be capable of supporting macroalgae or seagrass depending on whether they were amongst reef of soft sediments.

7.4.2.1 Physical Disturbance of the Seabed

The physical disturbance of the seabed required to implement the Revised Proposal will result in losses of BPP within the dredging, dredge spoil and infrastructure footprints as

well as impacts associated with smothering by deposited sediments and shading by fine sediments suspended in the water column. Dredging sediment dispersion modelling has been undertaken to predict the magnitude and spatial extent of sediment dispersal and deposition. The outputs of this modelling has been used to estimate impacts to BPP in a manner consistent with *EPA Guidance Statement No. 29 (Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment)* (EPA 2004a).

Implementation of the Revised Proposal will directly impact the following benthic primary producer habitats (BPPH):

- beds of macroalgae and scattered corals that grow on fringing reef platforms
- subtidal reef with sand and macroinvertebrate communities (seapens or sponges)
- scattered seagrasses on soft sediments
- coral communities.

The Revised Proposal MOF access channel is smaller in area by approximately 6.3 ha than the Approved Development channel design and covers the same benthic habitat types as the Approved Development footprint. The eastern end of the channel begins at the same point as the Approved Development design, but is shorter in length. Less dredging and blasting through the subtidal limestone platform reef will be required, reducing the overall disturbance to BPPH. In addition to a shorter access channel, the Revised Proposal MOF will be constructed prior to completion of the causeway allowing more efficient tidal flushing of suspended sediment during the construction phase.

The location of the Revised Proposal LNG berth and turning basin is offset to the south-west of the Approved Development footprint, placing it into a natural depression in the seabed. While the size of the basin and LNG berth has increased by approximately 18.8 ha, the dredge volume is not significantly different. The BPPH that will be impacted are the same under the Revised Proposal as the Approved Development.

The area proposed for dredge spoil disposal and the BPPH likely to be impacted remains the same under the Revised Proposal as the Approved Development. There will be no additional impacts to benthic habitats and similarly any maintenance dredging required during operation of the Revised Proposal to maintain access channels will be the same as the Approved Development.

Dredge Plume Model Results (Zones of Impact)

The marine infrastructure optimisations under the Revised Proposal resulted in the need for a revision of the hydrodynamic dredge plume modelling and zones of impact. The modelling used adjusted dredge logs containing updated operational information on the dredge configuration and included shut-down periods during coral spawning periods as required by Statement No. 748. The detailed results of the hydrodynamic modelling and the dredge logs are included in the GEMS *Gorgon Development – Dredging Simulation Studies to Support the PER for the Revised Proposal July 2008* report (Appendix E). The process by which the hydrodynamic model results were translated into the dredge plume Zones of Impact is outlined in Figure 7.1.

The Revised Proposal's zones of impact for BPP were defined based on the dredge plume modelling outputs together with the cumulative coral health threshold criteria that were used for the Approved Development (Figure 7.5 and Figure 7.6). Zones of Impact for turbidity and sedimentation criteria (as predicted by the dredge plume modelling, Appendix E) were overlaid with the outer most line taken to represent the extremity for the Zones of High and Moderate Impact and the Zone of Influence.

Buffer zones to account for damage to BPP caused by non-dredging construction activities were then added around the Revised Proposal's causeway and LNG jetty as these impacts were not included in the dredge model outputs. These buffer zones have been added in order to account for potential model limitations.

A zone 75 m wide on both sides of the causeway was included in the Zone of High Impact and 400 m for the Zone of Moderate Impact. While the edge effects associated with causeway construction are expected to be minimal due to management (screening) of the fill material, nominal buffer zones were included to account for possible impacts from fine particle release and rocks rolling off the main structure. The impacts of construction vessel anchoring were also considered in nominating these buffer distances. The buffer zones are considered conservative.

The construction method for the causeway involves building an external rock wall (or bund) from selected rock sourced from either Barrow Island or the mainland. The inside of this wall will then be lined with geo-textile fabric which reduces the release of course and fine sediment through the rock wall into the surrounding water. The area between the rock walls is then filled in using dredge spoil and material from earthworks onshore. Rock dumping for the causeway walls alone will not cause a widespread reduction in water quality (turbidity) and the fill material is contained within the geotextile fabric. The substrate the rocks are landing on is limestone pavement with varying depths of overlying sand which is unlikely to release large quantities of fine material when disturbed. Coarse sediments suspended by the impact of rocks on the seabed are expected to settle rapidly within close proximity of the structure. Diurnal tidal flushing will assist in dispersing any sediment suspended in the water column.

The buffer zone for the Zone of Moderate Impact around the causeway is consistent with the size of the contiguous Zone of Moderate Impact for dredging, taking into account the much smaller volumes of sediment/fines released from construction activities other than dredging. The impacts of construction vessel anchoring were also considered in nominating this buffer distance.

For the indication of the Zone of High Impact for the LNG Jetty construction, a 200 m wide disturbance corridor (buffer) was included. This allows for drilling and seabed disturbance from construction vessel anchor spread. No additional buffer zone has been included for the Zone of Moderate Impact associated with the construction of the LNG Jetty as all likely impacts are anticipated to occur within the Zone of Moderate Impact predicted by the Dredge Plume Modelling (Appendix E).

Where modelling indicated that thresholds were not exceeded adjacent to the LNG turning basin, a 250 m buffer zone was applied for the Zone of High Impact and a 500 m buffer for the Zone of Moderate Impact to account for dredge locations not specifically covered by the model outputs (the model can not account for every square metre of the dredge footprint, which can result in impacts from part of the dredge footprint being underestimated).

Figure 7.7 has been included in order to display comparison between the Zones of Impact from the Approved Development and the Zones of Impact predicted for the Revised Proposal, which are displayed in Figures 7.5 and 7.6. Modelling results indicate that there has been a reduction in the size and geographic extent of the Zones of High and Moderate Impact for the Revised Proposal.

A 30 m wide corridor was allowed for disturbance along the length of the Domestic Gas Pipeline and a 10 m buffer for the existing Barrow Island oilfield condensate export line. It is proposed that the Domestic Gas pipeline will tie into the Revised Proposal marine

facilities at some point along the causeway or LNG jetty and then run to the mainland, as described in the EIS/ERMP for the Approved Development (Chevron Australia 2005a). The location of the Domestic Gas Pipeline in Figure 7.5 and Figure 7.6 is only indicative at this stage and the route will be modified to avoid sensitive coral habitat as the design develops.

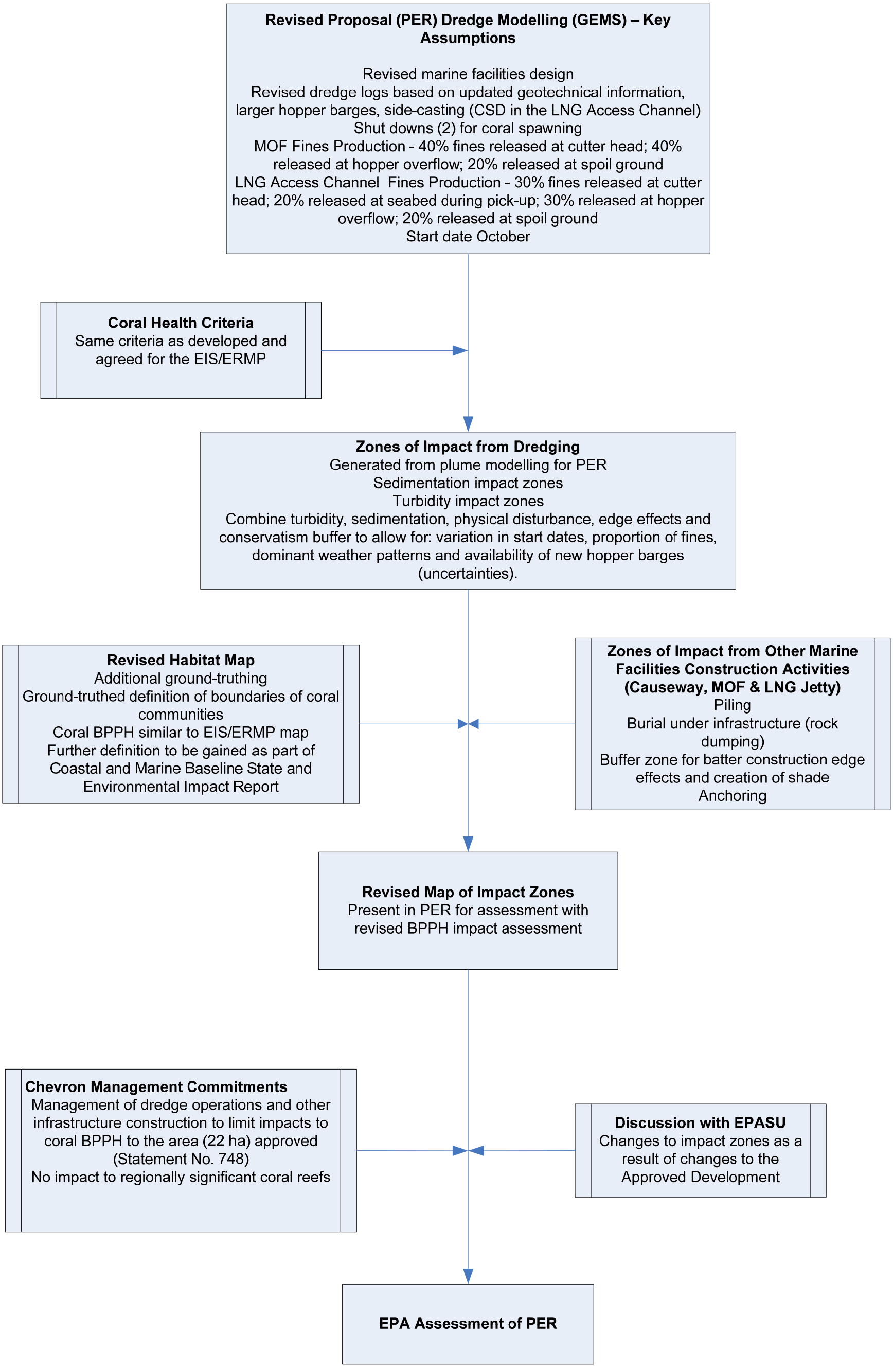


Figure 7.4: Methodology for the Determination of Zones of Impact Associated with the Construction of the Revised Proposal Marine Facilities on the East Coast of Barrow Island

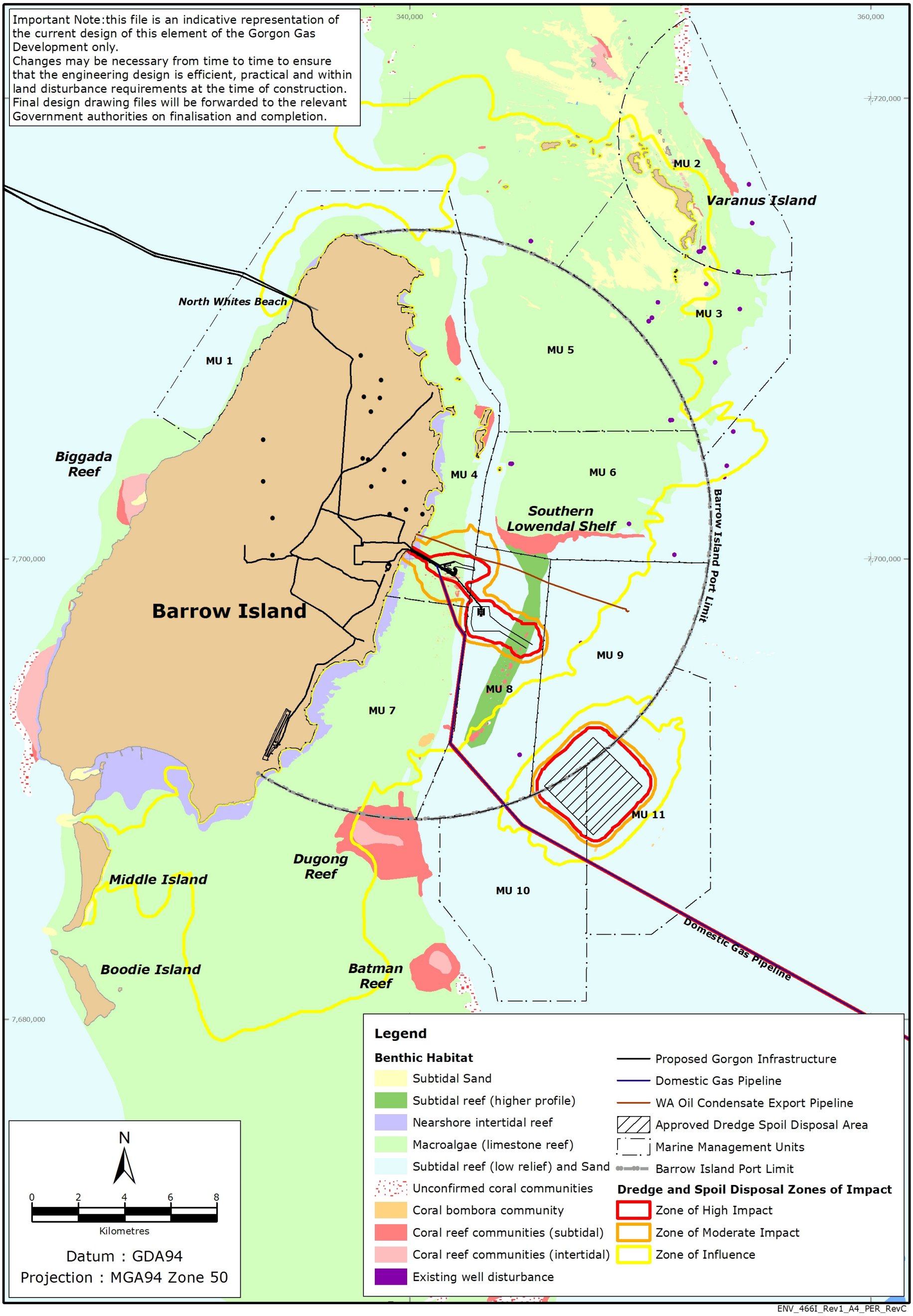


Figure 7.5: Benthic Habitats and Dredge and Spoil Disposal Zones of Impact for the Revised Proposal

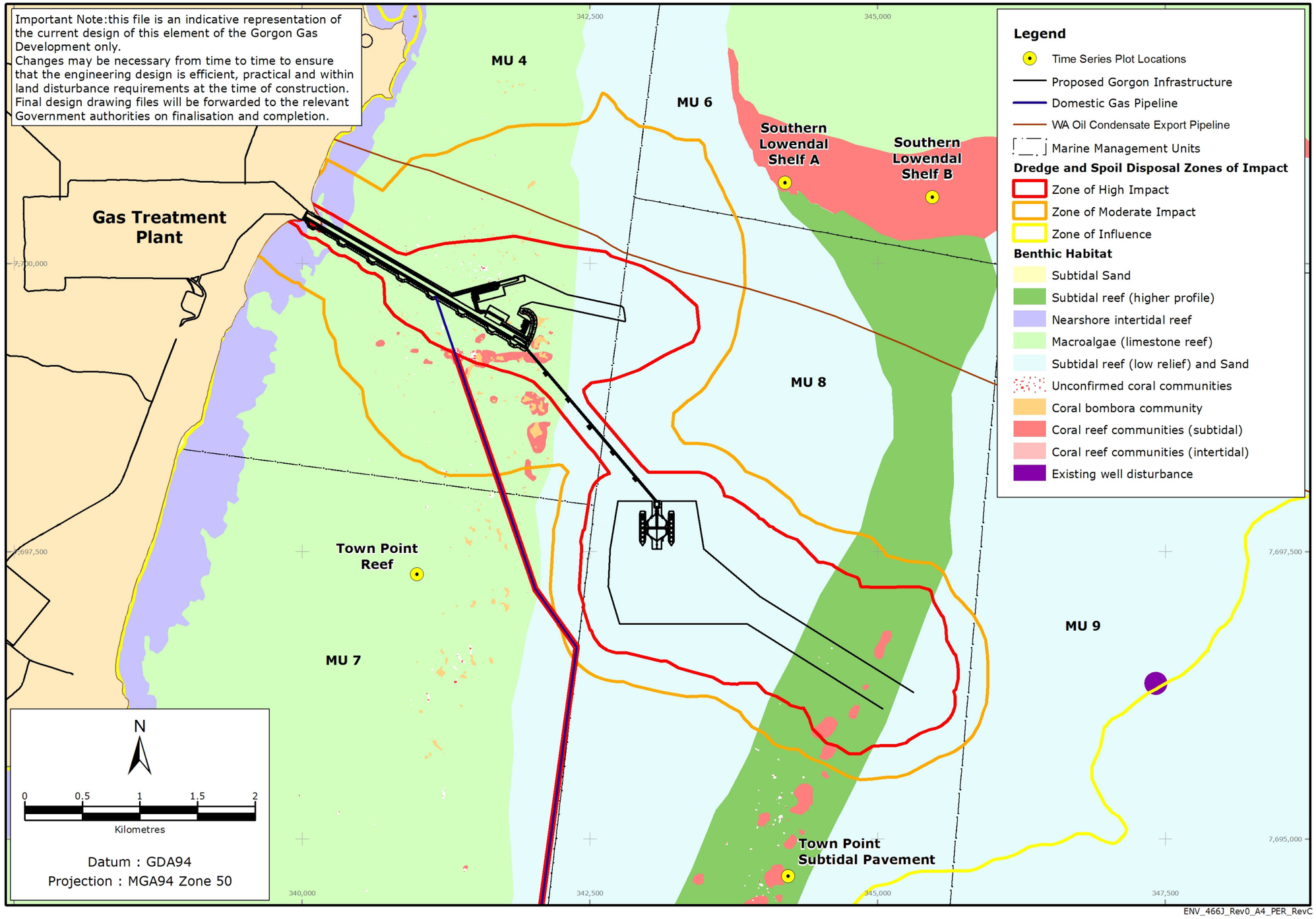


Figure 7.6: Dredge and Spoil Disposal Zones of Impact in the Vicinity of Marine Facilities for the Revised Proposal

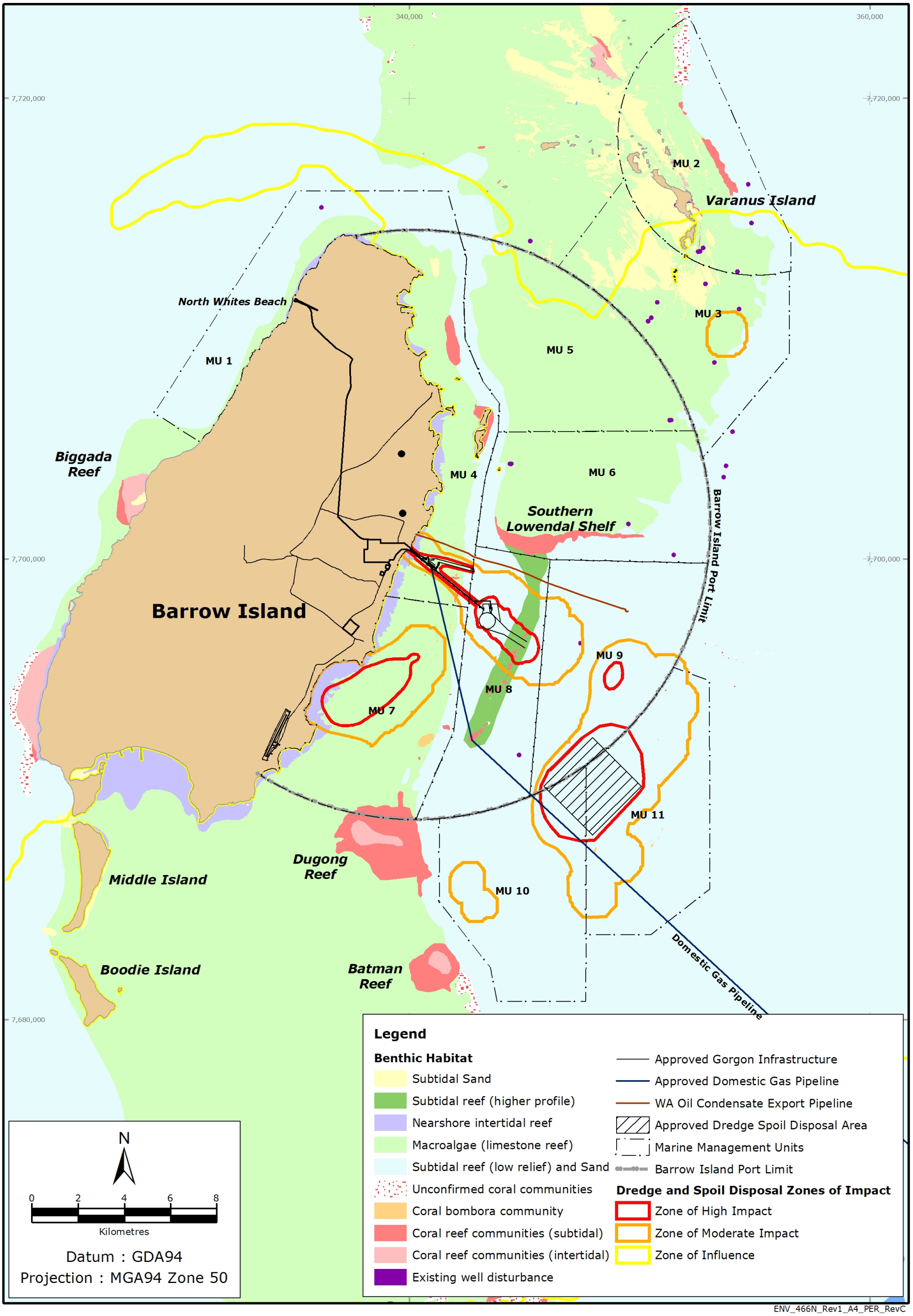


Figure 7.7: Approved Development Marine Facilities Construction Zones of Impact

No regionally significant coral assemblages or well developed assemblages of sensitive *Acropora* corals are predicted to be affected by dredging or spoil disposal under the Revised Proposal. There are scattered small colonies of *Acropora* within the Zones of High and Moderate Impact but these are not regionally significant. There are also scattered *Porites* bombora within the Zone of Moderate and High Impact around the Revised Causeway, MOF and LNG jetty. It is assumed that *Porites* bombora would be permanently lost within the Zone of High Impact. Partial mortality (<30%) of *Porites* bombora, in terms of a reduction in live coral cover or partial damage to larger colonies, is predicted (the Zone of Moderate Impact). If the BPP or BPPH are predicted to take in excess of 30 years to recover they are considered to be permanently lost.

Scattered coral communities on the nearshore pavement (nearshore intertidal reef), such as *Turbinaria* or smaller *Acropora* colonies, may suffer effects ranging from bleaching of individual colonies to partial mortality of some individuals in the Zone of Moderate Impact. In order to build a level of conservatism into the calculations, permanent loss of all coral, other than *Porites* bombora (for which 100% loss is predicted for High Impact Zone and 30% loss predicted for the Moderate Impact Zone), was presumed within the High and Moderate Zones of Impact. This is due to changes in substrate structure, physical disturbance to the seabed and/or declines in water quality due to mobilisation of sediment during dredging and spoil disposal. However this represents a temporary loss, and it is predicted that within five years sediment would migrate away from the Zones of High and Moderate Impact allowing these corals, such as *Turbinaria* and *Acropora,* to potentially re-colonise limestone pavement habitats.

The main BPP communities in the Zones of High and Moderate Impact are macroalgal dominated limestone reef and subtidal reef (low relief) with sand and scattered seagrass. Seagrass and macroalgal communities are well adapted to cycles of disturbance and recovery and these habitats are expected to recover rapidly (<five years in areas not permanently modified) following the cessation of the marine construction phase. A summary of the predicted impacts to BPP in the zones of impact and effect for all of the options are in Table 7.9.

There is no predicted measurable impact upon marine BPPH within the Zone of Influence.

Table 7.9: Predicted Impacts to Marine Benthic Primary Producers in the High Impact and Moderate Impact Zone

			High Impact Zone			Moderate Impact Zone		
Benthic habitat type	**Key receptor**	**Reason for selection**	Predicted effects	Presence in zone	Predicted Recovery time frame	Predicted effects	Presence in zone	Predicted Recovery time frame
Coral communities - More resilient species - Large bombora	*Porites lobata*	Large colonies; widespread in region, resilient but slow growing, ecologically important	High mortality (up to 100%)	Yes (MU 4 & 8)	Permanent loss (> 30yr recovery)	Some mortality (up to 30% of live coral cover)	Yes	If only partial damage, recovery in 2-5 yrs. Permanent loss if whole colony dies.
Coral communities - More sensitive species - Large coral thickets	*Acropora* thickets	Large thicket on Southern Lowendal Shelf (within Zone of Influence); sensitive but fast growing	High mortality (up to 100%)	No	N/A	High mortality (up to 100%)	No	N/A
Macroalgae dominated (limestone reef)	*Sargassum* spp.	Widespread and abundant	High mortality (up to 100%)	Yes (MU4,7 & 8)	Temporary loss, recovery 2-5 yrs	High mortality (up to 100%)	Yes	Temporary loss, recovery 2-5 yrs
Subtidal reef (low relief) with sand and scattered seagrass	*Halophila ovalis*	Most abundant and widespread genus, ephemeral	High mortality (up to 100%)	Yes (MU 4, 6, 8, 9, 10 & 11)	Temporary loss, recovery 2-5 yrs	High mortality (up to 100%)	Yes	Temporary loss, recovery 2-5 yrs

Total Suspended Solids – Pulses and Sediment Accumulation

To investigate possible impacts to marine BPP from acute increases in Total Suspended Solid (TSS) concentrations or the accumulation of sediment during the Revised Proposal's dredging program, the model predicted behaviour and intensity of sediment plumes at selected sites were examined as depicted in Figure 7.6. Details of the four locations for which time series plots have been created are presented in Table 7.10

Maximum daily TSS (mg/L) and on bottom sediment load (mg/cm^2) above background at four sites is presented graphically for 57 weeks of the proposed dredging program from the dredge model output (Figure 7.8). Southern Lowendal Shelf A, Town Point Reef, Southern Lowendal Shelf B and Town Point Subtidal Pavement are all within the Zone of Influence and are not predicted to be impacted other than a visible plume.

At each site TSS is predicted to vary markedly over short temporal scales, primarily due to the strong currents and tides in the waters offshore of the east coast of Barrow Island which rapidly dilute and disperse sediment plumes. The model predicts TSS will exceed 25 mg/L several times over the first 60 days of dredging operations at Southern Lowendal Shelf B, however these are very short term events (less than one hour) and are not expected to affect BPP. TSS at Town Point Subtidal Pavement is less than at Southern Lowendal Shelf B and is less than 10 mg/L for the duration of the program. No long term, persistent turbid pulses or high levels of TSS are predicted to occur at either site. Cumulative coral health threshold criteria for the Zone of Influence are 'triggered' by elevated TSS over long periods, rather than short, high TSS; therefore there are no predicted measurable impacts on BPP at these sites. These sites were both examined for the EIS/ERMP and there are no increases in impact at these sites when compared with the Approved Development, as they still fall within the predicted Zone of Influence.

The TSS concentrations at the remaining two sites (Southern Lowendal Shelf A and Town Point Reef), also within the Zone of Influence, show peaks in concentration higher than the first two sites and above 25 mg/L for short periods. However the cumulative coral health threshold criteria for the Zone of Influence at these sites are also 'triggered' by elevated TSS for long periods, rather than short, high TSS pulses over several days. The higher concentrations at these sites are expected because they are closer to the dredging sites but also demonstrate that the effects of dredging are localised.

The time series sedimentation plots (Figure 7.9) show the maximum daily sediment load at each of the modelled locations over the dredging programme. The model takes into account re-suspension of the sediment and is therefore not presented as accumulated sediment as it was for the EIS/ERMP. The plots (Figure 7.9) indicate low sediment concentrations settling on the seabed and contributing to on bottom sediment load. Declines in sediment concentrations over time indicate that a greater proportion of sediment is resuspended than is settling during each 24 hour period, reducing the overall prediction of bottom sediment load.

Very low levels of sedimentation are expected to occur in areas more than several hundred metres to 1 km from dredging and spoil disposal operations. Larger, heavier particles will tend to settle very close to dredging operations and will not resuspend under normal conditions. Fine material is predicted to continually settle and then resuspend, slowly diluting and dispersing into deeper, offshore waters. Only very low levels of fine sediment (< 2.5 mg/cm^2) are anticipated to accumulate on the seabed at Town Point Subtidal Pavement and Southern Lowendal Shelf B within the Zone of Influence (Figure 7.9). The predicted levels of sediment accumulation at these sites are far below those that are expected to have a negative effect on marine BPP. No large 'pulses' of sedimentation are predicted to occur under the modelled conditions (Figure 7.9).

Coral health threshold criteria for the remaining two sites within the Zone of Influence, Southern Lowendal Shelf A and Town Point Reef were also triggered by low levels of sedimentation over a long period rather than by large pulses over short periods. Sedimentation was higher at these two sites than at Southern Lowendal Shelf B and Town Point Subtidal Pavement due to closer proximity to dredging activity, but sedimentation is still low enough not to impact corals.

Table 7.10: Location of Sites for Time Series Plots

Sites – Time Series Plots	Easting (m)	Northing (m)
Southern Lowendal Shelf A	344200	7700700
Town Point Reef	341000	7697300
Town Point Subtidal Pavement	344225	7694674
Southern Lowendal Shelf B	345479	7700574

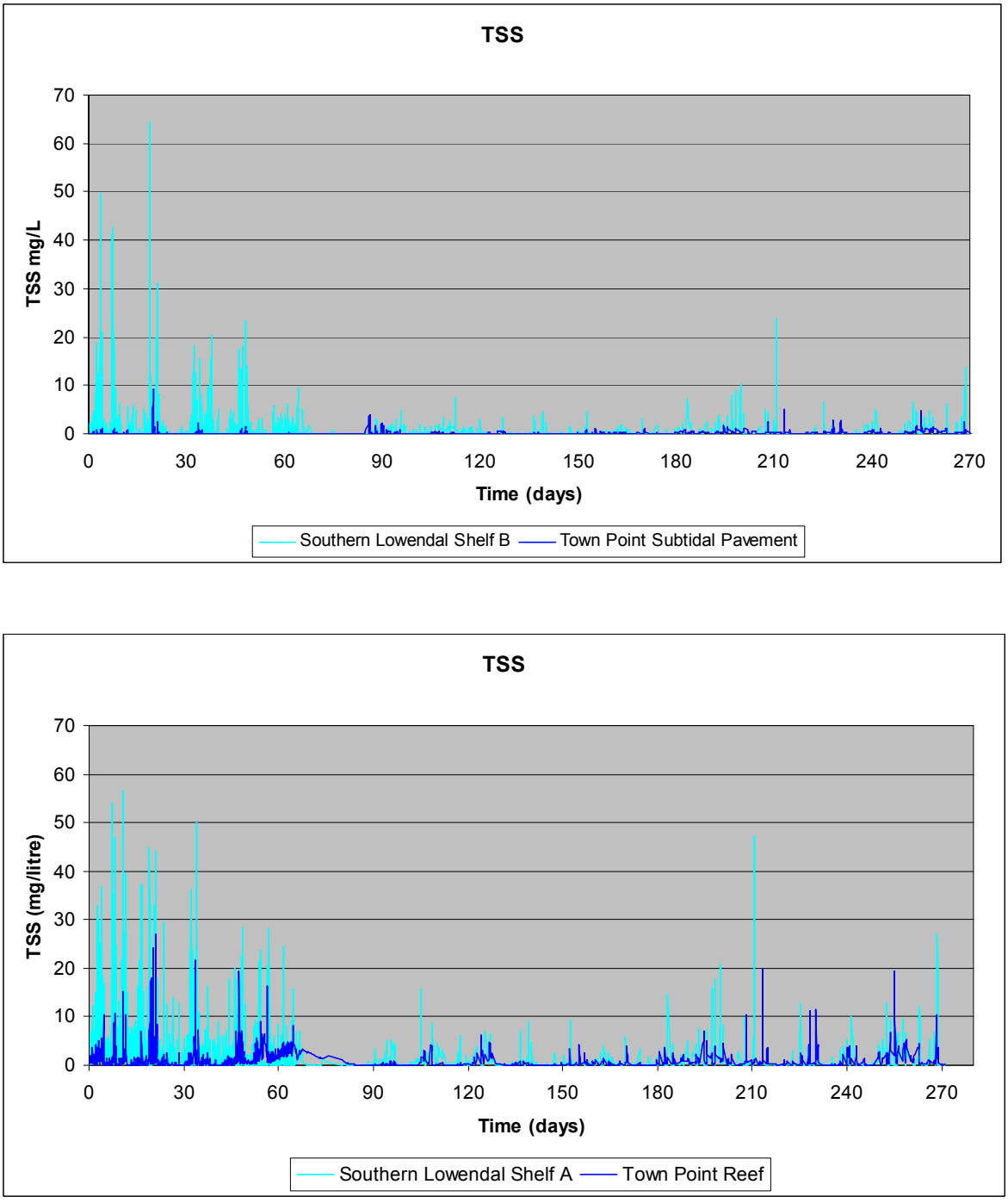
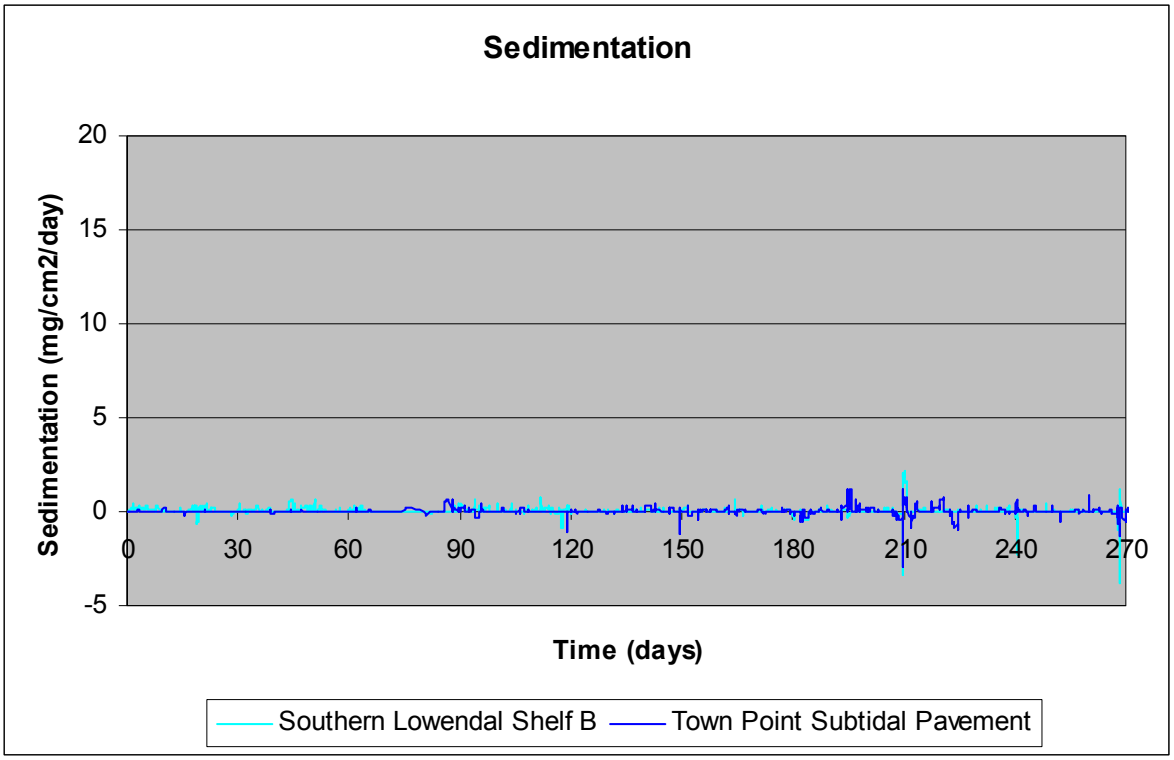


Figure 7.8: Time Series Plots of Predicted TSS at Four Sites under Normal Conditions



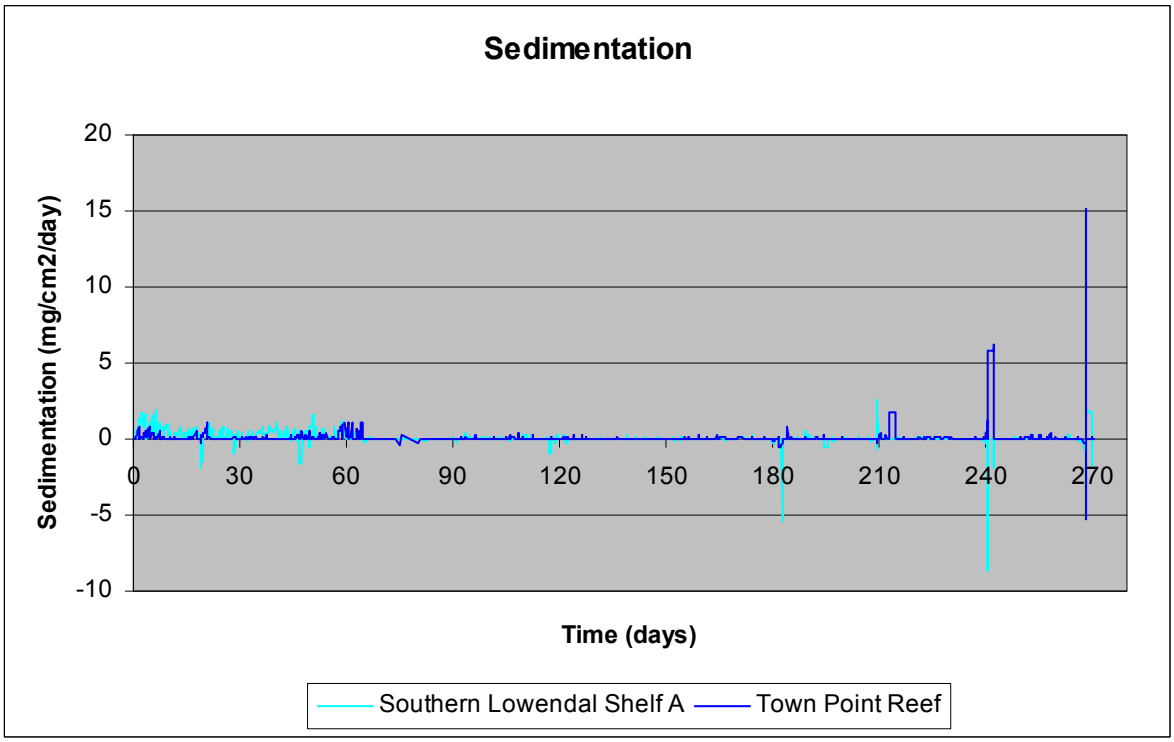


Figure 7.9: Time Series Plots of Predicted Sedimentation at Four Sites under Normal Conditions

Benthic Primary Producer Habitat Calculations

The assessment of impacts to Benthic Primary Producer Habitats (BPPH) in this section is a revision of the BPPH assessment conducted for the Final EIS/ERMP (Chevron Australia 2006). The current assessment was based on the same east coast Management Units as defined in the Final EIS/ERMP (Section 8.8, pp 453; Chevron Australia 2006). The loss of BPPH has only been re-calculated in the Management Units that are predicted to be affected by the Revised Proposal. The total areas of BPPH and the predicted permanent and temporary losses of each BPPH type, including loss through direct removal, sedimentation and turbidity effects of dredging and existing anthropogenic disturbance is presented for each of the affected Management Units in Table 7.11.

It is important to note that the impact zones displayed in Figures 7.5 and 7.6 represent the predicted impacts of dredging *and* marine facilities construction for the Revised Proposal. The Zone of High Impact includes the areas disturbed by dredging and the disposal of dredge spoil at the spoil ground (including turbidity and sedimentation), by the direct placement of infrastructure on the seabed and in buffer zones around the infrastructure (as described in section 7.4.2.1, ***Dredge Plume Model Results (Zones of Impact)***).

Consistent with the BPPH assessment in the EIS/ERMP, Permanent Loss refers to the loss of BPPH that are not expected to recover in less than 30 years. All coral within the Zones of High Impact is predicted to be permanently lost, although there is likely to be some recovery within the 30 years post-dredging. Up to 30 % of *Porites* bombora are predicted to be permanently lost from the Zones of Moderate Impact. All of the other hard corals are predicted to recover within five years within the Zone of Moderate Impact. Other BPPH (macroalgae and seagrass) are only predicted to be permanently lost if the area is covered by marine infrastructure or the dredge spoil ground.

Existing disturbance to BPP along the east coast of Barrow Island was also taken into account when calculating habitat losses. This included existing oil and gas well disturbance in Management Units 6, 8 and 9 and a 10 m buffer zone around the existing Barrow Island oilfield condensate export line. This is a conservative approach because aerial photography and ground truthing have shown that this area around the existing Barrow Island oilfield condensate export line has now been largely re-colonised by macroalgae and small corals and is a functioning BPPH.

In the BPPH assessment for the Final EIS/ERMP (Chevron 2006), High or Moderate Impacts were predicted in seven of the east coast Management Units (3, 4, 7, 8, 9, 10 and 11). The current assessment, based on revised hydrodynamic dredge plume modelling for the Revised Proposal and revised infrastructure locations, predicts impacts to BPPH in seven Management Units (4, 6, 7, 8, 9, 10 and 11). Impacts that were predicted in Management Unit 3 are now not predicted to occur under the Revised Proposal. A small Moderate Impact Zone is now predicted in Management Unit 6 that was not predicted under the Approved Development. Predicted impacts for the BPPs within the affected Management Units are described in the following.

Management Unit 4, 6, 7 & 8 – East Coast Barrow Island

The main coastal components of the Gorgon Gas Development are concentrated in the mid–east coast of Barrow Island at Town Point and include the causeway, MOF, dredged shipping channels, open-pile jetty and Domestic Gas Pipeline. Revised dredge plume modelling predicts impacts from dredging and spoil disposal to BPPH in five of the existing Management Units (4, 6, 7, 8 & 9) established within the Barrow Island Port Area (Figure 7.5). Management Unit 9 is included in the subsequent section as it encompasses impacts associated with the dredge spoil ground.

These Management Units lie within the Barrow Island Port Area, designated by the *Shipping and Pilotage Act 1967* (WA) and vested under the *Marine and Harbours Act 1981* (WA). Under the BPPH Guidance Statement (EPA 2004), a port may be classified as a Development Area (Category E) with a Cumulative Loss Threshold (CLT) of 10%. The whole port area represents a higher level management unit within which the significance of the predicted cumulative BPPH losses can be assessed. Consistent with the intent of the BPPH Guidance Statement (EPA 2004), the high impacts are restricted to the inner port areas immediately adjacent to marine infrastructure, dredge and dredge spoil zones.

The Port Management Units encompass a large proportion of the benthic habitats along the east coast of Barrow Island. They include nearshore intertidal reef and macroalgae dominated limestone reef platform adjacent to the east coast of Barrow Island, coral reef communities (subtidal) at the Southern Lowendal Shelf and on the reef ridge running south from the Shelf, and areas subtidal reef (low relief) with sand veneers (Figure 7.5).

Permanent loss within these Management Units is associated with proposed construction of the solid causeway and MOF, the dredged access channel for the MOF, the Domestic Gas Pipeline (30 m disturbance corridor), the open-piled jetty (200 m disturbance corridor; increased from the Approved Development to account for revised anchor spread), the dredged LNG tanker turning basin and the dredged shipping channel.

Permanent loss of coral is predicted to be below the CLT of 10% in Management Units 4, 6 and 7 (Table 7.11). Predicted coral loss for MU 8 is 15% of the total coral habitat for that management unit, which is above the CLT but represents a decrease in coral loss from the Approved Development which was predicted as 21% of total coral habitat (Chevron Australia 2006). Scattered large *Porites* bombora on the rocky ridge running south from the Lowendal Shelf may take longer than 30 years to fully recover and are assessed as permanent loss. While these losses exceed the CLT for the Revised Proposal, not all of the corals are long-lived *Porites* bombora and the affected *Porites* bombora are the smallest of those in the area. There are much better developed *Porites* bombora fields to the north and to the south of the Revised Proposal dredge area that are not predicted to be affected. The physical structure of these bombora (*Porites* bombora fields to the north and to the south of the Revised Proposal dredge area) will continue to provide complex habitat for the faunal assemblages currently inhabiting the area even if the coral is lost as a result of the proposed construction activities.

Sedimentation and elevated TSS concentrations are predicted to cause temporary loss of BPPH (other than corals) in all of the port area Management Units (Table 7.11). The largest temporary losses are predicted for the Management Units encompassing the dredged areas. The permanent loss of BPPH (other than coral), is not predicted to exceed the CLT for Management Units 4, 6, 7 or 8. The temporarily affected areas will recover their function as BPPH when excess sediment and TSS have been reduced to a level that BPP communities can survive. Current modelling indicates that most sediment deposits will disperse rapidly after construction dredging ceases. Sediment may persist in the immediate vicinity of the areas subjected to maintenance dredging during operations. In BPPH beyond the dredged areas on the east coast, macroalgae and seagrass are predicted to recover in less than five years.

Management Units 9, 10 & 11 – Spoil Ground

The BPPH within the dredge spoil Management Units are characterised by deep sandy seabed with occasional emergent pavement reef which supports scattered seagrass meadows dominated by *Halophila*. The whole of this area is conservatively assumed to

be capable of supporting seagrass and is considered as seagrass BPPH. The disposal of boulders and rubble at this site will lead to a change in the substrate type from sandy seabed to boulder reef. This is expected to be a permanent change to the characteristics of the BPPH in the area which is taken into account for the BPP loss calculations in Table 7.11.

Management Unit 9 covers the area within the Barrow Island Port limits that would be affected by the spoil ground and the small area of additional dredging for the offshore part of the shipping channel (Figure 7.5). Management Units 10 and 11 encompass the area outside the Barrow Island Port limits, which is proposed for the disposal of dredged material from the MOF access channel and LNG shipping turning basin and channel (Figure 7.5).

Management Unit 9 lies within the Barrow Island Port limits and has a CLT of 10%. Management Unit 10 lies within the Marine Conservation Reserve boundary and has a CLT of 2%. Management Unit 11 is outside the Reserve and as a general coastal area has a CLT of 5%.

The dredge spoil area, the shipping channel and the Domestic Gas Pipeline (indicative location only) will permanently modify approximately 3, 5 and 10% of the seabed defined as subtidal reef platform (low relief) and sand in Management Units 9, 10 and 11 respectively (Figure 7.5,Table 7.11.). This is a decrease in predicted loss of BPP other than coral compared to the Approved Development for these Management Units (4, 5 and 11% respectively for the Approved Development). These figures represent loss of BPP other than coral within the disturbance area associated with the direct placement of infrastructure and the spoil ground. While the losses exceed the BPPH guidance cumulative threshold levels for the latter two Management Units, these habitats have low conservation significance. A new area (approximately 3 ha) of coral has been mapped in Management Unit 9 since the EIS/ERMP (Chevron Australia 2006). Eight percent of coral in Management Unit 9 is predicted to be lost, which is less than the 10% CLT for this management unit. Spoil disposal management options will be reviewed with the aim of protecting this coral where reasonably practicable.

Table 7.11: BPPH Assessment Under Revised Dredge Plume Modelling and Prediction of Impact Zones Using Cumulative Impact Criteria

Benthic Primary Producer Habitat Type	Total Area of BPPH before Disturbance (ha)	Predicted *Permanent BPPH Loss (%)	Predicted Temporary BPPH Loss (%)	Cumulative Loss Threshold (CLT)
Management Unit 4				
Coral habitats	220.04	7.31	3.92	10%
Macroalgae dominated limestone reef	2647.29	1.88	17.92	10%
Nearshore intertidal reef	433.37	0.22	7.60	10%
Subtidal sand	32.14	0	0.24	10%
Subtidal reef (higher profile)	2.99	0	0	10%
Subtidal reef platform (low relief) and sand	951.92	0.6	14.71	10%
Total Size	4287.75			
Management Unit 6				
Coral habitats	259.57	0	0	10%
Macroalgae dominated limestone reef	3265.44	0	0	10%
Subtidal sand	1.78	0	0	10%
Subtidal reef (higher profile)	28.42	0	0	10%
Subtidal reef platform and sand	1765.60	0	2.29	10%
Total Size	5320.8			
Management Unit 7				10%
Coral habitats	169.37	0	0	10%
Macroalgae dominated limestone reef	3998.48	0	0.07	10%
Nearshore intertidal reef	5090.5	0	0	10%
Subtidal sand	0.84	0	0	10%
Subtidal reef (higher profile)	1.30	0	0	10%
Subtidal reef platform (low relief) and sand	471.73	0.11	10.20	10%
Total Size	5150.77			

Benthic Primary Producer Habitat Type	Total Area of BPPH before Disturbance (ha)	Predicted *Permanent BPPH Loss (%)	Predicted Temporary BPPH Loss (%)	CLT
Management Unit 8				10%
Coral habitats	42.35	14.50	2.85	10%
Subtidal reef (higher profile)	767.21	3.23	19.53	10%
Subtidal reef platform (low relief) and sand	3298.75	3.61	17.31	10%
Total Size	4108.33			

Management Unit 9				10%
Coral habitats	2.58	8.18	19.09	10%
Subtidal reef platform (low relief) and sand	4985.63	3.22	7.00	10%
Total Size	4988.21			

BPPH Type	Total Area of BPPH before Disturbance (ha)	Predicted *Permanent BPPH Loss (%)	Predicted Temporary BPPH Loss (%)	CLT
Management Unit 10				
Subtidal reef platform (low relief) and sand	4923.86	4.75	3.44	2%
Total Size	4923.86			

Management Unit 11				
Coral habitats	5.21	0	0	5%
Subtidal reef platform (low relief) and sand	4987.61	10.17	8.83	5%
Total Size	4992.82			

NOTE:
**The permanent coral loss has been calculated using the entire Zone of High Impact plus 30% of the Zone of Moderate Impact. BPP loss (other than coral) has been calculated using the disturbance area associated with the direct placement of infrastructure and the spoil ground.*

The risk of impacts to benthic primary producers from seabed disturbance for the Revised Proposal has not changed from the Approved Development and is classified as Medium.

Coral Habitat Losses

Predicted loss of coral communities from dredging, spoil disposal and construction activities from the construction of the MOF and LNG jetty for the Revised Proposal across all management units on the east and west coasts of Barrow Island is approximately 22.06 ha. This figure takes into account the complete loss of coral from within the Zone of High Impact and 30% loss of coral from within the Zone of Moderate Impact. This does not include losses of coral habitat from the construction of the Domestic Gas Pipeline nor the existing WA Oil Condensate Export Line which is approximately 0.37 ha of coral. Loss of coral habitat from all east coast activities including the pipelines is predicted to be approximately 22.43 ha.

The coral predicted to be lost during the Revised Proposal construction and/or operations activities includes *Porites* bombora and scattered corals on limestone pavement. These habitat types are well represented in the broader Barrow Island/Montebello Island region.

The GJVs commit to managing marine construction, dredging and spoil disposal operations to not exceed the 22 ha limit on net coral mortality within the High and Moderate Zones of Impact, as prescribed for the Approved Development in Condition 18 of Statement No. 748 (Appendix A).

Table 7.12: Predicted Coral Loss from the Revised Proposal Compared to the Approved Development

	Approved Development	Revised Proposal
Total coral habitat within east coast Barrow Island Management Units (4, 6, 7, 8, 9, 10 &11)	652 ha	699 ha
Predicted coral loss	22 ha	22.06 ha
Predicted coral loss (%)	<3.37%	<3.15%

Summary of BPPH Impacts

The macrophyte and coral assemblages in the vicinity of revised marine facilities are widespread and are capable of readily colonising new substrates. Any new area of hard substrate, such as the causeway, is likely to be colonised by macroalgae and corals. Areas affected by anchor scour are expected to recover fully within short periods (< five years). Areas of bare sand, for example in the bottom of dredged channels, may be colonised by seagrasses but these are unlikely to persist as access channels will require regular maintenance dredging.

The area proposed for dredge spoil disposal comprises mostly bare substrates, with sparse epibenthic assemblages. This area will be substantially modified as a result of spoil disposal but are predicted to become more productive, due to the creation of hard surfaces that will encourage coral and algae recruitment. In some areas, sparse *Halophila* will be buried by the spoil. *Halophila* is a genus of mostly ephemeral seagrass species that are known to flourish in the region after disturbance, and are expected to be among the first taxa to recolonise those areas of the spoil ground dominated by soft sediments. Brown algae, such as *Sargassum*, and corals may colonise the rocky substrates created within the spoil ground after completion of construction. These BPP may persist and complex communities may develop if the substrate is stable over the long-term.

The open-pile jetty will traverse isolated coral communities and some corals may be smothered by cuttings associated with pile drilling. In anchoring areas nearby, corals

may be physically damaged by anchor scour. These communities will recover from the disturbance and corals may colonise jetty piles. The taxa in affected coral communities are widespread along the eastern coast of Barrow Island and throughout the Montebello/Lowendal/Barrow Island region.

The areas impacted by direct physical removal or burial are readily predicted from the given dimensions of the dredged channels and infrastructure. However, predicting the scale of indirect impacts due to sedimentation and elevated turbidity generated during drilling and dredging is more complex. Factors affecting the scale of effects from these stressors include the volumes of discharged sediments, the particle size of the sediments, the post-discharge behaviour of the sediments and receptor sensitivity. The behaviour of the sediments after discharge is dependent on the hydrodynamic regime at the time they are released. Sedimentation modelling for the Revised Proposal, unlike the modelling presented in the EIS/ERMP, also includes sediment re-suspension in the results.

The predicted Net Coral Mortality within the Zones of High and Moderate Impact is 22.1 ha for the marine works associated with construction of the MOF and LNG jetty and dredging and dredge spoil activities for the Revised Proposal. The permanent loss of coral for the Revised Development represents approximately 3% of the total coral habitat within affected east coast Management Units. The GJVs commit to managing dredging and spoil disposal operations to not exceed the 22 ha limit on Net Coral Mortality within the High and Moderate Zones of Impact, as prescribed for the Approved Development in Condition 18 of Statement No. 748 (Appendix A).

It is considered that the Revised Proposal does not present significant additional or different environmental risk to benthic primary producers from physical disturbance of the seabed than the Approved Development.

7.4.2.2 Leaks and Spills

The potential for significant impacts to marine BPP from a leak or spill incident associated with the Revised Proposal relates primarily to the risk of a spill of condensate or liquid hydrocarbons from work vessels, LNG and condensate tankers and work barges that will have bunkers of diesel and possibly other liquid fuels on board. The Revised Proposal will attract an approximate 25% increase in shipping associated with the third LNG train.

Unlike other liquid hydrocarbons, LNG is not toxic and produces a buoyant vapour cloud when spilled on to water (ABS Consulting 2004). As this cloud mixes with air, it warms and disperses into the atmosphere. The potential for environmental impacts on BPP from a release of LNG are therefore considered negligible (ABS Consulting 2004).

The predicted dispersion trajectories of credible hydrocarbon spill scenarios were modelled for the Approved Development in the EIS/ERMP (APASA 2004). The dispersion trajectories remain the same for the Revised Proposal. Briefly, sources of a marine hydrocarbon spill from the Revised Proposal include release of:

- diesel from shore facilities or vessels operating around marine facilities on the east coast of Barrow Island
- condensate, crude oil (from other sources) and bunker fuel oil from tankers brought to the export terminal.

Modelling for each of these scenarios under the Approved Development provided quantitative data on the potential frequency of a release of liquid hydrocarbon and indicated that the overall risk of a spill or leak was unlikely (Technical Appendix B5

EIS/ERMP, Chevron Australia 2005a). The original modelling was based on conservative, worst case, credible spill scenarios for the Approved Development. The approximate 25% increase in shipping activity associated with the increased LNG production from the Revised Proposal potentially poses an increased risk of hydrocarbon spills from vessel grounding or collision due to the increase in vessel traffic. However, the spill trajectory has not changed and the likelihood of a large spill remains extremely low. Offshore oil and gas exploration and production activities have been occurring in Australian waters for more than 30 years and in this time the largest recorded spill involved 60 m^3 of diesel (Woodside Energy Ltd 2003). A spill of this magnitude was considered to be the worst case scenario during the risk assessment.

Spilled liquid hydrocarbons can adversely affect marine benthic primary producers if there is direct contact at low tide, through the dispersal of oil droplets into shallow subtidal areas or by dissolution of hydrocarbons into the water column. The extent to which a spill will affect BPP in any area depends on a complex suite of interacting physical, chemical and biological factors. Of particular importance will be the physical and chemical properties of the oil involved, the prevailing sea and weather conditions, the pre-existing stress and energy levels in the receiving environment and the species composition of the community affected. The timing of an incident in relation to the lifecycle stage of an impacted community can also be of considerable significance. For example, an oil spill during mass coral spawning, when coral spawn floats at or near the surface of the ocean, could affect recruitment rates in local communities.

Coral, seagrass and mangrove communities are particularly sensitive to liquid hydrocarbons. In general, deeper subtidal communities tend to be buffered from the effects of a spill by the water overlying them. Although strong winds and rough sea conditions can disperse oils through the water column, light oils such as diesel and condensate have a strong tendency to float and dissolution of even the most soluble aromatic components is approximately a hundred times slower than evaporative loss (Kagi *et al.* 1988).

Within the area potentially at risk from a small-volume leak or spill (<10 m^3), the intertidal coral communities at Town Point and mangroves to the north and south of Town Point on the east coast of Barrow Island are the most vulnerable BPP communities. Intertidal coral communities have low conservation significance and the mangroves are considered to be distant enough to avoid impacts. Significant coral communities on the east coast are mostly subtidal, as are the denser macroalgae and seagrass communities. Modelling indicates that a small-volume spill from a refuelling incident on the east coast of Barrow Island would be unlikely to result in significant exposure of BPP to hydrocarbons.

A large-volume leak of liquid hydrocarbons from a vessel grounding or collision on the east coast may impact BPP over a large area and could cause widespread and long-term impacts to significant coral communities or mangroves along the south-east coastline of Barrow Island.

These scenarios are extremely unlikely; however there is potentially an increased risk of a leak or spill occurring because of the increase in shipping traffic associated with the Revised Proposal. The increase in shipping traffic is unlikely to result in a major spill due to management measures in place for a controlled port.

It is considered that the Revised Proposal does not present significant additional or different environmental risk to BPPs from hydrocarbon leaks and spills than the Approved Development. The results of the Completed Residual Risk Assessment indicate that a level of conservatism has been taken into account based on the increase

in shipping traffic. The results of the risk assessment processes shown in Table 7.13 confirm this assumption.

7.4.3 Proposed Management Actions

The Revised Proposal will be implemented adopting best practicable measures to minimise impacts to the environment.

Impacts to marine benthic primary producers will be addressed by several EMPs, systems and programs that are required under conditions prescribed for the Approved Development in Statement No. 748 and Commonwealth Approval EPBC Reference: 2003/1294.

As part of the implementation of Statement No. 748, the proponent will submit the plans, which includes discussion of the key stressors to benthic primary producers:

- Marine Facilities Construction Environmental Management Plan
- Dredge and Spoil Disposal Management and Monitoring Plan.

The objectives management measures for each of these plans are detailed in Section 15.

Construction and operation environmental management plans for the Revised Proposal will also be developed to be consistent with Commonwealth Approval Decision EPBC Reference: 2003/1294 to address stressors to marine BPP.

Furthermore, the Chevron Australia Oil Spill Contingency Plan will be implemented to fulfil the requirements of AMSA, DoIR and NATPLAN.

The purpose, scope and objectives of the EMPs, programs and systems required under the conditions of approval for the Approved Development have been reviewed. It is considered that the impacts and risks of the Revised Proposal can be effectively managed under Ministerial Conditions the same as or consistent with those already set by the Western Australian Minister for the Environment in Statement No. 748. No additional measures or controls are anticipated to be necessary to manage the potential marine fauna impacts.

7.4.4 Predicted Residual Environmental Risk

The Revised Proposal is not considered to pose any significant new or additional risks to Marine Benthic Primary Producers in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts on marine Benthic Primary Producers as a result of the Gorgon Gas Development. The implementation of various plans, systems and programs consistent with those that are required under conditions prescribed for the Approved Development in Statement No. 748 and EPBC Reference: 2003/1294 is expected to manage the following Revised Proposal marine benthic primary producer impacts to a level consistent with that considered acceptable and therefore approved for the Approved Development:

The residual risks for stressors with potential Medium and High risks is summarised in Table 7.10. Also refer to Table 5.4 Risk Matrix: **L** = Likelihood, **C** = Consequence and **RR** = Residual Risk,

Table 7.13: Environmental Risk Assessment for BPP

Stressor	Impact	Mitigation	Residual Risk For Approved Development			Tentative Residual Risk For Revised Proposal (Approved + Revised Footprint)			Completed Residual Risk For Revised Proposal (Approved + Revised Footprint)		
			L	C	RR	L	C	RR			
Physical disturbance of the seabed	Turbidity, light attenuation and reduced photosynthetic potential in dredge plume	Marine Facilities Construction Environmental Management Plan Dredge and Spoil Disposal Management and Monitoring Program	1	5-4	L-M	1	4	M	1	5-4	L-M
Leaks and Spills	Smothering of exposed intertidal biota from contact with slick of hydrocarbons	Marine Facilities Construction Environmental Management Plan Dredge and Spoil Disposal Management and Monitoring Program Oil Spill Contingency Plan includes protection of mangroves and other sensitive resources.	4	5-4	L-M	4	3	M	4	4	M
	Minor spill (<10 m^3) resulting in smothering of intertidal biota	Controlled Port Area – vessel speed limits apply Oil Spill Contingency Plan includes protection of mangroves and other sensitive resources.	4	5-4	L-M	4	3	M	4	4	M
	Major spill (>10 m^3) resulting in smothering of intertidal biota		4	3-2	M	4	3	M	4	3	M

8.0 QUARANTINE MANAGEMENT AND RISKS

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

8.1 Assessment Framework or Policy

The overarching objective of the quarantine strategy for the Gorgon Gas Development, as described in the EIS/ERMP (Chevron Australia 2005a), is to "facilitate the construction and operation of a gas processing facility on Barrow Island and simultaneously protect the conservation vales of the island".

8.2 Detailed Assessment of Potentially Significant Impacts

8.2.1 Overview

The Barrow Island Quarantine Management System (QMS) has been designed and developed in consultation with Chevron Australia's Quarantine Expert Panel (QEP), the Quarantine Advisory Committee (QAC), and community stakeholders. When developing standards for acceptable quarantine risk, the view of the community was that a low level of risk of introducing non-indigenous species (NIS) and marine pests to Barrow Island must be achieved ('a slight chance of infection' in the qualitative risk assessment process) – a view accepted by the GJVs and endorsed by the QEP and QAC.

As such, a comprehensive and independent expert-based risk assessment process was undertaken from 2003 to 2006 (as part of the assessment of the Approved Development) to identify and assess the threats of introduction for all pathways of exposure to Barrow Island, and to demonstrate the management measures that could be adopted to reduce the risk of introduction to a 'low' level for all pathways. In doing so, a set of systematic and pathway-specific quarantine barriers were analysed in detail for each pathway, in consideration of the circumstances and quantities of people, material and vessels anticipated to be travelling to Barrow Island. Quarantine barriers which could not reduce these risks to a 'low' level were replaced or augmented with barriers that achieved this mandate. The QMS captures and operationalises these pre-border systematic and pathway-specific management measures for preventing introductions, as well as post-border surveillance systems for NIS and marine pests, and contingencies for response and eradication. The QAC stated (refer to letter from the Chairman of the QAC to the Chairman of the EPA, dated 18 February 2008):

'The Committee is of the view that the outcomes of the workshops, as described in the draft Quarantine Supplement (Part 2 of the Additional Information Package), are well

founded and the barriers proposed are likely to result in a low risk of incursions to Barrow Island provided they are implemented in a timely, efficient and effective manner.'

In all cases, the prevention of NIS introductions to Barrow Island in the pre-border supply chain involves multiple layers of cleaning, inspection, treatment, storage and transport requirements at all pathway steps in the chain, resulting in a substantial degree of precaution and redundancy in the absence of performance data. All of these quarantine barriers are required for each project-related person, item or vessel to be transported to Barrow Island, and are therefore scalable to ensure the same standard of prevention is applied in the event that quantities of people, material or vessels increase or decrease. The changes associated with the Revised Proposal do not change the nature of the materials that will be subject to these quarantine barriers, and no new pathways have been proposed which are different from those already assessed for the Approved Development.

8.2.2 Assessment of Quarantine Risk for the Revised Proposal

Each pathway associated with the Revised Proposal was described in detail to enable independent experts to identify threats of introduction, consider the efficacy of quarantine management measures (barriers), and assess risk. In doing so, the quantities and physical descriptions of material and the logistics activities undertaken to move people, material and vessels to Barrow Island were explicitly considered, from the vendor's premises through the entire supply chain to Barrow Island.

As the engineering design of the Approved Development and the Revised Proposal has matured, increasing opportunities for Gas Treatment Plant 'modularisation' during construction have been explored and adopted, resulting in less 'stick-build' effort for construction of the Gas Treatment Plant on Barrow Island. While the duration of the construction phase is expected to increase by three to six months, the required volumes of individual items and raw materials have been decreased to streamline the logistics effort for construction wherever possible, and opportunities to reduce quarantine risk exposure have been embraced.

Examples of the static or reduced construction quantities for the Revised Proposal include:

- no increase in the size of the on-island workforce, from the numbers required for the 'stick-build' construction project originally assessed (Approved Development) to the highly modularised construction project (Revised Proposal) under current design circumstances (with no increase in food and perishable volumes or accommodation units originally assessed)
- reduction in sand and aggregate from an estimated 330 000 tonnes (in 2004) to 160 000 tonnes at the time when the risk assessments were completed (in 2006), to 97 000 tonnes at the time when Statement No. 748 was published, as a result of sourcing more material from the site preparation works on Barrow Island and shipping pre-cast construction components
- reduction in the number of 'stick-build' components for construction, replaced by larger and pre-constructed 'modules'.

Although the number of on-island construction workers may decrease with modularisation, and volumes of individual items and raw materials have decreased in a more modularised construction approach, the GJVs do not seek to reduce or compromise on their commitments for preventing NIS introductions in the QMS.

It is notable that the personnel and luggage, sand and aggregate, and food and perishables pathways will not involve increased numbers of construction workers or quantities of materials and supplies, as these pathways were identified as the most challenging to assess by the QEP and were acknowledged as such in community consultation. The risk of introduction for all pathways for the Revised Proposal remains Low, and does not warrant re-assessment. Opportunities to further reduce risk will be identified through the performance monitoring and continuous improvement aspects of the QMS.

The Approved Development was based on the shipment of a large quantity of building materials to construct much of the Gas Treatment Plant 'from the ground up' (otherwise called a 'stick-build' construction approach). Some of the larger components of the Gas Treatment Plant were to be pre-fabricated as large modules and shipped to Barrow Island on heavy lift vessels. As the engineering design of the Approved Development and the (subsequent) Revised Proposal has matured, opportunities to perform additional off-island construction tasks have been adopted, resulting in larger and more complete pre-fabricated modules for the Revised Proposal.

It is recognised that pre-fabricated modules are exposed to the possibility of infection, particularly by invertebrates, at the fabrication yard. Independent experts who assessed the risk of introduction on the pre-fabricated modules pathway pointed out that the upper limit of risk 'is due to the possibility of a rare episodic event occurring during the transport of a module at sea' (E-Systems 2006). A rare episodic event (e.g. swarm of flying invertebrates offshore) does not increase the risk of contamination to any individual module shipped over a marginally longer construction period (three to six months longer for the Revised Proposal). Hence, the risk of exposure to these rare episodic events remains unchanged.

The quarantine barriers developed in the risk assessment process included specific inspection and treatment (wash down and remediation) of the modules on arrival at Barrow Island, in case of a rare episodic event of invertebrate contamination at sea. Larger and more complete modules in the Revised Proposal are subject to the same potential infection modes and the corresponding set of quarantine barriers adopted in the Approved Development to reduce risk to 'a slight chance of infection' are therefore equally applicable. These approved barriers include:

- inspection of modules by the Australian Quarantine Inspection Service (AQIS) at the fabrication yard prior to departure for Australia
- final cleaning and treatment of the module immediately prior to departure
- a Voyage Management Plan including daily quarantine checks which are formally recorded
- inspection of modules by AQIS upon arrival at Barrow Island
- following release of the module as compliant by AQIS, a wash down of the module in a secure holding area
- a 'release' inspection of the module prior to movement to the construction site
- contingency plans for further treatment in the event of detecting contamination.

8.3 Management of Quarantine Risk for the Revised Proposal

A Quarantine Hazard Analysis (QHAZ) conducted by experts found that the Revised Proposal does not increase the risk of introducing weeds to Barrow Island over the Approved Development because the revised proposal has no impact on the effectiveness of the assessed barriers that are designed to prevent the introduction and

proliferation of species not native to Barrow Island. The barriers assessed form the basis of the quarantine management on the island which is detailed in the Quarantine Management System.

The Quarantine Management System is focused on preventing introductions, detecting the presence of non-indigenous species on Barrow Island and in the waters surrounding Barrow Island and controlling or eradicating non-indigenous species from Barrow Island that were introduced or which proliferated as a result of the activities of the project on the island. Managing new and existing weeds is a core component of this focus.

The management of weeds will be fully described in a Weed Management Plan (WMP) for Barrow Island. The WMP will address a number of factors including personnel and vehicle hygiene management, the control and eradication of existing weeds, management of soil stockpiles and rehabilitation of disturbed areas. In addition, a Detection Program will form part of a long term commitment to observation, surveillance and ecological monitoring which will endeavour to understand the invasive ecology of the known weeds on the island, as well as the potential invading weeds that are present in the areas from which the project will mobilise on the mainland and from international marshalling yards.

In addition to the quarantine barriers adopted in the Approved Development, the GJVs have well-advanced plans to license a Quarantine Approved Premises (QAP) on Barrow Island to facilitate direct shipments of material and modules and avoid potential cross-contamination in other Australian first ports of entry. The additional safeguard of the QAP at the point of arrival for all material delivered to Barrow Island by sea was not incorporated into the quarantine risk assessment process for the Approved Development, and therefore this approach represents an important additional layer of protection to prevent introductions and reduce risk for the Revised Proposal.

Important features of the QAP that will reduce the likelihood of NIS introductions, prior to releasing modules and other material to the construction site, are:

- Australian government-licensed facility incorporating all biosecurity measures required for a first port of entry to Australia, manned by experienced AQIS inspectors who will have overall authority for direct shipments of material and modules from foreign ports to Australia
- operation of the QAP at all times as a secure facility where all material shipped by sea enters Barrow Island, with strictly limited access to appropriately trained and qualified persons
- on-site diagnostic and laboratory facilities, including web-based imaging systems for rapid identification of any contamination that may be detected
- perimeter fencing which incorporates proven biosecurity designs and materials (e.g. invertebrate mesh barrier, ‘inverted-J’ barrier to rodents and reptiles)
- purpose-built secure wash down facility designed to accommodate the size of the largest modules
- purpose-built fumigation facilities to be used as a treatment contingency in the event of discovering contaminated materials.

These risk management measures required under Statement No. 748 will be implemented in the Quarantine Management System for the Revised Proposal.

8.4 Predicted Environmental Risk

The environmental risks posed by the Revised Proposal are no greater than the risks identified in the Approved Development, which were found to be environmentally acceptable, subject to implementation of prescribed conditions (Statement No. 748 and EPBC Reference: 2003/1294) (Appendix A). These conditions include the establishment of a QEP to provide advice to the GJVs and to the Minister on the development and implementation of the QMS. Furthermore, there are no unacceptable cumulative risks related to quarantine as a result of the Gorgon Gas Development.

The construction approach for the Revised Proposal relies more heavily on 'modularisation', requiring decreased volumes of construction supplies and raw materials to be shipped to Barrow Island; therefore a lower exposure of quarantine risk will result, compared to the Approved Development. The quarantine barriers developed for pre-fabricated modules in the Approved Development are scalable, i.e., they apply to modules regardless of size, and continue to result in a low risk of introduction for larger modules in the Revised Proposal. Similarly, the Statement No. 748 conditions relating to quarantine for the Approved Development are applicable and relevant to the Revised Proposal (refer to Appendix A, Condition 10), and do not have any diminished effect regarding the proposed construction of a third LNG Train (or any of the Associated Terrestrial Infrastructure) on Barrow Island. Finally, the licensed QAP provides an additional layer of protection to prevent introductions, over and above the barriers adopted for Approved Development.

The development of the QMS for the Approved Development, in accordance with Statement No. 748 and EPBC Reference: 2003/1294 is well advanced, meeting all of the commitments made by the GJVs. All risk-based pathway barriers have been developed and are being trialled and implemented to ensure that the risk of introduction is low. The quarantine detection program is progressing toward completion, and is being developed to address the Ministerial Condition for statistical power. Progress is being made to develop on-island diagnostic, response and eradication capabilities in the event of an incursion. The QMS will be made available for review by the DEC and the Western Australian Minister for the Environment as required by Statement No. 748, and the Federal Minister for the Environment as required by Condition 1 of EPBC Reference: 2003/1294, prior to commencement of construction of the Gorgon Gas Development. All quarantine-related approaches that have been advanced for the Approved Development are equally applicable to the Revised Proposal.

9.0 AIR EMISSIONS – RISKS AND MANAGEMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

9.1 Assessment Framework or Policy

9.1.1 EPA Objective

To maintain that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards (EPA 2004b).

9.1.2 Commonwealth Policy

The National Environment Protection Council (NEPC) has determined a number of measures for air quality including:

- National Environment Protection (Ambient Air Quality) Measure (NEPM) (NEPC 2003)
- National Environment Protection (Air Toxics) Measure (NEPC 2004).

The measures provide guidelines for levels of target species (including CO, NO_2 and SO_2) below which air quality is deemed to be acceptable. DEC has adopted NEPM guidelines for application in air quality management.

Further guidance on emission reduction technology specific to gas turbines is provided by the Australian Environment Council (AEC)/National Health and Medical Research Centre (NHMRC).

EPA Guidance Statement No. 15 (EPA 2000a) generally follows the guidelines established by these national organisations (Section 9.1.3.3).

As the workforce will be in proximity to the operations, the following sources of occupational exposure air quality measures/guidelines are also relevant to the assessment of the Revised Proposal:

- National Occupational Health and Safety Commission (NOHSC)/WorkSafe Australia (NOHSC 1995).

9.1.3 State (WA) Policy

9.1.3.1 DEC Guidelines – Ambient Air Quality Guidelines (DOE 2004)

This Guideline outlines the relevant standards used by the DEC for the assessment of the impacts of air emissions. Proposals are required to demonstrate compliance with:

- the NEPM for Ambient Air Quality (NEPC 2003; 2004)
- in the absence of a NEPM standard, the World Health Organisation (WHO) Guidelines for Air Quality (WHO 2000), with appropriate amendments to suit the Western Australian context
- in the absence of a NEPM standard or WHO guideline, criteria from another jurisdiction (once they have been assessed by DEC and found to be applicable to the Western Australian context).

9.1.3.2 DEC Guidelines – Air Quality Modelling Guidance Notes (DOE 2006b)

These Guidelines have been prepared to provide a clear understanding of the DEC's expectations with respect to air quality modelling and associated meteorological monitoring and/or modelling. Specifically, these Guidelines require:

- identification and quantification of all emissions to the atmosphere which have the potential for non-trivial impact on the environment
- for all those primary and secondary target species which cannot be dismissed as being of no significance, the proponent must provide model predictions of the impact of emissions on the various elements of the environment, in the form of concentrations and/or rates of deposition over the range of averaging periods normally associated with relevant standards for each target species, and assess the magnitude of this impact against the relevant standards
- inputs into the model (emissions estimates, background concentrations etc.) and model capability should contain sufficient detail to render the model accurate, incorporating considerations outlined in this Guideline
- presentation of modelling results in the prescribed form and with reference to appropriate standards as outlined in this Guideline.

9.1.3.3 EPA Guidance Statement No. 15 – Emissions of Oxides of Nitrogen from Gas Turbines (EPA 2000a)

This Guidance Statement requires proposals to demonstrate the following:

- All reasonable and practicable measures should be taken to minimise the discharge of waste into the environment.
- Multiple discharges of waste must not cause cumulative impacts beyond environmentally acceptable limits/standards/criteria. This depends upon the ambient conditions of the receiving environment, and therefore needs to be addressed on a case-by-case basis on advice from the EPA.

9.2 Assessment of Potential Impacts

9.2.1 Overview

The emission of contaminants and subsequent change in ambient air quality has the potential to impact human health, welfare and amenity and to act as a stressor to vegetation.

Construction and operational phase air emissions have been reviewed for the Revised Proposal.

The increase in construction related emissions for the Revised Proposal compared to the Approved Development are considered to be insignificant (the duration of construction activities for the Revised Proposal has increased by approximately three to six months from that for the Approved Development). In addition, the duration of emissions during construction is minor compared to the operations phase.

The focus of the air quality assessment has been on the operational phase impacts. The detailed air quality assessment presented below has considered the cumulative impact of existing and approved sources of air emissions in the region and the emissions for the Revised Proposal. Due to a significant advance in engineering design, along with the use of a new version of the air quality model, results previously presented in the EIS/ERMP (Chevron Australia 2005a) are not directly comparable to the results of the assessment presented in this Section.

No unacceptable impacts to human health or the environment arise from the air emissions associated with the Revised Proposal. Predicted ambient air quality remains well below defined criteria for all modelled air emissions except for ozone in the non-routine case where CO_2 venting occurs. In this case, ground level concentrations stay below, but close to the 1-hr NEPM criteria.

It is considered that, with regard to air emissions, the Revised Proposal does not present significantly different environmental risk in comparison to the Approved Development.

A detailed description of air emission sources, meteorological data analysis, modelling methodology and model configuration is presented in Appendix G and summarised below.

9.2.2 Air Emissions

9.2.2.1 Air Emissions from Existing and Approved Projects

Air quality in the vicinity of the Revised Proposal is expected to be influenced by the following projects (existing and approved):

- Woodside LNG operations (including trains four [operational] and five [approved]) – Burrup Peninsula
- future approved Pluto LNG project – 190km north-west of Karratha
- existing Hamersley Iron Power Station - Dampier
- existing condensate production operations on Barrow Island (operated by the Barrow Island Joint Venture)
- existing Burrup Fertilisers ammonia production facilities – Burrup Peninsula
- shipping emissions (from above mentioned operations).

Other air emission sources in the region, such as Varanus Island, do not contribute significantly to the regional emissions concentrations and hence, have not been included in the model setup.

Collectively, the key air emissions from these operations are considered to be oxides of nitrogen (NO_x), particulates (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs).

9.2.2.2 Air Emissions from the Approved Development

The key sources of air emissions during the operational phase of the Approved Development, as identified in the EIS/ERMP (Chevron Australia 2005a) include:

- power generation (4 turbines)
- process area compression gas turbines (4 turbines)
- heating medium heaters (furnaces)
- flaring of hydrocarbons (main plant flare and boil off gas (BOG) flare)
- CO_2 venting (non-routine)
- shipping (supply vessels and LNG and condensate tanker movements).

9.2.2.3 Air Emissions from the Revised Proposal

In comparison to the Approved Development, the Revised Proposal includes the following key additional sources of air emissions, being:

- one additional power generation turbine (a total of five gas turbine generators, all fitted with DLN burners). Note that as Gorgon Gas Development's engineering design has advanced it has been determined that all gas turbines will be fitted with DLN burners. At the time of the EIS/ERMP assessment, only process area compression gas turbines were designed to be fitted with DLN burners
- two additional process area compression gas turbines (a total of six gas turbines, all fitted with DLN burners and waste heat recovery units)
- one additional BOG elevated flare on hot stand-by (note the additional BOG flare is not a change from the Approved Development, but it was not identified as a source of emissions in the EIS/ ERMP (Chevron Australia 2005a).

The key air emissions from the Revised Proposal will be from the combustion of fuel gas in the process and power generation plant gas turbines, flaring hydrocarbons during routine and non-routine plant operations and CO_2 venting (non-routine in the event the CO_2 injection process is not operational). CO_2 venting occurs at the Acid Gas Recovery Units (AGRUs). While there are no additional point sources for CO_2 venting, the flow through the previously defined AGRU units will be increased during non-routine venting.

The key air emissions associated with the Revised Proposal from the combustion of natural gas include CO_2 and NO_x, together with some CO and non-combusted hydrocarbons or volatile organic compounds VOCs. There may also be traces of PM_{10} and sulphur dioxide (SO_2). During CO_2 venting, trace quantities of H_2S and BTEX (precursor to ozone formation) would also be vented to the atmosphere with the CO_2.

The key emissions anticipated to be influenced by the change from the Approved Development to the Revised Proposal are CO, NO_x, PM_{10} and SO_2. Refer to Section 12 for detailed discussion relating to greenhouse gases.

A conceptual layout of the Revised Proposal Gas Treatment Plant highlighting the proposed location of the key emission sources is shown in Figure 9.1.

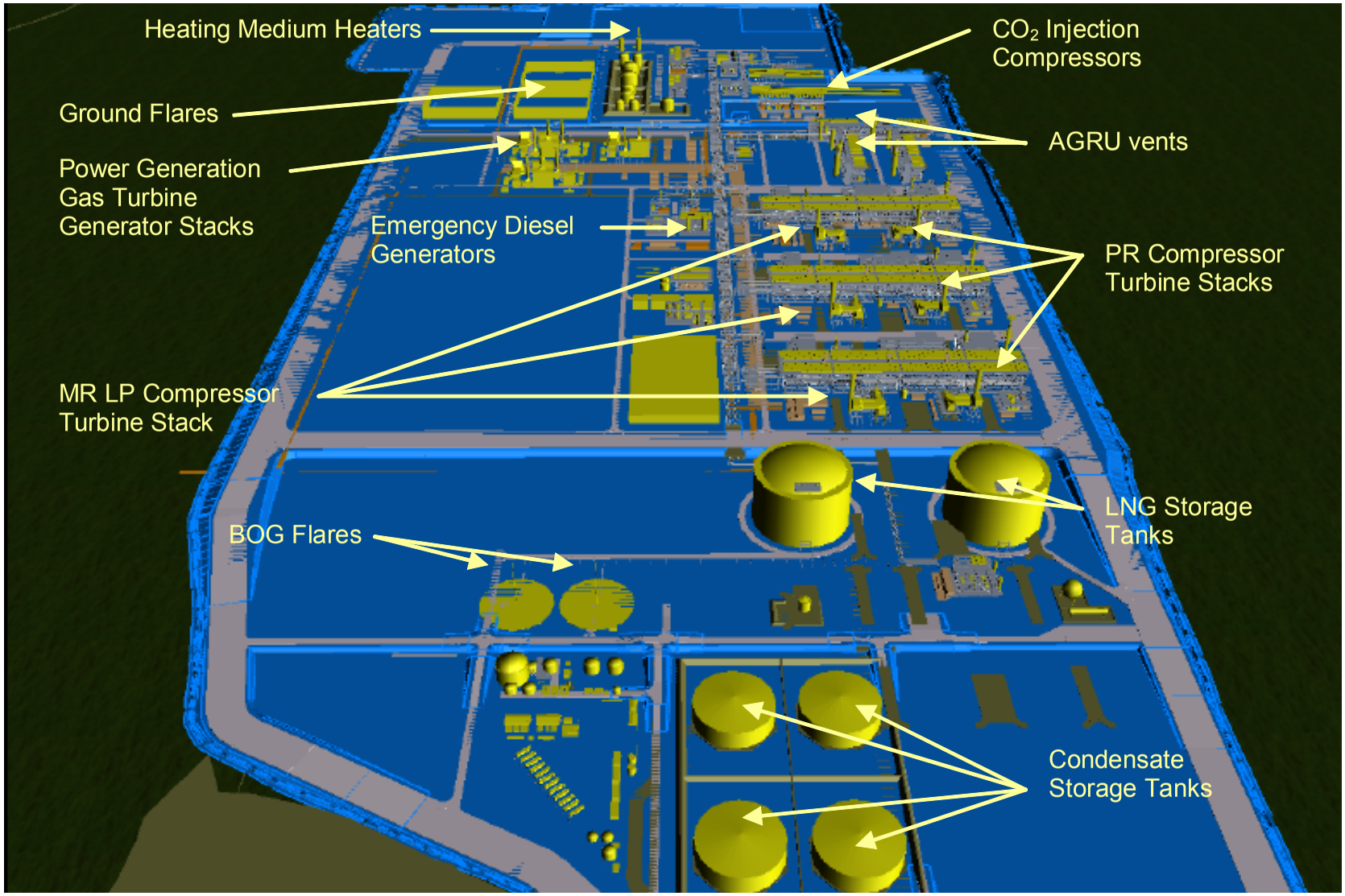


Figure 9.1: Conceptual Layout of Proposed 3 x 5 MTPA Gas Processing Facility

9.2.3 Atmospheric Dispersion Modelling Methodology

9.2.3.1 Atmospheric Dispersion Model

Atmospheric dispersion modelling of key air emissions under a series of operating conditions has been performed and the results (ground level concentration of target species) assessed and compared to relevant criteria. The air quality assessment was carried out in accordance with DEC (formerly known as DOE) Guidelines for Air Quality Modelling (DOE 2006b).

For this assessment, the atmospheric dispersion model TAPM (The Air Pollution Model) was utilised. TAPM is a prognostic three-dimensional model designed by CSIRO that can be used to predict meteorological and air quality parameters on an hourly basis (Physick and Blockley 2001). The TAPM modelling package consists of a model and databases of synoptic meteorology, terrain and land use categories for the Australasian region. The region covered by the model extends approximately 300 km from Barrow Island across to the mainland with the Burrup Peninsula to the northern extent and Onslow to the south.

A detailed description of the meteorological data analysis, modelling methodology and model configuration is presented in Appendix G.

9.2.3.2 Receptors of Interest

The existing Chevron Camp and the proposed Gorgon Construction Village/Turnaround Camp are the selected sensitive receptor locations on Barrow Island. These locations are presented in Figure 9.2.

The potential impact of emissions to the health of the workforce located on Barrow Island has also been assessed under the routine and non-routine operating conditions.

Potential impacts to native vegetation have also been considered.

9.2.3.3 Air Quality Criteria

Air quality criteria in this assessment have been sourced from those listed in Section 9.1.

These criteria have been used to assess whether air emissions are harmful to human health and/or, the environment. The assessment criteria are summarised in Table 9.1.

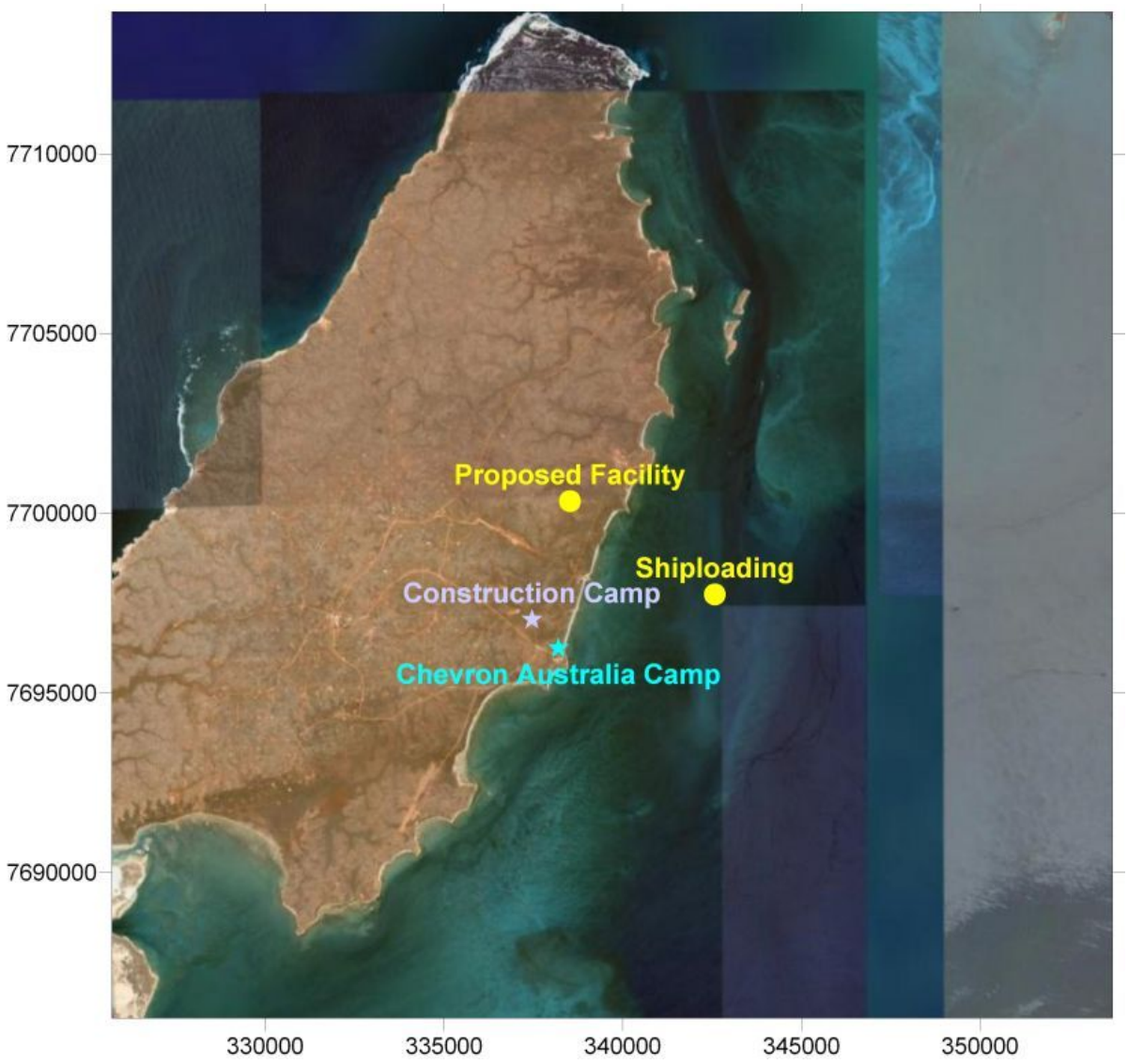


Figure 9.2: Location of Proposed Processing Facility, Shiploading and Sensitive Receptors

Table 9.1: Assessment Criteria

Emission Species	Criteria Category	Averaging Period	Assessment Criteria (µg/m^3)	Reference
SO_2	Human Health Sensitive Receptors	1-hour	571	NEPM (NEPC 2003; 2004)
		24-hour	229	
		Annual	57	
	Human Health Occupational	8-hour TWA	5 200	WorkSafe (NOHSC 1995)
	Vegetation	Annual	8-16 kg/ha	WHO (WHO 2000)
NO_2	Human Health Sensitive Receptors	1-hour	246	NEPM (NEPC 2003; 2004)
		Annual	62	
	Human Health Occupational	8-hour TWA	5–600	WorkSafe (NOHSC 1995)
	Vegetation (NO_x)	Annual	5–35 kg/ha[1]	WHO (WHO 2000)
		Annual	15–20 kg/ha[2]	
PM_{10}	Human Health Sensitive Receptors	24-hour	50	NEPM (NEPC 2003; 2004)
		Annual	30	
O_3	Human Health Sensitive Receptors	1-hour	214	NEPM (NEPC 2003; 2004)
	Human Health Occupational	8-hour TWA	200	WorkSafe (NOHSC 1995)
H_2S	Human Health Occupational	8-hour TWA	14 000	WorkSafe (NOHSC 1995)

NOTES:
[1] critical load for nitrogen.
[2] specified by WHO for lowland dry heathlands as nitrogen.

9.2.3.4 Modelling Scenarios

In the absence of appropriate ambient air quality monitoring data for the Barrow Island location, atmospheric dispersion modelling of the existing and approved sources (for the Approved Gorgon Gas Development identified in Section 9.2.2.1) was undertaken to define the existing air quality.

A series of operating scenarios (both routine and non-routine) were modelled to assess the potential impacts arising from the discharge of emissions to the atmosphere from the Revised Proposal. The non-routine operations modelled are considered to represent reasonable worst-case conditions, and include:

- a cold start-up, i.e. start up of the facility after a prolonged shutdown, expected to occur at least once a year for a six hour period
- a process emergency shut-down, either planned or unplanned, that results in some gas being directed to the flare system for up to an hour
- a Reservoir Carbon Dioxide Injection System shutdown, planned or unplanned, resulting in reservoir CO_2 venting from the acid gas removal units to the atmosphere (trace quantities of H_2S will also be vented in this situation).

9.2.4 Results of Atmospheric Modelling

The air emission modelling was completed for the cumulative impacts of existing operations, approved projects and the Revised Proposal during operations. The maximum predicted concentration anywhere within the defined air quality assessment area (grid) is also reported and compared to the assessment criteria. A detailed discussion of all the modelling results is presented in Appendix G, including graphical representation (contour concentrations).

In summary, no unacceptable impacts to human health or the environment arise due to the air emissions associated with the Revised Proposal. All emissions modelled are within the assessment criteria.

9.2.5 Potential Impact to Human Health (Sensitive Receptors)

This section summarises the atmospheric dispersion modelling results with regard to the sensitive receptor locations and the relevant NEPM assessment criteria.

9.2.5.1 Modelling Results for Existing and Approved Projects

Model predictions show that the existing concentrations of NO_2 (both short and long-term duration) are relatively low across the regional model grid when compared with the assessment criteria (based on the NEPM standards). The maximum predicted 1-hour, and annual NO_2 concentrations are very low, being 6.1% and 0.3% of the respective assessment criteria (based on the NEPM standards) at the existing Chevron Camp on Barrow Island.

The model prediction for ozone demonstrates the regional influence of emissions sources on the Burrup Peninsula. Both the 1-hour ozone and 4-hour ozone concentration on Barrow Island are within the assessment criteria (based on the NEPM standards). The maximum concentrations on the larger modelling grid are equivalent to 61.2% and 63.6% of the assessment criteria, respectively and occur near the Burrup Peninsula on mainland Western Australia. Predicted ozone levels at Barrow Island are significantly lower, with the 1-hour maximum concentration at the Chevron Camp being 35.5% of the NEPM criteria.

Model predictions show that the existing concentrations of SO_2 (both short and long-term duration) are relatively low across the regional model grid when compared with the assessment criteria, (based on the NEPM standards). The maximum predicted 1-hour, 24-hour and annual SO_2 concentrations are very low, being 0.1%, 0.04% and 0.02% of the respective assessment criteria (based on the NEPM standards) at the existing Chevron Camp on Barrow Island.

These modelled results (i.e. concentrations well below relevant assessment criteria on Barrow Island) are to be expected, given the relatively small sources currently located on Barrow Island and the scale of development and emissions from the Burrup Peninsula.

9.2.5.2 Modelling Results for the Revised Proposal

Table 9.2 and Table 9.3 summarise the maximum modelled emissions concentrations at the Chevron Australia Camp and the proposed Gorgon Construction Village, respectively. These results are presented for existing and approved operations and for routine and non-routine operation of the Revised Proposal, as a percentage of the assessment criteria (based on NEPM standards).

Table 9.2: Maximum Predicted Percentages of Assessment Criteria at Existing Chevron Camp

Air Emission	Assessment Criteria ($\mu g/m^3$) (NEPC 2003; 2004)	Averaging Period	Percentage of Assessment Criteria				
			Existing and Approved	Revised Proposal			
				Routine	Cold Start	Emergency Shutdown	CO_2 Venting
NO_2	246	1-hour	6.1	8.1	33.3	6.5	7.7
O_3	214	1-hour	35.5	37.9	46.7	37.9	93.5
SO_2	571	1-hour	0.1	0.9	0.7	0.5	0.9
PM_{10}	50	24-hour	n/a	0.6	0.6	0.6	1.6

Table 9.3: Maximum Predicted Percentages of Assessment Criteria at Proposed Gorgon Construction Village

Air Emissions	Assessment Criteria ($\mu g/m^3$) (NEPC 2003; 2004)	Averaging Period	Percentage of Assessment Criteria				
			Existing and Approved	Revised Proposal			
				Routine	Cold Start	Emergency Shutdown	CO_2 Venting
NO_2	246	1-hour	7.3	8.5	33.3	8.5	8.5
O_3	214	1-hour	35.5	37.9	46.7	37.9	93.5
SO_2	571	1-hour	0.1	1.1	1.1	0.5	1.1
PM_{10}	50	24-hour	n/a	0.6	0.7	0.6	1.6

Elevated levels of ozone are predicted to occur during non-routine CO_2 venting events. The modelling for this non-routine condition was conducted for every hour of the year, making the results extremely conservative.

9.2.6 Potential Impact to Occupational Health (Workforce)

The potential impact of emissions to the health of the workforce located on Barrow Island has also been assessed under the routine and non-routine operating conditions.

No unacceptable impacts to the occupational health of the workforce arise from the emissions associated with the Revised Proposal. All air emissions modelled are well below the relevant occupational exposure criteria. The maximum concentration for all emissions modelled was less than 15% of the relevant occupational health criteria (H_2S).

Table 9.4 summarises the maximum modelled emission concentrations on Barrow Island. These results are presented as a percentage of the assessment criteria (based on WorkSafe standards [NOHSC 1995]).

Table 9.4: Maximum Predicted Ground Level Concentration on 1-Km Modelled Grid During Routine and Non-Routine Operating Conditions

Air Emission	Assessment Criteria TWA ($\mu g/m^3$) (NOHSC 1995)	Averaging Period	Percentage of Assessment Criteria				
			Existing	Revised Proposal			
				Routine	Cold Start	Emergency Shutdown	CO_2 Venting
NO_2	5 600	8-hour	0.14	0.25	1.5	0.22	0.28
O_3	200	8-hour	30	38	41	37	50
SO_2	5 200	8-hour	0.001	0.12	0.11	0.08	0.12
H_2S	14 000	8-hour	NA	NA	NA	NA	12.7

9.2.7 Potential Impact to Vegetation

The potential impact of emissions on the vegetation of Barrow Island has been assessed by comparison to the WHO standards (WHO 2000) for the deposition of SO_2 and NO_2. In the absence of local standards, and as agreed to in the scoping stages of the assessment process (Chevron Australia 2008d), it has been determined that these criteria are the most relevant available.

The modelled deposition rates in the region around Barrow Island due to the air emissions associated with the Revised Proposal are well within the specified limits. Results (contour concentrations) are provided in Appendix G. The results are summarised in Table 9.5.

Table 9.5: Maximum Predicted Deposition Rates in the Region

Air Emissions	Assessment Criteria (kg/ha/annum) (WHO 2000)	Maximum on Grid – Existing and Approved (kg/ha/annum)	Maximum on Grid Revised Proposal (kg/ha/annum)
SO_2	8–16	0.02	0.16
NO_2	5–35 (critical load for nitrogen) 15–20 (critical load for heathlands)	0.34	0.61

9.3 Proposed Management Actions

The GJVs will undertake the following approach to the management of air emissions from the Revised Proposal:

- best practice management in the design and construction of the LNG facilities
- installation of DLN technology on turbines to minimise NOx emissions

The management of air quality impacts will be addressed by several EMPs, systems and monitoring programs that are required under conditions prescribed for the Approved Development under Statement No. 748 and Commonwealth approval EPBC Reference: 2003/1294.

As part of the implementation of Statement No. 748, the proponent will submit the following, which will include discussion of air quality:

- Terrestrial and Subterranean Environment Protection Plan
- Best Practice Pollution Control Design
- Air Quality Management Plan

- Marine Facilities Construction EMP
- Horizontal Direction Drilling Management and Monitoring Plan
- Offshore Gas Pipeline Installation Management Plans

The objectives and key management actions for each of these documents are detailed in Section 15.0.

Operations and construction environmental management plans for the Revised Proposal will also be developed to be consistent with Commonwealth Approval Decision EPBC Reference: 2003/1294.

The purpose, scope and objectives of the EMPs, programs and systems required under the conditions of approval for the Approved Development have been reviewed and it is considered that the air emissions – related impacts and risks associated with the Revised Proposal can be effectively managed under the Ministerial Conditions already set by the Western Australian Minister for the Environment (and described in Statement No. 748) for the Approved Development. No additional measures or controls are anticipated to be necessary to manage the potential air quality impacts associated with the Revised Proposal.

9.4 Predicted Environmental Risk

Based on the modelling completed, the air emissions arising from the routine operation of the Revised Proposal can be managed to achieve the EPA's objective for air quality (i.e. air emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses).

Similarly, the conservative approach adopted for the modelling of air emissions during the non-routine upset conditions, also demonstrates that the potential impacts are manageable during these periods and the desired environmental outcome is achieved.

The addition of the Gorgon Gas Development as a regional emission source will influence ground level concentrations of emissions both at Barrow Island and on the mainland in the vicinity of the Burrup Peninsula. However, there are no unacceptable cumulative impacts related to air emissions as a result of the Gorgon Gas Development. The relative increase in regional concentrations is not significant, and the EPA's air quality objective in the region is achieved.

Based on these results, the GJVs are confident that the changes associated with the Revised Proposal can be effectively managed under the Ministerial Conditions already set by the Western Australian Minister for the Environment (and described in Statement No. 748). No additional measures or controls are anticipated to be necessary to manage the potential air quality impacts.

10.0 LIGHT EMISSIONS – RISKS AND MANAGEMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

10.1 Assessment Framework or Policy

10.1.1 EPA Objective

To avoid or manage potential impacts from light overspill and comply with acceptable standards (EPA 2004b).

10.2 Detailed Assessment of Potential Impacts

10.2.1 Overview

The proposed changes to the Gas Treatment Plant in the Revised Proposal include the following elements that will contribute to an increase in light spill:

- the physical presence of an additional LNG train (module)
- additional non-routine flaring associated with the operation of the third LNG train
- an increase in LNG and condensate offloading frequency.

At Barrow Island, light spill and light characteristics (e.g. light colour, intensity, etc.) from the Gorgon Gas Development have the potential to affect the following key environmental receptors:

- flatback turtles visiting the beaches either side of Town Point to mate, rest in the near shore waters and lay eggs on the beaches
- the bridled tern and wedge tail shearwater colony on Double Island.

The effects of increased artificial lighting on sea turtles are dependent on the intensity and wavelength of the light, the extent to which light spills into areas that are significant for breeding and foraging (direct light spill), and the glow (indirect light spill) from the Gas Treatment Plant and marine facility operations. Artificial light can also be a stimulus for some bird species.

The focus of the light spill assessment is on the operational phase of the Revised Proposal; any changes to light emissions during the construction phase are considered to be insignificant. The detailed light spill assessment presented below has considered the cumulative impact of light emissions (i.e. emissions from the Approved Development and Revised Proposal), and results are presented in terms of illuminance levels at key

locations. Discussion of the potential affects of light spill from the Revised Proposal to terrestrial and marine fauna are provided in Sections 6.1 and 7.1 respectively.

The results of the light modelling studies for the Approved Development and the Revised Proposal cannot be directly compared for the following main reasons:

- Use of two completely different models (i.e. the AGI32 software program was used for the purposes of the Approved Development EIS/ERMP, whilst a proprietary software Chamit version 4.04 was used for this Revised Proposal). The AGI32 software used approximately 200 x 250 Watt individual high pressure sodium lights located strategically around the Gas Treatment Plant at 10 metre high poles. The Chalmit model was built upon the three dimensional model of the Gas Treatment Plant and used more than 999 light sources in various areas of the plant. The Chalmit modelling software was selected for the purposes of the light spill modelling study in the PER as this will be the software used in the design of the Gas Treatment Plant and associated infrastructure lighting systems.
- The Gas Treatment Plant layout has changed significantly with the three LNG trains now aligned in an east–westerly direction rather than along the north–south axis as previously located on the 2x5 MTPA Gas Treatment Plant plot plan (Approved Development).

10.2.2 Light Spill Modelling Methodology

10.2.2.1 Light Spill Model

A light spill modelling study was commissioned by Chevron Australia (KJVG 2008a) (Appendix D) to determine the extent of light spill around the Revised Proposal Gas Treatment Plant including light intensity levels at the adjacent beaches for a number of normal and emergency operational scenarios. The study was conducted by Chalmit, an international company, based in Scotland, UK that designs, manufactures and distributes various lighting products for use in hazardous areas, industrial and marine environments.

Chalmit used proprietary software (Chalmit version 4.04) to model light emissions from the Gas Treatment Plant. The model provides a two dimensional (single plane) output, however light spill over the plant has also been estimated with the same model by rotating the output plane at 90^{o} from the horizontal (Figures 10.2, 10.4 and 10.6).

The scope of the light modelling study included light sources from the Gas Treatment Plant (three LNG trains) and the nearby Administration Area. The marine infrastructure facilities, (i.e. the MOF and Jetty), were excluded from the model as they are a significant distance away from the beach (i.e. approximately 2 km and 4 km respectively). Flares were also excluded as they could not be accommodated by the model.

The model utilises the three dimensional (3D) model of the Revised Proposal Gas Treatment Plant to position light sources at various heights in line with equipment and walkways within the LNG modules and tank heights. The model will continue to be used throughout the design process to determine the best positioning of light sources such that light spill is minimised whilst sufficient light levels are provided for operability and safety reasons.

10.2.2.2 Locations of Interest

The results of the light spill modelling are discussed in terms of luminance levels at Terminal and Bivalve Beaches (north and south of Town Point respectively), which are important beaches for flatback turtles, and Double Island (approximately 5 km to the north of Town Point), which supports the bridled tern and wedge tail shearwater colony.

10.2.2.3 Natural Illumination Levels

Typical natural illuminance levels were used in this assessment to compare the modelled illuminance levels against. Natural illuminance levels used were sourced from Middleton (1952) and are listed in Table 10.1.

Table 10.1: Typical Natural Luminance Levels (lux)

Sky Condition	Approximate Levels of Luminance lux (lm/m^2)
Direct Sunlight	100 000–130 000
Full Daylight (not direct sunlight)	10 000–20 000
Overcast Day	1000
Very Dark Day	100
Twilight	10
Deep Twilight	1
Fullmoon	0.1
Quartermoon	0.01
Moonless, clear night sky	0.001
Moonless, overcast night sky	0.0001

10.2.2.4 Modelling Scenarios

Routine and emergency operational scenarios have been modelled (Table 10.2). Vertical profiles showing light spill above the Gas Treatment Plant have been produced for Options A, B and C, which are outlined below.

Table 10.2: Modelling Scenarios

Scenario	Description	Model Assumptions
A: Normal Operations	Normal operations for the three LNG trains. Lighting levels set for normal operations and movements of personnel within the plant.	Mean lighting levels of 20 lux for Trains 1, 2 and 3 and 5 lux for road lighting.
B: Train Maintenance	One train under maintenance whilst two other operating in normal mode. Task lighting provided for Train 3.	Mean lighting levels of 20 lux for Trains 1, 2 and 5 lux for road lighting. Train 3 (worst case scenario for light spill to the beach) illuminated to a mean lighting level of 50 lux.
C: LNG Tank Rooftop Maintenance	Normal operations for three LNG trains and maintenance works on LNG tanks rooftops.	Mean lighting levels of 20 lux for Trains 1, 2 and 3 and 5 lux for road lighting. LNG tanks rooftops illuminated to a local mean lighting level of 50 lux.
D: Maintenance Works in General Utilities Area	Normal operations for three LNG trains and maintenance works in the general utilities area.	Mean lighting levels of 20 lux for Trains 1, 2 and 3 and 5 lux for road lighting. General utilities area illuminated to a mean lighting level of 50 lux.
E: Administration Area	Administration area illuminated to normal operating levels.	Mean lighting levels of 20 lux for Administration Building.

10.2.3 Results of Light Spill Modelling

Light spill modelling was completed for Revised Proposal during operations. In summary, results from the modelling studies indicate the illumination levels on Terminal and Bivalve Beaches caused by light spill from the Revised Proposal Gas Treatment Plant were comparable to illumination levels on clear nights with full or quarter moon. It also needs to be noted that some shielding effects will be provided by the sand dune at

Bivalve Beach and additional large structures on the Gas Treatment Plant, which have not been accounted for in the model (i.e. the model has been projected on a flat plane).

Table 10.3 summarises the illumination levels for the modelled options at the adjacent Bivalve and Terminal Beaches. Figure 10.1 through Figure 10.8 present isolux contours (horizontal and vertical) for the various modelled scenarios.

Table 10.3: Mean Luminance Levels (lux) at Adjacent Beaches

Modelling Option	Bivalve Beach Mean Illuminance Levels (lux)	Terminal Beach Mean Illuminance Levels (lux)
Option A – Normal Operations	0.04 – 0.08	0.03
Option B – Train Maintenance	0.04 – 0.09	0.04
Option C – LNG Tank Rooftop Maintenance	0.04 – 0.09	0.04
Option D – Maintenance Works in General Utilities Area	0.04 – 0.08	0.03
Option E – Administration Area	practically zero	practically zero

For all scenarios modelled, the mean illumination levels on the adjacent Bivalve and Terminal Beaches compare similarly with natural illumination levels from moon light (between full and quarter moon, Table 10.1). In addition, as the modelling results are projected onto a flat plane and do not take into account the effects of the natural topography of the site, there will be additional shielding effects provided by the sand dune between the Gas Treatment Plant plot plan and the Bivalve Beach and additional shielding effects from the LNG and condensate storage tanks at the site. Therefore, actual illumination levels at Terminal and Bivalve Beaches are likely to be less than the illumination levels indicated in Table 10.3.

Considering the fact that light intensity diminishes by the square of the distance to the source, light illuminance levels at the closest edge of Double Island, which is 5 km to the north of Town Point, will be practically zero.

Light spill above the plant will be lowest during normal plant operations (145 m to the 0.5 lux contour) (Figure 10.2) and highest for the option where one of the LNG trains is task lit for maintenance (215 m to the 0.5 lux contour) (Figure 10.4). The effects of this light spill will be accentuated in overcast weather where the cloud covers reflects back the light spill from the plant.

10.2.4 Additional Sources of Light Spill

Additional sources of light spill not modelled in the Chalmit light study include the ground and marine/Boil Off Gas (BOG) flares and the marine infrastructure facilities at Town Point (i.e. the causeway, MOF and LNG Jetty). The increased Gas Treatment Plant throughput under the Revised Proposal will affect these light sources through the increase in non-routine flaring events (increase by approximately 50% compared to the Approved Development) and the increase in the number of LNG and condensate tanker movements.

The Gas Treatment Plant ground flares will be installed at the far south-west corner of the Plant, some 1450 m from the beach. The flares tips will be installed approximately one metre off the ground shielded by solid walls on all sides, several metres in height, to minimise radiation and light spill to the surrounding environment. Under normal operating conditions, only the flare pilots will be lit whilst the flare headers will be purged with minimal amounts of fuel gas to maintain positive pressure and sweep small scale hydrocarbon strains from on-site equipment. Non-routine flaring events caused by plant

upsets or scheduled maintenance shutdowns are expected to occur at a maximum frequency of ten times a year for any given year of operations. The ground flares will contribute to light glow, which will be detectable mostly during periods of overcast, high humidity weather (experienced only during the cyclone season).

The marine/BOG flare will be constructed as an elevated flare (height to be determined based on engineering, operability, environmental and safety considerations) with pilots lit at all times for safety reasons. The flare is provided as a safe disposal route for BOG from the LNG tanks and the return BOG vapour from the LNG loading operations in the event of a BOG compressor failure. The flares will also be used to dispose of the inert/hydrocarbon gas mixture associated with cooling of 'warm' LNG ships at Barrow Island. The frequency of warm LNG ship visits is expected to be 12 times/annum (average of one warm LNG ship/month).

Field experiments with light spill from a continuously flaring ground (pit) flare and an elevated flare on Thevenard Island concluded the following (Pendoley Environmental 1999):

- hydrocarbon flares emit in the visible light spectrum (between 400 and 800 nm)
- increase in flow rate does not change either the spectrum of light above the flares or the amount of measured illumination
- flare glow can be attributed mostly to glowing soot or naturally occurring particles (marine aerosols) in the air which scatter the light
- contribution of other illumination sources rather than the flares was significantly greater than the flares
- flares disoriented marine turtle hatchlings on nights near the new moon but had less of an influence on moonlit nights
- flares did not attract marine turtle hatchlings from beaches 300 – 400 m away on either full or new moon nights.

Based on the above conclusions and the fact that both the ground and marine flares are located more than 400 m from Bivalve Beach (the closest beach), the effect of these flares on marine turtles is considered to be negligible; see also Section 7.1. Similarly, the effect on the Double Island bird colonies is also considered to be negligible given the large separation distance between Double Island and Town Point (5 km across a direct line); see also Section 6.1.

The proposed marine infrastructure is potentially another source of disorientation for turtle hatchlings once they get to the water. Again, the significant distance of the MOF and LNG Jetty from the beach will allow hatchlings to disperse well in the water and will diminish the effect of these additional light sources on the turtles; see also Section 7.1.2.2.

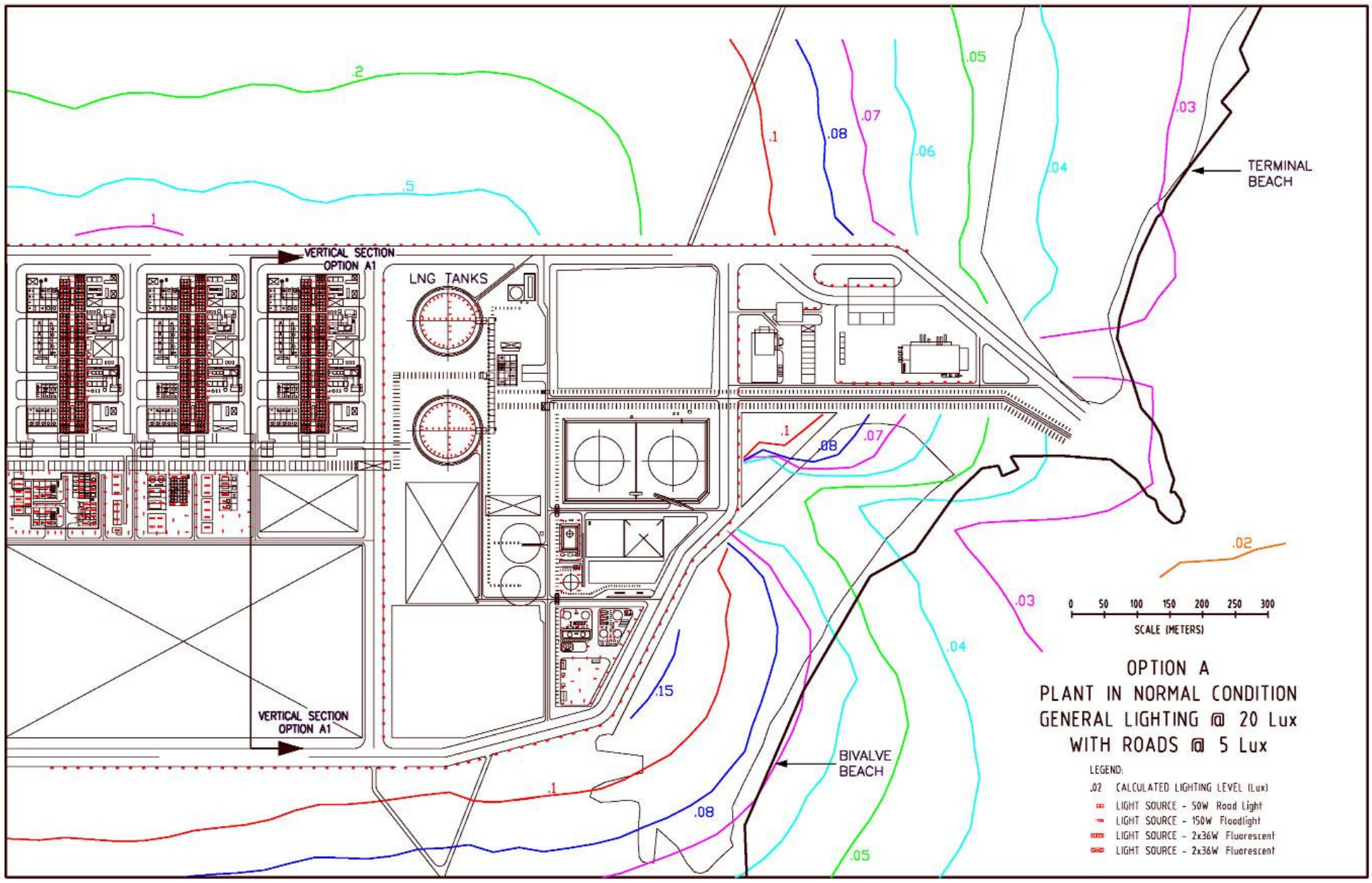


Figure 10.1: Option A – Normal Operations – Horizontal Isolux Contours (lux)

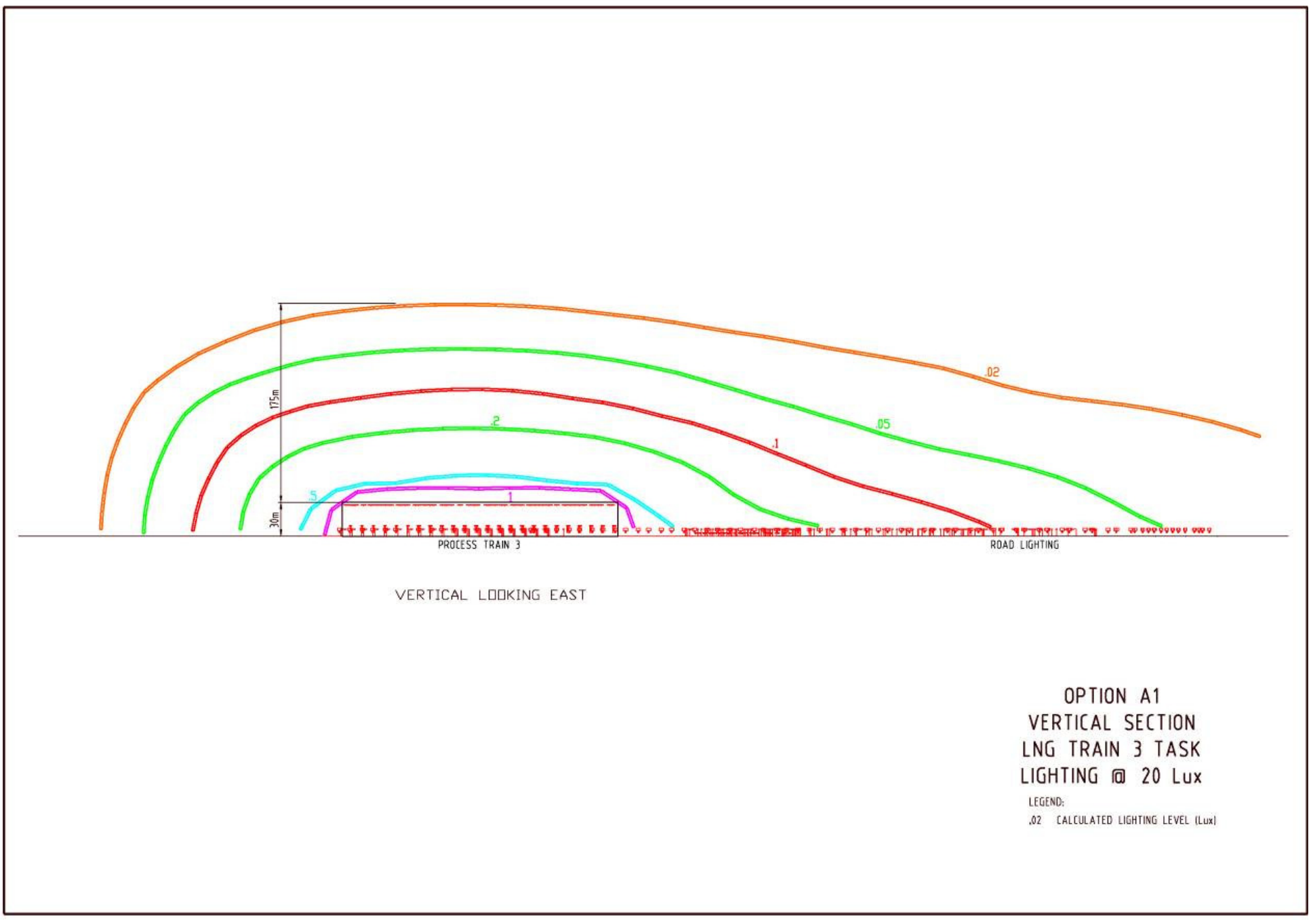


Figure 10.2: Option A1 – Normal Operations – Vertical Isolux Contours (lux)

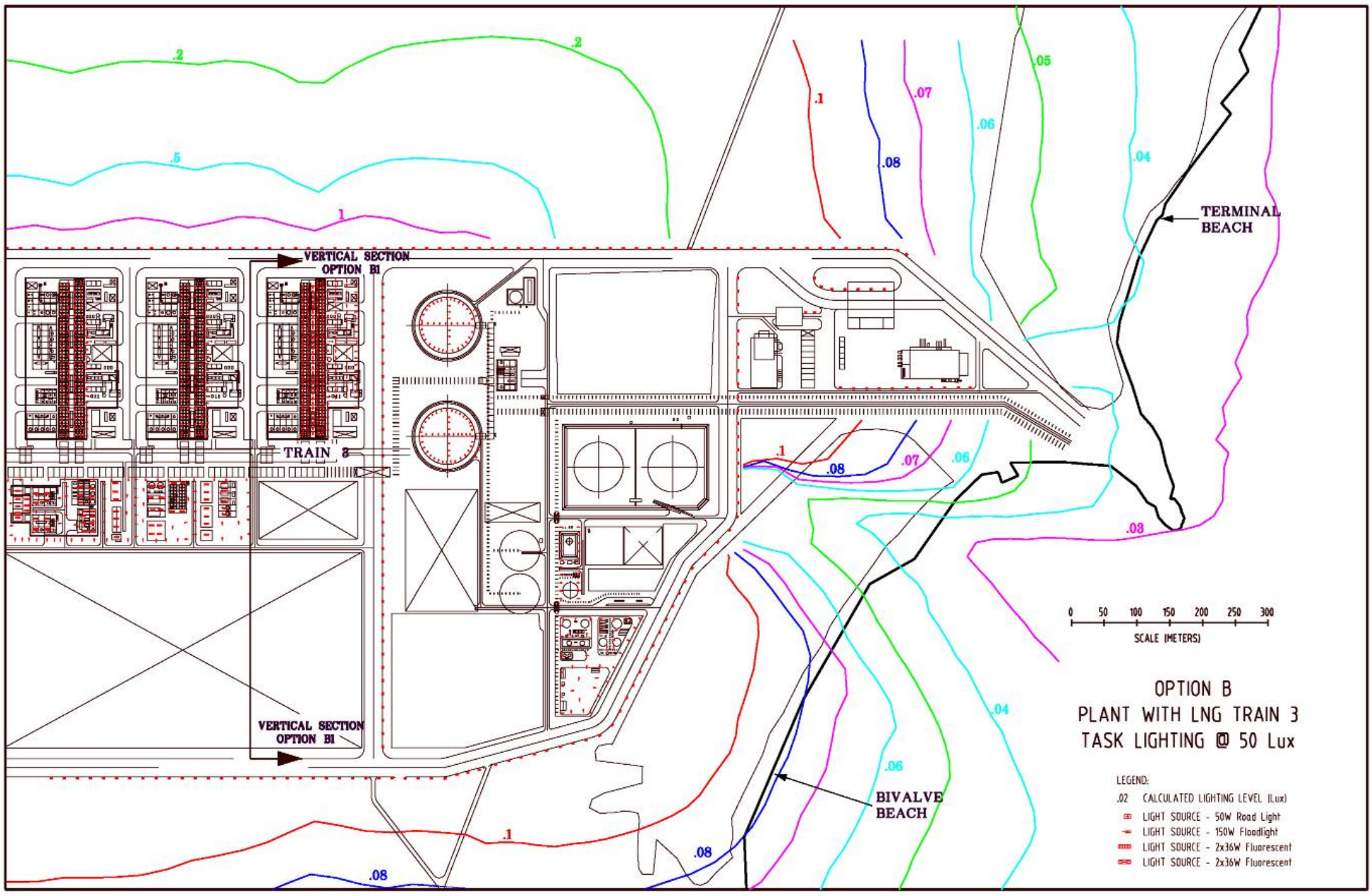


Figure 10.3: Option B – Train 3 Maintenance – Horizontal Isolux Contours (lux)

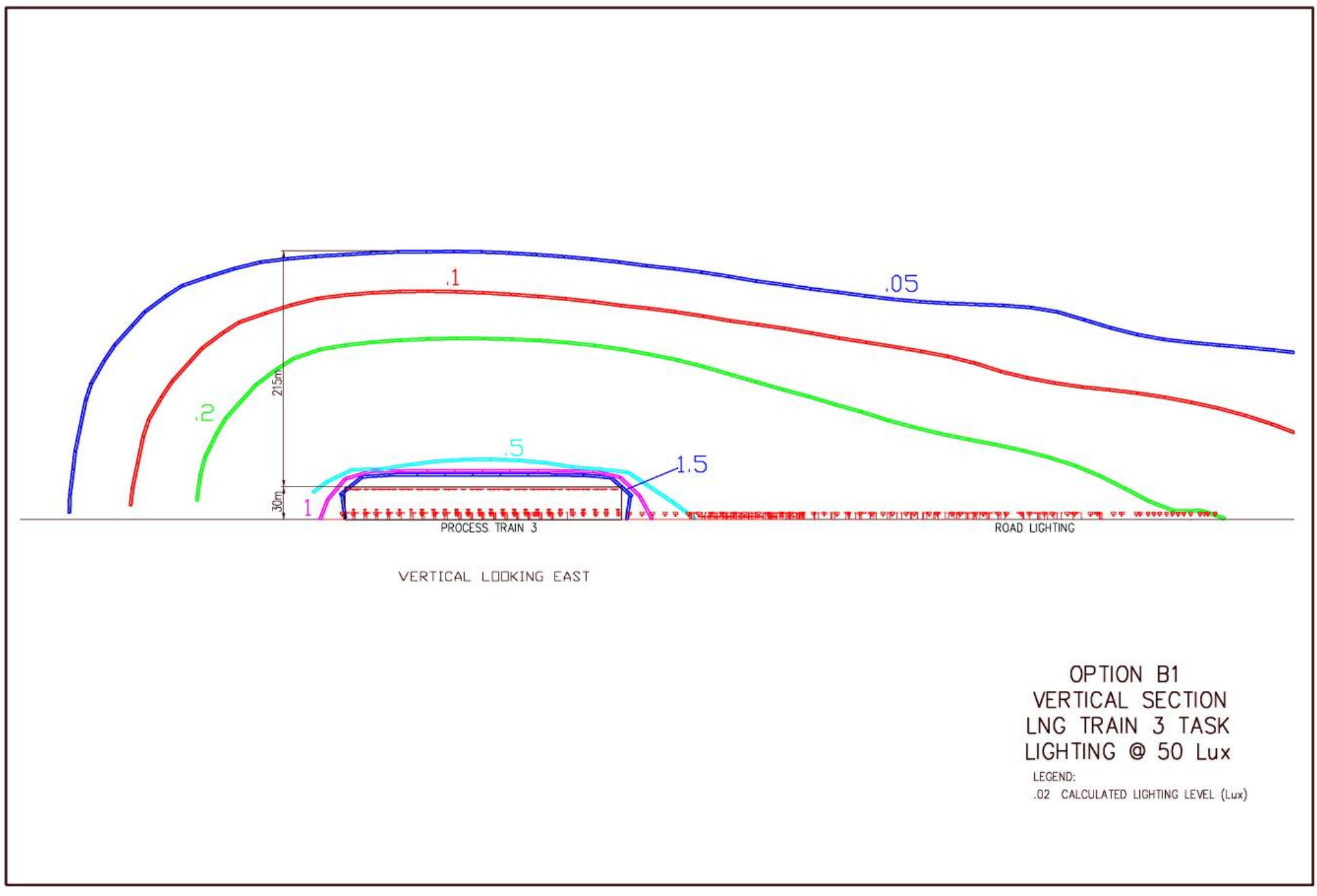


Figure 10.1: Option B1 – Train 3 Maintenance – Vertical Isolux Contours (lux)

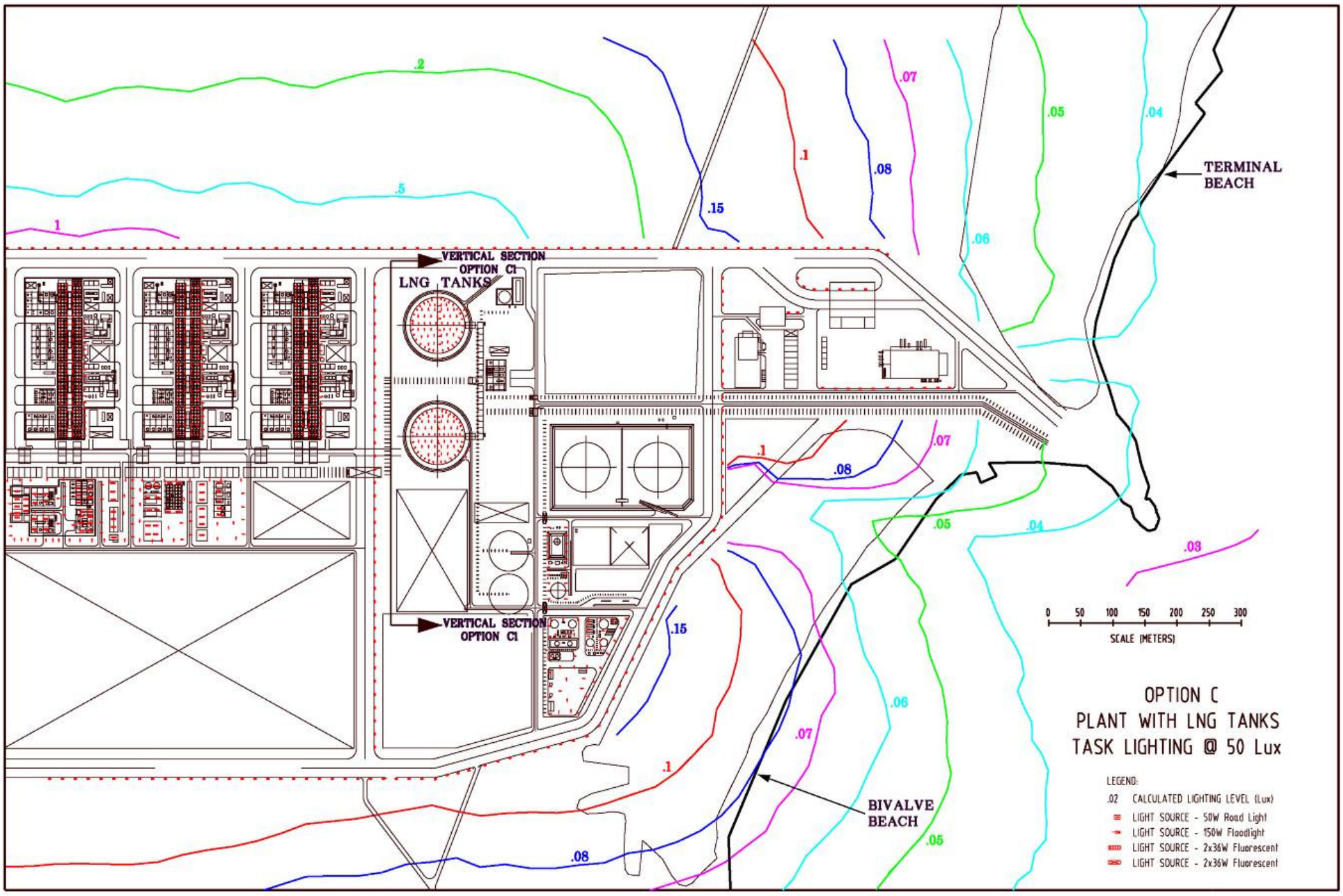


Figure 10.4: Option C – LNG Tank Rooftop Maintenance – Horizontal Isolux Contours (lux)

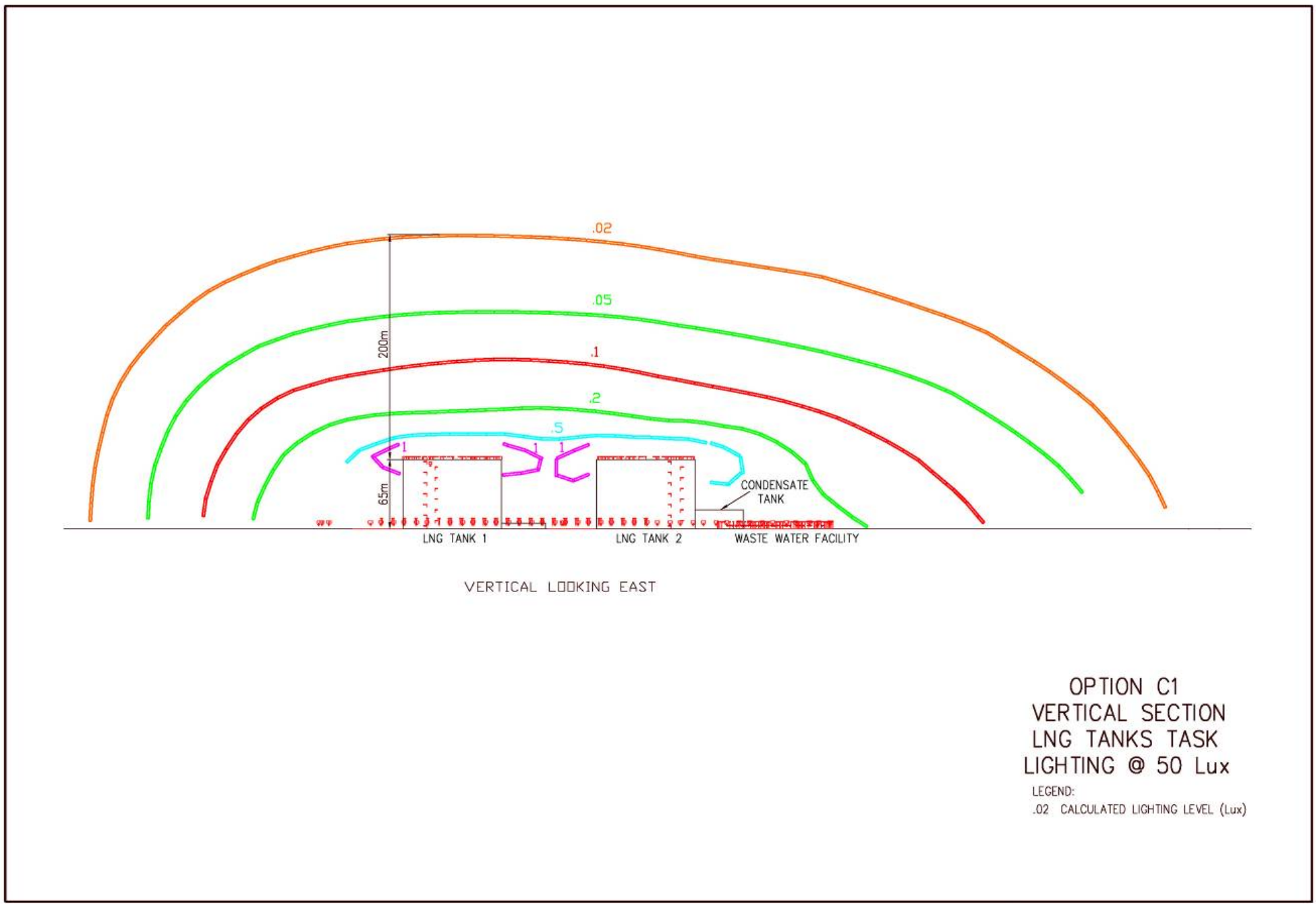


Figure 10.5: Option C1 – LNG Tank Rooftop Maintenance – Vertical Isolux Contours (lux)

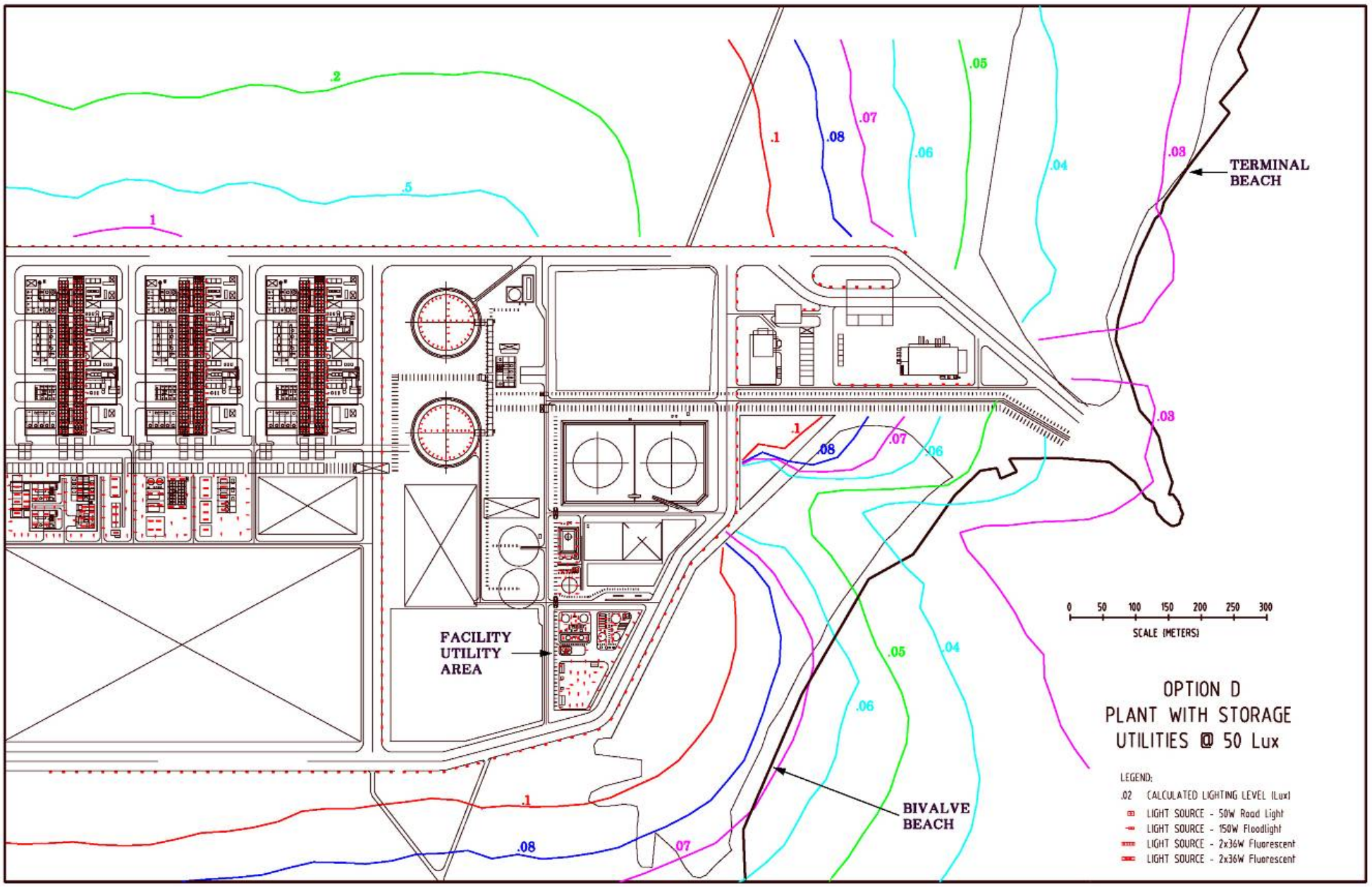


Figure 10.6: Option D – Maintenance Works in General Utilities Area – Horizontal Isolux Contours (lux)

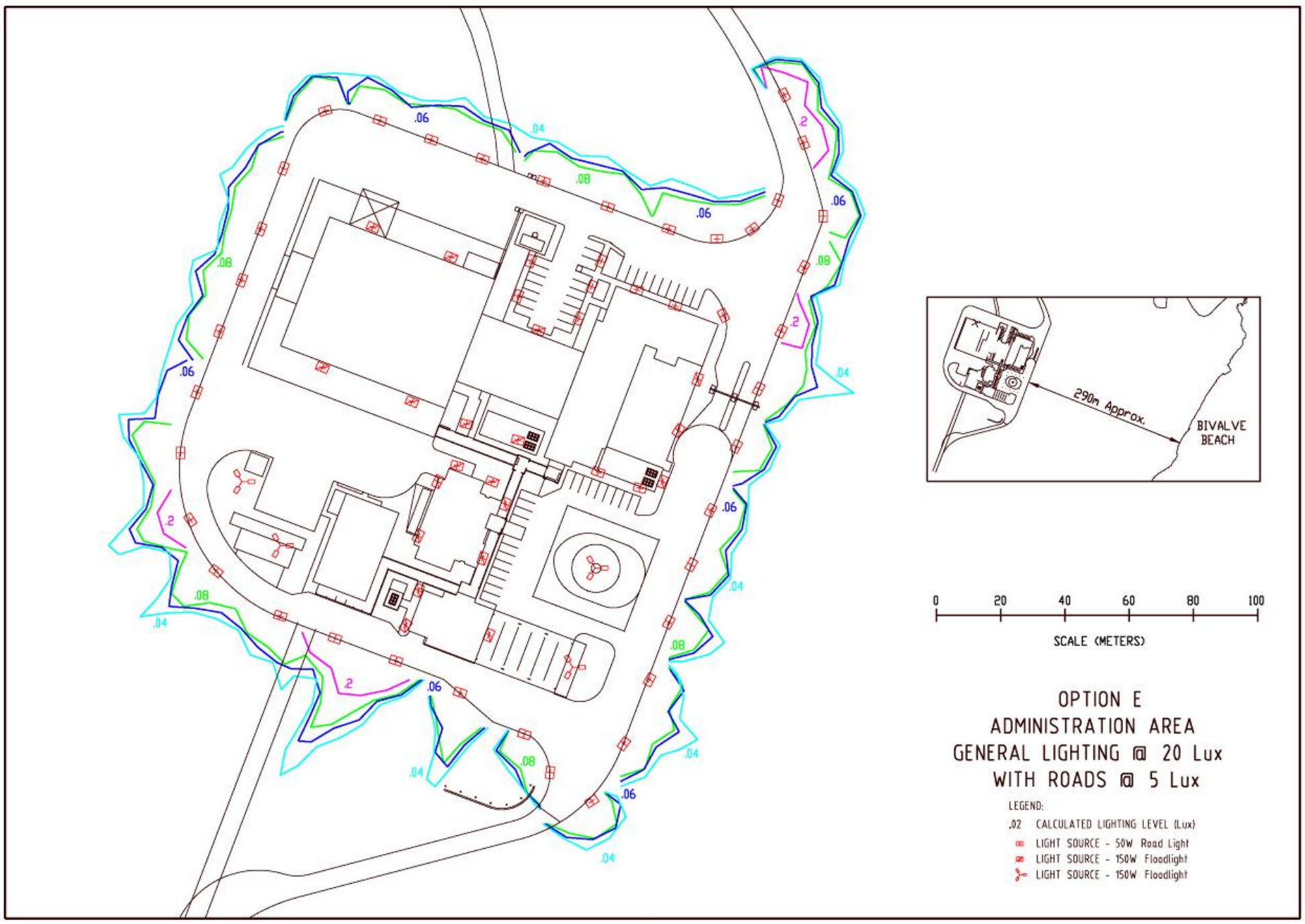


Figure 10.8: Option E – Administration Areas – Horizontal Isolux Contours (lux) Proposed Management Actions

10.3 Proposed Management Actions

Chevron Australia has identified management measures that will be incorporated into the lighting design for the Gorgon Gas Development (Chevron Australia 2007); these include:

- Lighting shall not be provided for waste disposal ponds, plant security fence, roads between process areas, roads between storage tanks, roads to jetties, or roads following a security fence.
- All outdoor lighting shall be photocell controlled.
- Light intensity will be reduced as much as reasonably practicable.
- Luminaires shall be directed below the horizontal rather than above the horizontal. If up lighting must be used, then shields and baffles shall be provided to reduce spill light to an absolute minimum.
- Exterior luminaires shall be designed and positioned so that:
  - the point source of light or any reflective surface of the light luminaire is no directly visible from the beach
  - areas seaward of the frontal dune are not directly or indirectly illuminated
  - areas seaward of the frontal dune are not cumulatively illuminated.
- Exterior luminaires within direct line-of-sight of the beach will be completely shielded down-light luminaires or recessed luminaires having low wattage (i.e. 50 watts or less) and non-reflective interior.
- All luminaires will be mounted as low in elevation as possible through use of low-mounted wall luminaires, low bollards and ground level luminaires.
- No floodlights, up-lights or spotlights for decorative and accent purposes that are directly visible from the beach, or which indirectly or cumulatively illuminate the beach.
- Exterior lights used expressly for safety or security purposes shall be limited to the minimum number and configuration required to achieve their functional role(s). The use of motion detector switches that keep lights off except when approached and that switch lights on for the minimum duration possible shall be used.
- Parking areas, roadways, lighting for security and similar applications will use shielded low pressure sodium lighting.
- Lighting for causeway, MOF and LNG jetty will use narrow spectrum light luminaries such as low pressure sodium lamps. In these areas lighting on the causeway will be activated only after a vehicle has passed through a certain checkpoint on either end of the causeway. Lighting will be mounted low, shielded and focused to avoid light spill on the surrounding waters.
- Gorgon LNG Terminal tugs, which will be custom built, will be specified to minimise overboard light spill.

In addition, impact mitigation strategies will be implemented through marine operating procedures during the operations phase of the project. The Gorgon LNG Lifting Agreement and Lifting Coordinator Guidelines shall recommend restrictions for loading of warm LNG carriers during known flatback turtle, wedge-tail shearwater and bridled tern vulnerability periods. Warm LNG carriers require purging and gas-up (cooldown), which results in flaring (and resultant light spill) from the Boil-off Gas (BOG) Flare. The restrictions can be achieved by forward planning of the Annual Delivery Program.

10.4 Predicted Residual Environmental Risk

Based on the modelling completed, illumination levels on Terminal and Bivalve Beaches caused by light spill from the Revised Proposal were comparable to illumination levels on clear nights with full or quarter moon. In addition, natural shielding afforded by sand dunes and the additional large structures on the plant site are expected to contribute to lower illuminance levels at the beach than the levels predicted by the model. The GJVs therefore consider there to be no unacceptable cumulative impacts related to light emissions as a result of the Gorgon Gas Development. The environmental design measures and operating procedures (developed to be consistent with EIS/ERMP commitments made in relation to the Approved Development) are expected to manage the minor increase in light emissions from the Revised Proposal to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the EPA objective on light emissions (section 10.1.1).

11.0 NOISE EMISSIONS – RISKS AND MANAGEMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

11.1 Assessment Framework or Policy

11.1.1 EPA Objective

To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards (EPA 2004b).

11.1.2 State (WA) Legislation

Sections 51, 62(4), 65 and 74(3)/50, and 75 of the *Environmental Protection Act 1986* (WA) (EP Act) provide the legislative framework for managing noise impacts. The noise limits cited by the EP Act are assigned in the Environmental Protection (Noise) Regulations 1997 (Noise Regulations) and further guidance exists in EPA Guidance Statement No. 8 (EPA 2007a) (Section 11.1.3). Regulation 7 of the Noise Regulations requires that noise emitted from any premises must comply with assigned noise levels when received at any other premises. The assigned levels are specified under regulation 8 of the Noise Regulations, according to the type of premises receiving the noise. Proposals need to demonstrate compliance with the relevant noise levels prescribed in the Noise Regulations.

11.1.3 State (WA) Guidelines

The noise assessment for the Revised Proposal Gas Treatment Plant was conducted in accordance with the requirements of EPA Draft Guidance Statement No. 8 - The Assessment of Environmental Factors, Environmental Noise (EPA 2007a).

11.2 Detailed Assessment of Potential Impacts

11.2.1 Overview

The change in levels of terrestrial noise emissions from the Revised Proposal are linked to the operation of the additional LNG train and the increase in number of non-routine flaring events associated with the operation of the additional train. Noise emissions from marine activities are also expected to increase due to the increase in LNG and condensate tanker offtakes and associated infield marine vessel activities.

At Barrow Island, noise emissions from the Revised Proposal have the potential to affect sensitive terrestrial and marine fauna.

The focus of the noise emissions assessment for the Revised Proposal is on operational phase noise emissions, changes to noise levels during the construction phase are considered to be insignificant. The detailed noise emission assessment results are presented in terms of noise levels at sensitive receptors around the Gas Treatment Plant. Specific discussion of the potential effects of noise emissions from the Revised Proposal to terrestrial and marine fauna are provided in Sections 6.1 and 7.1 respectively.

11.2.2 Background Noise Levels

A baseline noise survey on Barrow Island was conducted by SVT Acoustic Engineering Consultants during the period 20 January to 10 February 2004 and reported in the draft EIS/ERMP (Chevron Australia 2005a). A summary of the results of the study is presented in Table 11.1. Noise levels at the existing Chevron Camp were found to be dominated by the local air conditioning units, whilst the background noise levels at the proposed Gas Treatment Plant Site were found to be dominated by noise from winds and the nearby sea.

Table 11.1: Background Noise Levels

Location	Background Noise Levels L90 dB(A)		
	0700 – 1900 hrs Monday to Saturday	1900 – 2200 hrs Monday to Saturday 0900 – 2200 hrs on Sunday	2200 – 0700 hrs Monday to Saturday 2200 – 0900 hrs on Sunday
Existing Chevron Camp	50.0	50.0	49.5
Proposed Gas Treatment Plant Site	30.0	24.5	23.5

11.2.3 Noise Acceptance Criteria

Noise levels within the Proposed Gas Treatment Plant were assessed against the maximum noise exposure levels for workers as specified in the National Standard for Occupational Noise (NOHSC:1007[2000]), which are:

- an eight-hour equivalent continuous A-weighted sound pressure level (Laeq,8h), of 85dB(A)
- a C-weighted peak noise level of 140 dB(C).

Occupied buildings in the vicinity of the Gas Treatment Plant and the Gorgon Construction village/ Turnaround Camp will be built to comply with the recommended noise levels in AS2107:2000 (Acoustics – Recommended design sound levels and reverberation times for building interiors).

Ambient noise levels from the development will be assessed against the noise acceptance criteria listed in Table 11.2. These criteria are referenced from the Western Australian Noise Regulations.

Table 11.2: Assigned Noise Limits for Industrial and Noise-Sensitive Premises

Type of Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		LA_{10}	LA_1	LA max
Industrial and utility premises[1]	All hours	65	80	90
Noise-sensitive[2]	All hours	60 + Influencing factor	75 + Influencing factor	80 + Influencing factor

NOTES:
LAmax: A noise level that is not to be exceeded at any time.
L_{A1}: A noise level that is not to be exceeded for more than 1% of the time.
LA_{10}: A noise level that is not to be exceeded for more than 10% of the time.
1. *Industrial and utility premises: classification under Schedule 1, Part A (5) of the Noise Regulations – any premises used for sand, gravel, clay, limestone, or rock excavation (i.e. a quarry).*
2. *Noise-sensitive: applies at locations further than 15 m from a building associated with a noise-sensitive use.*

It is proposed to apply the assigned noise limits for industrial and utility premises to the proposed Gorgon Administration Area, and the noise sensitive development noise limits to the Gorgon Construction Village and existing Chevon Camp.

Where the noise is received 15 m from a dwelling (or the like) on noise sensitive premises, the Noise Regulations require that the assigned levels be determined by inclusion of the influencing factor. The factor accounts for the presence of industrial/utility or commercial land or major roads within 450 m of the receiving premises. In the case of the Gorgon Construction Village and the existing Chevron Camp, there is no such development or a major road within 450 m of these, therefore the influencing factor should be taken as nil decibels.

11.2.4 Predicted Noise Emissions from Approved Development

Predicted noise levels for the Approved Development at the Gorgon Construction Village/Turnaround Camp were modelled as part of the assessment of the Approved Development. These noise levels were subsequently re-estimated by Kellogg Joint Venture Gorgon (KJVG) as part of the engineering design for the Approved Development Gas Treatment Plant. The results for the sensitive noise receptors (e.g. Gorgon Administration Area, Gorgon Construction Village/Turnaround Camp and the existing Chevron Camp) are summarised in Table 11.3. These noise levels are considerably below the assigned noise limits for the Gorgon Administration Area and the Gorgon Construction Village and existing Chevron Camp as per Table 11.2.

Table 11.3: Predicted Sound Pressure Levels dB(A) at Sensitive Receptors

Location	Approved Development Predicted Sound Pressure Levels dB(A)
Gorgon Administration Area	Approximately 54
Gorgon Construction Village	38
Existing Chevron Camp	36

11.2.5 Noise Modelling Methodology for the Revised Proposal

11.2.5.1 Noise Model

Chevron Australia utilised in-house noise modelling capabilities provided by its Gas Treatment Plant engineering contractor, KJVG. KJVG has used proprietary Plant Noise Modelling System (PNMS) software, in combination with commercial software (SoundPlan) for the development of the Revised Proposal Gas Treatment Plant noise models and the prediction of in-plant and surrounding environmental sound pressure levels near the Gas Treatment Plant site and at specified sensitive receptor locations. The full modelling study report (KJVG 2008b) is presented in Appendix D.

11.2.5.2 Receptors of Interest

The noise modelling study was conducted as a desktop study with the purpose of establishing cumulative noise levels from the Revised Proposal Gas Treatment Plant operations for the following sensitive receptor locations:

- existing Chevron Camp
- proposed Gorgon Construction Village/Turnaround Camp
- proposed Gorgon Administration Area.

11.2.5.3 Noise Model Assumptions and Inputs

The PNMS software follows the prediction methodology defined in the Engineering Equipment Material Users Association (EEMUA), Publication No. 141 "Guide to the Use of Noise Procedure Specification" (EEMUA 1985) and International Standard ISO 9613-2: Acoustics-Attenuation of Sound during Propagation Outdoors, Part 2: General Prediction Method, 1996. The PNMS software is used to assemble a matrix of Sound Power Level input data. The SoundPlan software then uses this PNMS data to calculate and graphically present both in-plant and noise levels experienced at the specified sensitive receptor locations. Both in-plant noise and community noise predictions are performed using the ISO 9613-2 prediction method (EEMUA 1985).

Equipment noise limits were based on the general project requirement of 82 dB(A) at 1 m from equipment casings or surfaces, with the exception of air coolers, where the prescribed limit is 85 dB(A) at 1 m underneath the air cooler fan.

Noise contour maps were calculated at an elevation of 1.5 m above grade. These maps represent a composite model of the noise emissions from the Gas Treatment Plant.

11.2.6 Results of Noise Modelling

This section summarises the noise emission modelling results for the Revised Proposal with regard to the sensitive receptor locations and compares these to the predicted noise levels for the Approved Development.

In summary, although the predicted noise levels from the Revised Proposal at sensitive receptors are predicted to increase in comparison to the Approved Development, this increase is relatively small and noise levels still comply with the assigned levels under the Western Australian Noise Regulations.

Noise predictions for the Revised Proposal at the specified sensitive receptor locations are provided in Table 11.4, Figure 11.1 and Figure 11.2. These predictions do not consider the ambient noise conditions, which in some cases could overpower noise contributions from the Gas Treatment Plant.

Table 11.4 presents a comparison of the Revised Proposal results to the Approved Development noise study results conducted by KJVG for the Approved Development Gas Treatment Plant.

Table 11.4: Predicted Environmental Sound Pressure Levels in dB(A)

Location	Approved Development Predicted Sound Pressure Levels dB(A)	Revised Proposal Predicted Sound Pressure Levels dB(A)
Gorgon Administration Area	54 (approx.)	60.6
Gorgon Construction Village	38	46.7
Existing Chevron Camp	36	42.3

The increase of in predicted sound pressure levels (i.e. between 6 and 8 dB(A) on average) is due to several factors:

- the increase in sound power level of the Gas Treatment Plant due to contributions of the additional LNG train, Acid Gas Removal Units (AGRUs), and CO_2 re-injection compressor
- the change of assumptions for the ground type over which sound is propagating. It is now assumed that an acoustically "hard" ground is present for all areas over which sound is propagating, which is in accordance with noise level prediction methodology outlined in EPA Guidance Statement No.8 (EPA 2007a)
- the small change in temperature and humidity assumptions to align with requirements outlined in EPA Guidance Statement No. 8 (EPA 2007a).

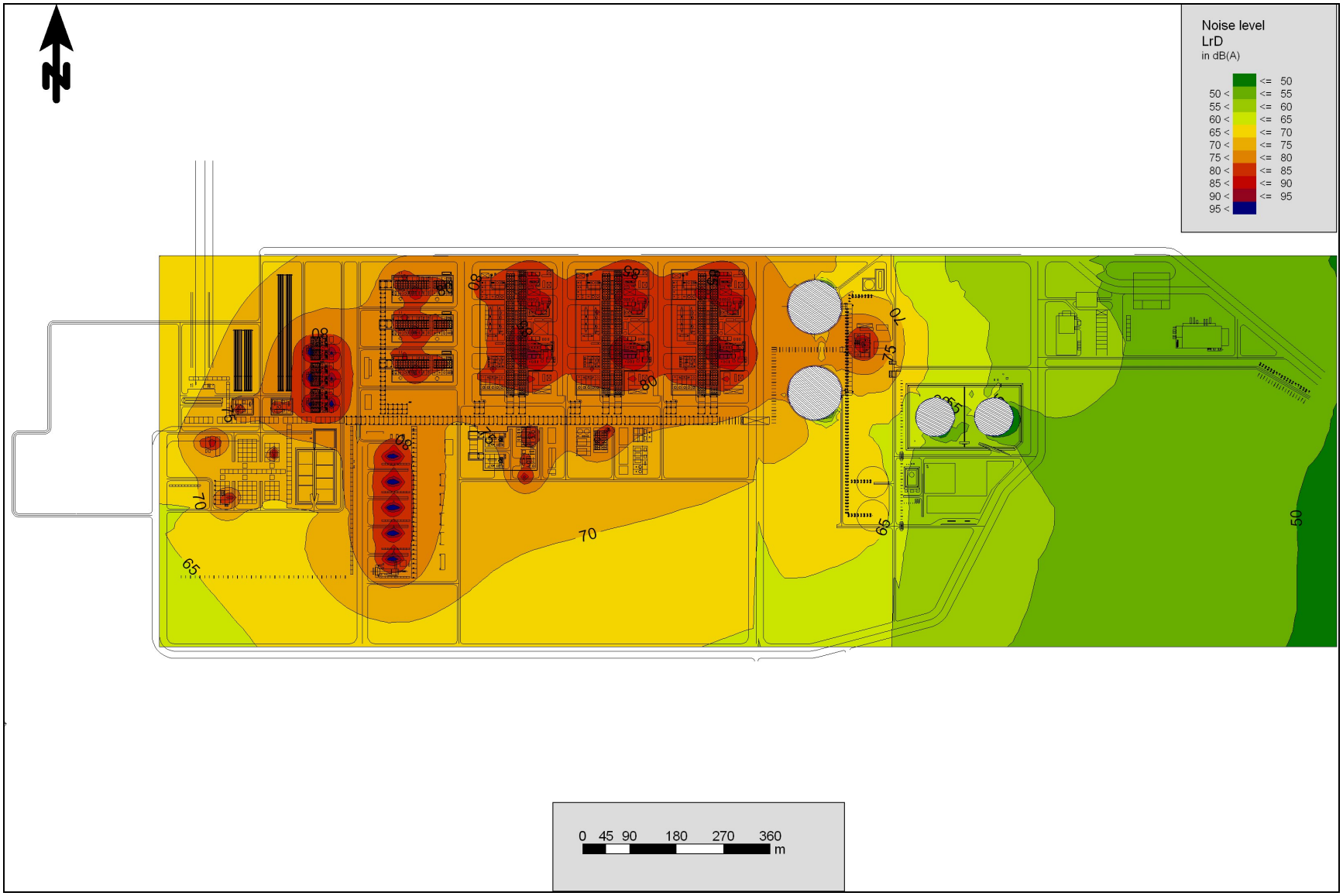


Figure 11.1: Noise Contours within the Gas Treatment Plant and at Plant Boundary

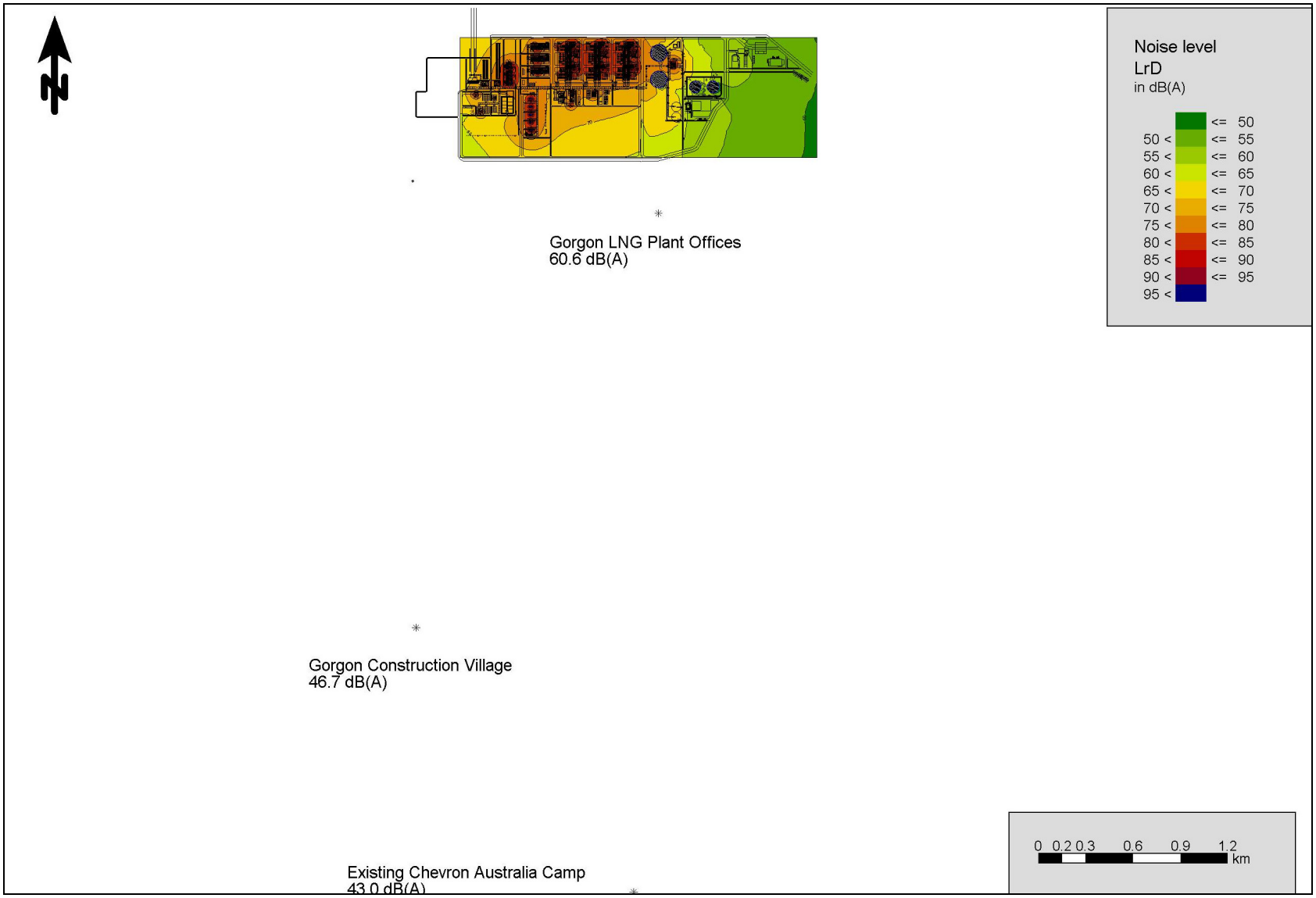


Figure 11.2: Noise Levels at Sensitive Receptor Locations [dB(A)]

11.2.7 Additional Sources of Noise During Operations

An additional noise emission source during operations will be the wet and dry gas ground flares during a process upset or emergency flaring scenario. A noise modelling study for the ground flare was conducted (separate to the noise modelling undertaken for the Revised Proposal) as part of the engineering design for these systems specifically comparing a ground versus an elevated flare configuration. The study modelled noise emissions for the highest flowrate emergency flaring event (i.e. a propane compressor relief to the dry flare at a flowrate of 582 kg/s). The overall sound power level for the selected ground flare options was 156 dB(A) as supplied by the flare vendor.

Table 11.5 presents the results of a noise study for noise levels from the ground flare at 1.75 m above ground.

Table 11.5: Flare Noise Study Results

Sound Pressure Levels in dB(A)	Distance from Source (metres)
>105	100
85–90	505
75–80	1131
70–75	1697
65–70	2505

With the present location of the ground flare (on the western side of the Gas Treatment Plant plot plan) the noise levels likely to be experienced at the Gorgon Construction Village/Turnaround Camp and the existing Chevron Camp during plant upset or emergency events are well below 65 dB(A). These noise levels may never be experienced as a flaring rate of the magnitude used in the study is considered to be a very unlikely event.

11.2.8 Discussion of Modelling Results

Due to the large separation distance between the Gas Treatment Plant and the sensitive receptor locations at the Gorgon Construction Village/Turnaround Camp, and the existing Chevron Camp, contribution from the Revised Proposal Gas Treatment Plant operations to noise levels at these locations is expected to be minimal and the resultant noise levels will still comply with the noise levels prescribed in the Western Australian Noise Regulations. The levels at the existing Chevron Camp will continue to be dominated by local sources of noise (i.e. air conditioning units). The same is expected to occur at the proposed Gorgon Construction Village/Turnaround Camp which will also have local sources of noise (e.g. air conditioning units, a diesel generator etc.).

The Administration Area, although in proximity to the Gas Treatment Plant, will be built and acoustically insulated to ensure the relevant Australian occupational health and safety standards are met.

11.2.9 Marine Vessel Noise Emissions

Movements of marine vessels (e.g. LNG carriers, condensate export tankers, supply vessels and infield vessels, tugs and pilot boats) will increase due to the increase in throughput at the Gas Treatment Plant under the Revised Proposal. This increase in vessel movements will not increase cumulative noise levels, however it will increase the frequency of which the noise source (e.g. marine vessel) is present/operating in the Port of Barrow Island. The noise emissions from the marine vessels will be concentrated

around the LNG Jetty and the MOF which are approximately 4 and 2 km respectively from the beaches at Town Point.

Speed restrictions imposed on LNG carriers and condensate tankers within the Port limits will ensure that noise associated with engines will be kept as low as reasonably practicable. LNG carriers and condensate tankers, escorted by infield vessels (pilot boat and tugs) will also follow a pre-determined safe access corridor to the LNG Jetty, which will therefore result in noise affecting the same marine areas in and out of the Port of Barrow Island.

Supply vessel visits will not increase at the same proportion as the increase in LNG carriers and condensate tanker visits and therefore the frequency at which this noise source is present in the Port of Barrow Island should not significantly increase.

Support vessels (i.e. pilot boat and tugs) will be purpose built to GJV's specifications and requirements. These specifications include a number of environmental considerations including light spill, noise and air emissions, as well as marine discharges.

11.3 Proposed Management Actions

The noise control philosophy for the Revised Proposal [refer to full Noise Study Report (KJVG 2008b) (Appendix D) is aligned with the design basis planned for the Approved Development. This philosophy is reiterated below:

- All compressor suction/discharge/recycle piping and connected piping are to be insulated with an appropriate acoustic insulation system.
- Acoustic enclosures limiting noise to 90 dB(A) at 1 metre from the equipment surface for gas turbine drives for Mixed Refrigerant Compressors and Propane Compressors are recommended.
- No enclosures on compressors and expanders for safety and operability reasons.
- No enclosures on generators themselves for safety and operability reasons.
- Compressor gas turbine drive and generator gas turbine drive intake/exhaust ducting are to be acoustically insulated.
- Exhaust silencers are required for gas turbine drives of generators.
- Use of vibration isolation pads, such as Fabreeka or equivalent, for compressor suction/ discharge pipe supports to reduce the noise radiation from pipe supports.
- Low noise type air coolers not to exceed sound pressure level of 85 dB(A) per fan 1 metre below fan centre.
- Inlet silencers required for the gas turbines of Mixed Refrigerant and Propane Compressors.
- Exhaust silencers required for gas turbine drives of Mixed Refrigerant and Propane compressors.
- Inlet silencers for generator gas turbine drives are required.
- Noisy control valves, if any, and compressor recycle valves and their downstream piping are to be acoustically insulated.
- Personnel hearing protection will be mandatory in the designated "Restricted Areas" in the Gas Treatment Plant, where sound pressure levels exceed 85 dB(A).

These measures define the best practice approach to noise mitigation for this type of Gas Treatment Plant.

11.4 Predicted Residual Environmental Risk

Noise emissions from the Revised Proposal are not considered to pose any significant new or additional risks to noise sensitive receptors in comparison to the Approved Development. Furthermore, there are no unacceptable cumulative impacts related to noise emissions as a result of the Gorgon gas Development.

Based on the modelling completed, increases in noise levels at the Gorgon Construction Village and the existing Chevron Camp are expected to be minimal and well below the noise levels prescribed in the Noise Regulations. The noise design philosophy (developed to be consistent with EIS/ERMP commitments made in relation to the Approved Development) is expected to manage the increase in noise emissions from the Revised Proposal to a level consistent with that considered acceptable and therefore approved for the Approved Development, and to meet the EPA objective on noise emissions (section 11.1.1).

12.0 GREENHOUSE GAS EMISSIONS – RISKS AND MANAGEMENT

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal in a generic or cumulative manner, This descriptor may be used when the reference is being made to elements of "the Revised Proposal" when they are combined with elements of "the Approved Development" to create the final product as proposed in this PER.

12.1 Assessment Framework or Policy

12.1.1 EPA Objective

To minimise emissions to levels as low as practicable on an on-going basis and consider offsets to further reduce cumulative emissions (EPA 2004b).

12.1.2 Commonwealth Legislation/Policies

In her speech to the Committee for Economic Development of Australia on the 6th of June 2008, the Federal Minister for Climate Change and Water, Senator Penny Wong, summarised the Commonwealth Government's proposed Carbon Pollution Reduction Scheme principles as:

- being a cap and trade scheme
- being designed to place Australia on a low emissions path in a way that best manages the economic impacts of transition while assuring our ongoing economic prosperity
- having maximal coverage of greenhouse gases and sectors to the extent that is practical
- designed to enable international linkages, while ensuring it suits Australia's economic conditions
- addressing the competitive challenges facing emission-intensive trade-exposed industries in Australia
- addressing the impact on strongly affected industries.

A critical component of any emissions trading scheme will be the accurate determination of emissions. In order to facilitate this, the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act) was enacted in 2007. This legislation establishes a single, national system for reporting greenhouse gas emissions, abatement actions, and energy consumption and production by corporations. As from 1 July 2008 it will be mandatory for corporations emitting above 125 000 tonnes carbon dioxide equivalents per annum (t CO_2e per annum), or 25 000 t CO_2e per annum for a facility, to register and report annually under the NGER Act.

The GJVs anticipate that the Revised Proposal will be included within the coverage of the national emissions trading scheme once it is introduced and will be required to operate within the requirements governing that scheme. It is currently unclear what additional or complementary policies at both Commonwealth and State level will be used to support the emissions trading scheme.

The future introduction of emissions trading in greenhouse gases provides a powerful market-based incentive for the GJVs to design a facility with emissions that are as low as reasonably practicable and will provide a continuing incentive to further reduce emissions over the life of the facility where these can be achieved at a cost lower than the prevailing market price.

Additional Commonwealth programs currently impacting upon the regulation of greenhouse gas emissions from major projects include:

- Generator Efficiency Standards
- Mandatory Energy Efficiency Performance Standards For Three Phase Electric Motors.

12.1.3 Western Australian Legislation Policies

The State Greenhouse Strategy (Western Australia Greenhouse Task Force 2004) details the Western Australian Government's response to climate change. Key components of the Strategy include government leadership, reducing emissions, local government and community involvement, and national and international representation.

On 6 May 2007, the Western Australian Premier released the Premier's Climate Change Action Statement, "Climate Change: Making Decisions for the Future" (Government of Western Australia 2007). In that statement the Premier made a number of commitments that will impact upon the Gorgon Gas Development. In particular he indicated that the Western Australian Government would:

- implement a policy to secure natural gas from the Gorgon Gas Development Project and future LNG projects for domestic use
- require the Gorgon Gas Development Project to undertake the largest carbon capture and storage initiative in the world by reinjecting reservoir CO_2 underground into permanent geological storage.

More broadly the Premier's Statement committed to "lead the nation in the adoption of natural gas as a primary energy source for households and industry" in recognition of the lower greenhouse gas emissions as a result of using natural gas, compared to fuels such as oil and coal, and to prepare Western Australia for the implementation of emissions trading in greenhouse gases.

Currently the primary mechanism by which the Western Australian Government regulates greenhouse gas emissions is by placing conditions on the environmental approval of large energy projects. The recommendations of the Western Australian EPA play a key role in determining the nature of these conditions.

The EPA has issued a number of Guidance Statements dealing with managing environmental impacts to assist with its assessment of new projects. Two of these Guidance Statements (No. 4 and No. 12 [EPA 2003b; 2002 respectively]) deal with subsurface disposal of liquid industrial waste and greenhouse gas emissions. Both of these Guidance Statements are of relevance to the GJVs' management of greenhouse gas emissions from the Gorgon Gas Development.

The GJVs have complied with the objectives outlined in both of these guidance notes.

12.1.3.1 Guidance Statement No. 4 – Deep and Shallow Well Injection for Disposal of Industrial Waste (EPA 2003b)

EPA Guidance Statement No. 4 (EPA 2003b) provides guidance on the environmental assessment of deep and shallow well injection of liquid industrial waste into the groundwaters of Western Australia by means of Class I, IV or V wells. The objective behind the Guidance Statement is the protection of groundwater resources which might be impacted by the subsurface injection of industrial waste. The guidance note outlines the approach that will be used by the EPA during its assessment of such proposals. In particular, the proponent would need to satisfy the EPA that no adverse effects on existing and potential environmental values and beneficial uses of water could occur.

The injection of reservoir CO_2 into the subsurface as a means to reduce greenhouse gas emissions does not appear to have been envisaged at the time this EPA Guidance Statement was drafted (the derivation of the well categories dates to 1994). Consequently the injection of reservoir CO_2 does not readily fall within any of the existing well categories discussed in the guidance note. In addition, the definitions of industrial waste do not include CO_2. Despite this, the GJVs consider it appropriate to apply the objectives of the Guidance Statement to the proposed reservoir CO_2 injection project on Barrow Island.

The technical studies undertaken by the GJVs indicate that there will be no adverse impact on the environmental values of Barrow Island associated with subsurface reservoir CO_2 injection. Further, as there is no significant groundwater resource in the vicinity of Barrow Island, the proposal to inject reservoir CO_2 into the Dupuy Formation is consistent with this Guidance Statement.

12.1.3.2 Guidance Statement No. 12 – Minimising Greenhouse Gases (EPA 2002a)

EPA Guidance Statement No. 12 (EPA 2002a) provides direction on the reduction of greenhouse gas emissions from significant new or expanding operations. The objective of the EPA is to reduce greenhouse emissions to a level which is as low as reasonably practicable by ensuring that emissions are adequately addressed in the planning, design and operations of the proposed facility.

The Gorgon Project has incorporated greenhouse gas efficiency and emissions management as key value drivers in designing the proposed project, and intends to restrict the air emission of greenhouse gases by the injection of reservoir CO_2 into the Dupuy Formation. These actions have delivered world class greenhouse efficiency, when normalised for climate and CO_2 content of reservoir gas, in accordance with the objectives of this Guidance Statement.

12.2 Approved Gorgon Gas Development

The Western Australian and Commonwealth Governments' environmental approvals for the Approved Development include conditions that relate to the management of atmospheric greenhouse gas emissions and the proposal to dispose of reservoir CO_2.

Emissions from the Approved Development will be primarily regulated in accordance with Statement No. 748 which places two conditions on the proponent in relation to the management of greenhouse gas emissions.

Condition No. 26, Reservoir Carbon Dioxide Injection System, requires the proponent to design and construct a CO_2 injection system capable of disposing, by underground injection, 100% of the volume of reservoir CO_2 removed during routine gas processing operations, and to implement all practicable means to inject at least 80% of reservoir CO_2, averaged over a five year period. The proponent is also required to implement a monitoring program to satisfy the annual reporting requirements for the performance of the Reservoir Carbon Dioxide Injection System.

Condition No. 27, Greenhouse Gas Abatement Program, requires the proponent to implement a Greenhouse Gas Emissions Abatement Program the objectives of which are to:

- ensure the plant is designed and operated in a manner which achieves reductions in "greenhouse gas" emissions as far as practicable
- provide for ongoing "greenhouse gas" emissions reductions over time
- ensure through the use of best practice, the total net "greenhouse gas" emissions and/or "greenhouse gas" emissions per unit of LNG produced from the project are minimised
- manage "greenhouse gas" emissions in accordance with the Framework Convention on Climate Change 1992, and consistent with the National Greenhouse Strategy.

Condition No. 27 requires the Greenhouse Gas Abatement Program for the Approved Gorgon Gas Development to address the following topics:

- Calculation of the "greenhouse gas" emissions associated with the proposal, using methodologies endorsed by the Australian Greenhouse Office (now Commonwealth Department of Climate Change).
- Specific measures to reduce the total net greenhouse gas emissions and/or the greenhouse gas emissions per unit of LNG produced by the proposal using a combination of "no regrets" and "beyond no regrets" measures.
- The ongoing review and implementation where practicable of "greenhouse gas" offset strategies with such offsets to remain in place for the life of the proposal.
- Estimation of the "greenhouse gas" efficiency of the project (per unit of LNG and/or other agreed performance indicators) and comparison with the efficiencies of other LNG producing facilities producing a similar product, both within Australia and overseas.
- Implementation of thermal efficiency design and operating goals for permanent installations consistent with the Australian Greenhouse Office – Generator Efficiency Standards.
- Actions for the monitoring, regular auditing and annual reporting of "greenhouse gas" emissions and emission reduction strategies.
- A target set by the proponent for the progressive reduction or abatement of total net "greenhouse gas" emissions or "greenhouse gas" emissions per unit of product and as a percentage of total emissions over time, and annual reporting of progress made in achieving this target. Consideration should be given to the use of renewable energy sources such as solar or wind.
- A program to achieve a reduction or abatement in "greenhouse gas" emissions, consistent with the target referred to in above.
- Apply for entry, whether on a proposal-specific basis, company wide arrangement or within and industrial grouping into the Commonwealth Government's Greenhouse Challenge Plus program.

- Reviewing and adopting a “Continuous improvement approach” so that advances in technology and potential operational improvements of plant performance are adopted.

The Commonwealth environmental approval for the Approved Development does not directly regulate greenhouse gas emissions from the Development, but does place conditions on the underground injection of reservoir CO_2 into the Dupuy Formation. EPBC Reference: 2003/1294 Condition No. 10 requires the proponent to implement “a carbon dioxide injection monitoring program that is able to indicate unexpected migration”. The condition further requires that “within three months of the monitoring program showing a significant increase in the risk of carbon dioxide leakage into the environment inhabited by the blind gudgeon (*Milyeringa vertia*), a survey focused on an assessment of the habitat of the blind gudgeon shall be carried out and a plan for practicable actions proposed to avoid or mitigate the risk of significant impact to the environment inhabited by the blind gudgeon developed.” Once this plan is approved by the Minister, the plan must be implemented.

Both the Western Australian and Commonwealth environmental approvals include conditions requiring the monitoring and reporting of flora and fauna on Barrow Island and the surrounding marine environment. While not directly aimed at detecting impacts from migration of reservoir CO_2 on the environment, these monitoring programs will provide verification with respect to any impacts from reservoir CO_2 leakage.

12.2.1 Forecast Greenhouse Gas Emissions – Approved Development

Annual greenhouse gas emissions from the Approved Development were estimated at 4.0 MTPA CO_2e. Table 12.1, as presented in section 13.3.4 of the EIS/ERMP (Chevron Australia 2005a), documents the estimated emissions from the LNG and domestic gas components of the Approved Development and the estimated emissions resulting in the provision of support infrastructure and logistics to Barrow Island.

Table 12.1: Estimated Annual Greenhouse Gas Emissions for Approved Development

Emissions Source	LNG Processing	Domestic Gas Processing	Island Infrastructure Support
	TPA CO_2e	TPA CO_2e	TPA CO_2e
Gas Turbine – Gas Processing Drivers	1 612 000	Nil	Nil
Gas Turbine – Power Generation	1 287 000	200 000	60 000
Fired Heaters	71 000	28 000	Nil
Flare – Events	60 000	Minor	Nil
Flare – Pilots	2 000	Minor	Nil
Fugitive Emissions	Less than 1 000	Less than 1 000	Nil
Transport	Nil	Nil	10 000
Diesel Engines	Less than 300	Minor	Minor
Reservoir CO_2 Vented	500 000	180 000	Minor
Total	3 534 000	409 000	70 000

NOTES:

Reference Case Assumptions:

- *LNG production is sourced equally from the Gorgon and Jansz fields.*
- *Domestic gas production is sourced from the Gorgon Field.*
- *Based on 8160 hours (340 days) plant operation per year.*
- *All power generation gas turbines (including spare) are operated at 67% part load, resulting in an additional 65 000 tonnes per year of emissions over case where spare is on cold standby and online turbines are operated at maximum efficiency.*
- *20% of reservoir CO_2 (0.68 MTPA) is vented rather than injected into the Dupuy Formation.*
- *Reservoir CO_2 vented is allocated between LNG and domestic gas production in proportion to throughput from the Gorgon gas field.*
- *Waste heat recovery is applied to LNG process drive gas turbines and hot oil used as the waste heat recovery medium.*

12.3 Revised Proposal Atmospheric Greenhouse Gas Emissions

The estimated annual greenhouse gas emissions (5.45 MTPA) predicted for the Revised Proposal will result in an increase in Australia's annual greenhouse gas emissions of approximately 0.94% and an increase in Western Australia's greenhouse gas emissions of 7.2% relative to their respective greenhouse gas emissions in 2006. Table 12.2 presents greenhouse gas emissions from the Revised Proposal relative to Australia's and Western Australia's 2006 emissions.

Table 12.2: Estimated Greenhouse Gas Emissions Relative to Australia's and Western Australia's 2006 Emissions

	Western Australia	Australia
2006 Emissions* (million tonnes CO_2e)	70.4	576.0
Approved Gorgon Gas Development plus additional 3rd LNG processing train - with reference case injection of reservoir CO_2 (million tonnes CO_2e)	5.45	5.45
Forecast increase over 2006 emissions (%)	7.2%	0.94%

NOTE:
** – Data from Australia's National Greenhouse Accounts – State and Territory Greenhouse Gas Inventories 2006, Australian Government, Department of Climate Change, June 2008.*

The use of Gorgon LNG for power generation in Pacific Basin economies will provide the potential to avoid an additional 46 MTPA of greenhouse gas emissions that would result if more carbon intensive fuels were used. Figure 12.1 shows the life cycle greenhouse gas emissions comparison between using LNG from the Revised Proposal to generate electricity in Asian markets compared to alternative fossil fuels. These data are based on a study conducted by the CSIRO into the life cycle advantages of LNG from the Gorgon Gas Development compared to alternative base load fuels such as coal and fuel oil (CSIRO 1996).

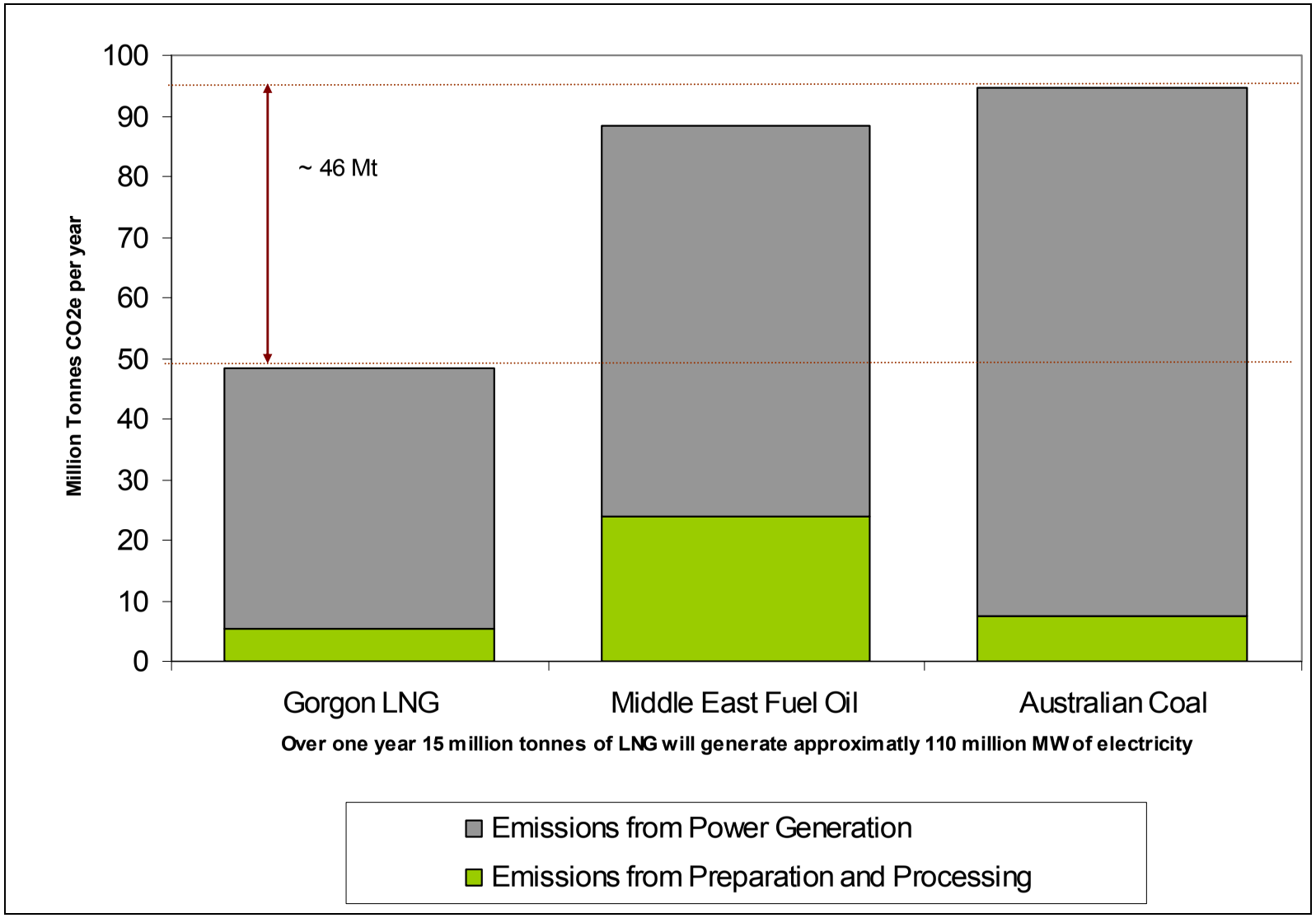


Figure 12.1: Comparison of Life Cycle Greenhouse Gas Emissions for Electrical Power Generation in Asia

12.3.1 Changes to Reference Case Assumptions

The following changes have been made to the reference case assumptions between the Approved Development and the Revised Proposal in order to determine the estimated greenhouse gas emissions for the Revised Proposal:

- the addition of two LNG process gas turbines
- the addition of one electrical power generation gas turbine
- LNG production is now sourced 65% from Gorgon Field and 35% from the Jansz Field (reference case assumptions for the Approved Project assumed that LNG production would be sourced equally from the two fields)
- domestic gas production is now sourced from the Jansz Field (reference case assumptions for the Approved Development assumed that domestic gas would be sourced from the Gorgon Field)
- reliability modelling has shown the anticipated annual operating hours has decreased from 8160 hours estimated for the Approved Development to 8076 hours for the Revised Proposal
- a change from hot oil to hot water for the waste heat recovery medium
- minor changes to the estimated electricity demand for the infrastructure provided on Barrow Island.

12.3.2 Estimated Greenhouse Gas Emissions – Revised Proposal (Approved Development and Revised Proposal)

Air emissions of combustion products will increase as a result of the extra energy requirements of the third LNG processing train over that of the Approved Development. The addition of the third LNG train is anticipated to increase the emission of greenhouse gases by 1.45 MTPA of carbon dioxide equivalent (CO_2e), from 4.0 MTPA CO_2e to a total of 5.45 MTPA CO_2e.

While the volume of greenhouse gas emissions has increased, the GJVs anticipate that the greenhouse emissions intensity for the Revised Proposal (0.348 tonnes CO_2e per tonne of LNG) will not significantly differ from intensity of the Approved Development (0.353 tonnes CO_2e per tonne of LNG).

The predicted annual greenhouse gas emissions for the Revised Proposal are presented in Table 12.3.

Table 12.3: Revised Proposal - Estimated Annual Greenhouse Gas Emissions

Emissions Source	LNG Processing	Domestic Gas Processing	Island Infrastructure Support
	TPA CO_2e	TPA CO_2e	TPA CO_2e
Gas Turbine – Gas Processing Drivers	2 450 000	Nil	Nil
Gas Turbine – Power Generation	1 810 000	170 000	50 000
Fired Heaters	60 000	Minor	Nil
Flare – Events	45 000	Minor	Nil
Flare – Pilots	10 000	Minor	Nil
Fugitive Emissions	30 000	Less than 1 000	Nil
Transport	Reported by others (refer to Section 12.3.2.6)	Reported by others (refer to Section 12.3.2.6)	Reported by others (refer to Section 12.3.2.6)
Diesel Engines	10 000	Minor	Minor
Reservoir CO_2 Vented	840 000	10 000	Nil
Total	**5 225 000**	**181 000**	**50 000**

NOTES:
Reference Case Assumptions:

- *LNG production is sourced 65% from the Gorgon Field and 35% from the Jansz Field.*
- *Domestic gas production is sourced exclusively from the Jansz Field.*
- *Based on 8076 hours (336.5 days) plant operation per year.*
- *All power generation gas turbines are operated at 67% part load.*
- *20% of reservoir CO_2 (0.84 MTPA) is vented rather than injected into the Dupuy Formation.*
- *Waste heat recovery is applied to LNG process drive gas turbines with hot water used as the waste heat recovery medium.*
- *Fugitive emissions include CO_2 released to the atmosphere as part of injection well back flushing operations.*

No perfluorocarbons are planned to be used in the gas processing facilities (and therefore, will not be emitted). Hydrofluorocarbons will be used in the heating ventilation and air conditioning systems and sulphur hexafluoride is likely to be used for electrical switch gear. However, both these uses are for closed systems, so total emissions of these substances will be negligible (< 0.01% of the total greenhouse gas emissions on a CO_2e basis) compared to the major emissions sources.

The greenhouse gas emissions due to reservoir CO_2 venting are based on a reference scenario that assumes 20% of the reservoir CO_2 is vented rather than injected. Emissions related to the venting of reservoir CO_2 have been prorated between LNG and domestic gas production based on the respective proportion of total gas throughput between these two uses.

The following sections expand on each of the main greenhouse gas emission sources. For large emission sources, the basis on which the emissions were calculated or the assumptions used in developing the reference case are outlined.

12.3.2.1 Gas Turbines – Gas Processing Drivers

The gas turbines to be used in the three LNG processing trains account for approximately 45% of the overall greenhouse gas emissions estimated for the Revised

Proposal. These gas turbines drive the refrigeration compressors at the core of the LNG process.

The level of emissions from the gas processing turbines is dictated by the natural gas liquefaction technology and process configuration selected for the Gorgon Gas Development. The EIS/ERMP for the Approved Development (Chevron Australia 2005a) identified the criteria used to select the chosen process configuration and liquefaction technology. It is proposed that the same configuration and technology selected for the Approved Development be applied to the Revised Proposal.

Liquefied natural gas processing train design incorporating direct drive gas turbines with an LNG throughput of approximately 5 MTPA represents established best practice in LNG plant design. This configuration is similar to that being applied to the North West Shelf Project for its Train 5 expansion. This configuration offers the optimum balance between capital cost, greenhouse gas emissions efficiency and risk profile.

The gas turbines in the LNG processing trains will be fitted with waste heat recovery units to recover additional energy from combustion of fuel gas. This waste heat will be used within the gas processing facility to provide processing heat, required for the regeneration of the CO_2 removal solvent (accelerated methyl-diethanolamine [MDEA]), regeneration of hydrate inhibitor, feed gas preheating and fractionation. In addition to providing approximately 450 MW of mechanical energy, 640 MW of process heat will be provided from the waste heat recovery units fitted to the exhausts of the gas processing drivers. Each of the gas processing driver turbines will be fitted with dry low NO_x emissions burner technology.

12.3.2.2 Gas Turbines – Power Generation

Greenhouse gas emissions from the gas turbines used to generate electrical power for the Gas Treatment Plant and support infrastructure represents approximately 37% of the overall greenhouse gas emissions estimated for the Revised Proposal.

The GJVs have undertaken extensive studies to identify and evaluate alternative power generation options. These studies considered a range of open cycle and combined cycle options as well as options for inlet cooling and water and steam injection. The options were evaluated using criteria including:

- safety and operational risks
- capital and operating cost
- availability and reliability
- fuel consumption and resulting greenhouse gas emissions
- land area required
- integration with gas treatment plant waste heat recovery system.

Given the remoteness of the proposed Gas Treatment Plant on Barrow Island, the Gorgon Gas Development's power generation configuration must be highly reliable in order to avoid unplanned outages of the LNG processing trains. The LNG processing trains operate most efficiently when running at full capacity over long time periods. An unreliable electrical power supply would result in the LNG processing trains operating at less than peak efficiency or in the worst case having to be shut down. Such an event would result in a large increase in greenhouse gas emissions as the gas inventory within the Gas Treatment Plant would be required to be flared.

Total power demand for the Revised Proposal comprises 375 MW for LNG processing trains and plant utilities; 35 MW for domestic gas processing; and 10 MW for Gorgon Construction Village/Turnaround Camp and offsite utilities.

These power generation studies have concluded that the most appropriate configuration for the required generation of approximately 420 MW of electrical demand was to employ five open cycle industrial gas turbines each of approximately 117.5 MW (gross) and 110.5 MW (site rated) capacity and operated at partial load. Having each turbine operating at partial load enables the operating turbines to quickly take up the load if one turbine should go off line, thereby maintaining a stable electrical supply to the LNG processing trains and avoiding LNG processing upsets that might result in increased flaring emissions.

Each of the power generation turbines is proposed to be fitted with dry low NOx emissions burner technology.

12.3.2.3 Fired Heaters

It is planned that the waste heat recovery units (WHRUs), fitted to the gas processing gas turbines, will provide all routine process heat requirements during normal operation of the gas treatment plant. Gas fired heaters and other WHRUs are also part of the heating medium system. The gas-fired heaters will provide process heat input during periods such as plant start-up, when the waste heat recovery units (on the LNG compression gas turbines) have not reached operating temperature.

As the fired heaters are incorporated into the waste heat recovery system, it will be necessary to maintain them in a warm standby mode during routine operations.

12.3.2.4 Flaring of Gases

The gas processing facility will be designed to avoid routine gas flaring or venting of hydrocarbons in accordance with Chevron Australia's policy of no routine venting or flaring of hydrocarbons. However, an emergency flare is required to ensure the safe operation of the Gas Treatment Plant. A continuous purge may be required along with pilots to ensure the safe ignition of the flare when required.

The most significant periods of flaring will be during the start-up and shut-down of the LNG processing trains. The ability to reduce the volume of gas flared during plant start-up is limited, as the flared gas 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 the facility by depressurising and flaring either the entire inventory of the gas in the facility, or in the section subject to the shutdown. The development of operating procedures for the facility will consider methods for reducing the amount of flared gas during shutdowns to the extent reasonably practicable. Minimising unintended plant outages, for example, by providing a highly reliable electrical supply, is critical to reducing flaring associated with plant shutdowns.

Flaring during commissioning will be limited by appropriate design and control of commissioning procedures.

As a result of the policy to operate the gas processing facility without routine gas flaring, all low pressure hydrocarbon streams in the facility (including those from the various regeneration processes) will be redirected either to the fuel gas system or back into the LNG or domestic gas processes. Compressors and other systems in the LNG process will be designed to start-up, operate continuously and shutdown on full recycle to minimise flaring.

In order to undertake inspections of the feed gas pipelines (those linking the offshore fields with the gas processing facility and the domestic gas pipeline), it may be necessary to de-pressure the pipelines during the life of the Gorgon Gas Development. Should this need arise, then the pipelines will be depressurised in accordance with approved operational plans such that the quantity of gas flared during pipeline depressurisation for inspection work is minimised.

12.3.2.5 Fugitive Emissions and Venting of Hydrocarbons

As fugitive emissions represent potential safety or environmental hazards, significant engineering work has focused on ensuring such emissions are kept to a very low level.

The main sources of fugitive emissions throughout the gas processing facility will be:

- compressor seal losses
- flanges and fittings
- condensate storage tanks
- valve stem seals.

Measures taken to reduce greenhouse gas emissions from fugitive sources include: dry gas seals on compressors, the use of internal floating roof condensate storage tanks, maximum practicable use of welded piping and the specification of high integrity valves (such as control valves), pump seals and joining materials.

Hydrocarbon venting will be minimised as it has safety and environmental implications and represents a loss of saleable product. All low pressure hydrocarbon vapour streams will be redirected back to the gas processing facility rather than being vented to atmosphere.

It is likely that the CO_2 injection wells will be required to be back flushed from time to time in order to ensure the maintenance of well injectivity. During these back flushing operations relatively small volumes (several thousand tonnes) of reservoir CO_2 will be released into the atmosphere. This source of emissions has been included in the estimation of fugitive emissions under LNG processing.

12.3.2.6 Off Barrow Island Transport

The proposed gas processing facility will require logistics support that would not be required if the facility was located on the mainland. This support will consist of aircraft and supply vessels to move personnel, equipment and supplies to Barrow Island. These services are anticipated to be primarily provided by contractors. In line with emissions reporting regulations under the Commonwealth NGER Act, reporting emissions from these operations are anticipated to be the responsibility of the respective contractors. Consequently these transport emissions have not been included in the estimate of greenhouse gas emissions from the Revised Proposal.

12.3.2.7 Diesel Engines

While most of the Gas Treatment Plant and associated infrastructure energy requirements will be supplied from natural gas, a relatively small amount of diesel will be used to fuel emergency equipment, vehicle operations and marine support vessels.

Equipment such as emergency fire pumps and back-up power generation systems are required to be operable even in the event of a major incident within the Gas Treatment Plant. These facilities will be fuelled with diesel and although they will not operate routinely, they will be tested on a regular basis to ensure operational integrity.

It is anticipated that personnel movements between the airport, accommodation and the Gas Treatment Plant will be via a bus service. The buses along with other vehicles used to transport supplies from the materials offloading facility and for maintenance are proposed to be fuelled with diesel.

The estimated greenhouse gas emissions from diesel use include emissions from marine support vessels such as tug boats used to help navigate the LNG and condensate tankers in Port waters.

12.3.2.8 Reservoir Carbon Dioxide Venting

As for the Approved Development, it will be necessary to remove CO_2 and minor traces of H_2S from the reservoir gas stream as one of the first steps in gas processing. The volume of reservoir CO_2 will vary over the operational life of the facility due to the natural variability of the CO_2 content within the gas fields.

The CO_2 removal and injection facilities will be designed to handle the expected maximum rate of reservoir CO_2 removed during routine gas processing operations. The percentage of carbon dioxide contained in the reservoir gas varies throughout each reservoir unit. Consequently the amount of reservoir CO_2 available for injection varies depending upon which parts of each gas fields are being produced and at what rates. The GJVs anticipate that the volume of reservoir carbon dioxide available for injection in any year will range between 3.8 and 4.2 MTPA. For the purposes of estimating air emissions of greenhouse gases, an annual rate of 4.2 MTPA has been assumed as the reference case.

Under routine operations all reservoir CO_2 removed from the incoming gas stream is proposed to be injected into the Dupuy Formation. However, venting of the reservoir CO_2 will be required during periods of facility or injection system maintenance, unplanned downtime and in the event of unforeseen reservoir or injection well constraints. While it is anticipated that the amount of reservoir CO_2 vented in any particular 12 month period will be less than 200 000 tonnes CO_2e, there is potential for a higher level of venting, particularly in the event of unexpected injection well failure or an unexpected subsurface outcome. As a consequence, the reference case for greenhouse gas emissions used in this document assumes 850 000 tonnes (or 20% of the reservoir CO_2 available for injection) will be vented on an annual basis. This represents a worst-case outcome which is likely to be improved upon during the front end engineering and Front End Engineering Design (FEED) phase and with the development of operational procedures.

The anticipated volumes of reservoir CO_2 that will be vented and the volumes anticipated to be injected are identified in Table 12.4. Volumes vented are anticipated to decline over time as the facility operation and CO_2 injection are optimised.

Table 12.4: Volumes of Reservoir CO_2 Anticipated to be Vented and Injected

Percentage of Reservoir CO_2	Year 1	Year 2–5	Year 6+	Long Run Performance Target
Percentage of Reservoir CO_2 injected into the Dupuy Formation	60–90% (2.52–3.78 MTPA)	70–95% (2.94–3.99 MTPA)	80–95% (3.36–3.99 MTPA)	95% (3.99 MTPA)
Vented due to scheduled maintenance and unplanned facilities downtime	5–15% (0.21-0.63 MTPA)	5–10% (0.21–0.42 MTPA)	3–5% (0.13–0.21 MTPA)	3% (0.13 MTPA)
Vented due to unforeseen reservoir constraints (including well injectivity failure)	0–25% (0–1.05 MTPA)	0–20% (0–0.84MTPA)	0–15% (0–0.63 MTPA)	2% (0.08 MTPA)

NOTE: As the concentration of CO_2 varies in different parts of the Gorgon Field, these figures represent the anticipated maximum annual rate of 4.2 MTPA.

12.3.3 Construction Commissioning and Decommissioning Emissions

The EIS/ERMP for the Approved Development (Chevron Australia 2005a) contained estimates of emissions from construction and commissioning activities and related to the decommissioning of the Gorgon Gas Development.

The GJVs estimate that greenhouse gas emissions during these periods will increase by approximately 50% with the addition of the third LNG processing train in the Revised Proposal.

Consequently, construction and commissioning activities are now anticipated to result in between 2.5 and 2.6 million tonnes CO_2e. As many of the construction and commissioning activities remain to be finalised, these emission estimates should be considered provisional.

Greenhouse gas emissions related to decommissioning activities are estimated at between 330 000 and 400 000 tonnes CO_2e. Given the inherent uncertainty in estimating emissions from future activities, emissions estimates related to decommissioning should be considered as order of magnitude estimates.

12.3.4 Environmental and Workforce Exposure to Elevated CO_2 Levels

The environmental impacts and risks associated with CO_2 and its interaction with the atmosphere, soil, water and biota are relatively well understood. Apart from potential climate change impacts, a CO_2 release to the atmosphere poses little environmental hazard provided that it is able to disperse quickly so that localised soil and atmospheric concentrations remain at or near normal levels. A hazard can arise if CO_2, which is denser than air, is allowed to accumulate in low lying, confined or poorly ventilated areas.

The effect of elevated CO_2 levels depends not only on the concentration but also the duration of exposure. The ambient concentration of CO_2 in the atmosphere is currently around 370 ppm or less than 0.004%. For humans, there are no adverse health effects for CO_2 concentrations up to 3%. Whilst some discomfort occurs between 3% and 5%, it is only for concentrations above 5% that there are serious, possibly fatal, consequences.

The National Occupational Health and Safety Commission (NOHSC) has published standards (NOHSC 2005) for human exposure to CO_2. These standards will be adhered to in limiting human exposure to CO_2 resulting from the proposal to inject reservoir CO_2.

The NOHSC exposure standards for CO_2 are:

- Time Weighted Average which covers exposure for an eight hour work shift: 5 000 ppm or 9 000 mg/m^3.
- Short Term Exposure Limit which covers exposure for a maximum period of 15 minutes: 30 000 ppm or 54 000 mg/m^3. Exposure at Short Term Exposure Limits should not occur more than four times in a work shift.

12.3.5 Benchmarked Greenhouse Gas Emissions Performance

The GJVs benchmarked the greenhouse gas emissions intensity of the LNG component of the Approved Development as part of the EIS/ERMP (Chevron Australia 2005a).

Benchmark data for comparing the greenhouse gas emissions intensity of major gas developments continues to be seldom published. Since the publication of the EIS/ERMP the only additional LNG intensity benchmark data of which the GJVs are aware of is for the proposed Pluto LNG project, also in Western Australia. The Pluto LNG project is anticipated to have a greenhouse gas emission intensity of 0.35 tonnes of CO_2e per tonne of LNG shipped.

This compares favourably with the forecast emissions intensity of the Revised Proposal of 0.348 tonnes CO_2e per tonne of LNG shipped.

12.4 Proposed Management Actions

12.4.1 Actions Proposed by the Gorgon Joint Venturers

The GJVs' commitment to responsible greenhouse gas emissions management was reflected in the adoption of the Gorgon Gas Development Greenhouse Gas Management Strategy early in the conceptual design work for the Approved Development. The Strategy was presented in the EIS/ERMP (Chevron Australia 2005a) for the Approved Development, and continues to guide the GJVs in their planning for the Revised Proposal and as a framework for the ongoing management of greenhouse gas emissions.

Key commitments in the Strategy include:

- design of the production facilities to incorporate current best practice in thermal efficiency and greenhouse emissions control where reasonably practicable
- development of a project to inject the removed reservoir CO_2 into the Dupuy Formation
- investigation of potential synergies with existing Barrow Island operations
- review of options for funding of greenhouse gas related research and development projects, such as Cooperative Research Centres and technical research.

In accordance with this Greenhouse Gas Emissions Management Strategy, a number of actions are planned by the GJVs, with the objective of further reducing the Gorgon Gas Development's greenhouse gas emissions below those estimated in this PER.

These actions include:

- Investigating the further integration of the Gorgon Gas Development and the Barrow Island GJV activities on Barrow Island, with the aim of reducing greenhouse gas emissions, for example, the integration of electrical power systems.
- Developing operational and maintenance procedures with the objective of reducing greenhouse gas emissions. Minimising unplanned outages of the LNG processing trains and maximising the percentage of reservoir CO_2 injected will be a primary focus in developing these operational and maintenance procedures.
- Once the gas processing facility is operational, undertake Energy Optimisation Studies in line with requirements in Chevron Australia's Operational Excellence Management System (OEMS), and in accordance with the *Energy Efficiency Opportunities Act 2006* (Cth).
- Continued support research into carbon dioxide capture and storage technology development within Australia and overseas.

The GJVs have undertaken to make monitoring data from the CO_2 injection project publicly available. The decision on how to make these data available to the public will be made once the project enters construction. Several options have been considered. These options include:

- GJV publicly disclosing monitoring data via a project website
- forming an alliance with the Cooperative Research Centre for Greenhouse Gas Technologies or its successor organization
- forming an alliance with a university or consortium of universities
- formation of a stand alone Joint Industry Program (JIP)
- participation in the Carbon Sequestration Leadership Forum (CSLF)
- participation in the Asia Pacific Partnership on Clean Development and Climate (APCDC).

A consideration in deciding how best to disclose the monitoring data will be the degree to which the disclosure process can assist in developing Western Australia as a centre of excellence in the underground injection of CO_2 and how this might facilitate greater community acceptance and further uptake of this technology.

12.4.2 Performance Indicators

As documented in the EIS/ERMP for the Approved Development, the GJVs have established a series of performance indicators for the Gorgon Project. Once in operation, greenhouse gas emissions from the Revised Proposal will be determined for each of the following performance indicators:

- tonnes of CO_2e emitted from LNG processing operations
- tonnes of CO_2e emitted from domestic gas processing operations
- tonnes of CO_2e emitted from support infrastructure on Barrow Island
- tonnes of CO_2e emitted from LNG processing operations per tonne of LNG loaded onto ships
- percentage of reservoir CO_2e vented to atmosphere/injected into the subsurface
- tonnes of reservoir CO_2e injected into the subsurface
- incremental emissions of CO_2e resulting from injection of reservoir CO_2.

12.4.3 Government Program Compliance

In addition to the actions proposed by the GJVs and imposed by the setting of environmental approval conditions, the Revised Proposal will be subject to a range of Commonwealth and Western Australian laws and programs regulating greenhouse gas emissions and energy efficiency.

These programs currently include:

- energy and greenhouse gas emissions reporting
- generator efficiency standards
- efficiency standards for large electric motors
- energy efficiency opportunities assessments
- membership of the Greenhouse Challenge Plus program.

The climate change policy framework in Australia is rapidly evolving, and it is anticipated that significant changes will be made to the government programs that regulate greenhouse gas emissions between the approval of the project and its commissioning (e.g. the introduction of a Commonwealth Carbon Pollution Reduction Scheme).

12.5 Disposal of Reservoir Carbon Dioxide by Injection into the Dupuy Formation

The opportunity to reduce greenhouse gas emissions associated with the Gorgon Gas Development by the subsurface injection of reservoir CO_2 was presented in the EIS/ERMP (Chevron Australia 2005a) for the Approved Development. Readers should refer to that document for a description of site selection process, the geology around the proposed injection site, a discussion of the behaviour of the reservoir CO_2 in the subsurface and an overview of the GJVs' proposed integration of monitoring, uncertainty management and risk mitigation. The GJVs' approach to the management of long term responsibilities was also presented in the EIS/ERMP.

Since the publication of the EIS/ERMP, the GJVs have continued to undertake technical studies to better understand the nature of the geology below Barrow Island and to further narrow the range of subsurface uncertainty. These studies include drilling a bore on Barrow Island in order to fully core the target injection interval, and the acquisition of a seismic pilot survey to test alternative seismic acquisition technologies in order to maximise the potential of seismic technology to image the injected reservoir CO_2 plume.

Over the last four years, two additional commercial scale projects (In Salah Algeria and Snohvit Norway) have been commissioned that employ the underground injection of reservoir CO_2 extracted during natural gas processing as a greenhouse gas emissions mitigation tool. These projects join the Sliepner Project (Norway), which has been in operation since 1996. The practical demonstration of this technology has been further supported by a number of smaller scale demonstration projects such as the Otway Basin Pilot Project being undertaken by the Cooperative Research Centre for Greenhouse Gas Technologies in Victoria, Australia. Insights gained from reviewing these projects continue to be incorporated into the GJVs' ongoing technical evaluation of the reservoir CO_2 injection proposal on Barrow Island.

This Section:

- summarises key advances in the GJVs' technical understanding since the publication of the EIS/ERMP
- reviews and updates uncertainty management plans associated with the increased rate of injection of reservoir CO_2
- revises the independent technical assessment of potential failure modes and effects in light of the improved technical understanding, and the proposed increase in the rate of injection of reservoir CO_2.

The GJVs have also taken the opportunity to contribute to the global development of this technology by publishing a number of technical papers and presenting at international conferences on the underground storage of greenhouse gases since 2004. A list of a number of published technical papers or conference presentations is contained in Section 12.7. A number of these can be publicly accessed for the more technically inclined reader.

In addition to the work undertaken by the GJVs, the Western Australian Department of Industry and Resources (DoIR) has recently completed the third in a series of independent reviews of the Gorgon Gas Development to dispose of reservoir CO_2 by subsurface injection into the Dupuy Formation. These reviews have been commissioned by DoIR in order to provide independent validation of the work undertaken by the GJVs and to suggest areas for further investigation.

The Phase III assessment was undertaken on the injection concept associated with the Approved Development, and noted that:

- the GJVs have demonstrated many of the major requirements for CO_2 storage are satisfied
- based on information available to the due diligence team at the time of the Phase III review, there appear to be no significant issues which may compromise the feasibility of the project
- the associated risks are also considered manageable through technically comprehensive monitoring and remediation plans.

The Phase III assessment team identified a series of recommendations for the GJVs to address as part of their ongoing work plans. The GJVs have embraced these recommendations, and have either undertaken the proposed recommendation or plan to address them as part of their ongoing work program. A copy of the executive summary of the DoIR Phase III Report can be downloaded from the DoIR Web Site at: http://www.doir.wa.gov.au/documents/Executive_Summary.pdf

12.5.1 Revised Proposal – CO_2 Injection Concept

The addition of a third LNG processing train will increase the annual average volume of reservoir CO_2 anticipated to be injected into the Dupuy Formation from approximately 2.7 million tonnes per year for the Approved Development to a total of approximately 3.36 million tonnes per year for the Revised Proposal.

The accelerated rate at which reservoir CO_2 is proposed to be injected will require additional injection wells and drill centres, with a corresponding increase in the length of the approved CO_2 pipeline. The CO_2 pipeline will transport reservoir CO_2 from the compressors located at the Gas Treatment Plant to the drill centres. As the exact drill centre locations are subject to change following the 3D seismic baseline survey, the final

pipeline route is also subject to change. As such, final route selection and survey cannot be conducted at this time.

The CO_2 pipeline is described in Table 2.1 as being above ground and approximately 10km in length. The pipeline easement width is 10m, but portions of already cleared roads will be used to minimise further clearing for the CO_2 pipeline easement to approximately 8 ha. All utilities, power, and fibre optic cables to the drill centres will be within the CO_2 pipeline easement. The potential impacts from the Revised Proposal are limited to the additional 2 ha clearing (see Table 2.1). All land disturbances associated with the injection of reservoir CO_2 will be managed in accordance with the limits imposed by the Gorgon Gas Processing and Infrastructure Project Agreement.

The number of injection wells drilled is likely to increase from seven wells, drilled from two or three drill centres identified for the Approved Development, to eight or nine wells drilled from three to four drill centres for the Revised Proposal.

The development concept for the Approved Development and the development concept for the Revised Proposal are shown in Figure 12.2 and Figure 12.3, respectively. The predicted lateral extent of the CO_2 plume after 1000 years of migration is also shown on these two figures. The sub–surface location of the injection wells for the Revised Proposal is geographically dispersed in order to avoid areas of high reservoir pressure between the injection wells. This has the consequence of increasing the geographic extent of the CO_2 plume shown in Figure 12.3.

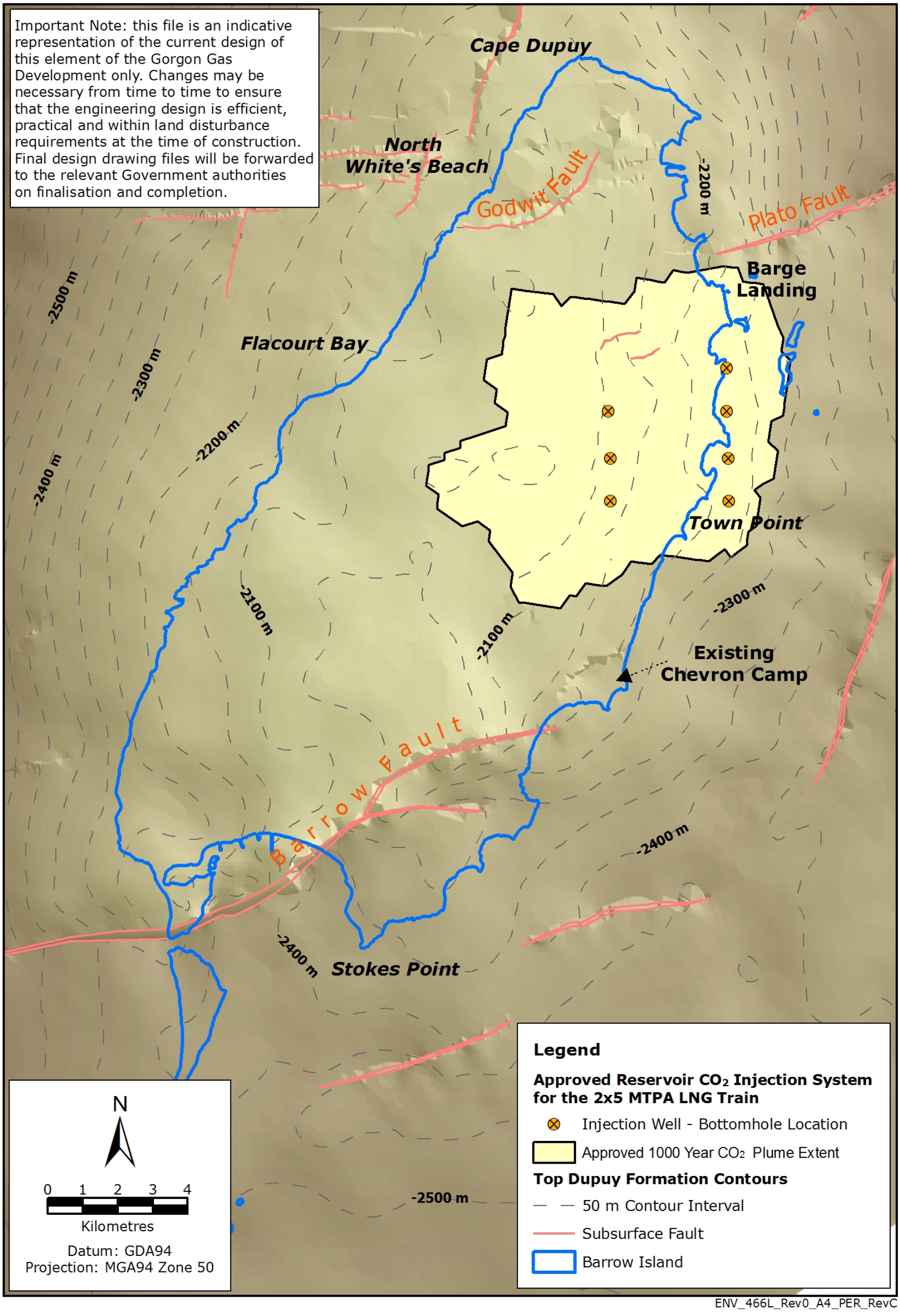


Figure 12.2: Approved Development Reservoir Carbon Dioxide Injection System Concept and Extent of Plume Migration after 1000 Years

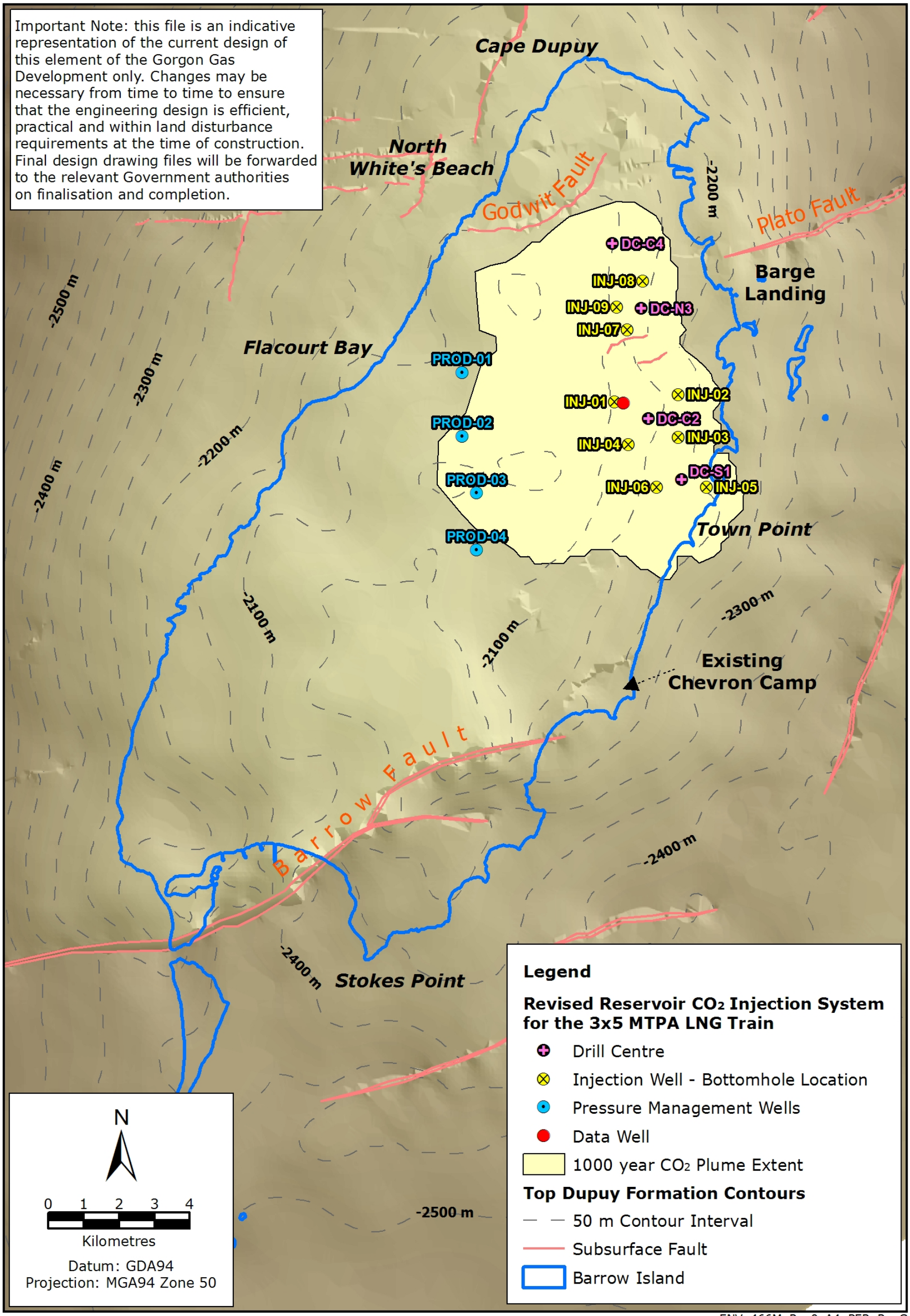


Figure 12.3: Revised Proposal Reservoir Carbon Dioxide Injection System Concept and Extent of Plume Migration after 1000 Years

Active pressure management of the Dupuy Formation was identified in the EIS/ERMP for the Approved Development as a risk mitigation strategy that may have to be implemented after several years of reservoir CO_2 injection. This process involves the extraction of formation water from the Dupuy Formation, lowering reservoir pressure and thereby further reducing the risk of fracturing the formations in proximity to the injection wells due to high injection well pressure. The extracted formation water is proposed to be injected into the overlying Barrow Group. The Barrow Group is a regionally extensive geologic unit and exhibits regional pressure depletion as a consequence of extensive oil and gas extraction operations in the Barrow–Sub Basin.

To offset the anticipated CO_2 injection volumes, water production from Dupuy Formation, and subsequent injection into the Barrow Group aquifer, will occur at a nominal production / injection rate of approximately 20 000 bbl/d/well, with a total volume of approximately 80 000 bbl/d if required. The GJVs do not believe there is potential for commercial scale hydrothermal energy production from these wells on Barrow Island or use in the reverse osmosis / desalination plant.

The production / injection scheme is a closed system with no potential impacts on known subterranean fauna habitat or surface ecosystems other than the additional clearing for the Revised Proposal.

The Dupuy Formation static bottomhole temperature is 107 °C at 2300m Total Vertical Depth Sub-sea (TVDss) and the maximum flowing tubing head temperature for the water production wells is 54 °C. The water has approximately 7000 ppm Total Dissolved Solids (TDS) with approximately 2000 ppm Chlorides and pH of 7.1. The Barrow Group static bottomhole temperature is 90 °C at 1600m TVDss and the water in this aquifer has approximately 30 000 TDS and a higher salinity of 18000 ppm and pH of 6.9.

The Dupuy water is chemically compatible with the Barrow Group aquifer (i.e. no scaling tendency). The impacts of injecting Dupuy Formation water into the drawn down Barrow Group aquifer are reduced salinity near the injection wells and some additional pressure support. Note that both of these aquifers are deep saline aquifers and not potable ground water systems. Large amounts of fluid have been removed from the Barrow Group reservoir and large amounts are extracted and reinjected into it each day through the existing Chevron Australia-operated oilfield operations on Barrow Island.

Modelling studies involving the higher CO_2 injection rates associated with the Revised Proposal indicate that implementation of a pressure management strategy is likely to be required soon after the commencement of reservoir CO_2 injection. It is anticipated that approximately four pressure management wells will be drilled to the south west of the CO_2 plume. Figure 12.3 shows several of these wells within the outline of the plume after 1000 years. It is anticipated that during the injection phase of the project these pressure management wells will be located some distance outside the plume. Active pressure management is only required during the injection phase of the project.

It is anticipated that four water injection wells and ancillary surface equipment, such as pumps, water pipelines, electrical power and control lines and road access, will be required to support the pressure management wells.

The location of the pressure management wells, associated water injection wells and the related infrastructure will be further revised during the ongoing technical assessment undertaken by the GJVs in order to ensure risks associated with the injection of reservoir CO_2 are as low as reasonably practicable.

A cathodic protection system will be installed to protect the CO_2 injection, pressure management and water injection wells. Cathodic protection is a requirement for all wells on Barrow Island to manage ground water level corrosion of surface casing to prevent CO_2 leakage and impact to subterranean fauna as described in the Failure Mode and Effects Assessment (Appendix I). The Cathodic Protection design for the proposed well layout will be similar to the conventional Chevron design which has been in operation on Barrow Island since the early 1980s without evidence of impact to subterranean fauna habitat. Each drill centre will be protected by four shallow anode wells. Each anode well would be located about 250 - 350m from the centre of each drill centre in a north, south, east and west direction. Each anode well would be driven by a transformer rectifier. The transformer rectifier cabinets will likely be located on each drill centre.

The Reservoir Carbon Dioxide Injection System, in terms of compression, power supply and controls, is operated from the Gas Treatment Plant. The scope and the impacts from operation of the Reservoir Carbon Dioxide Injection System, which are unchanged from the Approved Development, were discussed along with the other impacts from the Gas Treatment Plant in the EIS/ERMP for the Approved Development.

12.5.2 Advances in Subsurface Understanding

Since the publication of the EIS/ERMP, the GJVs have drilled a data well to obtain additional data on the geology below Barrow Island. The Gorgon Data Well (GDW1) was drilled in 2006 at a location within the forecast CO_2 plume area. Figure 12.3 shows the location of GDW1 and the anticipated extent of the CO_2 plume after 1000 years. The primary objective behind the drilling of GDW1 was to gather data which would help to further improve the GJVs understanding of the geology below Barrow Island.

While there is extensive knowledge about the geology below Barrow Island by virtue of the extensive oil and gas exploration activities since the 1950s, it was considered that the technology used to evaluate many of the existing wells was not as sophisticated as available today. Importantly, core samples are lacking over the proposed injection intervals in the lower Dupuy Formation and the upper massive sand interval, and what core is available may have weathered, which introduces uncertainty into any new analysis of that old core. Hence the GJVs undertook to drill GDW1 in order to obtain a contemporary suite of evaluation tools, and over 500 m of core over the entire reservoir and overlying barrier unit, upon which to undertake detailed core analysis. In addition to providing a valuable data set in their own right, the core and contemporary wireline log data can be used to correlate and correct older data sets from the existing wells.

In addition to this wire line data, the entire section was cored, with the core being subject to detailed routine and special core analysis. This highlights the extensive work done to evaluate the Dupuy Formation and is in excess of the evaluation routinely undertaken in an oil and gas well.

The data from GDW1 has been used to refine the characterisation of the physical properties of the Dupuy Formation. Having the full reservoir section represented in core provides a unique insight into the environment in which the Dupuy Formation was deposited. By comparing the core with analogue rock units in outcrop and sediments being deposited in similar modern day environments, geologists are better able to predict the reservoir quality and geometries of the individual sand units that comprise the reservoir and the geometries of the various baffles and barriers that act to restrict the migration of the injected reservoir CO_2. This work confirmed the previous interpretation of a layered reservoir. This geometry is important as the layering will assist in the migration of the CO_2 plume during the injection phase, thereby increasing the volume of

rock which will be filled with reservoir CO_2 before the gas starts to migrate vertically towards the regional seal (the base Barrow Group shale).

Data from GDW1 has highlighted the capacity of the lower Dupuy Formation as an injection location. Comparatively little was known about the lowermost parts of the Dupuy formation as it had been only penetrated by seven wells in the area proximal to the proposed injection location. Core data from GDW1 have shown the lowermost unit to have good permeability such that it could also function as an injection interval. This enables a greater thickness of the Dupuy Formation to be used for reservoir CO_2 injection which has the added benefit of lowering the expected pressure increases across the Formation. The injection capacity of the lower Dupuy Formation was confirmed in GDW1 with localised flow tests.

The capacity of the base Barrow Group shale to act as a vertical barrier (seal) to the migration of the reservoir CO_2 was also confirmed through special core analysis (mercury injection capillary pressure measurements). These data showed that the Base Barrow Group has the necessary physical properties to trap a column of CO_2 between 500 and 600 m in thickness. It is anticipated that the maximum column height for the injected reservoir CO_2 to be trapped below this vertical migration barrier is less than 100 m.

Drilling of GDW1 has provided a number of additional insights into the geology below Barrow Island:

- Uncertainty regarding any residual hydrocarbon saturation within the Dupuy Formation has been reduced. Analysis of wireline logs from existing wells on Barrow Island had suggested that residual hydrocarbons may have been present within the Dupuy Formation, which may have reduced the relative permeability of the formation to injected reservoir CO_2. Data from GDW1 indicates that residual hydrocarbon saturation in the Dupuy Formation is essentially zero, increasing certainty about the ability for the injected reservoir CO_2 to move through the reservoir.
- The nature and distribution of permeability throughout the Dupuy Formation has been confirmed. Permeability within the lower Dupuy Formation is better than indicated by the data available for the existing wells and suggests greater potential to inject reservoir CO_2 into this deeper zone.
- Core and wireline data have improved the GJVs' understanding of the environment in which the Dupuy Formation was deposited with the Formation interpreted to have been deposited on the continental slope dominated by sand gravity flows. The presence of numerous baffles within the reservoir was confirmed by the core and log data from GDW1. Understanding the environment in which the Dupuy Formation was deposited assists in predicting the nature of the reservoir in areas where it has not been penetrated by wells. This then facilitates the creation of geologic and reservoir simulation models that accurately reflect fluid movement throughout the reservoir.
- Minimal post–depositional fracturing was observed in the core, which decreases the likelihood of leakage of injected reservoir CO_2 from faults and fractures that cannot be resolved by seismic data.
- A large volume of geotechnical data was acquired, which provides greater confidence as to the horizontal stress fields. These data are used to plan the drilling of the injection wells and to ensure that safe working pressures are not exceeded in the reservoir.
- Reactive transport modelling based on core data (the analysis of the reservoir rock and fluids to understand the chemical reactions that are likely to occur with the introduction of reservoir CO_2 into the system) has confirmed little if any chemical

reactions will occur and, those that do, will act over the 1000 year time frame. The ability to undertake these studies on extensive fresh core reduces the risk of unexpected chemical reactions associated with injection operations.

- The design and methodology proposed to be used in the construction of the injection wells has been revised following a lessons learned review of the drilling of the GDW1 well. The GJVs routinely use lessons learned reviews to assist in planning for future activities.
- A back flushing strategy has been established where the injection wells will be periodically back–flowed (possibly once every few years for several hours at a time) in order to avoid a loss of injectivity as a result of movement of fine particles or other plugging material (oil and dust) around the well–rock interface.

It is anticipated that repeat seismic surveys will play an important role in monitoring the behaviour of the injected reservoir CO_2 in the subsurface as it is the only technology that has the potential to physically image the CO_2 plume in areas distant from the injection or observation wells. The last major seismic survey on Barrow Island was undertaken in 1994 and produced areas of relatively poor data quality due to the surface karst limestone that covers parts of the island. In addition to the drilling of the GDW1, the GJVs have conducted an extensive seismic acquisition pilot program on Barrow Island. The pilot seismic program was designed to investigate alternative seismic acquisition parameters with the objective of improving data acquisition quality and providing improved confidence in the ability to use repeat seismic data as an effective monitoring tool. Results from the pilot survey show improved data quality is possible by using explosives in highly karstified topography (generally areas over 30 m in elevation), and applying large crossed receiver arrays and using multiple sweeps recorded at small move-up intervals where Vibroseis is used as the energy source.

12.5.3 Injection of Reservoir CO_2 Associated Risks Assessment

The GJVs' approach to assessment of environmental risk is documented in Section 5.0 and incorporates risks associated with the underground injection of reservoir CO_2.

Failures in the surface injection facilities or leakage of the injected reservoir CO_2 from the subsurface can create potential health, safety and environmental hazards. Hazards caused by the failure of the surface injection facilities are understood by drawing analogies from the operation of CO_2 injection projects and oil and gas operations around the world. Less is known about the risks of leakage from the subsurface as the opportunity to manage greenhouse emissions using subsurface injection of CO_2 has been applied since 1996. The GJVs are unaware of any unplanned subsurface release of injected CO_2 from any of the three facilities currently injecting reservoir CO_2 on a commercial scale or from any of the pilot scale demonstration projects. Analogies can however be made with the understanding of the subsurface behaviour of fluids (gases and liquids) drawn from the GJVs' extensive experience in the oil and gas industry.

Building on the approach adopted for the Approved Development, the objective of this section of the PER is to clearly identify significant changes to the likelihood and consequence of potential CO_2 injection failure modes between the Approved Development and the Revised Proposal. The likelihood and consequence of these failure modes then provides a stressor for use in the assessment of terrestrial impacts in Section 6.1 through Section 6.3 and marine impacts in Section 7.1.

This approach is intended to provide a transparent comparison between the risks associated with injection of reservoir carbon dioxide for the Approved Development and the risks for the Revised Proposal.

12.5.3.1 Methodology

The approach to assessing potential failure modes for the Revised Proposal follows that used during the assessment of the Approved Development. A Failure Modes and Effects Workshop was held to consider the uncertainty management plans developed for the Revised Proposals and then assess potential failure modes that might result in an environmental impact. The Failure Mode and Effects Workshop was conducted in accordance with the principles and guidelines contained in AS/NZS 4360 for risk management and AS/NZS 3931 for risk analysis of technological systems (Standards Australia 1998 and 2004).

As the likelihood and consequence of a particular failure mode are dependent upon the degree to which safeguards, mitigation or management actions are adopted, the workshop commenced with a review of the uncertainty management plans documented in the EIS/ERMP for the Approved Gorgon Gas Development. The objective was to determine if these plans remain appropriate and are adequate to manage subsurface uncertainty. Revisions or additions to the previously documented management plans have been identified and documented in Section 12.5.3.3.

A Technical Panel comprising independent experts in the underground injection of CO_2 then considered each aspect of the failure modes identified in the EIS/ERMP. The Panel was asked to assess if the likelihood or consequence of a particular failure mode had changed as a result of the GJVs ongoing technical evaluation or as a result of the increase in injection rate and the cumulative injection rate associated with the Revised Proposal. The Technical Panel was asked also to identify any additional failure modes not previously considered by the GJVs. Any identified changes or additional failure modes not previously identified have been documented in Section 12.5.3.3.

Three different groups of participants were represented at the Workshop:

- Representatives of the GJV Operator to provide technical presentations and to answer any questions from the Technical Panel.
- A Technical Panel comprising experts in the field of subsurface CO_2 injection. The Technical Panel was used to determine the level of likelihood and consequence of a particular failure mode.
- Observers from Western Australian and Commonwealth Government Agencies involved in either the regulation of the Gorgon Gas Development or Greenhouse Gas Storage Projects generally. GJV participants were also invited to participate as observers.

Observers were invited to attend the Workshop to experience firsthand, the issues that were being discussed and the nature of comments made by the Technical Panel. Attendance by observers from government agencies does not imply any endorsement of the outcomes of the Workshop, either by those observers or their government agency. A list of participants in the workshop is provided in Table 12.6.

Table 12.5: Failure Modes and Effects Workshop Attendees

Name	Organisation /Company Affiliation
John Bradshaw	Greenhouse Gas Storage Solutions
Technical Panel	
Lynton Spence	Greenhouse Gas Storage Solutions
Geoff Weir	Energy Resource Institute
Eris O'Brien	Cooperative Research Centre for Greenhouse Gas Technologies
David Dewhurst	Commonwealth Scientific and Industrial Research Organisation
Gorgon Joint Venture Operator	
Roger Bartlett	Chevron Australia
Mark Trupp	Chevron Australia
Laurene Green	Chevron Australia
Randal Gurton	Chevron Australia
Matthew Flett	Chevron Australia
Chris Dauth	Chevron Australia
Jason McKenna	Chevron Australia
John Torkington	Chevron Australia
Mike Wagner (Part Time)	Chevron Australia
Scott Monro (Part Time)	Chevron Australia
Observers	
Warren Tacey (Part Time)	Western Australian Department of Environment and Conservation
Rick Causbrook	Geoscience Australia
Peter Wilson	Commonwealth Department of Resources, Energy and Tourism
Jian Hua Liu	Western Australian Department of Industry and Resources
Brian Cohen (Part Time)	Shell Development Australia
Facilitator	
Richard Stoklosa	E-Systems / Chevron Australia

12.5.3.2 Changes to Uncertainty Management Planning

The EIS/ERMP for the Approved Gorgon Gas Development presented the GJVs' process for managing subsurface uncertainty associated with the injection of reservoir CO_2. Interested readers should refer to the EIS/ERMP for a discussion on the approach taken by the GJVs in relation to the management of subsurface uncertainty.

The most significant change to the GJVs' uncertainty management plans, as a result of the proposed increase in injection rates associated with the Revised Proposal, centres around the management of reservoir pressure. Increasing the distance between injection wells, drilling additional injection wells, the earlier implementation of a pressure management strategy and the back flushing of injection wells were felt to adequately manage the risk of formation pressure not exceeding a safe value.

12.5.3.3 Changes to Assessment of Failure Modes and Effects

Table 1.2 in Appendix I documents the likelihood of possible failure modes relating to underground injection of reservoir CO_2 and possible effects of such a failure in terms of release of reservoir CO_2. The assessment builds upon the assessment presented in the EIS/ERMP for the Approved Development (Chevron Australia 2005a). The EIS/ERMP should be consulted for a discussion of potential leakage (flux) rates in the event of unplanned migration along faults or through barrier units.

The Panel of technical experts was asked to consider how the assessment of potential failure modes has changed in light of the changes to the Revised Proposal, predominantly an increase in injection rates, and changes to the uncertainty management plans discussed in Table 1.1 in Appendix I. Where the Technical Panel felt that a likelihood or effect of a particular failure mode differed from the assessment of the Approved Development has been documented in Appendix I. In addition a number of editorial changes have been incorporated, for example where a previously described outcome may not have been clear, in order to provide greater clarity for the reader. These editorial changes should not materially alter the technical content of the Table.

The Panel generally agreed with the assessment of likelihood and effects of various failure modes as described for the Approved Development. A significant area of difference was that the Technical Panel assessed the likelihood of leakage via the faults in north Barrow Island, the Pluto and Godwit Faults, as being possible. The GJVs have accepted this assessment and will consider how to reduce this likelihood as part of their ongoing technical assessment. Reduction of likelihood should be possible by changing the bottom hole location of a number of the injection wells proposed in the northern most portion of Barrow Island.

The Panel noted that the likelihood of CO_2 leakage either through existing well penetrations or via the faults in the north of the Island can be adequately mitigated by:

- adjusting the bottom hole locations of the CO_2 injection wells
- altering the rates of injection into the injection wells to preferentially inject the reservoir CO_2 towards the centre of Barrow Island
- influencing migration direction of the CO_2 by the use of the pressure management wells e.g. increasing the rate of water extraction from the pressure management wells will drive the migration of CO_2 in the direction of those wells and away from areas of potential leakage.

In addition, the Panel commented upon the GJVs' use of uncertainty management planning and its integration with the proposed monitoring activities. The Panel considered it essential to maintain an adaptive interpretation of subsurface CO_2 migration, and to use this to actively manage risks associated with the injection operations. This recommendation is aligned with the GJVs' uncertainty management processes.

12.6 Predicted Environmental Outcome

Table 12.7 provides a comparison between the estimated greenhouse gas emissions for the Revised Proposal compared to the Approved Development.

Table 12.6: Greenhouse Gas Emissions Comparison

Key Performance Indicator	Approved Development	Combined Approved Development and Revised Proposal
Annual greenhouse gas emissions	4.0 million tonnes per annum CO_2e	5.45 million tonnes per annum CO_2e
Annual volume of reservoir CO_2 injected	2.72 million tonnes	3.36 million tonnes
LNG emissions intensity (tonnes CO_2e per tonne LNG shipped)	0.353	0.348

The proposed actions by the GJVs to manage greenhouse gas emissions from the Revised Proposal represent the application of currently applied best practice in terms of energy efficiency and emissions control. Further the proposal to significantly reduce emissions from the Revised Proposal by the subsurface injection of reservoir CO_2 removed during the gas processing operations represents a significant "beyond no regrets" action to reduce greenhouse gas emissions. These actions have contributed to delivering a greenhouse gas emissions intensity that is comparable to many of the world's most greenhouse emissions efficient LNG projects.

There are no unacceptable cumulative risks related to greenhouse gas emissions as a result of the Gorgon Gas Development. Furthermore, the Revised Proposal complies with the intent of the relevant Western Australian EPA guidance notes (EPA 2002a; 2003b) in relation to the management of greenhouse gas emissions and the disposal of industrial waste by injection into deep or shallow wells.

The GJVs' public commitment to the disclosure of monitoring data associated with the injection of reservoir CO_2 has the potential to position Western Australia as a centre of excellence in the development of this technology with the potential to facilitate transfer of this technology, stimulating the wider uptake with the net result of further reducing Western Australia's and Australia's greenhouse gas emissions.

The Approved Development is subject to a number of environmental approval conditions that regulate emissions from the Gorgon Gas Development and address issues such as leakage of injected CO_2 into the near surface cave systems on Barrow Island (the environment inhabited by the blind gudgeon). These conditions provide a workable framework by which to manage greenhouse gas emissions resulting from the Revised Proposal.

12.7 Technical and Conference Publications

Published Technical Papers

Flett, M., Gurton, R. and Taggart, I. 2004. *The function of gas-water relative permeability hysteresis in the sequestration of carbon dioxide in saline formations*. SPE Asia-Pacific Oil and Gas Conference and Exhibition, Perth, Australia. SPE 88485

Flett, M., Gurton, R. and Taggart, I. 2004. *Heterogeneous saline formations: long term benefits for geo-sequestration of greenhouse gases*. Seventh International Conference on Greenhouse Gas Control Technologies (GHGT-7), Vancouver, Canada. Elsevier.

Flett, M., Gurton, R. and Weir, G. 2007. Heterogeneous saline formations for carbon dioxide disposal: Impact of varying heterogeneity on containment and trapping. *Journal of Petroleum Science and Engineering* 57(1-2): 106-118.

Schembre-McCabe, J.M., Kamath, J. and Gurton, R. *Mechanistic Studies of CO_2 Sequestration*. 2007. International Petroleum Technology Conference, Dubai, UAE, 4-6 December. IPTC 11391.

Flett, M., Beacher, G., Brantjes, J., Burt, A., Dauth, C., Koelmeyer, F., Lawrence, R., Leigh, S., McKenna, J., Gurton, R., Robinson W.F., Tankersley T. 2008. *Gorgon Project: Subsurface evaluation of carbon dioxide disposal under Barrow Island*. SPE Asia-Pacific Oil and Gas Conference and Exhibition, Perth, Australia. SPE 116372

Presentations at International Conferences

Flett, M., Gurton, R. and Weir, G. 2006. *Reservoir performance of disposed carbon dioxide in saline formations: impact of heterogeneity and dip*. 8th International conference on Greenhouse Gas Control Technologies, Trondheim, Norway.

Brantjes, J. 2008. *Formation evaluation for CO_2 disposal*. Society of Petrophysicists & Well Log Analysts 49th Annual Logging Symposium, Edinburgh, Scotland, May 2008.

13.0 SUMMARY OF ASSESSMENT OF POTENTIAL IMPACTS TO MATTERS OF NES

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

13.1 Introduction

Matters protected by the Commonwealth EPBC Act are known as matters of National Environmental Significance (NES) and include:

- World and National Heritage Places
- Wetlands of International Importance
- Listed threatened species
- Listed migratory species
- Nuclear actions
- Commonwealth Marine Area.

Under the Commonwealth EPBC Act, the Revised Proposal (as described in Section 3.0) was considered to be a 'controlled action', requiring assessment, due to the following controlling provisions:

- listed threatened species and communities (sections 18 and 18A)
- listed migratory species (sections 20 and 20A).

13.2 Matters of NES Relevant to the Revised Proposal

A total of 30 terrestrial and marine threatened and/or migratory species listed under the Commonwealth EPBC Act could potentially occur within the areas affected by the Revised Proposal and the Approved Development. This includes one species of stygofauna, *Milyeringa veritas* (blind gudgeon). No vegetation associations or flora species which are listed under the Commonwealth EPBC Act have been recorded within areas affected by the Gorgon Gas Development (including those affected by the Revised Proposal).

13.2.1 Listed Threatened Species

Results of a search of the EPBC Act Protected Matters Interactive Search Tool indicated that a total of 16 threatened fauna species listed under the Commonwealth EPBC Act as Endangered or Vulnerable could potentially occur within the areas affected by the

Revised Proposal and the Approved Development (Table 13.1). The threatened fauna included terrestrial and marine species, some of which are also protected by the Commonwealth EPBC Act as migratory species.

13.2.2 Listed Migratory Species

Results of a search of the EPBC Act Protected Matters Interactive Search Tool indicated that 23 migratory fauna species listed under the Commonwealth EPBC Act could potentially occur in the areas affected by the Revised Proposal and the Approved Development (Table 13.1). This included migratory terrestrial, wetland and marine species and migratory marine birds. Some of these species are also listed as threatened species under the Commonwealth EPBC Act.

13.3 Potential Sources of Impact to Matters of NES

Potential sources of impact to terrestrial, subterranean and marine fauna were identified in Section 6.1, Section 6.2 and Section 7.1 respectively. In summary, the key potential sources of impact to matters of NES from the Revised Proposal include:

- Additional utilisation of approximately 40 ha of the available 300 ha over and above the initial land use estimate for the Approved Development. The long-term land disturbance associated with the Revised Proposal (above that associated with the Approved Development) will decrease the area of available habitat (terrestrial and subterranean) and may increase the potential for loss or displacement of individual fauna.
- Accelerated rate of reservoir CO_2 injection into the Dupuy Formation when compared with the Approved Development. While total volumes of CO_2 to be injection remain unchanged, unplanned CO_2 release to the surface or near-surface environment from unplanned migration of CO_2 from deep faults could potentially lead to a localised anoxic environment for stygofauna in the superficial aquifer.
- Additional direct seabed disturbance associated with the proposed reconfiguration of the Approved Development causeway and MOF under the Revised Proposal. The Revised Proposal causeway and MOF will result in a minor increase in the area of the seabed permanently covered by marine infrastructure, noting that some of this additional area would have been subject to disturbance from the LNG Jetty (as part of the Approved Development).
- Physical presence of infrastructure of increased length resulting in disturbance to marine fauna behaviour patterns and a potential increase in predation of marine turtles.
- Increased light emissions (mainly associated with the operational phase of the Gorgon Gas Development) associated with the lighting requirements for the additional terrestrial infrastructure may affect both terrestrial and marine fauna behaviour.
- Increased LNG and condensate tanker movements under the Revised Proposal may have some level of additional impact to individual marine species on the east coast of Barrow Island (i.e. vessel strike).

13.4 Assessment of Potential Impacts to Matters of NES

Refer to Table 13.1 for a summary of impacts to matters of NES as taken from Sections 6.1, 6.2 and 7.1 of the PER.

Table 13.1: Summary of Assessment of Potential Impacts to Matters of NES

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
Balaenoptera musculus (blue whale) Threatened Migratory	Migratory species which is not likely to visit the shallow, turbid inshore waters in the vicinity of the east coast facilities that are the subject of the Revised Proposal; likely to be more abundant in offshore, deeper waters.	Vessel collision – the Revised Proposal will result in an increased number of LNG and condensate tanker movements.	The Revised Proposal is considered to present an unchanged risk and is unlikely to have a significant additional impact to this species primarily because there is a low likelihood of vessel strikes. If vessel strike was to occur, the event would have effects at the individual level only (rather than species or population level). Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 7.1
Megaptera novaeangliae (humpback whale) Migratory	Humpback whales pass through the Montebello/ Lowendal/Barrow Island region between June and October on their annual migration. Humpback whales are more common in waters west of Barrow Island and may occasionally occur in the offshore, deeper waters off the east coast.	As above.	As above.	Section 7.1
Balaenoptera edenia (Bryde's whale) Migratory	Known to occur off the north Western Australian coast; may occasionally occur in the waters around Barrow Island	As above.	As above.	Section 7.1
Orcinus orca (killer whale) Migratory	Are known in the area from sightings; are likely to be occasional visitors.	As above.	As above.	Section 7.1
Sousa chinensis (Indo-Pacific humpback dolphin) Migratory	Have resident populations within the shallow waters of the inner Rowley Shelf, including Barrow Island. The regional distribution of most dolphin species is poorly known and while many species may occur in the Pilbara region, most are likely to be only transients or occasional visitors to the waters around Barrow Island.	As above.	As above.	Section 7.1
Tursiops aduncus (spotted bottlenose	Are expected to occasionally visit all subtidal marine areas of the Revised Proposal. The regional distribution of most	As above.	As above.	Section 7.1

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
dolphin) Migratory	dolphin species is poorly known and while many species may occur in the Pilbara region, most are likely to be transients or occasional visitors.			
Rhincodon typus (whale shark) Threatened Migratory	Expected to be occasional visitors to either side of Barrow Island.	As above.	As above.	Section 7.1
Dugong dugon (dugong) Migratory	Dugong are generally associated with shallow seagrass meadows and are likely to be occasional visitors to the subtidal seagrass on the east coast of Barrow Island. However, there are no known major seagrass meadows along the east coast of Barrow Island that are likely to be critical feeding habitats for dugong.	As above	The Revised Proposal is considered to present an unchanged risk and is unlikely to have a significant additional impact to this species as dugong have not been observed in high numbers in the waters surrounding Barrow Island. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 7.1
Caretta caretta (loggerhead turtle) Threatened Migratory	Have been observed in the waters around Barrow Island and occasional nesting has occurred on Barrow Island beaches.	Light emissions – the Revised Proposal will result in further lighting from additional infrastructure and tankers. Vessel collision – the Revised Proposal will result in an increased number of LNG and condensate tanker movements.	The Revised Proposal is considered to present an unchanged risk and is unlikely to have a significant additional impact to this species as: ♦ the impacts to marine fauna from light spill are not expected to extend further or affect new areas that were not identified as being affected by the Approved Development ♦ light spill from the Revised Proposal Gas Treatment Plant (as modelled) was comparable to illumination levels on clear nights with full or quarter moon. It also needs to be noted that some shielding effects will be provided by the sand dune at Bivalve Beach and additional large structures on the plant, which have not been accounted for in the model (i.e. the model has been projected on a flat plane). ♦ the likelihood of vessel strike to this species is not anticipated to significantly increase above that assessed for the Approved Development; although there	Section 7.1

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
			will be additional vessel movements, most vessels will be slow moving, displacement type vessels. If vessel strike was to occur, the event would have affects at the individual level only (rather than species or population level). Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	
Eretmochelys imbricate (hawksbill turtle) Threatened Migratory	Barrow Island is not a regionally important nesting site; these turtles nest at low densities around the Island.	As above.	As above.	Section 7.1
Dermochelys coriacea (leathery or leatherback turtle) Threatened Migratory	Uncommon but expected to be regular visitors to the region; not known to nest in Western Australian waters.	As above.	The Revised Proposal is considered to present an unchanged risk and is unlikely to have a significant additional impact to this species primarily because species is uncommon in the region (and not known to nest in Western Australian waters). If species was present, potential impacts (if any) would be expected to be at the individual level rather than the species or population level. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 7.1
Natator depressus (flatback turtle) Threatened Migratory	Nest in high numbers on east coast beaches of Barrow Island and they feed in offshore waters. Post-hatchlings and juveniles may occur in shallow near-shore waters around the island.	Light emissions – the Revised Proposal will result in further lighting from additional infrastructure and tankers. Physical barrier created by marine solid causeway and MOF – the Revised Proposal will result in an increase in length of solid causeway. Vessel collision – the Revised Proposal will result in an increased number of LNG and condensate tanker movements.	The Revised Proposal is considered to present an unchanged risk and is unlikely to have a significant additional impact to this species as: ♦ the significant distance of the MOF and LNG Jetty from the beach will allow hatchlings to disperse well in the water and will diminish the effect of the additional light sources on the turtles ♦ The potential impact to behaviour and potential increase in predation resulting from the increased length of the solid	Section 7.1

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
			causeway/MOF are not anticipated to result in significant impacts to flatback turtles. ♦ the impacts to marine turtles from light spill are not expected to extend further or affect new areas that were not identified as being affected by the Approved Development ♦ light spill from the Revised Proposal (as modelled) was comparable to illumination levels on clear nights with full or quarter moon. It also needs to be noted that some shielding effects will be provided by the sand dune at Bivalve Beach and additional large structures on the plant, which have not been accounted for in the model (i.e. the model has been projected on a flat plane) ♦ the likelihood of vessel strike to this species is not anticipated to significantly increase above that assessed for the Approved Development; although there will be additional vessel movements, most vessels will be slow moving, displacement type vessels. If vessel strike was to occur, the event would have affects at the individual level only (rather than species or population level). Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	
Chelonia mydas (green turtle) Threatened Migratory	Barrow Island is a regionally important nesting area for green turtles. They nest predominantly on the west coast beaches and also mate close to Barrow Island during the summer breeding season and forage very close to shore year round (east and west coast).	As above.	As above.	Section 7.1
Bettongia lesueur unnamed subsp.	Boodie warrens are widely distributed on Barrow Island, generally in upland areas	Loss of an additional area of potential foraging habitat. There are	The Revised Proposal is considered to present an unchanged risk to this species	Section 6.1

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
(boodie) Threatened	of limestone cap rock. There are no additional active warrens (in addition to the one active warren within the disturbance area of the Approved Development) within the disturbance area of the Revised Proposal.	no additional active warrens within the disturbance area of the Revised Proposal.	and is unlikely to have a significant additional impact to this species as: ♦ no additional active warrens will be disturbed by the Revised Proposal (based on current survey data, July 2008) ♦ warrens are widely distributed across Barrow Island ♦ species not restricted to the area described by the Revised Proposal. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	
Isoodon auratus barrowensis (golden bandicoot) Threatened	Widespread and abundant throughout their range on Barrow Island, being the most abundant mammal on Barrow Island.	Loss of an additional area of potential habitat from the Revised Proposal.	The Revised Proposal is considered to have an unchanged risk to this species and is unlikely to have a significant additional impact to this species as: ♦ species not restricted to the area described by the Revised Proposal ♦ highly mobile species and able to move away from areas of disturbance ♦ Revised Proposal requires a small increase in total clearing (but within the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA)); however habitats are well represented outside the area of disturbance. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 6.1
Lagorchestes conspicillatus conspicillatus (spectacled hare-wallaby) Threatened	Widespread on Barrow Island.	Loss of an additional area of potential habitat as a result of the Revised Proposal.	The Revised Proposal is considered to have an unchanged risk to this species and is unlikely to have a significant additional impact to this species as: ♦ species not restricted to the area described by the Revised Proposal ♦ highly mobile species and able to move	Section 6.1

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
			away from areas of disturbance ♦ Revised Proposal requires a small increase in total clearing (but within the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA)); however habitats are well represented outside the area of disturbance. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	
Petrogale lateralis lateralis (black-flanked rock-wallaby) Threatened	The distribution of this species on Barrow Island is limited to rocky outcrops on the west coast.	No new or additional impacts as a result of the Revised Proposal.	Not applicable. Species is restricted to the west coast of Barrow Island and the Revised Proposal does not involve any changes to the facilities on the west coast.	Species not addressed in PER.
Macropus robustus isabellinus (Barrow Island euro) Threatened	This species is widespread on Barrow Island and require shade, especially during the hotter months, and often use artificial shelter.	Loss of an additional area of potential habitat as a result of the Revised Proposal.	The Revised Proposal is considered to have an unchanged risk to this species and is unlikely to have a significant additional impact to this species as: ♦ species not restricted to the area described by the Revised Proposal ♦ highly mobile species and able to move away from areas of disturbance ♦ Revised Proposal represents a small loss of additional potential habitat (but within the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA)); however habitats are well represented outside the area of disturbance. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 6.1
Malurus leucopterus edouardi (white-winged fairy	Barrow Island white-winged fairy wrens have been found to nest in a range of plant species including *Melaleuca cardiophylla, Acacia bivenosa, A.*	Loss of an additional area of potential habitat as a result of the Revised Proposal.	The Revised Proposal is considered to present an unchanged risk to this species and is unlikely to have a significant additional impact to this species as:	Section 6.1

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
Wren) Threatened	*coriacea, Hakea lorea, Grevillia pyramidalis and Triodia* sp. Nesting is not restricted to certain flora, and they nest in a variety of vegetation types (including Spinifex *Triodia angusta* along the roadways on Barrow Island in areas without *M. cardiophylla*)		♦ species not restricted to the area described by the Revised Proposal ♦ species nests widely over a range of habitats; such habitats are well represented outside the area of disturbance and will remain undisturbed ♦ Revised Proposal represents a small loss of additional potential habitat (but within the 300 ha available on Barrow Island for gas processing activities under the *Barrow Island Act 2003* (WA)). Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	
Haliaeetus leucogaster (white-bellied-sea-eagle) Migratory	Is considered a resident species on Barrow Island; occur and nest in a variety of locations around the coast of Barrow Island (typically high in trees or on cliffs).	Individuals may build nests on flare towers – the Revised Proposal includes a number of additional flare towers.	The Revised Proposal is considered to present an unchanged risk to this species and is unlikely to have a significant additional impact to this species as: ♦ species not restricted to the area described by the Revised Proposal ♦ low risk of individuals building nests on flare towers and if it was to occur would have affects at the individual level only (rather than species level). Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 6.1
Glareola maldivarum (oriental pratincole) Migratory	This species has not been recorded from Barrow Island and is very unlikely to occur in the area.	Not applicable.	Not applicable.	Species not addressed in PER.
Numenius minutes (little curlew) Migratory	Vagrant species to Barrow Island.	Not applicable. Only 2 records during littoral bird surveys in 2003.	Not applicable.	Species not addressed in PER.
Apus pacificus (fork-tailed swift)	Vagrant species to Barrow Island. This species has not been recorded from	Not applicable.	Not applicable.	Species not addressed in

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
Migratory	Barrow Island.			PER.
Puffinus pacificus (wedge-tailed shearwater) Migratory	This species feeds away from land areas in open water and is known to nest on North and South Double Islands off the east coast of Barrow Island. This species does not breed or nest on Barrow Island.	Lights and gas flares pose a risk to seabirds that frequent the coastline at night – the Revised Proposal will result in further lighting from additional infrastructure and includes a number of additional flare towers.	The Revised Proposal is considered to have an unchanged risk to this species and is unlikely to have a significant additional impact to this species as: ♦ species not found in the area described by the Revised Proposal ♦ species does not breed or nest on Barrow Island ♦ light spill studies have demonstrated that light emissions are not expected to significantly increase with a third LNG train compared to the Approved Development ♦ lighting strategy will be implemented to reduce light usage and their point-source intensity. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 6.1
Sterna caspia (Caspian tern) Migratory	This species is not abundant on Barrow Island, although coastal surveys have recorded them primarily in the north-east and mid-east regions of the Island (including beaches either side of Town Point).	No new or additional impacts as a result of the Revised Proposal as no additional coastal habitat will be disturbed as a result of the Revised Proposal.	Not applicable.	Species not addressed in PER.
Hirundo rustica (barn swallow) Migratory	This species has not been recorded from Barrow Island and is very unlikely to occur in the area.	Not applicable.	Not applicable.	Species not addressed in PER.
Macronectes giganteus (southern giant-petrel) Migratory	This species has not been recorded from Barrow Island and is very unlikely to occur in the area.	Not applicable.	Not applicable.	Species not addressed in PER.
Merops ornatus (rainbow bee-eater) Migratory	This species has not been recorded from Barrow Island and is very unlikely to occur in the area.	Not applicable.	Not applicable.	Species not addressed in PER.

Species and EPBC Act Status	Occurrence on Barrow Island or in the waters Around Barrow Island	Key Potential Impacts Arising from the Revised Proposal	Significance of Potential Impact	Section Addressed in PER
Milyeringa veritas (blind gudgeon) Threatened	Two individuals of this species have been collected during stygofauna surveys on Barrow Island in 2002 – 2003. Both specimens were collected from the same bore which is located approximately 6 km to the south-west of the Revised Proposal (i.e. bore located outside the disturbance area).	Unplanned CO_2 migration to the surface or near-surface environment – the Revised Proposal will result in an accelerated rate of reservoir CO_2 injection.	The Revised Proposal is considered to have an unchanged risk to this species and it is unlikely to have a significant additional impact to this species as: ♦ no direct impact to this species is expected ♦ risk of unplanned CO_2 migration is very low ♦ the bore where the species has been recorded is at least 3 km from the Barrow Fault and it is highly unlikely that any unplanned escape of CO_2 would migrate such a distance. Furthermore, there are no unacceptable cumulative impacts on this species as a result of the Gorgon Gas Development	Section 6.2

13.5 Proposed Management Actions

Potential impacts to matters of NES from the Revised Proposal will be addressed through a series of management plans consistent with those required under conditions prescribed for the Approved Development in EPBC Reference: 2003/1294. These management plans address impacts associated with particular aspects of the development or the receptors that may potentially be impacted.

The management plans, programs and systems required by EPBC Reference: 2003/1294 are listed below and the objectives and key management actions of these are summarised in Table 15.2.

- Terrestrial and Marine Quarantine Management System
- Terrestrial Facilities Baseline State and Environmental Monitoring Program
- Coastal and Marine Environmental Monitoring Program
- Terrestrial and Marine Facilities Construction Environment Management Plan
- Terrestrial and Marine Facilities Operations Environment Management Plan
- Long-Term Marine Turtle Management Plan
- Carbon Dioxide Injection Monitoring Program
- Decommissioning and Closure Plan.

In addition to the above management plans and systems, the following procedures and programs are being developed for the Gorgon Gas Development:

- Fauna Handling and Management Procedures
  These procedures will cover activities that are likely to interact with vertebrate fauna (including birds and reptiles, but excluding invertebrates) on Barrow Island. The procedures will prescribe actions for the initial response to sick, injured or orphaned animals and directions for obtaining further guidance and/or information. Actions will include: management of fauna within trenches and other open pits, including protocols to manage trenches during times of flooding (e.g. cyclones); handling sick or injured fauna; euthanasia of animals for welfare reasons; vouchering specimens that may be required by the Western Australian Museum; managing fauna cleared from areas being developed; restricting vehicle speed limits.
- Vegetation Clearing Audit Procedures
  The purpose of these procedures is to determine the extent of clearing and rehabilitation on an annual basis. Actions prescribed in the procedures will include restricting vegetation clearing to approved areas and locating infrastructure on already cleared or disturbed areas to the maximum extent reasonably practicable.
- Soil CO_2 Monitoring Program
  The purpose of this program is to record and monitor the natural release of CO_2 from across the area of the predicted 50-year CO_2 plume, including targeted sampling at geological conduits to the surface, and at groundwater wells established across the island. Key management actions will include managing produced water and altering the rates and locations of CO_2 injection wells, and establishing a soil CO_2 release monitoring program.

It should also be noted that the issue of an approval for the Revised Proposal will be consistent with Australia's obligations under the relevant international agreements as discussed in Section 1.7.4.

13.6 Predicted Environmental Outcome to Matters of NES

13.6.1 Marine Species

The Revised Proposal is not considered to pose any significant new or additional risks to marine fauna listed as matters of NES in comparison to the Approved Development. The Revised Proposal is considered to have an unchanged risk to all of these species, with the exception of the flatback turtles (see explanation below) and is unlikely to have a significant impact to these species as:

- some species are not known from the shallow waters of the west coast of Barrow Island, are uncommon in the region and/or are unlikely to be present in areas affected by the Revised Proposal (e.g. most whale species)
- there is a low likelihood of vessel strike as most susceptible species (e.g. whale species) are only occasional visitors to the offshore, deeper waters of the east coast of Barrow Island (consequently, if vessel strike did occur it would impact at the individual level rather than the species or population level)
- additional light spill is not expected to extend further or affect new areas that were not identified as being affected by the Approved Development or result in a reduction in local population viability of marine species populations.

It is possible that the additional 800 m of the Revised Proposal causeway may increase the risk of disruptions to adult flatback turtle behaviour, beyond predicted disruptions from the Approved Development causeway. Therefore the risk of impacts to flatback turtles from the physical presence of the Revised Proposal Causeway was assessed as Medium as opposed to the Low risk rating given for the Approved Development (Table 7.2).

The implementation of various plans, programs and systems consistent with those that are required under conditions prescribed for the Approved Development in EPBC Reference: 2003/1294 is expected to manage the potential impacts of the Revised Proposal to a level consistent with that considered acceptable and therefore approved for the Approved Development. Furthermore, there are no unacceptable cumulative impacts on marine fauna listed as matters of NES as a result of the Gorgon Gas Development.

13.6.2 Terrestrial and Subterranean Species

The Revised Proposal is not considered to pose any significant new or additional risks to terrestrial and subterranean fauna species that are listed as matters of NES in comparison to the Approved Development. Consequently, the Revised Proposal is considered to have an unchanged risk to such species and is unlikely to have a significant impact to these species as:

- some species have not been found in and are unlikely to occur in the disturbance footprint of the Revised Proposal (e.g. black-flanked rock wallaby)
- no species are expected to be restricted to the additional area of disturbance associated with the Revised Proposal and most species are widely distributed across Barrow Island
- most terrestrial species are highly mobile and would be able to avoid the areas of additional disturbance associated with the Revised Proposal
- relevant habitats are well represented outside the additional area of disturbance associated with the Revised Proposal and will remain undisturbed
- it is highly unlikely that any unplanned escape of CO_2 would migrate the distance to the area known to support the blind gudgeon. In addition, a comprehensive CO_2

monitoring plan is to be implemented to detect any potential unplanned CO_2 migration.

The implementation of various plans, systems and programs that are required under conditions prescribed for the Approved Development in EPBC Reference: 2003/1294 is expected to manage the Revised Proposal impacts to a level consistent with that considered acceptable and therefore approved for the Approved Development. Furthermore, there are no unacceptable cumulative impacts on terrestrial and subterranean fauna species that are listed as matters of NES as a result of the Gorgon Gas Development.

14.0 ENVIRONMENTAL MANAGEMENT FRAMEWORK

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

14.1 Operational Excellence Management System

Chevron Australia has established an Operational Excellence Management System (OEMS) which is the framework for management of safety, health and the environment. Chevron's OEMS aims to deliver industry leading performance through safe, reliable, efficient and environmentally sound operations.

The OEMS consists of three parts:

5. Leadership Accountability: leaders are accountable not only for achieving results, but achieving them in the right way by behaving in accordance with prescribed values.
6. Management System Process, comprising:
    a. developing Operational Excellence (OE) visions and objectives
    b. completing a comprehensive evaluation to identify priority areas in OE processes and performance against established objectives
    c. developing three-year plans to manage priorities and incorporating those plans into business plans and assigning accountabilities
    d. implementing planned actions and monitoring plan progress and OE performance
    e. annually evaluating progress on performance and identifying necessary adjustments to plans.
7. OE Expectations, which include (but are not limited to):
    a. designing and constructing facilities in an environmentally sound manner
    b. environmental stewardship: working to prevent pollution and waste; striving to continually improve environmental performance and limiting impacts from our operations
    c. complying and verifying conformance with company policy and all applicable laws and regulations.

The OEMS is designed to be consistent with and, in some respects, go beyond ISO 14001:2004 (Environmental Management Systems – Specifications with Guidance for Use) (AS/NZS 2004a).

14.2 Chevron ABU Vision, Values and Policies

Chevron Australia's commitment to sound environmental management in all aspects of operations is reflected in Chevron Policy 530 – Protecting People and the Environment.

The Chevron Australasia Strategic Business Unit (ABU) Vision is to have a culture and work environment where people and the environment are injury and incident free.

14.3 Principles of Environmental Protection

In 2003 the EP Act was amended to include a core set of principles that are applied by the EPA in assessments (EPA 2004a). As listed in Section 4a of the EP Act, these environmental protection principles are:

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

The GJVs have considered these principles in its assessment of the environmental impacts associated with the Revised Proposal (Table 14.1).

Table 14.1: Principles of Environmental Protection

Principle	Consideration Given In Revised Proposal	Section Addressed in PER
1. Precautionary Principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, decisions should be guided by: a. careful evaluation to avoid, where practicable, serious or irreversible damage to the environment b. an assessment of the risk-weighted consequences of various options.	A risk assessment process has been adopted in the development of this project with the intention of identifying issues early in the process to enable planning for avoidance and/or mitigation. Part of this process includes undertaking detailed site investigation of the biological and physical environs. Where these investigations identify significant environmental issues, project design was modified to avoid or reduce potential impacts, where reasonably practicable. A number of management plans will be prepared and implemented to manage potential affects on terrestrial, subterranean and marine flora and fauna, as relevant.	Refer to risk-based assessment approach outlined in Section 5.0 and detailed assessment of factors in PER Sections 6.0 through to 11.0.
2. Intergenerational Equity The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The GJVs are committed to meeting the ten sustainability principles developed for the Gorgon Gas Development to contribute to sustainable development in Australia. These principles ensure that the GJVs operations deliver more value with less impact. Integration of these sustainability principles ensures the environment in which the GJVs operate is maintained and, where possible, enhanced for future generations.	Refer to PER Section 14.4.
3. Conservation of Biological Diversity and Ecological Integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	Conservation of biological diversity and ecological integrity is a major consideration for the Gorgon Gas Development. Biological investigations were undertaken to provide sufficient	Refer to PER Sections 6.0, 7.0 and 15.0.

Principle	Consideration Given In Revised Proposal	Section Addressed in PER
	local and regional information to assess the environmental significance of the Revised Proposal. A number of management plans will be prepared and implemented to manage potential affects on terrestrial, subterranean and marine flora and fauna, as relevant.	
4. Improved Valuation, Pricing and Incentive Mechanisms.	Not applicable.	Not applicable.
5. Waste Minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	A number of waste minimisation measures are planned to be implemented, including implementing the principles of reduce, reuse and recycle in relation to solid and liquid waste management (as outlined in the Solid and Liquid Waste Management Plan). Injection of reservoir CO_2 into the Dupuy Formation	Refer to PER Section 15.0, and 12.0.

14.4 Environmental Management Plans

Numerous management plans are required to be prepared as conditions of the Approved Gorgon Gas Development. These conditions were issued by the Commonwealth and Western Australian governments (EPBC Reference: 2003/1294, Sea Dumping Permit No. SD2004/0030, and Statement No. 748 respectively); some of the conditions issued in the approvals are very similar.

Management plans required by the Commonwealth approval are as follows:

- Terrestrial and Marine Quarantine Management Plan or System
- Terrestrial Facilities Baseline State and Environmental Monitoring Program
- Coastal and Marine Baseline State Survey Plan and Marine Environmental Monitoring Program
- Terrestrial and Marine Facilities Construction Environment Management Plan(s) (including dredging and spoil disposal)
- Terrestrial and Marine Facilities Operations Environment Management Plan(s)
- Long-Term Marine Turtle Management Plan
- Carbon Dioxide Injection Monitoring Program
- Decommissioning and Closure Plan.

Management plans required by the State are as follows:

- Terrestrial and Subterranean Baseline State and Environmental Impact Report
- Terrestrial and Subterranean Environment Protection Plan
- Terrestrial and Subterranean Environment Monitoring Program
- Terrestrial and Marine Quarantine Management System
- Short Range Endemics and Subterranean Fauna Monitoring Plan
- Fire Management Plan
- Groundwater Abstraction Management Plan

- Coastal and Marine Baseline State and Environmental Impact Report
- Long-Term Marine Turtle Management Plan
- Marine Facilities Construction Environmental Management Plan
- Dredge and Spoil Disposal Management and Monitoring Plan
- Horizontal Directional Drilling Management and Monitoring Plan
- Offshore Gas Pipeline Installation Management Plans
- Coastal Stability Management and Monitoring Plan
- Greenhouse Gas Abatement Program
- Air Quality Management Plan
- Solid and Liquid Waste Management Plan
- Aboriginal Cultural Heritage Management Plan
- Post-construction Rehabilitation Plan
- Project Site Rehabilitation Plan
- Decommissioning and Closure Plan.

A summary of the application of the existing Conditions of the Commonwealth and Western Australian approvals to the Revised Proposal is presented in Appendix H.

The GJVs believe that the implementation of conditions consistent with those prescribed for the Approved Development, when applied in conjunction with current regulation, will effectively manage all environmental aspects of the Revised Proposal (Section 15.5).

Furthermore, as part of the Approved Development, the GJVs have agreed to implement a suite of environmental undertakings to address significant residual environmental risks, and to fund indexed Net Conservation Benefits as set out in the *Gorgon Gas Processing and Infrastructure Project Agreement* clause 11 (Schedule 1 *Barrow Island Act 2003* (WA). See Section 15 for more detailed description of these arrangements.

15.0 KEY MANAGEMENT ACTIONS AND PROPOSED ENVIRONMENTAL CONDITIONS

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

15.1 Overview

Numerous environmental conditions were set by the Western Australian and Commonwealth Ministers (Statement No. 748 and EPBC Reference: 2003/1294 respectively) in relation to the Approved Development in late 2007. The conditions set out the level of management required for the key environmental factors and the outcomes being sought. Decisions on the design and placement of infrastructure and operational standards are made to reduce impacts to as low as reasonably practicable (ALARP) and to meet prescribed standards or outcomes. The GJVs believe that conditions equivalent to or consistent with the existing conditions, when applied in conjunction with current regulations, will effectively manage the environmental aspects of the Revised Proposal as was the case for the Approved Development. The management actions and mitigation strategies identified and developed for the Approved Development are capable of applying equally to this Revised Proposal to manage environmental impacts.

In addition to approval under the Commonwealth EPBC Act and Western Australian EP Act, other approvals are and will be required for the construction and operation of the Approved Development and the Revised Proposal, including works approval and licensing requirements under Part V of the EP Act. A summary of these control instruments is contained in Section 15.2.

As part of the Approved Development, the GJVs have also agreed to a suite of additional environmental undertakings; a summary of these undertakings (which are also applicable to the Revised Proposal) is contained in Section 15.3.

15.2 Summary of Likely Environmental Control Instruments

Table 15.1 outlines the controls that already apply to the Approved Development and could equally be put in place to control the environmental compliance and appropriate environmental management of the Revised Proposal. Key environmental requirements or controls are drawn from the following:

- Environmental Conditions (as for the Approved Development; contained in Statement No. 748 and EPBC Reference: 2003/1294)

- environmental management matters covered by the *Barrow Island Act 2003* (WA)
- anticipated conditions of DEC Works Approval and Environmental Licence (to be applied for under Part V of the EP Act) for prescribed premises (see Section 1.8.3 for more discussion relating to EP Act Part V requirements).

With reference to the *Barrow Island Act 2003* (WA), there are several provisions of Schedule 1 (*Gorgon Gas Processing and Infrastructure Agreement*) that cover key environmental matters. These include a requirement to pay $40 million (indexed), into a CALM Trust Fund, to fund Net Conservation Benefits (NCBs). NCBs are defined as demonstrable and sustainable additions to, or improvement in, biodiversity conservation values of Western Australia targeting, where possible, the biodiversity conservation values affected or occurring in similar bio-regions to Barrow Island. The NCB funding requirement (prescribed in Clause 11 of Schedule 1) also states that proportionate additional funding of the NCBs payment shall be made by the GJVs if the project is expanded beyond a capacity of 10 MTPA. The Revised Proposal, if approved, will activate this additional funding requirement.

The GJVs are also required to comply with relevant legislation and regulations as indicated in the relevant sections of this PER document (and specifically in Table 1.1). Key legislation (and regulations) that apply to the environmental management of the Revised Proposal (in addition to the Commonwealth EPBC Act and the Western Australian EP Act and B*arrow Island Act*), include:

- *Conservation and Land Management Act 1984* (WA): conservation of reserves and protection of flora and fauna
- *Wildlife Conservation Act 1950* (WA): protection of flora and fauna (in particular rare or endangered species)
- *Aboriginal Heritage Act 1972* (WA): protection of Aboriginal heritage sites
- *Dangerous Goods and Safety Act 2004* (WA) (and associated regulations): specifies requirements for storage and handling of dangerous goods
- *National Greenhouse and Energy Reporting Act 2007* (Cth): reporting greenhouse gas emissions, energy consumption and production
- *Pollution of Waters by Oils and Noxious Substances Act 1987* (WA) and *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth): protection of the sea from discharges/dumping, oil and other noxious substances.
- Environmental Protection (Noise) Regulations 1997 (WA)

Table 15.1: Existing Statutory and Environmental Management Controls that may be Relevant to the Revised Proposal

Key Environmental Factors	Key Environmental Aspect	State (WA) Environmental Conditions[1]	Commonwealth Environmental Conditions[2]	Barrow Island Act 2003	DEC Works Approval and Licence[3]	Other Relevant Legislation and Regulations[4]
Terrestrial fauna (including matters of NES)	Vegetation clearing	✓	✓	✓		
	Site disturbance/excavation	✓	✓			
	Fire	✓				
	Physical interaction	✓				
	Air Emissions	✓			✓	
	Unplanned CO_2 migration or release to the surface or near surface environment	✓	✓			
Subterranean fauna (including matters of NES)	Vegetation clearing	✓	✓	✓		
	Site disturbance/excavation	✓	✓			
	Liquid and solid waste disposal	✓			✓	
	Spills and leaks	✓			✓	✓
	Physical presence of infrastructure	✓				
	Unplanned CO_2 migration or release to the surface or near surface environment		✓			
	Noise and vibration emissions		✓		✓	✓
Vegetation and flora	Vegetation clearing	✓	✓	✓		
	Fire	✓				
	Dust emissions	✓			✓	
	Unplanned CO_2 migration or release to the surface or near surface environment	✓	✓			
Marine fauna	Physical disturbance of the seabed	✓	✓			

Key Environmental Factors	Key Environmental Aspect	State (WA) Environmental Conditions[1]	Commonwealth Environmental Conditions[2]	Barrow Island Act 2003	DEC Works Approval and Licence[3]	Other Relevant Legislation and Regulations[4]
(including matters of NES)	Light spill		✓			
	Leaks and spills	✓			✓	✓
	Physical presence of marine infrastructure	✓	✓			
	Wastewater discharges	✓			✓	
	Physical interaction	✓	✓			
	Noise and vibration emissions		✓		✓	✓
Marine physical environment and coastal processes	Physical disturbance of the seabed	✓	✓			
	Physical presence of marine infrastructure	✓				
Marine water and sediment quality	Physical disturbance of the seabed	✓	✓			
	Leaks and spills	✓			✓	✓
	Wastewater discharge	✓			✓	
	Unplanned CO_2 migration or release to the surface or near surface environment		✓			
Marine Primary Producers	Physical disturbance of the seabed	✓	✓			
	Leaks and spills	✓			✓	✓
Quarantine	Introduction and/or spread of non-indigenous species	✓	✓	✓		

Key Environmental Factors	Key Environmental Aspect	State (WA) Environmental Conditions[1]	Commonwealth Environmental Conditions[2]	Barrow Island Act 2003	DEC Works Approval and Licence[3]	Other Relevant Legislation and Regulations[4]
Air quality	Air emissions	✓			✓	
	Greenhouse gas emissions	✓				
	Greenhouse gas reinjection	✓	✓	✓		

NOTES:
[1] As prescribed in Statement No. 748 and including those management plans described in Table 15.2.
[2] As prescribed in EPBC Reference: 2003/1294 and Sea Dumping Permit No. SD2004/0030 (as applicable) and including those management plans described in Table 15.2.
[3] Anticipated conditions that may be prescribed for the Works Approval and Environmental Licences required under Part V of the EP Act.
[4] Other relevant legislation and regulations are detailed in Section 15.2.

15.3 Additional Environmental Undertakings

In addition to the environmental conditions prescribed in Statement No. 748 and EPBC Reference: 2003/1294, and the provisions of the *Barrow Island Act* Schedule 1 (*Gorgon Gas Processing and Infrastructure Project Agreement*), the GJVs agreed to implement a suite of environmental undertakings to address residual environmental risks associated with the Approved Development. These undertakings were sought from the GJVs by the Premier of Western Australia "having regard to the need to minimise environmental disturbance on Barrow Island (a Class A nature reserve) and providing for the support of conservation programs relating to Barrow Island and other parts of the State". These undertakings are described in the preamble to Statement No. 748, Appendix B of this PER, and are summarised below.

North West Shelf Flatback Turtle Conservation Program
A 30-year North West Shelf Flatback Turtle Conservation Program will be undertaken to increase the protection of the population in areas away from Barrow Island. The program will include activities including:

- survey, monitor and research turtle populations
- mitigate loss by reducing interference to key feeding and breeding locations
- establish information programs to support protection.

North West Shelf Flatback Turtle Intervention Program
If the monitoring undertaken as part of the above mentioned program clearly demonstrates that the Gorgon Gas Development is having a significant adverse impact on the flatback turtle population, the GJVs will take or fund further actions to improve recruitment to the turtle population, potentially including the establishment of hatcheries.

Threatened Species Translocation and Reintroduction Program
A Threatened Species Translocation and Reintroduction Program for selected species from Barrow Island to other Pilbara islands will be undertaken. The program will include initial translocation actions, plus ongoing island management.

Eradication of Non-indigenous Species
In addition to the quarantine management conditions detailed in Statement No. 748, the GJVs will provide a financial guarantee to cover Western Australian State Government costs for eradication of non-indigenous species established on Barrow Island, other than through natural causes, and following commencement of the Gorgon Project.

Dredging
The GJVs will fund Western Australian State Government agency costs associated with surveillance of marine activities during dredging and marine construction, and ongoing evaluation of the marine environment response and recovery.

The GJVs consider that the environmental undertakings described above, and the indexed Net Conservation Benefits described in Section 15.2, are applicable and relevant to the Revised Proposal, and address the residual environmental risks of the Revised Proposal.

15.4 Key Management Actions

As previously stated, a number of environmental management plans, programs and systems are being prepared to comply with the Environmental Conditions prescribed in Statement No. 748 and EPBC Reference: 2003/1294 for the Approved Development. It is proposed that the relevant management plans, programs and systems be

amended/updated, as necessary, to incorporate the aspects of the Revised Proposal that are different from those associated with the Approved Development, and address the anticipated requirements of the State and Commonwealth environmental approval conditions for the Revised Proposal. The GJVs consider that the existing management plans, programs and systems prescribed for the Approved Development are capable of equally applying to, and being adequate to cover, the new and/or additional environmental impacts associated with the Revised Proposal. These plans, programs and systems are currently in preparation and will detail the key management actions proposed to be used to manage activities to achieve the stated objectives. The plans, programs and systems will require approval by the relevant regulators before the Gorgon Gas Development can proceed.

The objectives (as taken from Statement No. 748), and preliminary key management actions and performance criteria from the management plans, programs and systems relevant to the Revised Proposal, are outlined in Table 15.2. Since the environmental management plans, programs and systems are currently in preparation, the key management actions and performance criteria presented in Table 15.2 are preliminary only; they are subject to amendment/revision as the plans are further developed and more specific details become available.

Table 15.2: Objectives and Preliminary Key Management Actions and Performance Criteria of the Gorgon Gas Development's Environmental Management Plans, Programs and Systems

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
Terrestrial and Subterranean Environment Protection Plan	The objectives of the Plan (as outlined in Statement No. 748) are: ♦ to reduce the adverse impacts from the construction and operation of the Terrestrial Disturbance Footprint as far as practicable ♦ to ensure that construction and operation of the terrestrial facilities does not cause Material or Serious Environmental Harm outside and below the Terrestrial Disturbance Footprint.	♦ Reporting procedures. ♦ Developing triggers for investigation or management action prior to causing Material or Serious Environmental Harm. ♦ Vegetation Clearing Assessment procedures. ♦ Fauna Handling and Management procedures. ♦ Traffic Management procedures which will include measures for identifying designated roads and vehicle speed restrictions. ♦ Surface Water Management procedures.	♦ Compliance with the documents listed in the Key Management Actions column.
Terrestrial and Subterranean Environmental Monitoring Program[1]	The objective of this Program (as outlined in Statement No. 748) is to establish a statistically valid ecological monitoring program to detect any Material or Serious Environmental Harm to the ecological elements outside the Terrestrial Disturbance Footprint.	♦ Measure changes on significant ecological elements that are at risk of Material or Serious Environmental Harm using appropriate indicators, parameters and/or criteria. ♦ Report adverse changes to significant ecological elements. ♦ Develop protocols for identifying additional areas not originally identified that are at risk of sustaining Material or Serious Environmental Harm from the proposal. ♦ Establish a monitoring program with the ability to detect at a statistical power of 0.8 or greater, or an alternative statistical power as determined by the Minister, environmental harm to significant ecological elements. ♦ Locate monitoring sites in areas that are at risk of Material or Serious Environmental Harm due to the construction and operation of terrestrial facilities.	♦ Identification of 'at risk' areas. ♦ Identification of 'at risk' ecological elements. ♦ Identification of indices for measuring changes in ecological elements. ♦ Identification of detection thresholds for rates of change in ecological elements targeted for monitoring. ♦ Establishment of monitoring sites and reference sites.

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
		♦ Establish appropriate reference sites.	
Terrestrial and Marine Quarantine Management System[1]	The overall aim of the QMS (as outlined in Statement No. 748) is that the Proponent shall not introduce or proliferate Non-indigenous Terrestrial Species and Marine Pests to or within Barrow Island or the water surrounding Barrow Island, as a consequence of the Proposal. The specific objectives of the QMS are (as outlined in Statement No. 748): ♦ to prevent the introduction of Non-indigenous Terrestrial Species and Marine Pests ♦ to detect Non-indigenous Terrestrial Species (including weed introduction and/or proliferation) and Marine Pests ♦ to control and, unless otherwise determined by the Minister, eradicate detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests ♦ mitigate adverse impacts of any control and eradication actions taken against detected Non-indigenous Terrestrial Species (including weeds) and Marine Pests.	♦ Undertake risk assessments, supply chain management, vessel management and inspection. ♦ Develop non-indigenous species detection, control and eradication programs. ♦ Implement non-indigenous species eradication programs when needed. ♦ Reporting and recording of incidents. ♦ Implement an integrated whole of Island quarantine management approach. ♦ Review acquired data. ♦ Undertake further studies as needed. ♦ Establish measurable limits that specify the performance standards to be achieved by the QMS within the Terrestrial and Marine Quarantine Controlled Access Zones and Terrestrial and Marine Quarantine Limited Access Management Zones.	♦ Quarantine specifications implemented and audited within 12 months of commencement of construction of the terrestrial facilities listed in Condition 6.3. ♦ Quarantine procedures implemented and audited within 12 months of commencement of construction of the terrestrial facilities listed in Condition 6.3. ♦ Surveillance protocols implemented and meeting the statistical power of 0.8 or an alternative agreed upon level of confidence 12 months after the commencement of construction of the terrestrial facilities listed in Condition 6.3. ♦ Eradication protocols developed and tested prior to the commencement of construction of the terrestrial facilities listed in Condition 6.3.
Short Range Endemics and Subterranean Fauna Monitoring Plan	The specific objectives of the Plan (as outlined in Statement No. 748) are to: determine the occurrence of short range endemics and subterranean	♦ Survey reference areas to verify that the range for identified SREs extends beyond the Gas Treatment Plant footprint.	♦ Evidence or strong justification of whether identified SRE species exist outside the Gorgon Gas Development footprint.

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
	fauna species which have previously only been located on the Gas Treatment Plant site.		
Fire Management Plan	The specific objectives of the Plan (as outlined in Statement No. 748) are to ensure that: ♦ the Proposal does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint due to fire ♦ fire risk reduction measures are built into the design of the facilities to protect the Proponent's assets from the impact from fire on Barrow Island.	♦ Perform a fire risk assessment of all project infrastructure and develop measures to protect infrastructure and the surroundings from fires on Barrow Island. ♦ On-going management of infrastructure for fire prevention, suppression and management including incident control systems to manage fire within the Terrestrial Disturbance Footprint.	♦ Personnel working on the Gorgon Gas Development to be provided with induction training explaining the need to protect the natural environment from fire. ♦ Selected site personnel trained and equipment provided to manage and control fires. ♦ Systems are in place to manage potential high fire risk activities and reduce the risk. ♦ Incident management and reporting system in place to ensure timely response to fires. ♦ Facilities designed to reduce the risk of fire and outbreaks contained within the Terrestrial Disturbance Footprint.
Long-term Marine Turtle Management Plan[1]	The specific objectives of the Plan (as outlined in Statement No. 748) are to: ♦ address the long-term management of the marine turtle species that utilise the beaches on the east coast of Barrow Island adjacent to the east coast facilities identified in Conditions 6.3, and surrounding waters on the east coast of Barrow Island adjacent to the east coast facilities ♦ establish baseline information on the population of turtles that utilise the beaches on the east coast of Barrow Island adjacent to the east	♦ Conduct employee induction, awareness and other training aimed at building a culture of environmental awareness and an understanding of the conservation values of Barrow Island and the surrounding waters. ♦ Specify relevant project approval commitments in tenders and contracts specific to marine turtle protection. ♦ Avoid impacts to the extent reasonably practicable in areas of particular marine turtle habitat value (seabed or nesting beach disturbance). ♦ Prohibit non-essential lighting (minimum requirement to meet health and safety standards) during turtle nesting and hatchling emergence	♦ Personnel working on the Gorgon Gas Development to complete induction/training aimed at building a culture of environmental awareness and an understanding of the conservation values of Barrow Island and its surrounding waters (including marine turtles). ♦ Gorgon Gas Development tenders and contracts to specify relevant project environmental management commitments, including those specific to marine turtle protection. ♦ Impacts to areas of particular marine turtle habitat value to be avoided to the extent

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
	coast facilities ♦ establish a monitoring program to measure and detect changes to the flatback turtle population ♦ specify design features, management measures and operating controls to avoid adverse impacts to the marine turtle population.	periods (light spill). ♦ Use reduced spectrum (i.e. long wavelength yellow/orange) lighting with lights shielded, mounted as low as practical and directed away from the coastline (light spill). ♦ Design the causeway to reduce wave refraction (physical presence of infrastructure). ♦ Restrict vessel speed and access (physical interaction). ♦ Comply with the Chevron Australia Oil Spill Contingency Plan (leaks and spills).	reasonably practicable. ♦ Non-essential lighting (minimum requirement to meet health and safety standards) prohibited during turtle nesting and hatchling emergence periods (light spill). ♦ Environmental Basis of Design to specify the use of reduced spectrum (i.e. long wavelength yellow/orange) lighting with lights shielded, mounted as low as practical and directed away from the coastline (light spill). ♦ Procedures in place to restrict vessel speed and access inside Port limits where reasonably practicable (physical interaction). ♦ Compliance with Chevron Australia Oil Spill Contingency Plan (leaks and spills).
Marine Facilities Construction Environmental Management Plan[1]	The objectives of the Plan (as outlined in Statement No. 748) are: ♦ to reduce the impacts from the construction of the marine facilities (excepting from the generation of turbidity and sedimentation from dredging) as far as practicable ♦ to ensure that construction of the marine facilities does not cause Material or Serious Environmental Harm outside the Marine Disturbance Footprint (excepting from the generation of turbidity and sedimentation from dredging).	♦ Limit areas of seabed disturbance by constructing an open pile jetty, appropriately designing the causeway, and selecting a channel location and limiting the area and volume of dredging. ♦ Have a designated marine monitor on site during relevant marine construction activities. ♦ Conduct pre-construction planning to reduce the requirement for anchor sets in near shore areas. ♦ Examine the feasibility and effectiveness of using dynamically positioned vessels to reduce potential anchoring impacts. ♦ Reduce maintenance dredging through the appropriate design of channels. ♦ Reduce impacts associated with the construction of	♦ Permanent coral loss within the Zones of High and Moderate Impact will not exceed 22 ha. ♦ Limits of Acceptable Change to Corals defined in Statement No. 748 are not exceeded. ♦ Risk of impacts to sea turtles as a result of construction activities reduced to ALARP. ♦ Strategies developed and implemented to reduce impacts associated with vessel anchoring.

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
		marine facilities to the extent practicable. ♦ Designate areas for the mooring of vessels adjacent to the construction area and control vessel operating locations to reduce disturbances and encroachment on significant benthic substrates and communities. ♦ Conduct BPPH assessments prior to commencing offshore construction in accordance with EPA Guidance Statement 29 (EPA 2004a). ♦ Remodel and monitor turbidity plume dispersion. ♦ Design the LNG load-out facility for safe operation within defined weather conditions. ♦ Locate the LNG load-out facility away from sensitive areas of benthic habitat (e.g. intertidal areas) to the extent practicable.	
Dredge and Spoil Disposal Management and Monitoring Plan	The aim of the Plan (as outlined in Statement No. 748) is to ensure that the Limits of Environmental Impacts (specified in Condition 18.2 Table 1 or Statement No. 748) are not exceeded due to the impacts of the dredging or spoil disposal activities associated with the facilities.	♦ Select dredge spoil grounds to avoid areas that support well developed epifaunal assemblages. ♦ Avoid impacts to areas of particular habitat value to the extent reasonably practicable. ♦ Ensure that the Limits of Environmental Impacts are not exceeded due to the impacts of dredging or spoil disposal activities. ♦ Remove unconsolidated material in the construction area. ♦ Ensure that the quantity of dredge spoil from the Revised Proposal will not exceed that of the Approved Development. ♦ Ensure that there will be no increase in the size of the dredge spoil ground under the Revised Proposal. ♦ Monitor coral and mangrove health prior to, during and following the completion of dredging.	♦ Permanent coral loss within the Zones of High and Moderate Impact will not exceed 22 ha. ♦ Limits of Acceptable Change to Corals (defined in Statement No. 748) are not exceeded. ♦ Tiered Management Framework developed, including Impact Management Plans that specify the measures to be implemented in the event that the Management Trigger Criterion is exceeded. ♦ Ecological Monitoring Programme developed and implemented. ♦ Water quality criteria representing the link between water quality and coral health established. ♦ Reporting requirements satisfied.

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
		♦ Monitor water quality and sedimentation rates prior to, during and following the completion of dredging. ♦ Avoid dredging during coral spawning periods. ♦ Implement adaptive management planning to ensure water quality stays within pre-determined acceptable limits.	
Coastal Stability Management and Monitoring Plan	The objectives of the Plan (as outlined in Statement No. 748) are to: ♦ ensure that the facilities do not cause significant adverse impacts to the beaches adjacent to those facilities ♦ establish a monitoring programme to detect adverse changes to the beach structure and beach sediments that have implications for marine turtles nesting on those beaches.	♦ Capture 12 months of baseline data that include the effects of seasonal changes on beaches adjacent to Town Point. ♦ Establish a monitoring program to detect adverse project-attributable changes to the beach structure and beach sediments that have implications for marine turtles nesting on those beaches.	♦ Complete baseline data acquisition program prior to the commencement of construction to identify normal seasonal changes/variations in beach conditions. ♦ Continue monitoring during and after construction to detect changes beyond normal seasonal variations.
Greenhouse Gas Abatement Program	The objectives of the Program (as outlined in Statement No. 748) are to: ♦ ensure that the Gas Treatment Plant is designed and operated in a manner which achieves reductions in "greenhouse gas" emissions as far as practicable ♦ provide for ongoing "greenhouse gas" emissions reductions over time ♦ ensure that through the use of best practice, the total net "greenhouse gas" emissions and/or "greenhouse gas" emissions per unit of LNG produced from the project are	In the absence of specific Actions, the key Topics to be addressed in the Program include: ♦ calculate "greenhouse gas" emissions associated with the Gorgon Gas Development, using methodologies endorsed by the Australian Greenhouse Office (now Department of Climate Change) ♦ employ specific measures to reduce the total net greenhouse gas emissions and/or the greenhouse gas emissions per unit of LNG produced by the Gorgon Gas Development using a combination of "no regrets" and "beyond no regrets" measures ♦ undertake an ongoing review of and implement where practicable "greenhouse gas" offset	♦ Greenhouse gas emissions, energy use and energy production will be reported in accordance with the *National Greenhouse and Energy Reporting Act 2006* (Cth) ♦ Data on the following performance indicators will be included in the Gorgon Development – Annual Environmental Performance Report: ▪ tonnes of CO_2e emitted from LNG processing operations (without contribution from CO_2 venting) ▪ tonnes of CO_2e emitted from domestic gas processing operations (without contribution

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
	minimised ♦ manage “greenhouse gas” emissions in accordance with the Framework Convention on Climate Change 1992, and consistent with the National Greenhouse Strategy.	strategies ♦ estimate the “greenhouse gas” efficiency of the project (per unit of LNG and/or other agreed performance indicators) and comparitively with the efficiencies of other LNG producing facilities producing a similar product, both within Australia and overseas ♦ implement thermal efficiency design and operating goals for permanent installations that are consistent with the Australian Greenhouse Office – Generator Efficiency Standards ♦ undertake actions for the monitoring, regular auditing and annual reporting of “greenhouse gas” emissions and emissions reduction strategies ♦ set a non-binding target for the progressive reduction or abatement of total net "greenhouse gas" emissions or "greenhouse gas" emissions per unit of product and as a percentage of total emissions over time, and annual reporting of progress made in achieving this target. Consideration may be given to the use of renewable energy sources such as solar or wind ♦ undertake a program to achieve a reduction or abatement in “greenhouse gas” emissions, consistent with the non-binding target referred to above ♦ apply for entry, whether on a proposal-specific basis, company wide arrangement or within an industrial grouping into the Commonwealth Government’s Greenhouse Challenge Plus program ♦ review and adopt a “continuous improvement approach” so that advances in technology and potential operational improvements of plant	from CO_2 venting) ▪ tonnes of CO_2e emitted from and support infrastructure ▪ percentage of reservoir CO_2e injected into the subsurface/ vented to atmosphere ▪ tonnes of reservoir CO_2e injected into the subsurface ▪ tonnes of CO_2e emitted per tonne of LNG loaded on ship (includes contribution from CO_2 venting).

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
		performance are considered for adoption.	
Air Quality Management Plan	The Objectives of the Plan (as outlined in Statement No. 748) are to: ♦ ensure air quality meets appropriate standards for human health in the workplace ♦ ensure air emissions from the Gas Treatment Plant operations do not pose a risk of Material or Serious Environmental Harm to the flora, vegetation communities, terrestrial fauna, and subterranean fauna of Barrow Island.	♦ Establish an air quality monitoring program capable of measuring ambient air quality and validating air quality modelling results. ♦ Ensure the monitoring program can monitor and provide data to demonstrate Barrow Island air quality meets appropriate standards for human health and does not pose a serious risk to potential environmental receptors (flora, fauna). ♦ Reduce air emissions from construction activities and operating facilities to the extent practicable. ♦ Establish an emissions monitoring program to directly measure or estimate significant emissions sources. ♦ Establish an annual reporting mechanism for air emissions.	♦ Air quality modelling validated. ♦ Ambient air quality on Barrow Island conforms to appropriate standards (i.e. NEPM – Ambient Air and NOHSC – Occupational Environment) as presented in Chapter 7.2.4 of the approved EIS/ERMP (Chevron Australia 2005a). ♦ Demonstrate conformance with the National Environment Protection (Air Toxics) Measure. ♦ Deposited dust levels do not exceed authority concentration limits. ♦ Reporting of air quality monitoring program results annually. ♦ Conformance with Environmental Licence and Ministerial Conditions.
Solid and Liquid Waste Management Plan	The objectives of the Plan (as outlined in Statement No. 748) are to: ♦ ensure all Proposal-related solid and liquid wastes are either removed from Barrow Island or, if not, that all practicable means are used to ensure that waste disposal does not cause Material or Serious Environmental Harm to Barrow Island and its surrounding waters ♦ ensure discharges from any waste water treatment plant, reverse osmosis plant, or other process water are disposed of via deep well injection, unless otherwise	♦ Develop appropriate waste management strategies for each waste stream based on the conventional waste management hierarchy. ♦ Waste storage areas shall comply with applicable regulatory requirements. ♦ Appropriate at-source receptacles shall be provided at worksites to store segregated waste. ♦ All waste generated, stored and treated/disposed of shall be recorded, manifested and tracked to ultimate fate. ♦ All vessels to comply with the requirements of MARPOL (73/78) and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1993* (Cth). ♦ The deep well injection system (and flowlines) shall	♦ Compliance with the requirements of the Chevron Environmental Stewardship OE Process. ♦ Deep well injection of approved liquid wastes does not result in Serious or Material Environmental Harm to identified ecological elements. ♦ Compliance with the requirements of MARPOL (73/78) and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1993* (Cth). ♦ Recycling targets established and achieved. ♦ Adequate and appropriate waste storage facilities constructed to manage solid and

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
	authorised by the appropriate authority ♦ ensure any deep well injection of Proposal-related liquid wastes is conducted in a manner that will not cause Material or Serious Environmental Harm to subterranean fauna and their habitats on Barrow Island.	undergo regular inspection and maintenance to ensure integrity is maintained and the risk of leaks or spills is minimised. ♦ All solid waste, with the exception of waste concrete is sent from Barrow Island to Chevron-approved facilities for recycling, treatment, storage or disposal on the mainland.	liquid waste. ♦ Personnel made aware of their individual responsibilities for waste management through the induction process. ♦ Establishment of a list of approved recycling, treatment and disposal facilities on the mainland for use by the Gorgon Gas Development.
Post-construction Rehabilitation Plan	The objectives of the Plan (as outlined in Statement No. 748) are to: ♦ ensure that the rehabilitation of terrestrial areas following construction is properly planned in a manner which promotes self-sustaining ecosystems able to be managed as part of their surroundings consistent with the conservation objectives of a class 'A' Nature Reserve ♦ design rehabilitation of native vegetation to ultimately develop into viable ecological systems which are comparable and compatible with surrounding native vegetation and its land uses, and restores as closely as practicable the pre-disturbance biodiversity and functional values ♦ ensure planning, implementation, monitoring and reporting on rehabilitation is carried out in a manner consistent with industry best practice	♦ Identify the objectives for the rehabilitation program, including site-specific variation. ♦ Develop plans for topsoil hydrological function evaluation. ♦ Integrate rehabilitation with island-wide management programs. ♦ Identify knowledge gaps and on-going studies needed to address knowledge gaps. ♦ Ensure plant species composition including consideration of species vulnerability to and dependence on fire. ♦ Rehabilitate areas impacted by project-attributable fires.	♦ Topography and surface drainage of rehabilitated areas are consistent with, and complimentary to, the overall landscape. ♦ Soil surface of rehabilitated areas has similar stability to the surrounding soils. ♦ Soil physical and chemical properties of rehabilitated areas will be consistent with those of the target landscape. ♦ Flora species on the rehabilitated site are representative of the target ecosystem. ♦ Weed species are not present on rehabilitated sites. ♦ The capacity to retain water and nutrient resources is equivalent to target ecosystems. ♦ Vehicle access to rehabilitated areas is provided according to stakeholder requirements.

Management Plan, Program or System required by Statement No. 748	Objectives	Preliminary Key Management Actions	Preliminary Key Performance Criteria
	♦ ensure management of rehabilitation continues until affected areas are self sustaining ♦ better inform any on-going rehabilitation and post-closure rehabilitation.		

NOTE:
[1] Management Plan, Program or System also required to satisfy Commonwealth Environmental Conditions as prescribed in EPBC Reference: 2003/1294.

15.5 Proposed Environmental Conditions

The Revised Proposal is not expected to pose any significant new or additional risks to the biodiversity and physical environment values of Barrow Island and its waters over that already approved. Consequently, the GJVs consider that the existing Environmental Conditions prescribed for the Approved Development apply equally to the Revised Proposal and that they will be adequate and capable of addressing any new and/or additional environmental impacts associated with the Revised Proposal. The GJVs contend that it is not necessary to prescribe any different and/or additional conditions for the Revised Proposal for those environmental factors already covered by the Environmental Conditions in Statement No. 748 and EPBC Reference: 2003/1294 for the Approved Development. Therefore, the GJVs propose that the same Environmental Conditions prescribed in Statement No. 748 and EPBC Reference: 2003/1294 should be used in their entirety to form the new set of Environmental Conditions for the Gorgon Gas Development.

The GJVs propose that the only changes required to Statement No. 748 as a result of the Revised Proposal will relate to Schedule 1 (which describes the proposal) and Schedule 5 (which prescribes the geographic location of the impacts associated with the construction of the Revised Proposal's Marine Facilities – note, though, that the total area of disturbance as limited in condition 18 does not change). It is proposed that a new State Ministerial Implementation Statement with the same conditions be issued to supersede Statement No. 748, and that the new Statement apply to the entire Gorgon Gas Development (which includes the Revised Proposal) which has been the subject of environmental impact assessment documents and EPA Bulletins.

The GJVs contend that Conditions of Approval for the Revised Proposal consistent with the existing Commonwealth Environmental approval (prescribed in EPBC Reference: 2003/1294) would be suitable to manage the potential environmental impacts. ..

A summary of the relevance of the existing Environmental Conditions of the Commonwealth and State approvals to the scope and environmental aspects of Revised Proposal is presented in Appendix H. It is recognised that the Revised Proposal will be subject to new Ministerial approvals under both the State and Commonwealth environmental approval processes, and therefore the associated implementation conditions are yet to be set.

16.0 CONCLUSION

This PER and associated appendices make reference to both the Approved Gorgon Gas Development and the Revised Gorgon Gas Development, which is the subject of this PER. For clarification purposes, the following definitions are provided:

- "the Approved Gorgon Gas Development" or "the Approved Development" refers to the development proposed in the EIS/ERMP (Chevron Australia 2005a) and subsequently approved under Statement No. 748 and EPBC Reference: 2003/1294
- "the Gorgon Gas Development Revised and Expanded Proposal" or "the Revised Gorgon Gas Development" or "the Revised Proposal" refers to the development proposed in this PER, which is yet to gain approval
- "the Gorgon Gas Development" refers to the entire proposal. This descriptor may be used when the reference is being made to elements of "the Revised Proposal" described in the PER when they replace the elements of "the Approved Development" which have changed to create the final product as proposed in this PER.

16.1 Environmental Outcomes

The major environmental issues investigated during the environmental assessment process for the Revised Proposal were:

- additional and/or new impacts to biodiversity and conservation values of Barrow Island and its surrounding waters
- quarantine management
- cumulative air, light and noise emissions
- accelerated rate of disposal of reservoir CO_2 by injection into the Dupuy Formation.

The Revised Proposal is not expected to pose any significant new or additional risks to the biodiversity and physical environment values of Barrow Island and its waters over that already approved. Furthermore, there are no unacceptable cumulative impacts to the biodiversity and physical environment values of Barrow Island and its waters as a result of the Gorgon Gas Development. In summary, the Revised Proposal will:

- increase the long term utilisation of approximately 40 ha of the available 300 ha over and above the initial land use estimate for the Approved Development. This is not expected to pose any significant new or additional risks to the terrestrial and subterranean values of Barrow Island in comparison to the Approved Development. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to the terrestrial and subterranean environment of Barrow Island (discussed in Section 6) are met. Best practice management measures will be fully documented in a 'Terrestrial and Subterranean Environmental Protection Plan', which requires approval from State and Commonwealth governments as outlined in Section 14.4.
- increase the area of seabed disturbance and cause a minor increase in the area of the seabed permanently covered by marine infrastructure, noting that some of this additional area would have been subject to disturbance from the LNG Jetty (as part of the Approved Development). This is not expected to pose any significant new or additional risks to the marine values of Barrow Island in comparison to the Approved Development. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to seabed disturbance (discussed in Section 7) are met. The best practice management measures will be fully documented in a 'Marine Facilities Construction Environmental Management

Plan', which requires approval from State and Commonwealth governments as outlined in Section 14.4.

- result in an altered dredge plume footprint in comparison to the Approved Development, which is comparable in duration and extent to the Approved Development. This is not considered to pose any significant new or additional risks to benthic primary producers in comparison to the Approved Development. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to marine water and sediment quality (discussed in Section 7) are met. Best practice management measures will be fully documented in a 'Dredge and Spoil Disposal Management and Monitoring Plan', which requires approval from State and Commonwealth governments as outlined in Section 14.4.
- have no significant new or additional risks to the marine environment and coastal processes (which are restricted to changes in the seabed profile) in comparison to the Approved Development. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to the marine environment and coastal processes (discussed in Section 7) are met. Best practice management measures will be fully documented in a 'Marine Facilities Construction Environmental Management Plan' and a 'Coastal Stability Management and Monitoring Plan', which require approval from State and Commonwealth governments as outlined in Section 14.4.
- increase (marginally) ground level concentrations of air emissions both on Barrow Island and on the mainland in the vicinity of the Burrup Peninsula. The relative increase in regional concentrations of specific emissions is not significant, and the air quality objective will be achieved in the region and locally. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to air emissions (discussed in Section 9) are met. Best practice management measures will be fully documented in an 'Air Quality Management Plan', which requires approval from State and Commonwealth governments as outlined in Section 14.4.
- increase (marginally) light and noise emissions, although the effects of these emissions are not expected to extend further or affect new areas that were not identified as being affected by the Approved Development. These emissions are not expected to pose any significant new or additional risks to the terrestrial or marine values of Barrow Island in comparison to the Approved Development. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to light and noise emissions (discussed in Sections 10 and 11 respectively) are met. Best practice management measures will be fully documented in a 'Terrestrial and Subterranean Environmental Protection Plan' and a 'Marine Facilities Construction Environmental Management Plan', which require approval from State and Commonwealth governments as outlined in Section 14.4.
- increase the rate of reservoir CO_2 injection, with this management response demonstrating a significant "beyond no regrets" action to reduce greenhouse gas emissions. The accelerated rate of reservoir CO_2 injection is not expected to pose any significant new or additional risks in comparison to the Approved Development. Best practice management measures will be implemented to limit the associated impacts and ensure EPA objectives relevant to greenhouse gas emissions (discussed in Section 12) are met. The best practice management measures will be fully documented in a 'Greenhouse Gas Abatement Program, which requires approval from State and Commonwealth governments as outlined in Section 14.4.
- have no significant new or additional risks to the matters of NES in comparison to the Approved Development. Best practice management measures will be implemented to limit the potential impacts on matters of NES (discussed in Section 13). Best practice management measures will be fully documented in the relevant

management plans listed in Section 14.4, which require approval from State and Commonwealth governments.

The implementation of various plans, systems and programs consistent with those required under conditions prescribed for the Approved Development in Statement No. 748 and Commonwealth EPBC Reference: 2003/1294 is expected to manage the impacts associated with the Revised Proposal to a level consistent with that considered acceptable and therefore approved for the Approved Development. No additional measures or controls are anticipated to be necessary to manage the potential environmental impacts of the Revised Proposal.

16.2 Environmental Risks and Manageability

The approach taken in this environmental review has been based on a risk assessment approach to characterise environmental factors, determine potential impacts and develop avoidance and mitigation measures.

The GJVs have extensive experience in managing the development, operation and environmental compliance of similar projects and this experience is anticipated to lead to a greater certainty in achieving desirable environmental outcomes.

The environmental aspects of the Revised Proposal will be primarily managed through:

- implementation of the various Gorgon Gas Development environmental plans, programs and systems
- Chevron Australia's Operational Excellence Management System (which fully addresses and, in some respects, goes beyond ISO 14001: 2004)
- relevant environmental licences that will be required
- implementation of the other environmental conditions that will apply to the Revised Proposal.

This process will be greatly assisted by the establishment of three subject matter Expert Panels, as required by the conditions prescribed in Statement No. 748 (Appendix A), that will provide advice to both the GJVs and the Western Australian Minister for the Environment.

Furthermore, the environmental undertakings described in Section 15.3, and the indexed Net Conservation Benefits described in Section 15.2, are applicable and relevant to the Revised Proposal, and the GJVs consider that they adequately address the significant residual environmental risks of the Revised Proposal.

The GJVs have consulted with relevant stakeholders to scope the potential impacts of the Revised Proposal and to determine the significance of environmental issues and the level of mitigation required. This process substantially improves the likelihood that all significant environmental issues have been identified, investigated and avoided or mitigated as far as reasonably practicable.

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18.0 SHORT TITLES AND ACRONYMS

The table below sets out the short titles and acronyms used in this document.

Short Titles and Acronyms	Long Title
AGRU	Acid Gas Removal Unit
ALARP	As low as reasonably practicable
ANZECC	Australian and New Zealand Environment and Conservation Council
APCDC	Asia Pacific Partnership on Clean Development and Climate
APPEA	Australian Petroleum Production and Exploration Association
Approved Development	Approved Gorgon Gas Development
AQIS	Australian Quarantine Inspection Service
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ABU	Australasia Strategic Business Unit
AS/NZ	Australia/New Zealand
AS/NZS	Australia/New Zealand Standard
AEC	Australian Environment Council
bbl	Barrel (approximately 200 L)
BOG	Boil Off Gas
BP	Before Present
BPP	Benthic Primary Producers
BPPH	Benthic Primary Producers Habitat
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CALM Act	West Australian Conservation and Land Management Act 1984
CAMBA	China Australia Migratory Birds Agreement
CCIWA	Chamber of Commerce and Industry Western Australia
°C	Degrees Celsius
Chevron Australia	Chevron Australia Pty Ltd
CLT	Cumulative Loss Threshold
CHMP	Cultural Heritage Management Plan
CMEWA	Chamber of Minerals and Energy Western Australia
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CO	Carbon Monoxide
CSIRO	[Australian] Commonwealth Scientific and Industrial Research Organisation
dB(A)	Noise level measured in decibels with A-weighting system
dB(C)	Noise level measured in decibels with C-weighting

Short Titles and Acronyms	Long Title
	system
DEC	Western Australian Department of Environment and Conservation
CSLF	Carbon Sequestration Leadership Forum
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts
DIA	Western Australian Department of Indigenous Affairs
DISPMOD	Gaussian Plume Modelling System
DLN	Dry Low Nitrogen Oxides
DMA	Decision Making Authority
DNA	Deoxyribonucleic Acid
DoIR	Western Australian Department of Industry and Resources
DPI	Western Australian Department for Planning and Infrastructure
DRET	Commonwealth Department of Resources, Energy and Tourism
DRF	Declared Rare Flora
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme
eNGO	Environmental Non-Government Organisation
EMP	Environmental Management Plan
EPA	Western Australian Environmental Protection Authority
EP Act	Western Australian Environmental Protection Act 1986
EPA SU	Western Australian Environmental Protection Authority Service Unit
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EQC	Environmental Quality Criteria
ESD	Ecologically Sustainable Development
ESE	Environmental, Social and Economic
FEED	Front End Engineering and Design
GDA94	Geocentric Datum of Australia 1994
GDW1	Gorgon Data Well 1
GEMS	Global Environmental Modelling Systems
GJVs	Gorgon Joint Venturers
ha	Hectare
HDD	Horizontal Directional Drilling
HES	Health, Environment and Safety
H_2S	Hydrogen Sulphide
IMS	Impact Mitigation Strategy
ISO	International Organization for Standardization
IUCN	International Union for Conservation and Natural

Short Titles and Acronyms	Long Title
	Resources
ISQG	Interim Sediment Quality Guideline
JAMBA	Japan Australia Migratory Birds Agreement
JIP	Joint Industry Program
JVP	Joint Venture Partner
kg	Kilogram
kg/ha	Kilogram per hectare
km	Kilometre
km/hr	Kilometre per hour
L	Litre
LA_1:	A noise level that is not to be exceeded for more than 1% of the time.
LA_{10}:	Light Attenuation Coefficient
LAC	A noise level that is not to be exceeded for more than 10% of the time
LAmax:	A noise level that is not to be exceeded at any time.
LAeq	The Equivalent Continuous Sound Level, which is the level of a notional steady sound, that at a given position and over a defined period of time would have the same A-weighted acoustic energy as the fluctuating noise.
LAT	Lowest Astronomical Tide
LHV	Low heating value
LNG	Liquefied Natural Gas
m	Metre
mm	millimetre
m/s	Metres per second
m^2	Square metre
m^3	Cubic metre
µg/L	Microgram per litre
$µg/m_3$	Microgram per cubic metre
mg/cm^2	Milligram per square metre
mg/L	Milligram per litre
mg/m^3	Milligram per cubic metre
MARPOL	International Convention for the Prevention of Pollution from Ships
MDEA	methyl-diethanolamine
MDF	Marine Disturbance Footprint
MEB	Marine Ecology Branch (EPA SU) (WA)
MGA94	Map Grid of Australia 1994
MIS	Ministerial Implementation Statement
MOF	Materials Offloading Facility
MPa	Megapascal

Short Titles and Acronyms	Long Title
MSDS	Material Safety Data Sheet
MTEP	Marine Turtle Expert Panel
MTPA	Million Tonnes Per Annum
MW	Megawatt
N/A	Not Applicable
NavSim	Navigation Simulations
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NES	Matters of National Environmental Significance as defined by the EPBC Act
NGER Act	Commonwealth National Greenhouse and Energy Reporting Act 2007
NGO	Non-Government Organisation
NHMRC	National Health and Medical Research Centre
NIS	Non-indigenous Species
nm	Nautical Mile
NOx	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NOHSC	National Occupational Health and Safety Council
O_3	Ozone
ODAC	Western Australian Office of Development Approvals Coordination
OE	Operational Excellence
OEMS	Operational Excellence Management System
OSCP	Oil Spill Contingency Plan
PAH	Polycyclic Aromatic Hydrocarbon
PEC	Priority Ecological Community
PER	Public Environmental Review
PM_{10}	Particulate Matter of 10 Micrometres or Less
ppm	Parts per Million
QAC	Quarantine Advisory Committee
QAP	Quarantine Approved Premises
QEP	Quarantine Expert Panel
QHAZ	Quarantine Hazard Analysis
QMS	Quarantine Management System
RAMSAR	The Convention on Wetlands of International Importance
Revised Proposal	Gorgon Gas Development Revised and Expanded Proposal
RO	Reverse Osmosis
ROKAMBA	Republic of Korea Australia Migratory Birds Agreement
SAA	Australian Standards Australia
SOx	Oxides of Sulphur

Short Titles and Acronyms	Long Title
SO_2	Sulphur Dioxide
SRE	Short Range Endemic
SWQMS	State Water Quality Management Strategy
t	Tonne
TAPM	The Air Pollution Model
TBT	Tributyltin
TDF	Terrestrial Disturbance Footprint
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TPA	Tonnes per Annum
TP	Total Phosphorus
TSS	Total Suspended Solids
TVDss	Total Vertical Depth Sub-sea
VOC	Volatile Organic Compound
$\mu g/m^3$	Milligrams per Cubic Metre
UWA	University of Western Australia
WA	Western Australia
WHO	World Health Organisation
WHRU	Waste Heat Recovery Unit
Wildlife Act	Western Australian Wildlife Conservation Act 1950
WMP	Weed Management Plan
WWF	World Wide Fund for Nature
2D	Two Dimensional

19.0 DEFINITIONS

"As far as practicable", "to the extent practicable", "where practicable" and "practicable" all mean reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge.

Average Net Detectable Mortality - Average Net Detectable Mortality of coral is the result of averaging the Net Detectable Mortality of all Monitoring Sites within the Zone, i.e. the mean of Net Detectable Mortality of any Zone.

Barrow Island Industry Participants – The Gorgon Joint Venture Participants, the Barrow Island Joint Venture Participants and any other future Industry Participant.

Behavioural Impact – Disruption of established behavioural patterns affecting reproductive or survival success.

Best Practicable Measures - Has the meaning as defined in Western Australian Environmental Protection Authority Guidance Statement No 55 (2003)

Consequence – The implication of the impact (as defined).

Coral Mortality definitions

Direct loss is defined as permanent removal of Benthic Primary Producer Habitat (BPPH) substrate and mortality of coral.

Indirect loss is defined as mortality of coral with no removal BPPH. BPPH may return at some future time, but this will be dependent upon the condition of the substrate and successful recruitment.

The Change in coral mortality is determined by subtracting the baseline extent of Gross coral mortality from the extent of Gross coral mortality measured on a sampling occasion.

Net detectable coral mortality at a monitoring location is the result of subtracting the Change in coral mortality at the Reference Site from the Change in coral mortality at that Monitoring Site.

Average Net detectable coral mortality is the result of averaging the net mortality of all monitoring locations within the Zone i.e. the mean of net mortality of any Zone.

Gross coral mortality at a site is expressed as a percentage of total coral cover at the time of sampling at that monitoring location.

In determining the coral loss, measurement uncertainty is to be taken into consideration.

Construction – Construction includes any Proposal-related construction and commissioning activities within the Terrestrial and Marine Disturbance Footprints, excluding investigatory works such as, but not limited to, geotechnical, geophysical, biological and cultural heritage surveys, baseline monitoring surveys and technology trials.

Construction Period - The period from the date on which the Gorgon Joint Venturers first commence construction of the Proposal until the date on which the Gorgon Joint Venturers issue a notice of acceptance of work under the EPCM, or equivalent contract entered into in respect of the second LNG train of the Gas Treatment Plant.

Decrease in abundance – Loss of individual animals/plants.

Deep wells (in the context of liquid waste disposal) – refer to injection wells completed in the Barrow Group (a well defined geological formation approximately 1 000 – 1 800m below the surface).

Dominant coral species – species with the highest relative percentage cover. Percentage cover is expressed as the proportion of total coral cover.

Disposal of carbon dioxide (CO2) underground – an activity conducted pursuant to Part 4 section 13 and Clauses 7, 8 and 9 of Schedule 1 of the *Barrow Island Act 2003* (WA).

Disruption – Interruption to the flow or continuity of biological processes and/or behaviour.

Ecological Community – refers to all the interacting organisms living together in a specific habitat.

EIS/ERMP - the Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Development dated September 2005 as amended or supplemented from time to time.

Endemic – Unique to an area; found nowhere else.

Environmental Harm - has the meaning given by Part 3A of the *Environmental Protection Act 1986 (WA)*

Greenhouse gas abatement 'Beyond No Regrets Measures' – are measures that involve additional costs to the Proposal which are unlikely to be recovered

Greenhouse gas abatement 'No Regrets Measures' – are measures that are cost-neutral and do not add additional cost to the Proposal.

Hazard – A source of potential harm, or a situation with a potential to cause loss or adverse effect. Hazard has the same meaning as 'threat'.

Impact – Direct interaction of a stressor with the environment.

Impact on population - Decrease in abundance beyond natural variation in population size.

Immediate region – For aspects of the Gorgon Gas Development on Barrow Island or within the marine conservation reserves: Barrow Island, Lowendal Islands and Montebello Islands. For aspects of the Gorgon Gas Development offshore of Barrow Island: Pilbara Offshore Region. For aspects of the Gorgon Gas Development between Barrow Island and mainland: Pilbara Nearshore Region. For aspects of the Gorgon Gas Development on the mainland: Pilbara.

Introduced Terrestrial Species - non-indigenous terrestrial species (including weeds).

Likelihood – The probability of a stressor impacting on the key receptors.

Listed marine fauna – marine fauna that are included on lists of threatened species (State, Federal or International).

Local – Impacts restricted to the area directly affected by the Gorgon Gas Development and the immediate vicinity of the Gorgon Gas Development.

Long-term – Greater than five years.

Lux – a unit of measure of illuminance and luminous emittance.

Marine Disturbance Footprint – the area of the seabed to be disturbed by construction or operations activities associated with the Marine Facilities listed in Condition 14.3 (excepting that area of the seabed to be disturbed by the generation of turbidity and sedimentation from dredging and dredge spoil disposal).

Marine Pests – Species other than the native species known or those likely to occur in the waters of the Indo-West Pacific region and the Pilbara Offshore (PIO) marine bioregion in Interim Marine and Coastal Regionalisation for Australia: An Ecosystem Based Classification for Marine and Coastal Environments (IMCRA, 1997), of which

Barrow Island is a part, that do or may threaten biodiversity in the Pilbara Offshore (PIO) marine bioregion. As a minimum, the National Introduced Pest Information System Database (NIMPIS, Dept Environment and Water Resources, Commonwealth Government), National Priority Pests listed in the document National Priority Pests, Part II, Ranking of Australian Marine Pests (CSIRO Marine Research, 2005) will guide the interpretation of this definition. Additional species may be added on the advice of experts from the WA Department of Fisheries and the Quarantine Expert Panel.

Marine Quarantine Controlled Access Zone – The zone that extends from 500m offshore from the Barrow Island MHHW mark and encapsulates the entire coastline of Barrow Island. The zone also extends 500m from all marine facilities contiguous with Barrow Island.

Marine Quarantine Limited Access Management Zone – The zone that commences at the outer boundary approximately 2.5 km from the Barrow Island shoreline (MHHW Mark) up to the 500 metre mark from the shoreline.

Marine Turtles – Refers to flatback, green and hawksbill turtles nesting on Barrow Island.

Material Environmental Harm – means environmental harm that is neither trivial nor negligible.

Minister – WA Minister for the Environment

Non-indigenous terrestrial species - Any species of plant, animal or micro-organism not native to Barrow Island. (Native - species that are native to (naturally occurring in) a region. (Reference: State of the Environment Advisory Council (1996). Australia: State of the Environment 1996)

Operations – for the respective LNG trains, this is the period from the date on which the Gorgon Joint Venturers issue a notice of acceptance of work under the Engineering, Procurement and Construction Management (EPCM) contract, or equivalent contract entered into in respect of that LNG train of the Gas Treatment Plant; until the date on which the Gorgon Joint Venturers commence decommissioning of that LNG train.

Population – A group of organisms of the same species occupying an area.

Population viability – The ability of a group of organisms (occupying an area) to survive in that area.

Porites – An important genus of long-lived, reef building corals.

Receptor – An ecological entity (e.g. species, population, community or habitat) exposed to a stressor.

Reduced viability – Reduced ability of a population to persist through time.

Region – Pilbara.

Reservoir Carbon Dioxide - a gas stream that consists overwhelmingly of carbon dioxide and coming from the acid gas removal units of the Gas Treatment Plant to be located on Barrow Island. The carbon dioxide will contain incidental associated substances derived from the natural gas and the process used to separate the carbon dioxide from that natural gas.

Reservoir Carbon Dioxide Injection System – the mechanical components required to be constructed to enable the injection of reservoir carbon dioxide, including but not limited to compressors, pipelines and wells.

Restricted and significant marine benthic primary producer communities – benthic primary producer communities that are of high ecological value and are of high conservation value due to their limited representation in the local area or region

Serious Environmental Harm - means environmental harm that:

a. is irreversible, of a high impact or on a wide scale
b. is significant or in an area of high conservation value or special significance and is neither trivial nor negligible.

Short-Range Endemics - Taxonomic group of invertebrates that are unique to an area; found nowhere else and have naturally small distributions (i.e. <10 000km^2)

Short-term – Less than five years.

Species viability – The ability of the species to persist over time.

Statistical Power - The probability of detecting a meaningful difference, or effect, if one were to occur.

Stressor – A source of potential harm or a situation with the potential to cause loss or adverse effect.

Sub-dominant coral species – species, excluding Dominant coral species, which have greater than or equal to 5% cover. Percentage cover is expressed as the proportion of total coral cover.

Substantially Commenced - physical construction activities for, and progress of an important or essential element(s) of the Proposal scope.

Terrestrial Disturbance Footprint – the area to be disturbed by construction or operations activities associated with the terrestrial facilities listed in Condition 6.3.

Terrestrial Quarantine Controlled Access Zone – The zone encompassing the following points of entry to Barrow Island:

a. Quarantine Approved Premises (marine offloading facility, warehouse, remedial facility, quarantine washdown bay and first stage laydown)
b. Airport
c. WAPET Landing.

Terrestrial Quarantine Limited Access Management Zone – The Zone encompassing areas of the Terrestrial Disturbance Footprint which are used for intensive, long-term development activities on Barrow Island:

a. Gas Treatment Plant
b. Construction Village and Barrow Island Oil Joint Venture Camp
c. Administration and Operations Complex
d. Onshore Feed Gas Pipeline System and Carbon Dioxide Injection System corridors

Widespread – Impacts extending to areas well-outside the direct impact zone from the Gorgon Gas Development.

Gorgon Gas Development Revised and Expanded Proposal

Gorgon Gas Development Revised and Expanded Proposal