Gorgon Gas Development and Jansz Feed Gas Pipeline:

Terrestrial and Subterranean Baseline State and Environmental Impact Report

Document No:	G1-TE-H-0000-REPX027	Revision:	3 Amendment 1
Revision Date:	24 June 2014	Copy No:	
IP Security:	Public		

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Terms, Definitions and Abbreviations

Terms, definitions and abbreviations used in this document are listed below. These align with the terms, definitions and abbreviations defined in Schedule 2 of the Western Australian Gorgon Gas Development and Jansz Feed Gas Pipeline Ministerial Implementation Statements No. 800 and No. 769 respectively (Statements No. 800 and 769) and the Commonwealth Gorgon Gas Development and Jansz Feed Gas Pipeline Ministerial Approvals (EPBC Reference: 2003/1294, 2008/4178, and 2005/2184).

°C	Degrees Celsius
Abiotic	Non-living chemical and physical factors in the environment.
ABU	Australasia Business Unit
Additional Support Area	Gorgon Gas Development Additional Construction, Laydown, and Operations Support Area
Aeolian	Deposited or formed by wind, such as dunes.
AHD	The Australian Height Datum (AHD) is a geodetic datum for altitude measurement in Australia; it is the agreed sea level.
ALS	Airborne Laser Scanning
API	Assessment on Proponent Information
ARI	Assessment on Referral Information (for the proposed Jansz Feed Gas Pipeline dated September 2007) as amended or supplemented from time to time
AS/NZS	Australian Standard/New Zealand Standard
ASBU	Australasia Strategic Business Unit
At Risk	Being at risk of Material Environmental Harm or Serious Environmental Harm and/or, for the purposes of the EPBC Act relevant listed threatened species, threatened ecological communities and listed migratory species, at risk of Material Environmental Harm or Serious Environmental Harm.
Avifauna	Birds of a particular region
Biotic	Of or relating to living organisms
BTEX	Benzene, toluene, ethylbenzene, and xylene—primary toxins of soils and groundwater associated with petroleum products.
CAMBA	China–Australia Migratory Bird Agreement
Carbon Dioxide (CO_2) 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.
CH_4	Methane

cm	Centimetre
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Commonwealth Marine Areas	Zoned areas of waters of the sea, the seabed and the airspace above the waters of the sea, defined under section 24 of the EPBC Act (Cth).
Construction	Construction includes any Proposal-related (or action-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.
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth of Australia
dB	Decibel; a unit to measure sound
DBNGP	Dampier to Bunbury Natural Gas Pipeline
DCA	Detrended Correspondence Analysis
DEC	Former Western Australian Department of Environment and Conservation (now DPaW and/or DER)
DER	Western Australian Department of Environment Regulation (formerly DEC)
DEWHA	Former Commonwealth Department of the Environment, Water, Heritage and the Arts (now DotE)
DLN	Dry Low NO_x
DNA	Deoxyribonucleic Acid
Doline	A small to medium-sized closed depression, a few metres to a few hundred metres in diameter and depth, formed by one of several processes. Collapse doline forms when a cavity is hollowed out below the surface by dissolution of carbonate rocks and subsequently collapses. Subsidence doline is formed when thin cover of carbonate rocks collapse into an underlying dissolved cavity.
DomGas	Domestic Gas
DotE	Commonwealth Department of the Environment (formerly DEWHA and SEWPaC)
DPaW	Western Australian Department of Parks and Wildlife (formerly DEC)

DRF	Declared Rare Flora has the meaning given by the *Wildlife Conservation Act 1950* (WA).
DTM	Digital Terrain Model
Ecological Community	Refers to all the interacting organisms living together in a specific habitat.
Ecological Element	Element listed in Condition 6.1 of Statement No. 800 and Statement No. 769 and Condition 5.1 EPBC Act Reference 2003/1294 and 2008/4178.
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme (for the Proposed Gorgon Development dated September 2005) as amended or supplemented from time to time
Elliott Trap	Small aluminium traps with a pedal inside. When the animal steps on the pedal, it closes the trap door behind the animal. Elliott traps are most commonly used to capture small species such as marsupial mice.
Environmental Harm	Has the meaning given by Part 3A of the *Environmental Protection Act 1986* (WA).
EP Act	Western Australian *Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPBC Reference: 2003/1294	Commonwealth Ministerial Approval (for the Gorgon Gas Development) amended or replaced from time to time
EPBC Reference: 2005/2184	Commonwealth Ministerial Approval (for the Jansz Feed Gas Pipeline) as amended or replaced from time to time.
EPBC Reference: 2008/4178	Commonwealth Ministerial Approval (for the Revised Gorgon Gas Development) as amended or replaced from time to time.
EPCM	Engineering, Procurement and Construction Management
Flyrock	Material projected outside the declared danger zone by a blast.
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System
GL	Gigalitre
Gorgon Gas Development	The Gorgon Gas Development as approved under Statement Nos. 800 and 965, and EPBC References: 2003/1294 and 2008/4178 (as varied by the Commonwealth Environment Minister), as amended or replaced from time to time.

Gorgon Gas Development Footprint	Consists of the cleared areas and uncleared areas approved to be cleared on Barrow Island used for the construction and operation of the Gorgon Gas Development and Jansz Feed Gas Pipeline.
GPS	Global Positioning System
Ground Truth	To verify the correctness of remote sensing information by use of ancillary information such as field studies.
H_2S	Hydrogen Sulfide
ha	Hectare
Habitat	The area or areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography) and the biotic factors.
Halocline	A strong, vertical salinity gradient; the (sometimes indistinct) border between layers of water that contain different amounts of salt.
HDD	Horizontal Directional Drilling
Herpetofauna	Amphibians and reptiles.
HES	Health, Environment and Safety
Infauna	Benthic fauna (animals) living in the substrate and especially in a soft sea bottom.
Invertebrate Fauna	Animals that do not have a backbone (vertebrae). Examples include, but are not limited to, spiders, scorpions, land snails, millipedes and some subterranean fauna.
ISO	International Organization for Standardization
JAMBA	Japan–Australia Migratory Bird Agreement
Jansz Feed Gas Pipeline	The Jansz Feed Gas Pipeline as approved in Statement No. 769 and EPBC Reference 2005/2184 as amended or replaced from time to time.
Karst	An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.
kg	Kilogram
km	Kilometre
L	Litre
Littoral	A shore; the zone between high tide and low tide; of, or related to the shore, especially the seashore.
LNG	Liquefied Natural Gas

Lux	A standard for measuring light; equal to the amount of visible light per square metre incident on a surface. 1 lux = 1 lumen/square metre or 0.093 foot-candles.
m	Metre
m/s	Metres per second
m^3	Cubic metre
Macroalgae	Algae which can be seen easily, without using a microscope; includes large seaweeds.
Management Triggers	Are quantitative, or where this is demonstrated to be not practicable, qualitative matters above or below whichever relevant additional management measures must be considered.
Mangrove	Any of various tropical evergreen trees or shrubs that grow in shallow coastal water.
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 of Statement No. 800, Condition 12.3 of Statement No. 769, and Condition 11.3 of EPBC Reference: 2003/1294 and 2008/4178 (excepting that area of the seabed to be disturbed by the generation of turbidity and sedimentation from dredging and dredge spoil disposal) as set out in the Coastal and Marine Baseline State Report required under Condition 14.2 of Statement No. 800, Condition 12.2 of Statement 769, and Condition 11.2 of EPBC Reference: 2003/1294 and 2008/4178
Marine Facilities	In relation to Statement No. 800 and EPBC Reference 2003/1294 and 2008/4178, the Marine Facilities are the: • Materials Offloading Facility (MOF) • LNG Jetty • Dredge Spoil Disposal Ground • Offshore Feed Gas Pipeline System and marine component of the shore crossing • Domestic Gas Pipeline For the purposes of Statement No. 800, Marine Facilities also include: • Marine upgrade of the existing WAPET landing. In relation to Statement No. 769, Marine Facilities are the Offshore Feed Gas Pipeline System and marine component of the shore crossing.
Material Environmental Harm	Means Environmental Harm that is neither trivial nor negligible.
mg	Milligram

mg/L	Milligrams per litre
MGA 50, GDA94	Map Grid of Australia Zone 50 (WA); projection based on the Geocentric Datum of Australia 1994.
Migratory Species	Species listed as migratory under section 209 of the EPBC Act (Cth).
mm	Millimetre
MOF	Materials Offloading Facility
MTPA	Million Tonnes Per Annum
MW	Megawatt
Native	In relation to non-indigenous species means species that are naturally occurring in a region.
NES	National Environmental Significance
NIS	Non-indigenous Species
Non-indigenous Species (NIS)	Any species of plant, animal or micro-organism not native to Barrow Island.
NO_x	Nitrogen oxides (NO and NO_2)
NTU	Nephelometric Turbidity Unit
NVIS	National Vegetation Information System
OE	Operational Excellence
OEMS	Operational Excellence Management System
Onshore Domestic Gas Pipeline ROW	The Onshore Domestic Gas Pipeline ROW is the strip of land that runs along the onshore (intertidal) pipeline alignment that encompasses the pipelines, trenches, access tracks, stockpiles and associated features and in which the pipeline construction activities will be completed.
Operations (Gorgon Gas Development)	In relation to Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178, 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.

Operations (Jansz Feed Gas Pipeline)	In relation to Statement No. 769, for the pipeline, this is the period from the date on which the Proponent issues a notice of acceptance of work under the Engineering, Procurement and Construction Management (EPCM) contract, or equivalent contract entered into in respect of that pipeline; until the date on which the Proponent commences decommissioning of that pipeline.
PEC	Priority Ecological Community
PER	Public Environmental Review for the Gorgon Gas Development Revised and Expanded Proposal dated September 2008, as amended or supplemented from time to time.
Performance Standards	Are matters which are developed for assessing performance, not compliance, and are quantitative targets or where that is demonstrated to be not practicable, qualitative targets, against which progress towards achievement of the objectives of conditions can be measured.
PGPA	Policy, Government and Public Affairs
pH	Measure of acidity or basicity of a solution
Pisolitic	Sedimentary rock containing spherical or subspherical concretions more than 2 mm in diameter.
Pitfall	A concealed pit prepared as a trap for animals.
PM10	The dust fraction with an aerodynamic diameter of less than 10 microns.
Practicable	Practicable means reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge. For the purposes of EPBC Reference: 2003/1294 and 2008/4178, which include the term 'practicable', when considering whether the plan meets the requirements of these conditions, the Commonwealth Minister will determine what is 'practicable' having regard to local conditions and circumstances including but not limited to personnel safety, weather or geographical conditions, costs, environmental benefit and the current state of scientific and technical knowledge.
Priority Flora	Priority flora is a non-legislative category aimed to manage those plant taxa listed by DPaW on the basis that they are known from only a few collections, or a few sites, but which have not been adequately surveyed. Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until such survey work has been undertaken.
QEP	Quarantine Expert Panel
Quadrat	A rectangle or square measuring area used to sample living things in a given site; can vary in size.

Red Fill	Dark reddish brown soil, rich in iron.
Revised Proposal	Proposal comprising potential changes to the Gorgon Gas Development as described in the Gorgon Gas Development Revised and Expanded Proposal PER.
RiskMan2	Chevron HES Risk Management Process
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
Serious Environmental Harm	Environmental harm that is: a. irreversible, of a high impact or on a wide scale; or b. significant or in an area of high conservation value or special significance and is neither trivial nor negligible.
SEWPAC	Former Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now DotE)
Short-Range Endemics (SREs)	Taxonomic group of invertebrates that are unique to an area, found nowhere else and have naturally small distributions (i.e. <10 000 km^2).
Significant Ecological Element	Those ecological elements, as specified in the Statement No. 800, that have been identified as important ecological elements in the vicinity of the Gorgon Gas Development Footprint based on reference to Section 3.1.2, which sets out the methodology for determining them, and Section 4 which specifies them.
Significant Impact	An impact on a Matter of National Environmental Significance, relevant to EPBC Act Reference: 2003/1294 2005/2185 and 2008/4178 that is important, notable or of consequence having regard to its context or intensity.
SO_2	Sulfur Dioxide
SRE	Short-range Endemic
Statement No. 865	Western Australian Ministerial Implementation Statement No. 865 (for the Gorgon Gas Development).
Statement No. 748	Western Australian Ministerial Implementation Statement No. 748 (for the Gorgon Gas Development) as amended from time to time [superseded by Statement No. 800].
Statement No. 769	Western Australian Ministerial Implementation Statement No. 769 (for the Jansz Feed Gas Pipeline) as amended or replaced from time to time.

Statement No. 800	Western Australian Ministerial Implementation Statement No.800, issued for the Revised and Expanded Gas Development, as amended from time to time. Statement No. 800 supersedes the Gorgon Gas Development as originally approved by Statement No 748. The conditions of Statement No.800 also apply to the Additional Support Area under Statement 965.
Statement No. 965	Western Australian Ministerial Implementation Statement No. 965, issued for the Additional Support Area, as amended from time to time. Statement No.965 applies the conditions of Statement 800 to the Additional Support Area.
Stressor	An environmental condition or influence that stresses (i.e. causes stress for) an organism.
Stygofauna	Groundwater-dwelling aquatic fauna.
Substrate	The surface a plant or animal lives upon. The substrate can include biotic or abiotic materials. For example, encrusting algae that lives on a rock can be substrate for another animal that lives above the algae on the rock.
Subterranean Fauna	Fauna which have adapted to subterranean conditions, including stygofauna and troglofauna.
TAPL	Texaco Australia Pty Ltd
TDF	Terrestrial Disturbance Footprint
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
Terminal Tanks	The existing Barrow Island Oilfield Operator's storage tanks located just north of the Gas Treatment Plant site.
Terrestrial Disturbance Footprint (TDF)	The area to be disturbed by construction or operations activities associated with the Terrestrial Facilities listed in Condition 6.3 of Statement No. 800, including the Additional Support Area approved by Statement No. 965, Condition 6.3 of Statement No. 769, and Condition 5.2 of EPBC Reference: 2003/1294 and 2008/4178, as set out in Section 6.0 of this Report.

Terrestrial Facilities	In relation to Statement No. 800 and EPBC Reference 2003/1294 and 2008/4178, the Terrestrial Facilities are the: • Gas Treatment Plant • Carbon Dioxide Injection System • Associated Terrestrial Infrastructure forming part of the Proposal • Areas impacted for seismic data acquisition • Onshore Feed Gas Pipeline System and terrestrial component of the Shore Crossing. Terrestrial Facilities also include those defined in Condition 6.3 of Statement No. 769 (the Onshore Feed Gas pipeline system and the terrestrial component of the Shore Crossing) and Schedule 1 of Statement No. 965 (the Additional Support Area).
Threatened Ecological Communities (TEC)	Ecological communities listed as critically endangered, endangered, or vulnerable, under section 181 of the EPBC Act (Cth).
Threatened Species	Species listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable, or conservation dependent under section 178 of the EPBC Act (Cth).
Transect	The path along which a researcher moves, counts and records observations.
Troglofauna	Obligate cave- or karst-dwelling terrestrial subterranean fauna occurring above the watertable.
UWA	University of Western Australia
Vagrant	A bird found outside its species' usual range
Vegetation	Any aquatic or terrestrial plant, whether it is dead or alive. Examples include, but are not limited to, grass, shrubs, trees, tree stumps, tree roots, logs, seeds and brush.
Vegetation Association	Comprises unique flora assemblages, or unique vegetation communities, that help to identify the association.
Vertebrate Fauna	Animals that have a backbone (vertebrae). Examples include, but are not limited to, mammals, reptiles, amphibians and birds.
Vibroesis	A method of seismic exploration. The seismic energy source (ground vibration controlled by shaking the mass of the vibroseis truck) is distributed over a time of several seconds.
VOC	Volatile Organic Compounds; organic chemical compounds that have high enough vapour pressures under normal conditions to vaporise and enter the atmosphere.
Voucher Specimen	A whole plant or animal (usually a cadaver) or a part thereof, that serves as a basis of study and is retained as a reference.

WA	Western Australia
WAPET	West Australian Petroleum Pty Ltd.
WAPET Landing	Proper name referring to the site of the barge landing existing on the east coast of Barrow Island prior to the date of Statement No. 800.

Executive Summary

This Report fulfils the requirements of Condition 6.1 of Ministerial Implementation Statement No. 800 (Statement No. 800), Condition 6.1 of Ministerial Implementation Statement No. 769 (Statement No. 769), and Condition 5.1 of EPBC Reference: 2003/1294 and 2008/4178.

This Report substantially updates and supplements material previously provided in both the Draft and Final Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the Gorgon Gas Development (Chevron Australia 2005, 2006), the Environmental Impact Statement/Assessment on Referral Information (ARI) (Mobil Australia 2005), and the Environmental Assessment for the Gorgon Gas Development Additional Construction, Laydown and Operations Support Area (Additional Support Area) (Chevron Australia 2013a). This Report includes substantial additional information for fauna (subterranean fauna and terrestrial invertebrates), habitat (Boodie warrens, termite mounds and raptor nests), ecological communities (subterranean fauna, drainage line vegetation and mangroves), groundwater (the superficial aquifer), and other landforms (caves, fossils, cliffs and gorges).

A total of 226 plant taxa have been confirmed on Barrow Island. The current known fauna assemblage of the Island consists of 15 mammals, 119 birds, 44 reptiles, one amphibian, at least 1261 terrestrial invertebrates, 58 subterranean invertebrates, and one subterranean fish.

The significant ecological elements identified for Barrow Island are 40 species of plants, 63 subassociations of vegetation, 149 species of fauna (seven mammals, three reptiles, 11 terrestrial invertebrates, 58 subterranean invertebrates, one subterranean fish and 68 birds), three types of habitat, two ecological communities, one groundwater aquifer, three types of surface water landforms, and seven types of physical landforms.

The terrestrial and subterranean matters of National Environmental Significance (NES) (as defined under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cth)) identified on Barrow Island are one fish and five mammals (listed as Threatened Species), and 68 bird species (listed as marine species or under migratory treaties). Five of these mammals and six of these birds are identified for targeted monitoring for impacts.

A total of 38 non-indigenous terrestrial species are documented as currently occurring on Barrow Island (19 weed species and 19 invertebrates).

The significant ecological elements, the extent of boundary effects of the area referred to as the Terrestrial Disturbance Footprint, and reference areas, are identified in this Report. Taking these into account during the development of this Report did not result in a significant change to the assessed risk presented in the Draft EIS/ERMP (Chevron Australia 2005).

The Onshore Domestic Gas Pipeline will be located and installed on Mardie Station on the mainland. Sixty-four fauna species (ten reptile species, 51 bird species and three mammal species) are expected in this vicinity. The only terrestrial and subterranean matters of NES observed in the vicinity are 11 bird species. The overall risk to conservation-significant fauna is low. The Australian Bustard (*Ardeotis australis*) and Rainbow Bee-eater (*Merops ornatus*) are the species of significance most likely to interact with the construction and operation of the pipeline and neither is expected to be significantly impacted.

The vegetation along the Onshore Domestic Gas Pipeline appears to be extensive and unfragmented, but largely degraded. Outside the coastal mangrove and samphire vegetation units, the pipeline does not cross any lakes or water bodies. The pipeline route is expected to be trenched to approximately 1.8 m deep.

1.0 Introduction

1.1 Proponent

Chevron Australia Pty Ltd (Chevron Australia) is the proponent and the person taking the action for the Gorgon Gas Development on behalf of the following companies (collectively known as the Gorgon Joint Venturers):

- Chevron Australia Pty Ltd
- Chevron (TAPL) Pty Ltd
- Shell Development (Australia) Pty Ltd
- Mobil Australia Resources Company Pty Limited
- Osaka Gas Gorgon Pty Ltd
- Tokyo Gas Gorgon Pty Ltd
- Chubu Electric Power Gorgon Pty Ltd

pursuant to Statement No. 800 and EPBC Reference: 2003/1294 and 2008/4178.

Chevron Australia is also the proponent and the person for taking the action for the Jansz Feed Gas Pipeline on behalf of the Gorgon Joint Venturers, pursuant to Statement No. 769 and EPBC Reference: 2005/2184.

1.2 Project

Chevron Australia proposes to develop the gas reserves of the Greater Gorgon Area (Figure 1-1).

Subsea gathering systems and subsea pipelines will be installed to deliver feed gas from the Gorgon and Jansz–Io gas fields to the west coast of Barrow Island. The feed gas pipeline system will be buried as it traverses from the west coast to the east coast of the Island where the system will tie in to the Gas Treatment Plant located at Town Point. The Gas Treatment Plant will comprise three Liquefied Natural Gas (LNG) trains capable of producing a nominal capacity of five Million Tonnes Per Annum (MTPA) per train. The Gas Treatment Plant will also produce condensate and domestic gas. Carbon dioxide (CO_2), which occurs naturally in the feed gas, will be separated during the production process. As part of the Gorgon Gas Development, Chevron Australia will inject the separated CO_2 into deep formations below Barrow Island. The LNG and condensate will be loaded from a dedicated jetty offshore from Town Point and then transported by dedicated carriers to international markets. Gas for domestic use will be exported by a pipeline from Town Point to the domestic gas collection and distribution network on the mainland (Figure 1-2).

1.3 Location

The Gorgon gas field is located approximately 130 km and the Jansz–Io field approximately 200 km off the north-west coast of Western Australia. Barrow Island is located off the Pilbara coast 85 km north-north-east of the town of Onslow and 140 km west of Karratha. The Island is approximately 25 km long and 10 km wide and covers 23 567 ha. It is the largest of a group of islands, including the Montebello and Lowendal Islands.

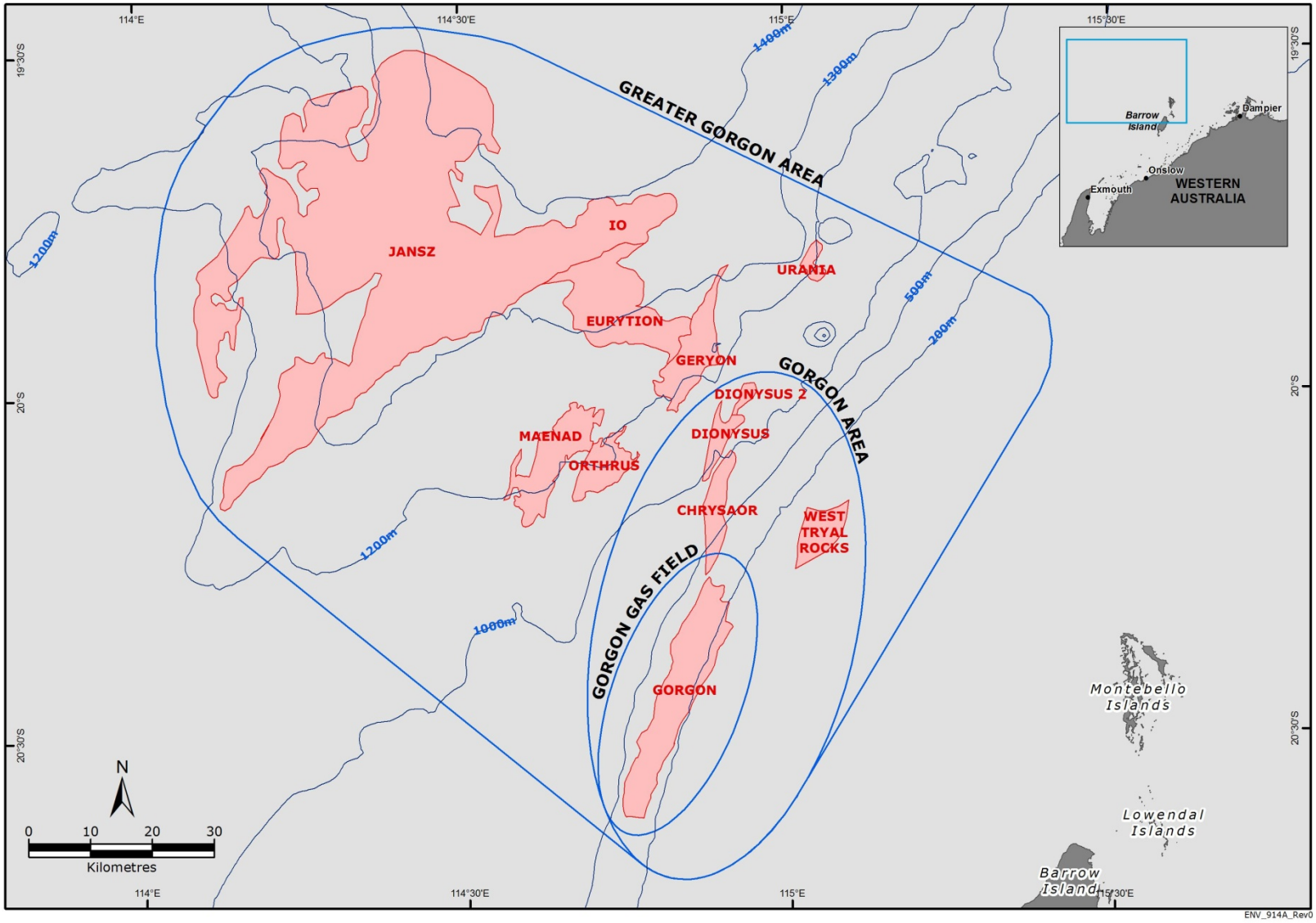


Figure 1-1 Location of the Greater Gorgon Area

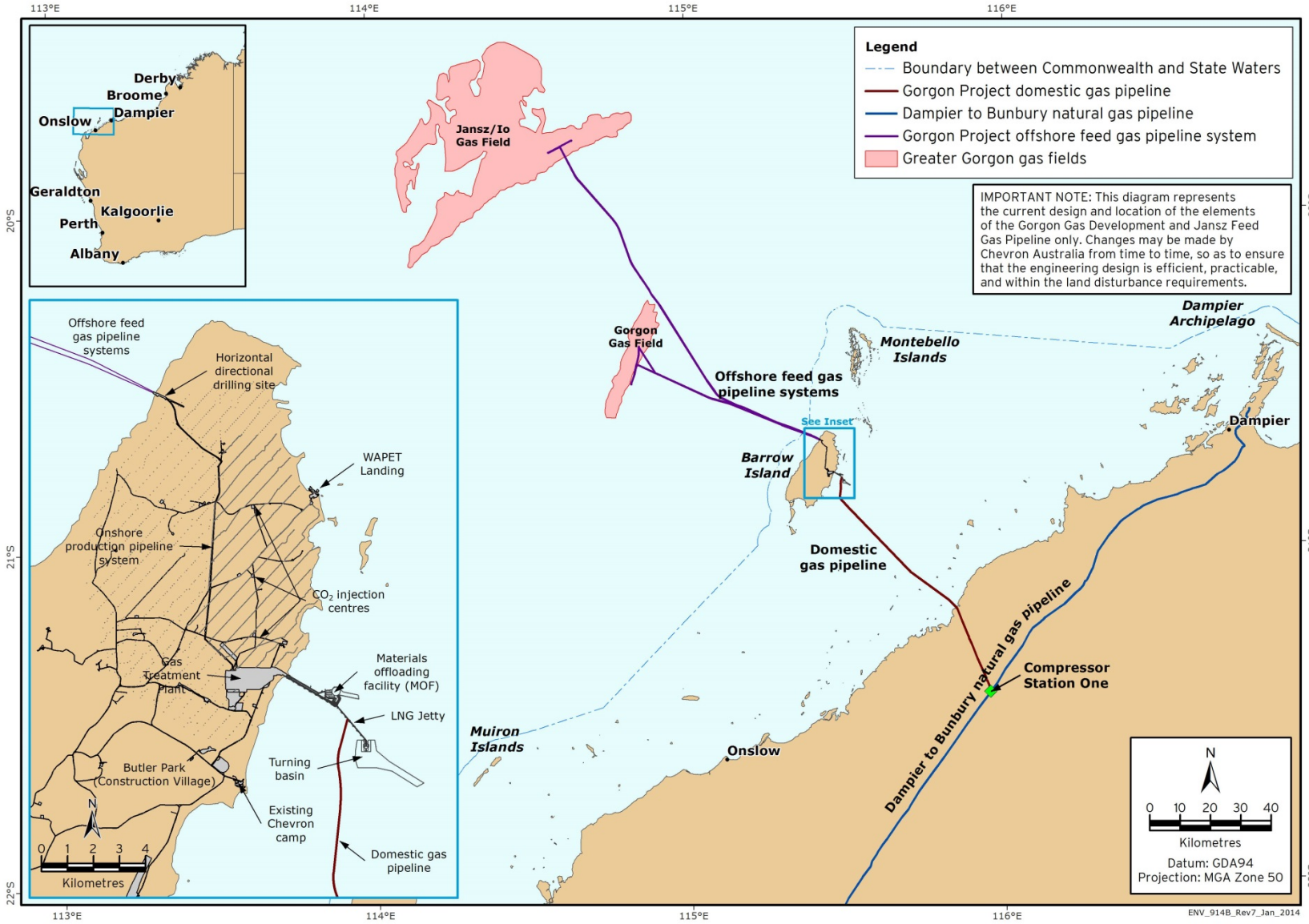


Figure 1-2 Location of the Gorgon Gas Development and Jansz Feed Gas Pipeline

1.4 Environmental Approvals

The initial Gorgon Gas Development was assessed through an Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) assessment process (Chevron Australia 2005, 2006).

The initial Gorgon Gas Development was approved by the Western Australian State 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 on 3 October 2007 (EPBC Reference: 2003/1294).

In May 2008, under section 45C of the Western Australian *Environmental Protection Act 1986* (EP Act), the Environmental Protection Authority (EPA) approved some minor changes to the Gorgon Gas Development that it considered 'not to result in a significant, detrimental, environmental effect in addition to, or different from, the effect of the original proposal' (EPA 2008). The approved changes are:

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

In September 2008, Chevron Australia sought both State and Commonwealth approval through a Public Environment Review (PER) assessment process (Chevron Australia 2008) for the Revised and Expanded Gorgon Gas Development to make some changes to 'Key Proposal Characteristics' of the initial Gorgon Gas Development, as outlined below:

- addition of a five MTPA LNG train, increasing the number of LNG trains from two to three
- expansion of the CO_2 Injection System, increasing the number of injection wells and surface drill locations
- extension of the causeway and the Materials Offloading Facility (MOF) into deeper water.

The Revised and Expanded Gorgon Gas Development was approved by the Western Australian State Minister for the Environment on 10 August 2009 by way of Ministerial Implementation Statement No. 800 (Statement No. 800). Statement No. 800 also superseded Statement No. 748 as the approval for the initial Gorgon Gas Development. Statement No. 800 therefore provides approval for both the initial Gorgon Gas Development and the Revised and Expanded Gorgon Gas Development, which together are known as the Gorgon Gas Development. Amendments to Statement No. 800 Conditions 18, 20 and 21 under Section 46 of the EP Act were approved by the Western Australian State Minister for the Environment on 7 June 2011 by way of Ministerial Implementation Statement No. 865 (Statement No. 865). However, implementation of the Gorgon Gas Development will continue to be in accordance with Statement No. 800.

On 26 August 2009, the then Commonwealth Minister for the Environment, Heritage and the Arts issued approval for the Revised and Expanded Gorgon Gas Development (EPBC Reference: 2008/4178), and varied the conditions for the initial Gorgon Gas Development (EPBC Reference: 2003/1294).

Since the Revised and Expanded Gorgon Gas Development was approved, further minor changes have also been made and/or approved to the Gorgon Gas Development and are now also part of the Development. Further changes may also be made/approved in the future.

Use of an additional 32 ha of uncleared land for the Gorgon Gas Development Additional Construction, Laydown, and Operations Support Area (Additional Support Area) was approved by the Western Australian State Minister for Environment on 2 April 2014 by way of Ministerial Implementation Statement No. 965 and by Variation issued by the Commonwealth Minister for

the Environment. Statement No.965 applies the conditions of Statement No.800 to the Additional Support Area and requires all implementation, management, monitoring, compliance assessment and reporting, environmental performance reporting, protocol setting and record keeping requirements applicable to the Additional Support Area under Statement No.800 to be carried out on a joint basis with the Gorgon Gas Development.

The Jansz Feed Gas Pipeline was assessed via Environmental Impact Statement/Assessment on Referral Information (ARI) and EPBC Referral assessment processes (Mobil Australia 2005, 2006).

The Jansz Feed Gas Pipeline was approved by the Western Australian State Minister for the Environment on 28 May 2008 by way of Ministerial Implementation Statement No. 769 (Statement No. 769) and the Commonwealth Minister for the Environment and Water Resources on 22 March 2006 (EPBC Reference: 2005/2184).

This Report covers the Gorgon Gas Development as approved under Statement No. 800 and as approved by EPBC Reference: 2003/1294 and 2008/4178, and including the Additional Support Area as approved by Statement No. 965 and as varied by the Commonwealth Minister for the Environment. In addition, this Report covers the Jansz Feed Gas Pipeline as approved by Ministerial Implementation Statement No. 769 and EPBC Reference: 2005/2184.

In respect of the Carbon Dioxide Seismic Baseline Survey Works Program, which were the only works approved under Statement No. 748 before it was superseded, and under EPBC Reference: 2003/1294 before the Minister approved a variation to it on 26 August 2009, note that under Condition 1A.1 of Ministerial Statement No. 800 and Condition 1.4 of EPBC Reference: 2003/1294 and 2008/4178 this Program is authorised to continue for six months subject to the existing approved plans, reports, programs and systems for the Program, and the works under that Program are not the subject of this Report.

1.5 Purpose of this Report

1.5.1 Legislative Requirements

1.5.1.1 State Ministerial Conditions

This Report is required under Condition 6.1 of Statement No. 800 and Statement No. 769, which is quoted below:

> *Prior to commencement of construction of terrestrial facilities on Barrow Island, as defined in Condition 6.3, the Proponent shall submit to the Minister a Terrestrial and Subterranean Baseline State and Environmental Impact Report (the Report) that meets the purposes set out in Condition 6.4, as determined by the Minister, unless otherwise allowed in Condition 6.3A.*

The following infrastructure comprises the Terrestrial Facilities (defined in Schedule 1 of Statement No. 800):

- Gas Treatment Plant
- CO_2 Injection System
- Associated terrestrial infrastructure forming part of the Proposal
- Areas impacted for seismic data acquisition
- Onshore Feed Gas Pipeline System as defined in Schedule 1.

Terrestrial Facilities also include those defined in Condition 6.3 of Statement No. 769 (the Onshore Feed Gas pipeline system and the terrestrial component of the Shore Crossing) and Schedule 1 of Statement No. 965 (the Additional Support Area).

In accordance with Condition 6.3A of Statement No. 800, in the event that any portions of the Report related to specific elements or sub-elements (Condition 6.3) are not submitted as required by Condition 6.1, the Proponent shall submit the portions of the Report relevant to that element or sub-element to the Minister prior to the commencement of construction of that element or sub-element. All portions of the Report shall meet the purposes identified in Condition 6.4 and the requirements of Condition 6.5 as determined by the Minister.

The report contains a definition for the Terrestrial Disturbance Footprint as required by Condition 6.6 of Statement No. 800 and Condition 6 of Statement No. 769.

1.5.1.2 Commonwealth Ministerial Conditions

This Report also satisfies the requirements of Condition 5.1 of EPBC Reference: 2003/1294 and 2008/4178, which is quoted below:

> *Prior to commencement of construction of the terrestrial facilities listed in Condition 5.2 on Barrow Island, the person taking the action must submit to the Minister, for approval, a Terrestrial and Subterranean Baseline State and Environmental Impact Report (the Report) that meets the purposes set out in Condition 5.3, as determined by the Minister, unless otherwise allowed in Condition 5.3A. The Report must cover the following ecological elements:*
>
> *i. vegetation;*
>
> *ii. fauna (including subterranean fauna);*
>
> *iii. habitat;*
>
> *iv. ecological communities;*
>
> *v. groundwater;*
>
> *vi. surface water landforms; and*
>
> *vii. physical landforms.*

The Terrestrial Facilities listed in Condition 5.2 of EPBC Reference: 2003/1294 and 2008/4178 are the:

i. Gas Treatment Plant;

ii. Carbon Dioxide Injection System

iii. Associated Terrestrial Infrastructure forming part of the action;

iv. Areas impacted for seismic data acquisition; and

v. Onshore Feed Gas Pipeline System.

This Report contains the baseline components of Condition 5 of EPBC Reference: 2003/1294 and 2008/4178. The monitoring aspects are addressed in the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a), which is required under Condition 8 of Statement No. 800 and Statement No. 769, and Condition 7 of EPBC Reference: 2003/1294 and 2008/4178.

1.5.2 Objectives

The objectives of this Report, as stated in Condition 6.4 of Statement No. 800 and Statement No. 769 are to:

- *define and map the pre-development baseline state for the ecological elements within the areas that are expected to, or may be, at risk of Material or Serious Environmental Harm due to any works associated with the terrestrial facilities listed in Condition 6.3*
- *define and map the ecological elements within the Terrestrial Disturbance Footprint*
- *define and map the ecological elements which are at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities listed in Condition 6.3 (Statement No. 769 only)*
- *define and map the ecological elements of reference sites to be used as part of Condition 8, which are not at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities listed in Condition 6.3*

The objectives of this Report, as stated in Condition 5.3 of EPBC Reference: 2003/1294 and 2008/4178, are to:

i. define and map the pre-development baseline state for the ecological elements within the areas that are expected to, or may be, at risk of Material or Serious Environmental Harm due to any works associated with the terrestrial facilities listed in Condition 5.2

ii. define and map the ecological elements within the Terrestrial Disturbance Footprint

iii. define and map the ecological elements of reference sites to be used as part of the Terrestrial and Subterranean Environment Monitoring Program Condition, which are not at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities listed in Condition 5.2.

In addition, the Report will provide information to support fulfilment of Condition 3.2.1 of EPBC Reference: 2003/1294 and 2008/4178, which requires:

- *a description of the EPBC listed species and their habitat likely to be impacted by the components of the action which are the subject of that plan, report, program or system (however described).*

1.5.3 Requirements

The requirements of this Report, as stated in Conditions 6.4,6.5 and 6.6 of Statement No. 800 and Statement No. 769, and Condition 5.4 of EPBC Reference: 2003/1294 and 2008/4178, are listed in Table 1-1.

Table 1-1 Requirements of this Report

Ministerial Document	Condition No.	Requirement	Section Reference in this Report
Statement No. 800 and Statement No. 769	6.2	The Proponent shall consult with the DEC (now DPaW) in the preparation of this Report required by Condition 6.1, including the methodology to be used to survey, collect and collate the baseline data and information for all ecological elements identified in Condition 6.1	Section 1.5.6
Statement No. 800 and Statement No. 769	6.4 i	Define and map the pre-development baseline state for the ecological elements within the areas that are expected to, or may be at risk of Material or Serious Environmental Harm due to any works associated with the terrestrial facilities listed in Condition 6.3 of Statement No. 800 and Statement No. 769.	Sections 3.0, 4.0 and 5.0 and Maps 1–12

Ministerial Document	Condition No.	Requirement	Section Reference in this Report
Statement No. 800 and Statement No. 769	6.4 ii	Define and map the ecological elements within the Terrestrial Disturbance Footprint.	Sections 3.0, 4.0, 5.0 and 6.0 and Maps 1–12
Statement No. 800 and Statement No. 769	6.4 iii (800) and 6.4 iv (769)	Define and map the ecological elements of reference sites to be used as part of Condition 8, which are not at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities listed in Condition 6.3 of Statement No. 800 and Statement No. 769.	Section 4.0 and Map 13
Statement No. 769	6.4 iii	Define and map the ecological elements which are at risk of Material and Serious Environmental Harm due to construction or operation of the terrestrial facilities listed in Condition 6.3 of Statement No. 769	Section 4.0 and Map 13
Statement No. 800 and Statement No. 769	6.5 i	A review of the results of the qualitative ecological risk assessments of the likelihood and consequence of Proposal impacts on the ecological elements identified in Condition 6.1 of Statement No. 800 and Statement No. 769.	Section 6.6
Statement No. 800 and Statement No. 769	6.5 ii	Details of the methodology that was used to survey, collect and collate the baseline data and information for all ecological elements identified in Condition 6.1 of Statement No. 800 and Statement No. 769.	Sections 4.0 and 5.0
Statement No. 800 and Statement No. 769	6.5 iii	A description and map of the ecological elements within the Terrestrial Disturbance Footprint.	Sections 3.0, 4.0, 5.0 and 6.0 and Maps 1–12
Statement No. 800 and Statement No. 769	6.5 iv	A description and map of the ecological elements which are at risk of Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint due to construction and operation of the terrestrial facilities listed in Condition 6.3 of Statement No. 800 and Statement No. 769.	Sections 4.0, 6.4, and Maps 1–12
Statement No. 800 and Statement No. 769	6.5 v	A review of the results to include existing areas of disturbance, including clearing, existing non-indigenous species (including weeds) and disturbed landscapes.	Section 4.0
Statement No. 800 and Statement No. 769	6.5 vi	Spatially accurate (i.e. rectified and geographically referenced) maps showing the baseline data and information for the ecological elements identified in Condition 6.1 of Statement No. 800 and Statement No. 769.	Section 4.0, Maps 1–12
Statement No. 800 and Statement No. 769	6.5 vii	Discussion of the data on the baseline biological, physical and chemical variables including any significant relationships, for the ecological elements identified in Condition 6.1 of Statement No. 800 and Statement No. 769.	Sections 4.0, 4.6, 3.1.4

Ministerial Document	Condition No.	Requirement	Section Reference in this Report
Statement No. 800 and Statement No. 769	6.5 viii	Significant ecological elements to be protected - e.g. Declared Rare Flora (DRF), threatened ecological communities, Threatened Species under the Commonwealth EPBC Act, habitats of rare fauna.	Sections 4.0, 3.1.2
Statement No. 800	6.5 ix	An analysis of, and procedures to address data and information gaps associated with the baseline data for the areas identified in Condition 6.5.iv for the ecological elements identified in Condition 6.1 of Statement No. 800.	Sections 4.11 and 5.9
Statement No. 769	6.5 ix	An analysis of, and procedures to address reasonable data and information gaps associate with the baseline data for the areas identified in iv. above (Condition6.5 iv) for the ecological elements identified in Condition 6.1 and associated relationships.	Sections 4.11 and 5.9
Statement No. 800 and Statement No. 769	6.5 x	A description and map of the ecological elements of reference sites in locations which are not at risk of Material or Serious Environmental harm due to construction and operation of the terrestrial facilities listed in Condition 6.3 of Statement No. 800 and Statement No. 769.	Section4.0, 6.0, Map 13 Additional maps of locations appear in the Terrestrial and Subterranean Environment Monitoring Program (required under Condition 8.4vii of Statement No. 800)
Statement No. 800 and Statement No. 769	6.6 (800) and 6 (769)	The Proponent shall not cause or allow Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint.	Section 6.2.2
EPBC Refs: 2003/1294 and 2008/4178	3.2.1	A description of the EPBC listed species and their habitat likely to be impacted by the components of the action which are the subject of that plan.	Section 3.1.3, 4.3.4.3 and 5.3.5 Table 3-1, Table 3-2
EPBC Refs: 2003/1294 and 2008/4178	3.2.2	an assessment of the risk to these species from the components of the action the subject of that plan, relevant to that plan	Appendix 11
EPBC Refs: 2003/1294 and 2008/4178	3.2.3	Details of the management measures proposed in relation to these species if it is a requirement of the condition requiring that plan.	Terrestrial and Subterranean Environment Protection Plan (Chevron Australia 2010)
EPBC Refs: 2003/1294 and 2008/4178	3.2.4	Details of monitoring proposed for that species if it is a requirement of the condition requiring that plan.	Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a)

Ministerial Document	Condition No.	Requirement	Section Reference in this Report
EPBC Refs: 2003/1294 and 2008/4178	3.2.5	Performance standards in relation to that species if it is a requirement of the condition requiring that plan	Terrestrial and Subterranean Environment Protection Plan (Chevron Australia 2010)
EPBC Refs: 2003/1294 and 2008/4178	3.2.6	Management triggers in relation to that species if it is a requirement of the condition requiring that plan.	Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a)
EPBC Refs: 2003/1294 and 2008/4178	3.2.7	Protocols for reporting impacts on the species to the Department.	Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia, 2012a)
EPBC Reference: 2003/1294 and 2008/4178	5.3i	Define and map the pre-development baseline state for the ecological elements within the areas that are expected to be, or may be, at risk of Material or Serious Environmental Harm due to any works associated with the terrestrial facilities listed in Condition 5.2.	Sections 3.0, 4.0 and 5.0 and Maps 1–12
EPBC Reference: 2003/1294 and 2008/4178	5.3ii	Define and map the ecological elements within the Terrestrial Disturbance Footprint.	Sections 3.0, 4.0, 5.0, 6.0 and Maps 1–12
EPBC Reference: 2003/1294 and 2008/4178	5.3iii	Define and map the ecological elements of reference sites to be used as part of the Terrestrial and Subterranean Environment Monitoring Program Condition, which are not at risk of Material or Serious Environmental Harm due to construction or operation of the terrestrial facilities listed in Condition 5.2.	Section 4.0, 6.0, Map 13 Additional maps of locations appear in the Terrestrial and Subterranean Environment Monitoring Program (required under Condition 8.4vii of Statement No. 800)
EPBC Reference: 2003/1294 and 2008/4178	5.4i	A review of the results of the qualitative ecological risk assessments of the likelihood and consequence of action impacts on the ecological elements identified in Condition 5.1;	Section 6.6
EPBC Reference: 2003/1294 and 2008/4178	5.4ii	Details of the methodology that was used to survey, collect and collate the baseline data and information for all ecological elements identified in Condition 5.1	Sections 4.0 and 5.0
EPBC Reference: 2003/1294 and 2008/4178	5.4iii	A description and map of the ecological elements within the Terrestrial Disturbance Footprint	Sections 3.0, 4.0, 5.0, 6.0 and Maps 1–12

Ministerial Document	Condition No.	Requirement	Section Reference in this Report
EPBC Reference: 2003/1294 and 2008/4178	5.4iv	A description and map of the ecological elements which are at risk of Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint due to construction and operation of the terrestrial facilities listed in Condition 5.2	Sections 4.0, 6.4, and Maps 1–12
EPBC Reference: 2003/1294 and 2008/4178	5.4v	A review of the results to include existing areas of disturbance, including clearing, existing non-indigenous species (including weeds) and disturbed landscapes	Section 4.0
EPBC Reference: 2003/1294 and 2008/4178	5.4vi	Spatially accurate (i.e. rectified and geographically referenced) maps showing the baseline data and information for the ecological elements identified in Condition 5.1	Section 4.0, Maps 1–12
EPBC Reference: 2003/1294 and 2008/4178	5.4vii	Discussion of the data on the baseline biological, physical and chemical variables including any significant relationships, for the ecological elements identified in Condition 5.1	Sections 4.0 and 3.1.4
EPBC Reference: 2003/1294 and 2008/4178	5.4viii	Significant ecological elements to be protected - e.g. EPBC Act listed species and their habitats	Sections 4.0 and 3.1.2
EPBC Reference: 2003/1294 and 2008/4178	5.4ix	An analysis of, and procedures to, address data and information gaps associated with the baseline data for the areas identified in Condition 5.4.iv for the ecological elements identified in Condition 5.1	Sections 4.11 and 5.9
EPBC Reference: 2003/1294 and 2008/4178	5.4x	A description and map of the ecological elements of reference sites in locations which are not at risk of Material or Serious Environmental harm due to construction and operation of the terrestrial facilities listed in Condition 5.2	Section 4.0, 6.0, Map 13 Additional maps of locations appear in the Terrestrial and Subterranean Environment Monitoring Program (required under Condition 8.4vii of Statement No. 800)

Statement No.965 requires the implementation of this report, in respect of the Additional Support Area and the Gorgon Gas Development, to be carried out on a joint basis.

Any matter specified in this Report is relevant to the Gorgon Gas Development or Jansz Feed Gas Pipeline only if that matter relates to the specific activities or facilities associated with that particular development.

The sections in this Report, which are noted in the above table to meet the conditions of EPBC Reference: 2003/1294 and 2008/4178, shall be read and interpreted as only requiring implementation under EPBC Reference: 2003/1294 and 2008/4178 for managing the impacts of the Gorgon Gas Development on, or protecting the EPBC Act matters listed in Table 3-1. The implementation of matters required only to meet the requirements of Ministerial Statement No. 800 (and No.769) are not the subject of the EPBC Reference: 2003/1294 and 2008/4178.

The spatial data associated with this Report have been captured in Chevron Australia's geographical information system (GIS), with data rectified and geographically referenced in formats compatible with ArcGIS software.

The Chevron Australia GIS team has formalised the requirement to supply spatial data in addition to any other stated deliverables for all surveys carried out for an asset or Chevron Project. This requirement is captured within the Chevron Australia document, Spatial Data Requirements: Requirements for the Supply of Field Captured Data (Chevron Australia 2008a). The supply of a spatial data record of survey will ensure:

- an unambiguous, permanent and maintained record of survey extent(s) and/or location(s) exists
- survey findings can be visualised and analysed both spatially and temporally in the context of other survey findings
- survey findings are in a suitable format for presentation in statutory reporting or delivery to authorities.

This document (Chevron Australia 2008a) also outlines the requirements for the supply of the spatial data, which will ensure:

- Chevron GIS data standards are adhered to
- data received is in the appropriate format
- relevant explanatory information is provided (metadata).

1.5.4 Hierarchy of Documentation

This Report will be implemented for the Gorgon Gas Development and the Jansz Feed Gas Pipeline via the Chevron Australasia Business Unit (ABU) Operational Excellence Management System (OEMS). The OEMS is the standardised approach that applies across the ABU to continuously improve the management of safety, health, environment, reliability, and efficiency to achieve world-class performance. Implementation of the OEMS enables the Chevron ABU to integrate its Operational Excellence (OE) objectives, processes, procedures, values and behaviours into the daily operations of Chevron Australia personnel and contractors working under Chevron Australia's supervision. The OEMS is designed to be consistent with and, in some respects, go beyond ISO 14001-2004 (Environmental Management Systems – Requirements with Guidance for Use) (Standards Australia/Standards New Zealand 2004a).

Figure 1-3 and Figure 1-4 provide an overview of the overall hierarchy of environmental management documentation within which this Report exists.

This Report provides input into the Terrestrial and Subterranean Environment Protection Plan (Chevron Australia 2010) and the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a). Figure 1-5 shows the link between these documents.

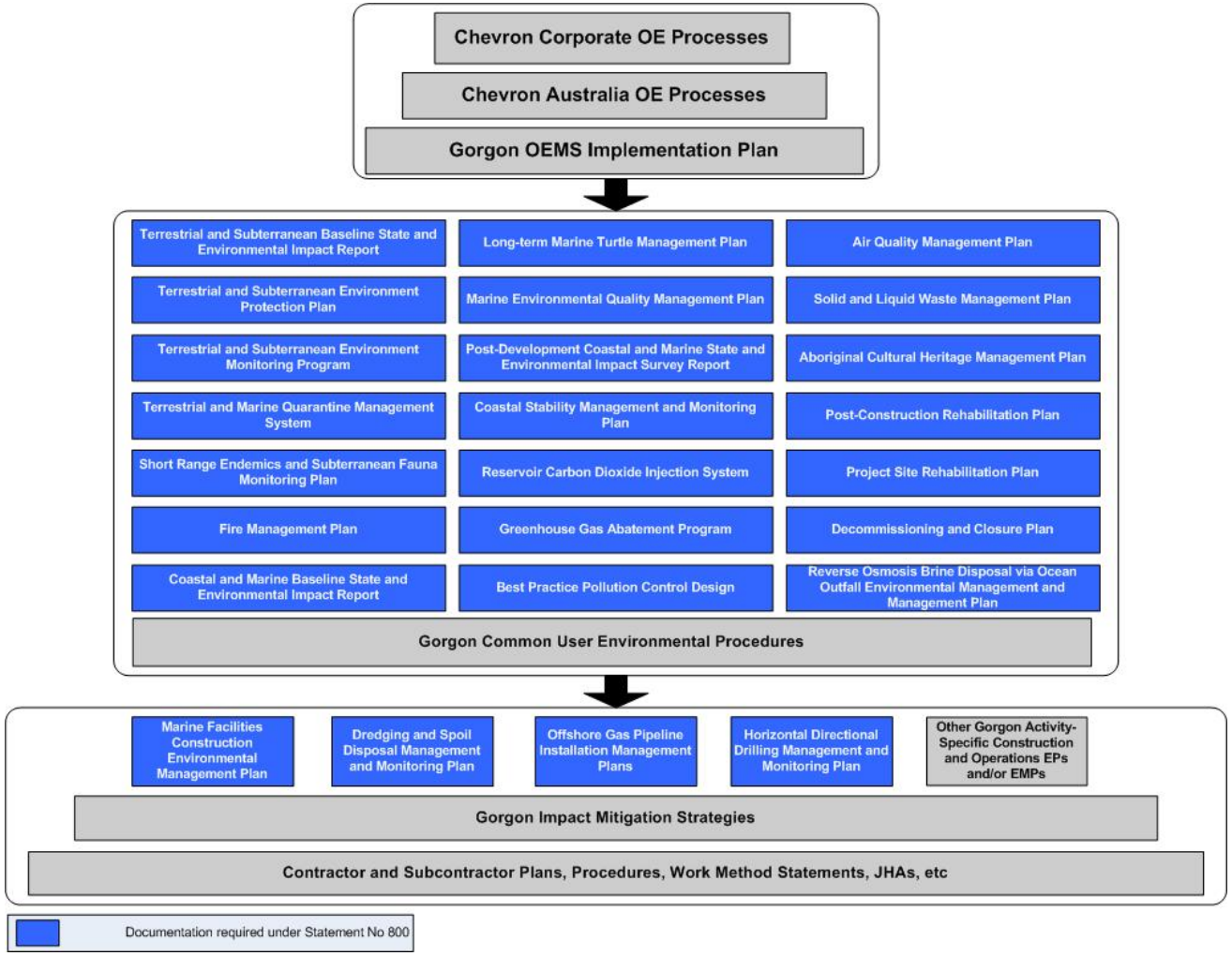


Figure 1-3 Hierarchy of Gorgon Gas Development Environmental Documentation

Note: Figure 1-3 refers to all Plans required for Statement No. 800. The Plans are only relevant to EPBC Reference: 2003/1294 and 2008/4178, if required for those conditions of those approvals.

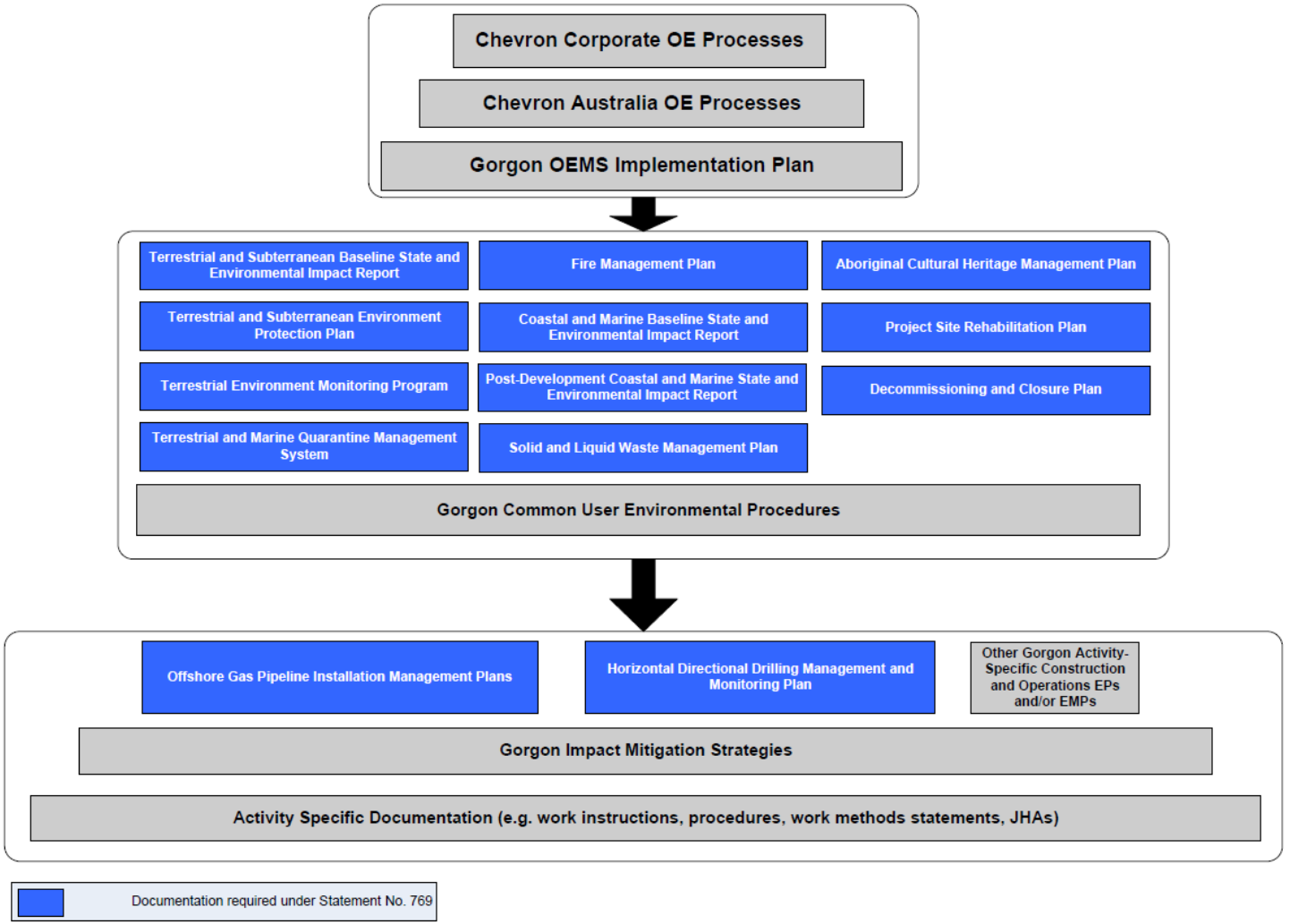


Figure 1-4 Hierarchy of Jansz Feed Gas Pipeline Environmental Documentation

Note: Figure 1-4 refers to all Plans required for Statement No. 769. They are only relevant to EPBC Reference: 2005/2184 if required for the conditions of that approval.

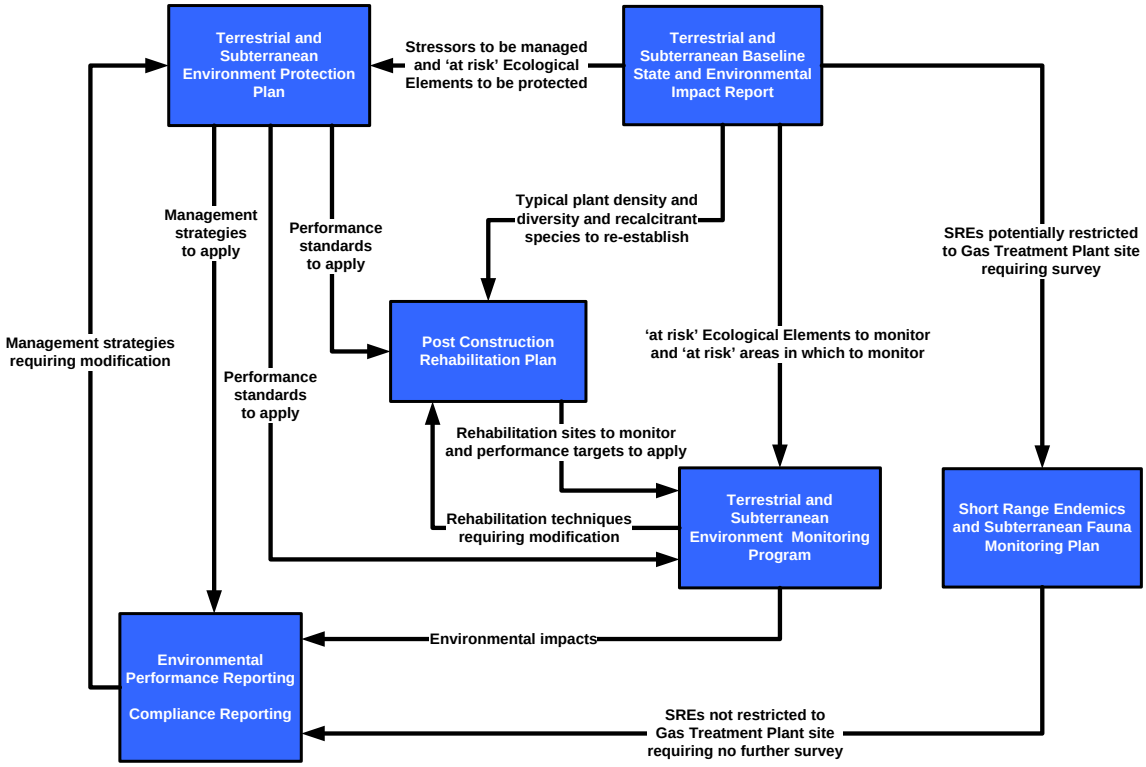


Figure 1-5 Context of Terrestrial and Subterranean Baseline State and Environmental Impact Report

1.5.5 Relevant Standards and Guidelines

The following standards and guidelines have been taken into account in preparing this Report:

- Australian Standards/New Zealand Standards (AS/NZS) 4369:2004: Risk Management (Standards Australia/Standards New Zealand 2004b)
- EPA Guidance Statement No. 1, Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2001)
- EPA Guidance Statement No. 51, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004)
- EPA Guidance Statement No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a)
- EPA Draft Guidance Statement No. 54a, Sampling Methods And Survey Considerations for Subterranean Fauna in Western Australia (EPA 2007)
- EPA Draft Guidance Statement No. 8, Environmental Noise (EPA 2007a).

1.5.6 Stakeholder Consultation

Regular consultation with stakeholders has been undertaken by Chevron Australia throughout the development of the environmental impact assessment management documentation for the Gorgon Gas Development and Jansz Feed Gas Pipeline. This stakeholder consultation has included engagement with the community, government departments, industry operators, and contractors to Chevron Australia via planning workshops, risk assessments, meetings, teleconferences, and the PER, EIS/ERMP and Environmental Review (Chevron Australia 2013) formal approval processes.

As required under Condition 6.2 of Statement No. 800 and Statement No. 769, Chevron Australia has consulted with the Western Australian Department of Environment and Conservation (DEC) and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) during the preparation of this Report.

This document has been prepared with input from:

- DEC (now the Department of Parks and Wildlife [DPaW]): Workshops and meetings were held involving the DEC and Chevron Australia personnel to discuss the scope and content of this Report during its development. The DEC reviewed draft revisions of this Report along with the feedback of the independent reviewers. The DEC's comments have been incorporated or otherwise resolved.
- SEWPaC (now the Department of the Environment [DotE]: SEWPaC reviewed draft revisions of this Report along with the feedback of the independent reviewers. SEWPaC's comments have been incorporated or otherwise resolved.
- Dr Owen Nichols, Environmental Management and Research Consultants. Dr Nichols reviewed this Report and his comments have been incorporated or otherwise resolved
- Dr Eddie van Etten, School of Natural Sciences, Edith Cowan University. Dr van Etten reviewed this Report and his comments have been incorporated or otherwise resolved
- Mr Brenton Knott, Faculty of Natural and Agricultural Sciences-Animal Biology, University of Western Australia: Mr Knott reviewed this Report and his comments have been incorporated or otherwise resolved
- Dr Andrew Burbidge, Consultant Conservation Biologist. Dr Burbidge reviewed this Report and his comments have been incorporated or otherwise resolved

Figure 1-6 shows the development, review, and approval process for this Report.

1.5.7 Public Availability

This Report will be made public as and when determined by the Minister, under Condition 35 of Statement No. 800, Condition 20 of Statement No. 769, and Condition 22 of EPBC Reference: 2003/1294 and 2008/4178.

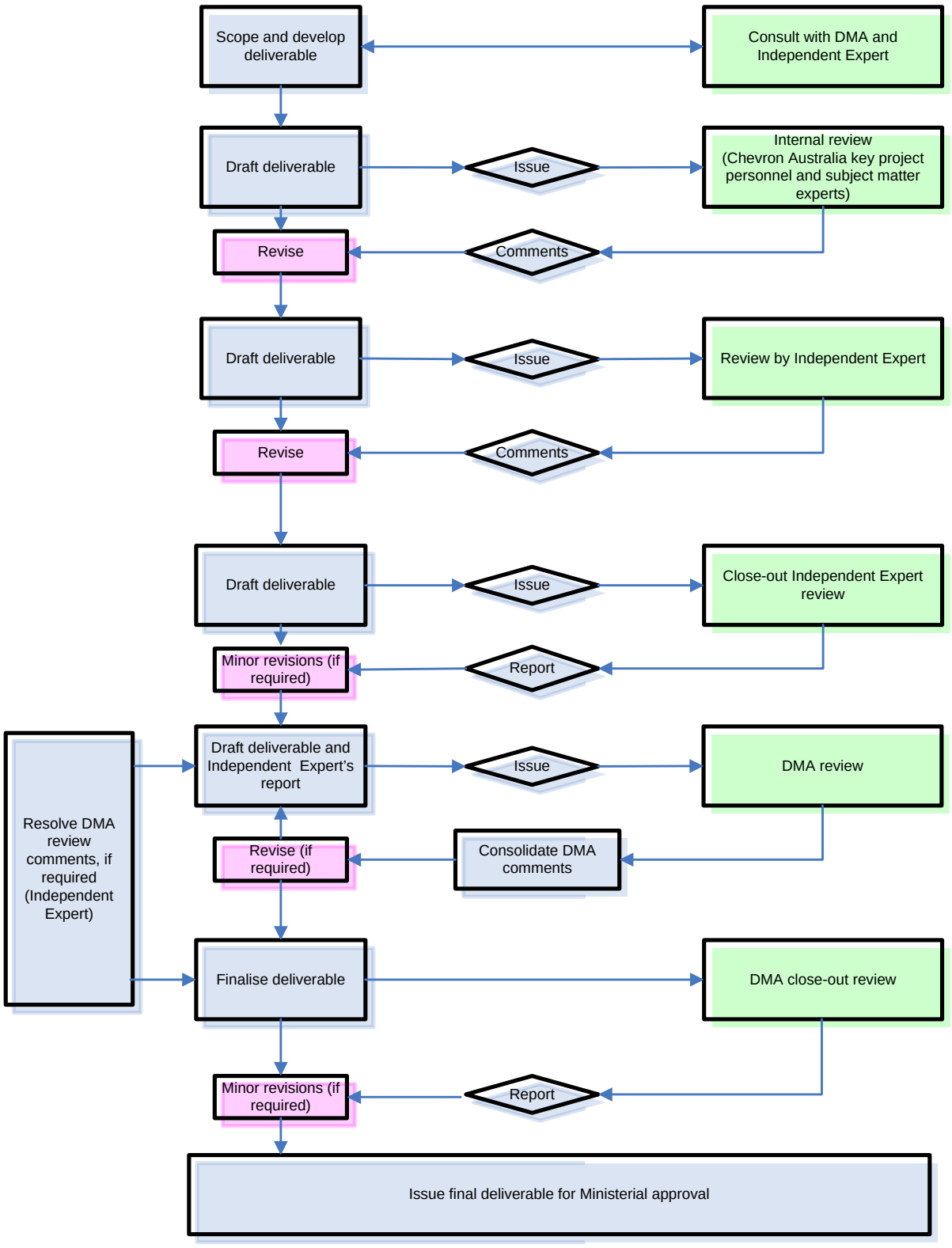


Figure 1-6 Deliverable Development, Review, and Approval Flow Chart

2.0 Relevant Facilities and Activities

2.1 Terrestrial Facilities

2.1.1 Overview

This Report addresses issues associated with the Terrestrial Facilities of the Gorgon Gas Development and the Terrestrial Facilities of the Jansz Feed Gas Pipeline, which are shown in Figure 1-2 and Section 10.0 of this Report. The Gorgon Gas Development Terrestrial Facilities are defined in Condition 6.3 of Statement No. 800 and Condition 5.2 of EPBC Reference: 2003/1294 and 2008/4178 as the:

- Gas Treatment Plant
- Carbon Dioxide Injection System
- Associated terrestrial infrastructure forming part of the Proposal
- Areas impacted for seismic data acquisition
- the Onshore Feed Gas Pipeline System and terrestrial component.

Terrestrial Facilities also include those defined in Condition 6.3 of Statement No. 769 as:

- the Onshore Feed Gas pipeline system and the terrestrial component of the Shore Crossing.

Terrestrial Facilities also include those defined in Schedule 1 of Statement No. 965 (the Additional Support Area).

Additional details on the Terrestrial Facilities can be found in the Draft EIS/ERMP (Chevron Australia 2005), the section 45C approval (EPA 2008), the PER (Chevron Australia 2008), and the Environmental Review (Chevron Australia 2013a).

Activities associated with the CO_2 Survey Program are briefly summarised in Section 2.1.5; however, more detailed information is provided in the 'Proposed Activity' section of the CO_2 Seismic Baseline Survey Environmental Management Plan (Chevron Australia 2009a).

Please note that the description of the Terrestrial Facilities provided in subsequent sections is as currently proposed. More specific details are contained in various Gorgon Gas Development approval and assessment documents which are issued from time to time.

2.1.2 Gas Treatment Plant

The Gas Treatment Plant will be located near Town Point (see map in Section 10.0), on the east coast of Barrow Island. The Gas Treatment Plant includes:

- LNG trains: 3 × 5 MTPA (nominal)
- Gas Processing Drivers: 6 × 80 MW (nominal) gas turbines fitted with dry low NO_x (DLN) burners
- Power Generation: 5 × 116 MW (nominal) conventional gas turbines without DLN burners
- Flare design: Ground flare for the main plant flare; boil-off gas (BOG) elevated flare in storage and loading area
- LNG Tanks: 2 × 180 000 m^3 (nominal)
- Condensate Tanks: 4 × 35 000 m^3.

The Gas Treatment Plant will produce three main products for export from Barrow Island:

- LNG for international export
- domestic gas for use on the Australian mainland

- hydrocarbon condensate (light oil).

Typical Gas Treatment Plant processes are described in Chapter 6 of the Draft EIS/ERMP (Chevron Australia 2005).

2.1.3 Carbon Dioxide Injection System

Reservoir Carbon dioxide (CO_2) will be disposed of by injection into the Dupuy Formation more than 2000 m below Barrow Island to limit the greenhouse gas emissions and atmospheric pollutant associated with the Gorgon Gas Development and Jansz Feed Gas Pipeline's production of LNG. The CO_2 injection process is described in the Draft EIS/ERMP (Chevron Australia 2005).

The CO_2 Injection System will consist of the mechanical components required to enable the injection of reservoir CO_2 and manage the performance integrity of the injection facilities and the Dupuy Formation. These include:

- CO_2 compression facilities located within the Gas Treatment Plant boundary
- CO_2 pipeline (approximately 10 km long in a 8 ha easement) between the Gas Treatment Plant and the three to four CO_2 injection drill centres to the north
- nine CO_2 injection wells directionally drilled from the three CO_2 injection drill centres north of the Gas Treatment Plant site (see map in Section 10.0)
- observation wells, required to monitor the subsurface spread of the CO_2 plume
- four pressure management water wells for managing pressure in the Dupuy Formation
- two pressure management water injection wells for the reinjection of water produced from the lower Dupuy Formation by pressure management wells. The water will be reinjected into the Barrow Group from a vertical depth of 1200 to 1600 m
- shallow drilled anode wells for the cathodic protection of all well types associated with the CO_2 Injection Project. Additional anode wells will be drilled for cathodic protection purposes for the pressure management wells and the pressure management water injection wells (one anode well pair for each water producer/injector pair). An anode well will also be required for each stand-alone observation well.

Monitoring activities, including the acquisition of seismic data will be undertaken as part of ongoing reservoir performance management. The total area occupied by the CO_2 Injection System outside the Gas Treatment Plant site will be approximately 12.5 ha.

2.1.4 Associated Terrestrial Infrastructure

Terrestrial infrastructure associated with the Gorgon Gas Development consists of:

- the terrestrial component of the Barge (WAPET) Landing
- the Construction Village
- the Administration and Operations Complex
- the permanent Utilities Area located within the Gas Treatment Plant
- the Utilities Corridors between the Utilities area and users within the Gas Treatment Plant and between the Utilities Area and the Construction Village, also servicing the Administration and Operations Complex
- road upgrades, including the road between WAPET Landing and Town Point, and from Town Point to the Airport (via the Construction Village), and the road along the feed gas pipeline system route

- airport modifications, consisting of the extension of the existing runway to the south and associated vegetation clearing
- communications, consisting of a microwave communications tower and associated communications infrastructure to be installed on Barrow Island
- onshore water supply infrastructure, consisting of a seawater demineralisation (reverse osmosis) plant, associated treated water and brine storage tanks, and treated water pumps and delivery piping to end users within the Gas Treatment Plant and utility corridors, reverse osmosis brine disposal pumps and the terrestrial component of the reverse osmosis brine pipeline.

Associated terrestrial infrastructure will be primarily located in the vicinity of, and south of, the Gas Treatment Plant site on the east coast of Barrow Island (see map in Section 10.0).

2.1.5 Areas Impacted for Seismic Data Acquisition

The expansion of the CO_2 plume injected into the Dupuy Formation below Barrow Island will be measured by comparing the reflection of vibrations through the subsurface. The terrestrial components of baseline seismic monitoring will use two vibration sources: subsurface explosives and vibroseis (see map in Section 10.0).

Approximately 1300 shot holes will be drilled for the placement of subsurface explosives. These will be drilled at 100 m intervals along lines spaced 500 m apart. The placement of explosives below the surface karst limestone layer will be done by drilling the holes to a depth of approximately 15 m below sea level. Purpose-built drill rigs that combine both sonic and air percussion drilling technology will be used, reducing the need to use drilling fluids. The charges will be 4 kg each and double detonators will be used.

Vibroseis consists of propagating energy signals into the earth from the surface via vibrator pads fitted to a truck. Vibroseis will be undertaken in the lower-lying, flatter terrain areas where good ground coupling is attainable and the effect on karst limestone is minimal. The vibroseis source lines will be spaced approximately 500 m apart, and the vibrator points will be every 12.5 m along these lines.

Seismic data acquisition is expected to be repeated a number of times throughout the life of the Gorgon Gas Development, in order to map the extent of the CO_2 plume as it migrates. Differences between the data obtained during the baseline seismic monitoring and repeat seismic monitoring will be used to map the extent of the CO_2 plume over time.

2.1.6 Onshore Feed Gas Pipeline System and Terrestrial Component of the Shore Crossing (Gorgon and Jansz)

The Onshore Feed Gas Pipeline System will traverse Barrow Island from the west coast at North Whites Beach to the Gas Treatment Plant site near Town Point on the east coast (see map in Section 10.0). The pipeline system will be approximately 14 km long and located within a right-of-way between 30 and 45 m wide. The pipelines will be buried with excavated material backfilled into the trench.

The installation of the Onshore Feed Gas Pipeline System (including trenching, welding and pipe lowering) is expected to be completed at a rate of approximately 300 m to 350 m per day. The trench will be limited to approximately 2 km of open trench at any one time; however, the trench required for the pipeline systems (cables and tubes) will require the entire trench open for a relatively short period of time.

The terrestrial component of the Shore Crossing will consist of infrastructure for drilling eight Horizontally Directionally Drilled (HDD) holes from the shore to an exit point approximately 500 m offshore, and insertion of pipe strings into these holes. A ninth hole will be drilled for a seawater intake system, which will provide water required for the activities associated with drilling and pre-commissioning.

The facilities required for construction of the Shore Crossing will include breakover supports and pipeline rollers for insertion of the pipelines. The HDD site will be approximately 80 m by 110 m.

The pipe stringing yard is located inland of the HDD site and includes a laydown area for the breakover supports and pipeline rollers. The portion of the stringing yard closest to the HDD site will be approximately 60 m wide and approximately 325 m long. The laydown area will extend an additional distance inland (up to 1010 m) at a narrower width (approximately 35 m).

2.2 Activities

The planned activities associated with the Gorgon Gas Development have been grouped into three categories (listed in Table 2-1). Activities associated with construction and operation on Barrow Island are also applicable to the Jansz Feed Gas Pipeline. These categories are based on the type, intensity, and frequency of potential impacts associated with the particular activity.

Please note that the description of the activities provided in subsequent sections is as currently proposed. More specific details are contained in various Gorgon Gas Development and Jansz Feed Gas Pipeline approval and assessment documents, which are issued from time to time.

Table 2-1 Planned Activities Associated with the Gorgon Gas Development

Construction and Operation on Barrow Island (also applicable to the Jansz Feed Gas Pipeline)	Surface Seismic Activities on Barrow Island	Subsurface Seismic Activities on Barrow Island
• clearing and earthworks • burning of vegetation • abrasive blasting • concrete batching • waste generation, storage and disposal • drilling and blasting • operation of machinery, plant and equipment • pipeline installation, operation, inspection, maintenance and site reinstatement • pipeline pressure testing, flooding and gauging • vehicle movements • winning and crushing of material • chemical and fuel transportation, storage, use and disposal • land use change • operation of Gas Treatment Plant.	• vibroseis • drilling for placement of subsurface explosives.	• explosion of 4 kg charges at approximately 15 m below sea level (below the watertable).

2.3 Stressors

The direct impacts of activities associated with the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island are detailed in Table 2-2 and include:

- clearing and earthworks
- liquid and solid wastes

- leaks and spills
- physical presence (due to clearing of land)
- fire
- physical interaction (e.g. due to vehicle strikes).

In addition the stressors with potential to cause considerable indirect impacts to terrestrial and subterranean ecological elements are also listed in Table 2-2. Further details of both direct and indirect predicted impacts are provided in the Terrestrial and Subterranean Environment Protection Plan (Chevron Australia 2010).

Table 2-2 Stressors Whose Influence May Extend Beyond the Gorgon Gas Development Footprint

Activities/Stressors	Construction and Operation on Barrow Island	Surface Seismic Activities on Barrow Island	Subsurface Seismic Activities on Barrow Island
Direct			
Clearing and Earthworks	X	X	
Liquid and Solid Waste	X		
Leaks or spills	X	X	X
Physical Presence	X		
Fire	X		
Physical Interaction	X		
Indirect			
Dust	X		
Erosion	X	X	
Sedimentation	X		X
Noise and Vibration	X		
Shockwaves			X
Change to Subsurface Water Regime	X		
Heat	X		
Cold			X
Light	X		
Shade	X		
Gaseous Emissions (excluding vehicles)			X

Non-indigenous species (NIS), such as weeds or introduced fauna, are stressors that could result in impacts outside the Gorgon Gas Development Footprint, if they are introduced. These are not included in Table 2-2 as these stressors are addressed in detail in the Terrestrial and Marine Quarantine Management System (required under Condition 10 of Statement No. 800 and Statement No. 769 and Condition 8 of EPBC Reference: 2003/1294 and 2008/4178).

The Terrestrial Disturbance Footprint (TDF) is defined as the area to be disturbed by construction or operations activities associated with the Terrestrial Facilities listed in Condition 6.3 of Statement No. 800, including the Additional Support Area approved by Satement No. 965, Condition 6.3 of Statement No. 769, and Condition 5.2 of EPBC Reference: 2003/1294 and 2008/4178, and as further described in this Report. The concept of the TDF is further developed, and applied, in Section 6.0.

3.0 Overview of Baseline State of Ecological Elements

3.1 Introduction

This Report provides the pre-development baseline state of ecological elements for the management and monitoring of impacts for the Terrestrial Facilities on Barrow Island and the Onshore Domestic Gas Pipeline. It also identifies those ecological elements deemed to be significant on Barrow Island, including matters of NES, or the reasons for this. A greater portion of this Report is dedicated to Barrow Island because:

- the Island is a Class A Nature Reserve with few weeds and no introduced mammals, whereas the Onshore Domestic Gas Pipeline route is located in the pastoral lease of Mardie Station. Van Vreeswyk *et al.* (2004) found that 39% of the perennial vegetation on Mardie Station is in poor to fair condition
- in comparison to island populations of animals, mainland populations can be more stable and less vulnerable to disturbances such as fire, disease, genetic diversity depressions, loss of habitat and predation (Department of Conservation and Land Management [CALM] 2005)
- the mainland infrastructure consists of a buried pipeline, with no processing or handling facilities (except a pressure reduction and custody transfer station) and no permanent workforce
- the Onshore Domestic Gas Pipeline will be immediately adjacent to the existing Apache Energy Gas Sales Pipeline
- the vegetation along the existing Apache Energy Gas Pipeline generally recovered well within five to six years, with the exception of the Snakewood (*Acacia xiphophylla*) community (Dames and Moore 1998).

3.1.1 Ecological Elements

This Report covers the ecological elements stated in Condition 6.1 of Statement No. 800 and Statement No. 769 and Condition 5.1 of EPBC Reference: 2003/1294 and 2008/4178, which are:

- flora
- vegetation
- fauna (including subterranean fauna and short-range endemics [SREs])
- habitat
- ecological communities
- groundwater
- surface water landforms
- physical landforms.

Note that Statement No. 769 refers to ‘other significant landforms’ rather than physical landforms, and ‘flora’ is not included in EPBC Reference: 2003/1294 and 2008/4178.

Ecological elements are characterised in this Report to the degree practicable for Barrow Island and the Onshore Domestic Gas Pipeline route on the basis of existing information.

On the mainland, ecological elements have been characterised in terms of regional datasets. On Barrow Island, ecological elements have been characterised at the scale of the Island to:

- limit omissions in identified significant ecological elements on Barrow Island (e.g. to ensure the significance of mammals is considered)

- provide a context in which the significance of each ecological element on Barrow Island can be determined (such as the distribution of a species within Barrow Island)
- limit omissions in the distribution of significant ecological elements both within and outside the TDF from the Gorgon Gas Development and Jansz Feed Gas Pipeline
- assist the development and implementation of management strategies that require data for, or have implications for the management of, the entirety of Barrow Island (e.g. providing baseline flora and fauna inventories for use within the Terrestrial and Marine Quarantine Management System)
- meet the requirements of Statement No. 800 and Statement No. 769 to characterise ecological elements inside and outside the Terrestrial Disturbance Footprint and areas of risk.

A number of species accumulation curves for Barrow Island data are presented in Appendix 1. Plateauing of slopes in these curves over time, or the number of sampling events, indicates that inventories are relatively comprehensive and few species remain undocumented on Barrow Island.

Baseline data on ecological elements found across Barrow Island and the area of the mainland where the DomGas Pipeline will be constructed are presented in Section 4.0 and Section 5.0 of this Report, respectively.

3.1.2 Significant Ecological Elements

Ecological elements have been characterised to the degree practicable; however, the focus in this Report is on those ecological elements that have been identified as significant ecological elements to be protected in areas in the vicinity of the Gorgon Gas Development Footprint, based on a process to define how these are significant and why they warrant attention. This framework provides the basis for identifying potential impacts on taxa and features as discussed in Section 6.4, and satisfies Condition 6.5viii of Statement No. 800 and Statement No. 769.

Note that Statement No. 800 and Statement No. 769 do not define significant ecological elements, but provide direction in Condition 6.5 viii) as follows: 'Declared Rare Flora (DRF), Threatened Ecological Communities, Threatened Species under the Commonwealth EPBC Act (Cth), [and] habitats of rare fauna'.

To appropriately manage the environment on Barrow Island, Chevron Australia considers that the significant ecological elements include those that are:

- listed as vulnerable, threatened, rare or endangered in Western Australian and Commonwealth legislation or formal lists
- restricted in distribution within Barrow Island
- critical to ecological processes on Barrow Island
- vulnerable to disturbance (neither resistant nor resilient to disturbance and is very slow to recover/self-regenerate after disturbance ceases)

  or

- disproportionately located in the Gorgon Gas Development Footprint.

The application of the criteria for significance is consistent with EPA Guidance Statements No. 51 and No. 56 (EPA 2004, 2004a). Significant ecological elements identified on Barrow Island in this Report are consistent with:

- the Draft and Final EIS/ERMP (Chevron Australia 2005, 2006)
- material presented in workshops attended by Chevron Australia and State government agencies in December 2007

- Clearing Permit CPS 123/2 issued by the DEC to Chevron Australia for the existing oilfield operation on Barrow Island. Sensitivities identified in the Clearing Permit are identified as significant ecological elements, with the exception of flora and vegetation; these sensitivities have been reviewed and the details are provided this Report.

The significance of impacts on Barrow Island is greater for species with few, small or vulnerable populations on other surrounding islands and the mainland. Species with relatively few populations should be identifiable through listings as vulnerable, threatened, rare, or endangered in State and Commonwealth legislation or formal lists. The significance of impacts on Barrow Island are considered to be greater for species whose populations on Barrow Island are genetically distinct from elsewhere.

Species that are restricted to certain areas on Barrow Island have been identified as significant. This conservative approach contributes towards ensuring the viability of species on Barrow Island (as opposed to just those listed as of conservation significance by government agencies). Greater management attention will be applied to the management of risks on Barrow Island, as island populations of many species can diverge genetically from mainland populations. This approach also avoids issues surrounding conjecture of the genetic distinctiveness, the inconsistent levels of genetic work completed for different groups of plant and animals, and any unresolved taxonomy.

On the mainland, the significance of taxa and features is assessed in terms of the listed conservation status of taxa and features under State and Commonwealth legislation, and formal lists maintained by State and Commonwealth agencies.

The conservation status of flora, vegetation, and fauna is listed in Appendix 2 to Appendix 8 of this Report. Significant ecological elements, including EPBC Act listed species, are shaded grey in these appendices.

3.1.3 Matters of National Environmental Significance

Under the EPBC Act (Cth), actions that have, or are likely to have, a Significant Impact on a matter of NES and their habitat, require approval from the Minister for Sustainability, Environment, Water, Population and Communities.

The matters of NES that are protected under the EPBC Act (Cth) are:

- World Heritage properties
- National Heritage places
- wetlands of international importance
- listed Threatened Species and Threatened Ecological Communities
- migratory species protected under international agreements
- Commonwealth marine areas
- nuclear actions (including uranium mines)
- the environment, where actions proposed are on, or will affect, Commonwealth land and the environment
- the environment, where Commonwealth agencies are proposing to take an action.

The terrestrial and subterranean matters of NES identified on Barrow Island are five mammal species (listed as Threatened Species), 68 bird species (39 species listed under the Japan–Australia Migratory Bird Agreement [JAMBA], China–Australia Migratory Bird Agreement [CAMBA] or Republic of Korea–Australia Migratory Bird Agreement [ROKAMBA] migratory treaties, 54 species listed as marine species under the EPBC Act [Cth], and one species listed under the Bonn Convention for Migratory Species), and one fish species. Of the 68 protected

bird species, 47 species are residents or regular migrants to the Island. The remainder are vagrants from the nearby mainland.

The habitat of these matters of NES are covered in Section 4.4.

Barrow Island and Mardie Station on the mainland are not on Commonwealth land and the proponent (Chevron Australia) is not a Commonwealth agency. There are no heritage properties or places, listed wetlands of international importance, nuclear actions, threatened plant species or ecological communities listed under the EPBC Act (Cth). Therefore the EPBC Act (Cth) considerations related to these matters are not pertinent to the Gorgon Gas Development and Jansz Feed Gas Pipeline.

The conservation significance of flora, vegetation and fauna is identified in the inventories in Appendix 2 to Appendix 8 of this Report. Matters of NES are described as significant ecological elements in the subsequent sections of this Report. Condition 3.2.1 of EPBC Reference: 2003/1294 and 2008/4178 require a description of the EPBC Act listed species likely to be impacted by the components of the action that is the subject of this Report. Those species are included in Table 3-1.

Table 3-1 EPBC Species Abundance and Habitat/Distribution on Barrow Island

	Species	Abundance on Barrow Island	Habitat / Distribution on Barrow Island	Species or Habitat Potentially Impacted [1]	Baseline Information in this Report
Land Birds	White-winged Fairy-wren (Barrow Island)	High	Widespread across vegetation communities	Yes – Noise	Section 4.3.4.3 Figure 4-2 Table 4-14 Table 4-15 Table 4-16 Map 6
	Sacred Kingfisher	Low	Restricted to mangroves / heavily vegetated creek lines	No	Section 4.3.4.3 Table 4-14
	Tree Martin	Rare	Coastal areas (but not actual beaches) with some extension into claypan areas	No	Section 4.3.4.3 Table 4-14
	Wood Swallow	High	Widespread	No	Section 4.3.4.3 Table 4-14
Littoral Birds	Australian Pelican, Eastern Reef, Nankeen Night Heron, Black-tailed Godwit, Whimbrel, Eastern Curlew, Common Greenshank, Terek Sandpiper, Common Sandpiper, Grey-tailed Tattler, Ruddy Turnstone, Great Knot, Red Knot, Sanderling Calidris, Red-	High	Concentrated on Barrow Island around Bandicoot Bay on south coast	No	Section 4.3.4.3 Table 4-11 Table 4-12 Table 4-13 Map 6

	Species	Abundance on Barrow Island	Habitat / Distribution on Barrow Island	Species or Habitat Potentially Impacted [1]	Baseline Information in this Report
	necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Pacific Golden Plover, Grey Plover, Lesser Sand Plover, Greater Sand Plover, Silver Gull, Gull-billed Tern, Caspian Tern, Lesser Crested Tern, Crested Tern, Roseate Tern, Common Tern, Little Tern, Fairy Tern, White-winged Black Tern				
	Bar-tailed Godwit Lesser Noddy	Low	Concentrated on Barrow Island around Bandicoot Bay on south coast	No	Section 4.3.4.3 Table 4-12 Table 4-13 Map 6
Raptors (Birds of Prey)	Spotted Harrier Brahminy Kite Osprey White-bellied Sea-eagle Australian Kestrel	Low	Widespread around the coastal margin of the island	Yes – Vehicles, vessel or building rigging	Section 4.3.4.3 Table 4-12 Section 4.4.4.2
Sea Birds	Wedge Tailed Shearwater Bridled Tern	High	Breeding colony on Double Island	Yes – Light, vessel or building rigging	Section 4.3.4.3 Map 6
Medium-sized Mammals	Boodie Golden Bandicoot Spectacled Hare-wallaby Barrow Island Euro	High	Widespread across landforms and vegetation communities	Yes – Vehicles, entrapment in trenches	Section 4.3.2.2 Table 4-9 Map 6
	Black-flanked Rock-wallaby	Low	Restricted to the deeply incised valleys on the west coast of Barrow Island	No	
Fish	Barrow Cave Gudgeon[2]	Unknown	Subterranean aquifer	Yes	Section 4.3.6 Section 6.2.1.3
	Blind Eel	Unknown	Subterranean aquifer	Yes	Section 4.3.6

Note: 1. Refer to Section 6.4

2. Pending EPBC classification. See note regarding taxonomic revision in Section 4.3.6

The extreme northern extent of the Southern Giant-Petrel (*Macronectes giganteus*), which is common in the Southern Ocean, may include Barrow Island but there are no records of this species on Barrow Island. This species is therefore not considered in this Report.

Twelve terrestrial bird species, which comprise matters of NES, have been confirmed in the vicinity of the Onshore Domestic Gas Pipeline on the mainland (Table 3-2).

Table 3-2 EPBC Species Abundance and Habitat/Distribution on Mainland

	Species	Abundance and/or Distribution in Australia	Species or Habitat Potentially Impacted[1]	Baseline Information in this Report
Land Birds	Rainbow Bee-eater	All of Australia except Tasmania and the arid interior of Western Australia. One of the 40 bird species most commonly recorded breeding in Australia.	No	Section 5.3.5 Table 5-6
	Nankeen Kestrel	Abundant and widespread. May have increased due to clearing and introduction of prey species. One of the 40 most commonly recorded bird species in Australia.	No	
	Pallid Cuckoo	Widespread throughout, except Nullarbor Plain.	No	
	Richard's Pipit	Widespread. One of the 40 most commonly recorded bird species in Australia.	No	
Littoral Birds	Osprey	Generally common and secure in Australia, particularly in northern Australia. Distributed along Australian coastlines but rare in Victoria and absent from Tasmania.	No	
	Brahminy Kite	Widespread, and common to abundant in northern Australia.	No	
	Australian Pelican	Only absent in arid interior.	No	
	Eastern Reef Egret	Widespread along coast except Victoria and Tasmania.	No	
	Bar-tailed Godwit	Widespread along coast. Australian population estimate: 185 000 individuals.	No	
	Whimbrel	Widespread along coast. Australian population estimate: 10 000 individuals.	No	
	Eastern Curlew	Widespread along coast, except Nullarbor Plain. Australian population estimate: 28 000 individuals.	No	
	Common Greenshank	Widespread along coast and also in southern interior.	No	

Note: 1. Refer to Section 6.4

3.1.4 Ecological Relationships

Direct relationships exist between the ecological elements defined in Condition 6.1 of Statement No. 800 and Statement No. 769, and Condition 5.1 of EPBC Reference: 2003/1294 and 2008/4178. Examples of such relationships include:

- taxa or features defined in multiple ways (e.g. creekline vegetation and the ecological community of creekline vegetation, and subterranean fauna and the ecological community of subterranean fauna)

- taxa or features at different scales or groupings (e.g. vegetation consists of the combination of plants in an area)
- co-occurring or interdependent species or features (e.g. fauna and habitat, and surface water landforms and creekline vegetation, and the ecological community of creekline vegetation).

Habitat is an ecological element that can be all encompassing. The EPA (2004, 2004a) defines habitat as '[t]he natural environment of an organism or a community, including all biotic and abiotic elements; a suitable place for it to live'. In this Report, the ecological element of 'habitat' is restricted to Boodie warrens, termite mounds, and raptor nests. Other aspects of habitat will be captured through the characterisation of other ecological elements. The EPA has a stated position that '[v]egetation can become a reasonable surrogate for outlining habitat when its main components, structure and the associated landform are also described' (EPA 2004, 2004a).

The significant and direct relationships between ecological elements are summarised in Table 3-3. Such relationships are discussed and characterised in the subsequent sections of this Report.

Table 3-3 Significant and Direct Relationships between Ecological Elements

	Physical Landforms	Surface Water Landforms	Groundwater	Ecological Communities	Habitat	Fauna	Vegetation
Flora							Plant Community
Vegetation		Creeklines Claypans		Mangroves Creeklines			
Fauna	Caves Cliffs Gorges	Creeklines Claypans	Stygofauna	Subterranean Fauna	Warrens Nests Termite Mounds		
Habitat							
Ecological Communities		Creeklines	Stygofauna				
Groundwater	Sinkholes Caves						
Physical Landforms							

Note: 'Physical Landforms' includes coastal foredunes, fossil beds, cliffs and gorges, caves, rock shelters and sinkholes, as described further in Section 4.8 of this Report.

4.0 Baseline State of Ecological Elements on Barrow Island

This section describes and discusses the ecological elements, including significant ecological elements, that occur on Barrow Island. This information is provided to satisfy the conditions of Statement No. 800 (Conditions 6.4i, 6.5ii, 6.5iii, 6.5iv, 6.5v, 6.5vi, 6.5vii, 6.5viii, 6.5ix, 6.5x), and EPBC Reference: 2003/1294 and 2008/4178 (Conditions 5.3i, 5.4ii, 5.4iii, 5.4iv, 5.4v, 5.4vii, 5.4viii, 5.4ix, 5.4x).

4.1 Flora

4.1.1 Methodology

4.1.1.1 Barrow Island Surveys and Targeted Surveys for the Gorgon Gas Development and Jansz Feed Gas Pipeline

There is substantial information on the flora of Barrow Island. An Annotated Bibliography of the Natural History of Barrow Island 1622–2004 (Smith *et al.* 2006) identified 110 reports and publications on the flora and vegetation of Barrow Island. Flora surveys have been undertaken across Barrow Island since the 1960s. These are summarised in Section 4.2 (Vegetation).

The flora inventory for Barrow Island in this Report has been developed on the basis of quadrats, as well as opportunistic observations. Quadrat data provide evidence as to the relative abundance and extent of plant distributions. These quadrats are shown in Map 2 (in Section 10.0), and are summarised in Table 4-1. Flora information is current at the time of this Report.

Table 4-1 Flora Quadrats on Barrow Island

Survey	Number of Samples	Sample Unit[1]	Data	No. Species	No. Species Vouchered	Source Data[2]
Goodall (1969)	640 in transects	5 m × 5 m	species	143	83	Yes
Buckley (1983)	70 70 35 525 in transects	1 m × 1m 5 m × 5 m 25 m × 25 m 5 m × 5 m	species	257[3]	135	No
Trudgen (1989)	54	40 m × 10 m	species alive % cover (each species)	69	0	Yes
Lewis and Grierson (1990)	37	1000 intercept points over 1.5 ha	species alive % cover (each species) % litter % stone % bare % termite mounds	56	0	Yes

Survey	Number of Samples	Sample Unit[1]	Data	No. Species	No. Species Vouchered	Source Data[2]
Mattiske (1993)	60	20 m × 20 m	species alive % cover (each species) dead % cover (each species landform soil type soil depth degree of outcropping litter	166	0	Yes
	350 km	road traverses	opportunistic observations			No
	15 km	foot traverses	opportunistic observations			No
Mattiske (1997)	64 64	2 m × 8 m 2 m × 10 m	alive individuals (each species) dead individuals (each species) alive % cover (each species) dead % cover (each species litter depth % litter	94	4	Yes
RPS BBG (2005)	1661	10 m × 10 m	species alive % cover (each species) vegetation description	70	0	Yes
RPS BBG (2006)	38	50 m × 50 m	species alive % cover (each species) vegetation description	127	0	Yes
Astron (2006)	19	Inherent Disturbance Classification	Habitat Disturbance Score	N/A	0	N/A
Astron (2008)	61	40 m × 40 m	weed species estimated area of weeds (or number of plants) vegetation description habitat type disturbance type and level	3	0	Yes

Notes: 1 Smallest quadrat size (may be nested in larger quadrats)

2 Raw data available/accessed for Report

3 All 219 vouchered and 39 unvouchered species recorded on Barrow Island at time

4.1.1.2 Definition of Significant Flora

Astron Environmental Services (2006) documented weeds at 19 sites on Barrow Island, which were predominantly located at sites used by the existing oilfield operations. Astron Environmental Services (2008) also surveyed weeds at the 61 sites not currently used by existing oilfield operations (including 28 historic infrastructure locations, 15 former borrow pits, 11 Boodie warrens, four burnt areas, and three undisturbed sites) shown in Map 2. A minimum area of 40 m × 40 m was surveyed at each site. Sixty sites were surveyed during September 2006 and April 2008. One site was surveyed in May 2008.

The focus of flora inventories for the Island has been vascular plants. This is consistent with EPA Guidance Statement No. 51 (EPA 2004), which 'is primarily directed at the subset of biodiversity contained in all terrestrial vascular plants', and does not give guidance on non-vascular plant surveys.

4.1.1.3 Definition of Significant Flora

Flora is considered significant on Barrow Island if it is:

- listed as Declared Rare or Priority Flora by DPaW
- restricted or poorly known on Barrow Island and/or the mainland in the vicinity of the Onshore Domestic Gas Pipeline route
- characterised by low regeneration rates after disturbance

  or

- at the southern, western, or northern limit of its known distributions.

4.1.2 Results

The flora of Barrow Island is relatively diverse, representing approximately 23% of the flora records documented for the Pilbara and 26% of the mainland Carnarvon Bioregion (CALM 2005).

All the plant taxa on Barrow Island also occur on the mainland, except *Cucumis* sp. Barrow Island (D.W. Goodall 1264) and *Amaranthus* sp. Barrow Island (R Buckley 6884). However, taxonomic identifications of the flora on Barrow Island show there is evidence that some flora show diversification to an insular environment (RPS BBG 2005).

Totals of 68 families, 180 genera and 397 vascular plant taxa have been recorded on Barrow Island (RPS BBG 2005). Some of these taxa may be erroneous, not able to be confirmed, or were recorded at higher taxonomic levels (e.g. at family or genus rather than species level). A total of 603 voucher specimens collected from Barrow Island have been lodged with the Western Australian Herbarium for 226 taxa from 131 genera and 68 families (Western Australian Herbarium 2008).

The distributions of significant plant species on Barrow Island are shown in Map 3 and the flora inventory is provided in Appendix 2. This inventory is restricted to the 226 taxa recorded on Barrow Island for identifications that can be confirmed through specimens retained at the Western Australian Herbarium.

A total of 70 taxa have been recorded in the 40 quadrats (each 50 × 50 m) in the Gorgon Gas Development Footprint (RPS BBG 2005).

Barrow Island is located within the Cape Range subregion of the Carnarvon Bioregion, and whilst the flora of Barrow Island is in some respects typical of the arid Pilbara region, it also has floral affinities with the Cape Range area on the mainland in the dominance of *Melaleuca* with *Triodia* hummock grasses and the presence of selected species such as *Acanthocarpus verticillatus*, *Lechenaultia divaricata*, *Olearia* sp., and *Scaevola crassifolia* (Trudgen 1989; Mattiske Consulting 1997), particularly in coastal areas (RPS BBG 2005).

The Draft EIS/ERMP (Chevron Australia 2005) identified 26 species of significance relevant to the Gorgon Gas Development. A review of the significance of the flora by Astron Environmental Services (2008a) has identified a total of 40 species of significance. Six of these have been recorded in the Gorgon Gas Development Footprint:

- *Acacia synchronicia* is recorded adjacent to the road between the current airport and Construction village. On Barrow Island, this medium shrub/small tree is restricted to the south-east portion of the Island (Mattiske 1993). The species is widespread in Western Australia. It has been collected in Western Australia between Kalgoorlie, Shark Bay and the Northern Territory border south of Halls Creek (Western Australian Herbarium 2008).

- One population of *Erythrina vespertilio* occurs near North Whites Beach where the Feed Gas Pipeline Shore Crossing is located. On Barrow Island, this deciduous tree is restricted to five main populations (Mattiske 1993); on the mainland, it is widespread across northern Australia and has been collected across northern Western Australia, from Shark Bay to the Northern Territory border south of Halls Creek (Western Australian Herbarium 2008).
- *Grevillea pyramidalis* subsp. *leucadendron* occurs in the Gas Treatment Plant site. While individual trees or shrubs on Barrow Island display low areal coverage (Astron Environmental Services 2008a), the subspecies is spatially widespread through the interior of Barrow Island (Mattiske 1993). The species has been collected across northern Western Australia, from Cape Range to the Northern Territory border south of Halls Creek (Western Australian Herbarium 2008).
- *Melaleuca cardiophylla* occurs at the Gas Treatment Plant site and the Additional Support Area. It has been recorded as having a low regeneration rate after disturbance (Astron Environmental Services 2008a). However, Butler (pers. comm. 2008) has observed that whilst it is readily grown from seed, it does require several consecutive good seasons of rainfall to establish in the field. *Melaleuca cardiophylla* does re-establish in disturbed sites on Barrow Island (Mattiske Consulting 1997; Butler pers. comm. 2008), although this establishment is often at a slower rate than many other species (Butler pers. comm. 2008). This erect to spreading shrub is widespread in the central part of Barrow Island on upland limestone areas (Mattiske 1993). On the mainland, it has largely been collected along the coast of Western Australia between Perth and Karratha (Western Australian Herbarium 2008).
- *Calandrinia* aff. *remota* occurs at the Gas Treatment Plant site. A specimen from Barrow Island of this taxon has been lodged with the Western Australian Herbarium for further taxonomic description. *Calandrinia remota* has predominately been collected between Shark Bay and Geraldton, including from both coastal and inland areas (Western Australian Herbarium 2008). Whilst *Calandrinia* aff. *remota* is at or near the edge of its geographical distribution, it is not identified as a species restricted on Barrow Island.
- *Whiteochloa airoides* occurs in the vicinity of the CO_2 Injection System. This tufted perennial (sometimes annual) grass has been recorded in western coastal and inland areas of Barrow Island and may be more widespread but grazed by native herbivores (Mattiske 1993). This species has been collected across northern Western Australia, from Cape Range to the Northern Territory border south of Halls Creek (Western Australian Herbarium 2008).

Melaleuca cardiophylla and *Grevillea pyradmidalis* are both associated with *Triodia wiseana* and tend to be more abundant on broken limestone gravel of lower ridges and slopes (Buckley 1983). The extent of these species to be cleared on Barrow Island (based on population boundaries) for the Gorgon Gas Development and Jansz Feed Gas Pipeline is indicated in Table 4-2 and is shown in Section 10.0, Map 3. The total extent of these species across Barrow Island has not been mapped. As mapping over a broader area occurs, the proportion of these species calculated as cleared decreases. It should be noted that the apparent distribution of species can vary over time due to influences such as fire, grazing, and other disturbances. The distributions of these two species mapped in 1969 by Goodall and in 1983 by Buckley are not directly comparable due to different mapping techniques, but do indicate that the core areas of the populations of these species remained relatively consistent over this 14-year period.

Table 4-2 Approximate Number of Hectares of *Melaleuca cardiophylla* and *Grevillea pyramidalis* to be Cleared

Terrestrial Facility	*Melaleuca cardiophylla*[1]	*Melaleuca cardiophylla*[2]	*Grevillea pyramidalis*[1]	*Grevillea pyramidalis*[2]
Gas Treatment Plant	28.63	54.30	33.35	0.00
CO_2 Injection System	0.83	0.80	0.16	0.00

Terrestrial Facility	*Melaleuca cardiophylla*[1]	*Melaleuca cardiophylla*[2]	*Grevillea pyramidalis*[1]	*Grevillea pyramidalis*[2]
Associated Terrestrial Infrastructure[3]	33.96	23.68	0.13	0.00
Areas impacted for seismic data acquisition	0.56	1.10	0.26	0.00
Onshore Feed Gas Pipeline System	0.98	3.90	2.02	0.00
Terrestrial component of the Shore Crossing	0.00	0.00	0.00	0.00
Total to be Cleared	**33.36**	**83.40**	**35.92**	**0.00**
Total Mapped Extent	**333.01**	**3263.97**	**220.87**	**53.07**

Notes: 1 Based on mapping from Chevron Australia (2005)
2 Based on mapping from Buckley (1983)

No DRF species, as listed under subsection (2) of Section 23F of the *Wildlife Conservation Act 1950* (WA) and as listed by DPaW, have been recorded on Barrow Island (DEC 2008).

Three Priority species have been collected on Barrow Island. Priority flora is a non-legislative category aimed to manage those plant taxa listed by DPaW on the basis that they are known from only a few collections, or a few sites, but which have not been adequately surveyed. Such flora may be rare or threatened, but cannot be considered for declaration as rare flora until such survey work has been undertaken.

The annual Priority 1 daisy species *Helichrysum oligochaetum* was recorded twice on Barrow Island by Mattiske (1993) but not recorded since. Specimens of this species were not vouchered with the Western Australian Herbarium, and CALM (2005) suggested that this species may not occur on Barrow Island and that these records represent a misidentification. No plants were found within the Gorgon Gas Development Footprint, during post-cyclonic rain surveys conducted in April and May 2004, when seeds would be expected to have germinated if they were present. The six specimens of this taxon in the Western Australian Herbarium are from sites across the Pilbara, up to 500 km apart (Western Australian Herbarium 2008).

The Priority 2 species identified in the Draft EIS/ERMP (Chevron Australia 2005) as *Mukia* sp. Barrow Island (D.W. Goodall 1264) has been renamed *Cucumis* sp. Barrow Island (D.W. Goodall 1264) but remains a Priority 2 species. The species is documented in the centre and on the west coast of Barrow Island. The closest documented recording of this species by the DEC (2008a) is 4.5 km outside the Gorgon Gas Development Footprint; it was recorded at one location during a survey of seismic lines at less than 2% cover (Astron Environmental Services 2010a). No specimens of this taxon have been collected from the mainland and lodged with the Western Australian Herbarium (Western Australian Herbarium 2008).

The Priority 3 species *Corchorus congener* was recorded in the Draft EIS/ERMP (Chevron Australia 2005) within the Gas Treatment Plant site and the North Whites Beach Feed Gas Pipeline Shore Crossing, during a survey of proposed seismic line corridors during the 2008 vegetation survey (Astron Environmental Services 2010a) and in the Additional Support Area (Astron Environmental Services 2013). This spreading shrub is widely distributed on parts of the Island, is well recorded from Cape Range on the mainland (Astron Environmental Services 2008a), and 'has also been observed to regenerate successfully on rehabilitated sites' (Astron Environmental Services 2002). 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 subassociations mapped across Barrow Island. On the mainland, this species has been collected predominately from Cape Range (Western Australian Herbarium 2008).

The weeds of Barrow Island are listed in Table 4-3 and are shown in Map 3 in Section 10.0. Nineteen vascular plant taxa have been recorded as being introduced to Barrow Island, three of which have not been recorded since 1993.

The sites surveyed in 2006 were outside the scope of the then current weed control program but Astron Environmental Services (2008) did record that Blackberry Nightshade was removed from five sites in 2006, as was the one Buffel Grass germinant observed. Spiked Malvastrum was not controlled.

Nine weeds (Poppy, Caltrop, Buffel Grass, Blackberry Nightshade, Kapok, Milk Thistle, Spiked Malvastrum, Stinking Passion Flower, and Tomato) have been recorded at a total of nine locations within 100 m of the Gorgon Gas Development Footprint (including previously cleared areas that may be used).

Only three weeds were recorded in the 61 sites monitored in 2006 and 2008, and approximately 71% of sites (43 of 61) were weed-free. Historically, infrastructure areas have higher weed occurrences than Boodie warrens or borrow pits.

The largest infestation of the three weeds recorded in non-infrastructure areas are 510% cover of Spiked Malvastrum (*Malvastrum americanum*), 1000 plants of Buffel Grass, and four plants of Blackberry Nightshade. Spiked Malvastrum was the most widespread weed species. Spiked Malvastrum can be considered naturalised on Barrow Island (Butler pers. comm. 2008). Spiked Malvastrum is a perennial weed of many arid zone habitats from the Kimberley to the Pilbara and Gascoyne Regions, and its establishment and survival may be aided by its inedibility to herbivores (Hussey *et al.* 2007). It was recorded across Barrow Island in the 1960s by Goodall (1969) and has a widespread distribution on Barrow Island, sometimes occurring in dense clusters (Astron Environmental Services 2008).

Table 4-3 Number of Recorded Occurrences of Weeds on Barrow Island

Scientific Name	Common Name	Sites Documented Prior to 2006	61 Sites Monitored in 2006	61 Sites Remonitored in 2008
Aerva javanica	Kapok Bush	2		
Arctotheca calendula	Cape Weed	0*		
Cenchrus ciliaris	Buffel Grass	7	1	2
Centaurium erythraea	Common Centaury	0*		
Conyza sumatrensis	Tall Fleabane	2		
Cynodon dactylon	Couch Grass	1		
Dactyloctenium aegyptium	Coast Button Grass	1		
Emex australis	Doublegee	1		
Eucalyptus camaldulensis	River Gum	1		
Eucalyptus gomphocephala	Tuart	1		
Lycopersicon esculentum	Tomato	2		
Malvastrum americanum	Spiked Malvastrum	Numerous	18	19
Papaver somniferum	Poppy	1		
Passiflora foetida var. *hispida*	Wild Passionfruit	3		
Pseudognaphalium luteoalbum	Jersey Cudweed	0*		

Scientific Name	Common Name	Sites Documented Prior to 2006	61 Sites Monitored in 2006	61 Sites Remonitored in 2008
Setaria verticillata	Whorled Pigeon Grass	1		
Solanum nigrum	Blackberry Nightshade	2	5	0
Sonchus oleraceus	Milk Thistle	5		
Tribulus terrestris	Caltrop	1		

*Notes: * Last recorded 1993, previous locations unknown*

Source: Astron Environmental Services (2006, 2008)

There are voucher specimens for the weeds Caltrop and Poppy retained at the Western Australian Herbarium from near Terminal Tanks in 1991, and in the existing accommodation camp in 2006 respectively (Western Australian Herbarium 2008).

In addition to these introduced weed species, it appears that human activity may have led to the establishment of *Eucalyptus xerothermica* in the centre of Barrow Island, as it only occurs naturally on Barrow Island near the west coast (Burbidge pers. comm. 2008).

There is no inventory of the lower plants of Barrow Island such as mosses and lichens. This is consistent with EPA Guidance Statement No. 51 (EPA 2004) which 'is primarily directed at the subset of biodiversity contained in all terrestrial vascular plants'. Fungi occur on Barrow Island (Butler pers. comm. 2008), although Barrow Island's relative aridity is not conducive to abundant or diverse assemblages of non-vascular plants.

4.2 Vegetation

4.2.1 Methodology

4.2.1.1 Terminology

Vegetation consists of the plant biodiversity in an area; that is, the combinations of the populations of vascular plant species in a given area, taking into account the nature and extent of each combination (EPA 2004). These combinations include consideration of structure (height and density) and floristics (species presence and relative dominance).

Categories have been applied to Barrow Island vegetation at a range of scales with terms that do not have an established or standard scale or level of detail associated with them. To standardise terminology for vegetation units on Barrow Island, equivalent National Vegetation Information System (NVIS) descriptions have been applied to previously used categories (Table 4-4). The NVIS is a collaborative initiative between the Australian Commonwealth, State and Territory governments to enable the compilation of a nationally consistent vegetation dataset from data collected by states and territories. NVIS terms are used for vegetation units hereafter in this Report. This approach is consistent with EPA Guidance Statement No. 51 (EPA 2004) which states that 'where possible, information should be collected so that it is compatible with NVIS protocols'.

There have been various terms used to classify vegetation units between studies. In 2008, Chevron Australia commissioned Astron Environmental to re-assess the vegetation units on Barrow Island with the intent to align on a classification that is commensurate with current vegetation mapping and management requirements, and that aligns with NVIS protocols. Whilst the vegetation unit terms used among botanists varies from study to study, one approach has been to commence with the recognition of units that focus on vegetation formations (e.g. unit code C1, as per Mattiske 1993), vegetation subformations (e.g. unit code C1a) and vegetation associations (e.g. unit code C1a1).

This facilitates identifying the habitat of restricted plants and this formation or subformation classification level of mapping is now being applied elsewhere on Barrow Island by Astron Environmental Services (2008a).Vegetation information is current at the time of this Report.

Table 4-4 NVIS Descriptions for Mapped Vegetation Units

NVIS Description	Survey	Portion of Barrow Island Mapped	Mapping Scale	Units in Original Surveys	Example of Code for Unit
-	Mattiske (1993)	100%	1:25 000	Habitats	C
Broad Floristic Formation	Buckley (1983)	100%	1:20 000	Large scale vegetation unit	-
Formation	Mattiske (1993)	100%	1:25 000	Community	C1
Subformation	Astron Environmental Services (2008a)	11%	1:5000	Not named	C1a
Association	Chevron Australia (2005), Astron Environmental Services (2008a)	11%	1:5000	Association	C1a2

4.2.1.2 Barrow Island Surveys

There is substantial information on the vegetation of Barrow Island. An Annotated Bibliography of the Natural History of Barrow Island 1622–2004 (Smith *et al.* 2006) identified 110 reports and publications on the flora and vegetation of Barrow Island.

Beard (1975) mapped the vegetation of the entire Pilbara region at a scale of 1:1 000 000.

On Barrow Island, Buckley (1983) classified the vegetation into broad units based on analysis of the presence or absence of 218 taxa in 175 quadrats and five transects, and mapped this at a scale of 1:20 000 across the Island (with selected areas mapped using 1:10 000 aerial imagery).

Trudgen (1989) recorded detailed flora information in quadrats at 41 impact and 13 reference sites to compare the vegetation in areas being revegetated after disturbance to that in undisturbed areas.

Mattiske (1993) established more than 100 quadrats for vegetation mapping at a scale of 1:25 000 and assessed the revegetation of seismic lines across the Island. Mattiske (1993) classified plant communities based on major landform types, soil types and dominant species (including cluster analysis of percentage foliage cover in quadrats). This refined the vegetation units of Buckley (1983). Many of the vegetation types of Buckley (1983) and Mattiske (1993) are similar or overlap.

Disturbed vegetation (excluding seismic lines) were mapped by National Geographic Information Systems (2001) at a scale of 1:10 000 on the basis of aerial photography interpretation, with an assumption of an average road width of 7.5 m.

4.2.1.3 Targeted Surveys for the Gorgon Gas Development and Jansz Feed Gas Pipeline

Vegetation in the vicinity of the Gorgon Gas Development Footprint was assessed in accordance with EPA Guidance Statement No. 51 (EPA 2004), and mapping of vegetation at the scale of subformation and association has been undertaken across more than 11% of Barrow Island.

Vegetation was mapped within an area of approximately 1683 ha surrounding the Gas Treatment Plant, Administration and Operations Complex, and Construction Village on Barrow Island (refer to Map 2) as documented in the Draft EIS/ERMP (Chevron Australia 2005). A total of 72 permanent vegetation quadrats (50 × 50 m and 10 × 50 m) remain just outside the Gas Treatment Plant site (Chevron Australia 2005). Vegetation plots were established and surveyed in September and October 2003 and in January 2004. The area where the Gas Treatment Plant is located was resurveyed in April and May 2004 following cyclonic rains, to collect annual species.

Vegetation was characterised by RPS BBG in accordance with Trudgen's (2002) adaptation of Aplin's (1979) modification of Specht's (1970) vegetation classification system. This allowed for species with less than 2% cover to be considered, as is appropriate given the low cover of many strata in the vegetation of more arid areas (Trudgen 2002). The threshold for including plant species in vegetation descriptions was 0.5% cover. Vegetation subformations were described on the basis of a cluster analysis between 87 quadrats, using data of live and dead specimens, foliage cover, and field descriptions.

Surveys applying the same, or more refined but directly comparable, methodologies conducted since the Draft EIS/ERMP (Chevron Australia 2005) include the Onshore Feed Gas Pipeline route and airstrip realignments.

For the Onshore Feed Gas Pipeline, a continuous transect at least twice the width of the pipeline easement was surveyed on foot. Pipeline routes were surveyed in April and May 2004. Additional surveys to determine the extent of potentially restricted vegetation units were conducted in July 2004, and January to February 2008.

The coastal dunes at North Whites Beach were surveyed in June 2005 (RPS BBG 2006a). Field surveys of the area encompassing the HDD laydown and pipe stringing area were conducted in November and December 2005 (RPS BBG 2006a). Additional areas of the Onshore Feed Gas Pipeline were surveyed in 2006 as a result of minor realignments (RPS BBG 2006a). Finally, coastal vegetation communities at Whites Beach were surveyed in 2006 to discern vegetation communities along a potential access route for an investigatory drilling program (RPS BBG 2006a).

The vegetation survey at the operational airport site was conducted in October 2005 to support the expansion and realignment of the existing airstrip (RPS BBG 2006).

Flora and vegetation surveys were undertaken at the association scale between June and September 2008 in 10 m wide corridors along proposed seismic source lines (Astron Environmental Services 2010a). Flora and vegetation in the Additional Support Area was surveyed in October 2013 (Astron Environmental Services 2013). All vegetation associations described during surveys for the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island have been grouped by Astron Environmental Services (2008a) into subformations based on familiarity.

4.2.1.4 Definition of Significant Vegetation

The scale at which vegetation is described and mapped determines, in part, the number of vegetation units and the extent of individual vegetation types. Vegetation is described and mapped at an appropriate scale for assessing the significance of and managing the vegetation on Barrow Island.

More detailed vegetation mapping, at the scale of subformations and associations, is useful in more precisely delineating the boundaries of the formations defined by Mattiske (1993), and in identifying the habitat of restricted plants.

The significant vegetation units on Barrow Island consists of:

- formations restricted on Barrow Island to less than 90 ha

- formations vulnerable to degradation (neither resistant nor resilient to disturbance and very slow to recover/self-regenerate after disturbance ceases)
- subformations defined by, and typically containing greater than 2% cover of a plant taxon that is restricted to an area on Barrow Island
- subformations isolated in atypical landscape positions by geological processes.

Applying these criteria results in the following formations being identified as significant:

- stands of *Erythrina vespertilio*, *Eucalyptus xerothermica* and *Ficus virens* var. *virens*, which are restricted, mapped by Mattiske (1993) as F4, L8 and L2 respectively
- restricted plant communities, tidal (T1 and T2), marine areas (M1), claypans (S1 and S2), creekbeds (D1, D2 and D3) mapped by Mattiske (1993)
- restricted hummock grasslands of *Triodia angusta* with emergent *Acacia synchronicia*, mapped by Mattiske (1993) as F2. There are a range of short-lived and annual plant species in this formation, which has the highest levels of recorded species richness, with in excess of 100 species recorded in 100 m^2
- coastal dunes, mapped by Mattiske (1993) as C1, C2, C3, C4, C6 and C7, which are vulnerable to erosion.

In addition, formations F3 and L10 are identified as significant as they have an extent of 37 ha and 48 ha respectively. Associations that form part of significant subformations are also considered significant. The 63 significant subformations include the 36 subformations identified as significant in the Draft EIS/ERMP (Chevron Australia 2005), with the exception of L3c (which was described at a scale not appropriate for determining restriction).

The higher level of historical disturbance of drainage lines is reflected in their listing as a Priority Ecological Community (PEC). Threatened Ecological Communities (TECs) and PECs were not considered in determining the significance of vegetation associations as these are considered under the ecological element 'ecological communities' in Section 4.5.

4.2.2 Results

Limited published information is available on vegetation at the appropriate scale for the Pilbara region. Therefore, the comparison of vegetation between Barrow Island and the mainland provided below has been completed using Beard vegetation units as this is the only regional scale mapping completed at present.

In mapping the vegetation of the entire Pilbara region, Beard (1975) mapped the vegetation on Barrow Island as:

- Open Hummock Grassland of *Triodia pungens* on sands, south of the geological fault between Junction Beach and Eagles Nest Point
- Heterogeneous Sparse Shrub Steppe (including *Acacia bivenosa*, *Acacia coriacea*, *Hakea lorea* and *Melaleuca cardiophylla*) over Open Hummock Grassland of *Triodia wiseana* and *Triodia angusta* on limestone, north of the geological fault.

Beard (1975) also mapped Open Hummock Grassland of *Triodia pungens*, as scattered along the entire mainland coastline of the Pilbara mapsheet (between Cape Range and north of Cape Keraudren), and as occupying the entirety of the Dampier Peninsula, the Dampier Archipelago, the Montebello Islands, Thevenard Island, Long Island, and Muiron Island.

Beard (1975) did not map Heterogeneous Sparse Shrub Steppe over Open Hummock Grassland of *Triodia wiseana* and *Triodia angusta* on the Pilbara mainland, or any islands (other than Barrow Island).

The most similar vegetation types that Beard (1975) mapped and described were:

- Sparse Shrub Steppe of *Acacia bivenosa* over Open Hummock Grassland of *Triodia wiseana* on Rough Range in Cape Range (where the geological formations mainly consist of limestone). *Acacia bivenosa* and *Melaleuca cardiophylla* are the dominant shrub species in this vegetation unit, and are also present on Barrow Island. *Acacia gregorii* and *Triodia basedowii* are also dominant species in this vegetation unit, but this shrub species and this spinifex species are absent from Barrow Island.
- Shrub Steppe of *Acacia coriacea* over Open Hummock Grassland of *Triodia pungens* south of Vlaming Head along the west coast of Cape Range, including some areas where either *Triodia wiseana* or *Triodia angusta* replace *Triodia pungens*. In addition to *Acacia bivenosa* and *Acacia coriacea* (which also occur on Barrow Island), *Acacia tetragonophylla* (which does not occur on Barrow island) is also one of the more abundant shrubs in this vegetation unit.
- Sparse Shrub Steppe of Acacia bivenosa over Open Hummock Grassland of *Triodia wiseana* on very stony areas in the northern portion of Stuart Hills (the geological formations consisting mainly of shale, greywacke and dolomite with outcrops of granite). An '*Acacia elliptica*' (sic.) and *Triodia basedowii* are dominant species in this vegetation unit. The wattle species and this spinifex species are absent from Barrow Island.

The mainland coastal plains closest to Barrow Island are the Onslow Coastal Plain and Abydos Plains. Beard (1975) describes the soils of the Onslow Coastal Plain and Abydos Plains as differing from those on Barrow Island in being largely derived from alluvium, and alluvium and granite respectively, rather than stony limestone. *Acacia pyrifolia* is a dominate shrub species on these two mainland plains; it is absent from Barrow Island.

Whilst all the flora of Barrow Island occurs either on other islands or the mainland (except *Cucumis* sp. Barrow Island), Kruger (pers. comm. 2008) is of the opinion that the vegetation (i.e. combination of plants) is relatively unique, with the exception of the near-coastal vegetation, which is relatively consistent within the Pilbara region. Kruger (pers. comm. 2008) asserts that Barrow Island non-coastal vegetation is not similar to that of Varanus Island, the Dampier Archipelago islands, Cape Range, or the Onslow and Mardie coastlines.

The vegetation on Hermite Island in the Montebello Islands is 'very similar to that on Barrow Island', with inland areas dominated by *Triodia pungens* and T*riodia wiseana* (Burbidge 1971). The vegetation of the Lowendal Islands supports the coastal sand, coastal rock and mangrove assemblages similar to Barrow Island, but not inland vegetation assemblages (Buckley 1985). Of the four vegetation communities described on Cape Range by Keighery and Gibson (1993), community type 4 of mixed shrublands over hummock grasslands, which occurs on massive tertiary limestones, is similar in some respects to the upland limestone communities dominated by *Triodia wiseana* on Barrow Island.

Therefore, the vegetation is potentially significant at a regional scale, although a quantitative comparison of floristic communities, floristic richness and vegetation types between Barrow Island and the mainland has not been undertaken.

The eight habitats, into which the 34 formations mapped and described by Mattiske (1993) are grouped, are shown in Map 2.

To date, more detailed mapping of the vegetation has included descriptions of some 263 vegetation subformations (excluding 16 disturbed units) over 11% of Barrow Island (Astron Environmental Services 2008b). A separate survey of CO_2 Seismic Survey lines included descriptions of 447 vegetation subformations (excluding 55 disturbed units) over a total area of approximately 131 ha. A summary of the refinement of classification of Barrow Island's vegetation is shown in Table 4-5.

Table 4-5 Number of Vegetation Units Mapped in Habitat Types on Barrow Island

		Broad Floristic Formation (Buckley 1983)	**Sub formation** (Buckley 1983)	**Formation** (Mattiske 1993)	**Subformation** (Astron Environmental Services 2008b)	**Association** (Chevron Australia 2005, Astron Environmental Services 2008b)	**Association*** (Astron Environmental Services 2010a)
C	**Coastal Complex and Dune Systems**	2	3	7	30	51	4
D	**Drainage Lines and Creeks**	1	1	3	15	22	84
F	**Flats**	- (included with watercourses)	4	7	29	52	119
L	**Limestone Ridges and Slopes**	1	1	10	51	105	238
S	**Claypans**	1	2	2	2	4	2
V	**Valley Slopes and Escarpment Slopes**	- (included with watercourses)	4	2	11	29	Areas not mapped
M	**Marine**	1	2	1	Areas not mapped	Areas not mapped	Areas not mapped
T	**Tidal**	3	9	2	Areas not mapped	Areas not mapped	Areas not mapped
	Disturbed Areas	Areas not mapped	Areas not mapped	Areas not mapped	Areas not mapped	Areas not mapped	55
	Total	**9**	**28**	**34**	**138**	**263**	**502**

**Note: the Astron Environmental Services 2010a study included Gorgon Seismic Project Survey area only and did not cover the whole of Barrow Island.*

A summary of the characteristics of the formations mapped by Mattiske (1993) is provided in Appendix 3. Formations were delineated by Mattiske (1993) on the basis of clustering analysis using SYSTAT software with both average linkage and single linkage methods, and the Soreson dissimilarity index.

4.2.2.1 Clearing

The *Barrow Island Act 2003* (WA) defines the total area and breakdown (distribution) of uncleared land on Barrow Island that can be used for gas processing purposes. Under section 9 of the *Barrow Island Act 2003* (WA), no more than 332 ha in total of uncleared land on Barrow Island can be the subject of a lease, licence, or easement for gas processing purposes.

The types of previous clearing on Barrow Island are summarised in Table 4-6. The extent of vegetation formations on Barrow Island in which any construction-related clearing is proposed for the Gorgon Gas Development and Jansz Feed Gas Pipeline are summarised in Table 4-7, and equate to approximately 332 ha of area to be cleared on Barrow Island. These areas remain current at the time of this Report, but may change as vegetation boundaries or land tenure are revised.

The 63 subformations of significance mapped in the vicinity of the Gorgon Gas Development's Terrestrial Facilities are listed in Appendix 3. Nineteen of these subformations are partially included in the Gorgon Gas Development and Jansz Feed Gas Pipeline. Of the 2483 ha

surveyed at the subformation scale, approximately 224.5 ha was mapped as being previously disturbed.

Approximately 90 ha of land (approximately 30 km long by 30 m wide) will be disturbed by the Onshore Domestic Gas Pipeline on the mainland. The areas of direct impact from the Gorgon Gas Development and Jansz Feed Gas Pipeline are shown in Maps 1 to 12, which illustrate the distribution of ecological elements.

Table 4-6 Previous Clearing on Barrow Island

Type of Clearing		Area Cleared (ha)	% of Barrow Island
Long-term	Base – administration, workshops, warehouse	16.69	0.07%
	Infrastructure (e.g. camp, major stations)	60.24	0.25%
	Operating gravel pits	5.22	0.02%
	Disused gravel pits	344.53	1.46%
	Rehabilitated infrastructure	57.06	0.24%
	Roads	284.14	1.21%
	Bulk storage (terminal tanks)	10.63	0.05%
	Well pads	220.00	0.93%
	Airport	42.10	0.18%
	Old airport – storage and laydown area	10.21	0.04%
	Long-term Subtotal	**1050.82**	**4.45%**
Short-term	Seismic lines	170.73	0.72%
	Flow lines (carbon steel and glass reinforced epoxy)	1.2	0.005%
	Short-term Subtotal	**171.93**	**0.73%**
All	**Total**	**1222.75**	**5.18%**

Source: Chevron Australia 2005

Table 4-7 Approximate Extent of Vegetation Formations that will be Cleared in the Gorgon Gas Development Footprint on Barrow Island

Formation[1]	Total Extent[1] (ha)	Gas Treatment Plant	CO_2 Injection System	Associated Terrestrial Infrastructure	Areas impacted for seismic data acquisition	Onshore Feed Gas Pipeline System	Terrestrial component of the Shore Crossing	Total Extent to be Cleared* (ha)	Total % to be Cleared
C1	257.41						0.25	0.25	0.10%
C2	535.21	0.23	0.09	0.02	0.31		1.85	2.49	0.47%
C3	413.98			0.31	0.59		0.42	1.32	0.32%
C4	69.63							0.00	0.00%
C5	205.45	1.08		0.37				1.44	0.70%
C6	14.19							0.00	0.00%
C7	38.18							0.00	0.00%
D1	37.12			0.15	0.13			0.28	0.76%
D2	1096.68	19.74	1.34	4.80	1.65	1.76		29.28	2.67%
D3	0.64							0.00	0.00%
F1	1567.19	26.64	2.31	25.03	1.47			55.44	3.54%

Formation[1]	Total Extent[1] (ha)	Gas Treatment Plant	CO_2 Injection System	Associated Terrestrial Infrastructure	Areas impacted for seismic data acquisition	Onshore Feed Gas Pipeline System	Terrestrial component of the Shore Crossing	Total Extent to be Cleared* (ha)	Total % to be Cleared
F2	9.01							0.00	0.00%
F3	36.87							0.00	0.00%
F4	42.23							0.00	0.00%
F5	1374.32			0.26	1.23		1.92	3.42	0.25%
F6	137.47							0.00	0.00%
F7	856.25		0.28		2.74	0.92	1.22	5.16	0.60%
F8	NA							0.00	0.00%
L1	2727.84			0.40	0.31	1.29		2.00	0.07%
L2	19.60							0.00	0.00%
L3	2782.50	2.47	5.03	1.70	3.47	4.48		17.16	0.62%
L4	322.73			0.00	0.63	1.03		1.67	0.52%
L5	105.68			0.01	0.10			0.11	0.11%
L6	93.67			0.27	0.03	1.86	0.36	2.52	2.69%
L7	1583.41	55.96	1.33	13.37	1.98	7.45		80.09	5.06%
L8	8.83				0.00			0.00	0.01%
L9	1747.30		0.38	7.18	1.34		3.37	12.28	0.70%
L10	47.51							0.00	0.00%
M1	23.86							0.00	0.00%
S1	192.22							0.00	0.00%
S2	0.91							0.00	0.00%
T1	12.20				0.01			0.01	0.06%
T2	3.64							0.00	0.00%
V1	6822.93	61.21	4.21	26.78	5.14	12.06		109.39	1.60%
V2	144.57			0.29				0.29	0.20%
V3	NA							0.00	0.00%
Unvegetated/ Disturbed	121.51			0.19			0.44	0.64	0.52%
Total	23452.75	167.32	14.96	31.60	21.13	30.85	9.83	325.23	1.39%

Notes: 1 based on mapping of Mattiske 1993

Significant Ecological Elements are shaded in grey.

While Table 4-6 and Table 4-7 provide an indication of the extent of previous and forecasted clearing, a more precise delineation of cleared areas for the Gorgon Gas Development is defined in the Vegetation Clearing and Audit Common User Procedure (Chevron Australia 2012b).

A vegetation survey along a proposed Gorgon CO_2 Baseline Seismic Survey area was conducted in 2008 (Astron Environmental Services 2010a), covering an area of approximately 132 ha (Table 4-8). The vegetation mapping and field observations were used to identify restricted vegetation units and habitat features that were to be avoided, where practicable, during the subsequent CO_2 Baseline Seismic Survey operations (Table 4-9).

Table 4-8 Habitat Types Mapped within the Gorgon Seismic Project Vegetation Survey Area

Habitat	Description of Habitat Type within Vegetation Survey Area	Area of Gorgon Seismic Vegetation Survey Area (ha)
Claypans	Clay pan and small clay soak area on flat	0.4
Coastal complex and dune system	Fore dunes; swale between limestone coastal platform and fore dunes, supratidal drainage line and saline flat	0.5
Creeks or seasonal drainage lines	Broad drainage lines on flats and between hills; minor rocky drainage lines in limestone hill slopes; minor drainage lines on flats and between hills	6.6
Flats	Red sandy flats, sometimes over limestone platform and/or coastal; floor of basin with deep silty soils and mixed red loam and colluvial limestone flats	20.1
Limestone slopes and ridges	Limestone slopes and ridges with red loams and silts	97.4
Disturbed areas	Borrow pits on drainage lines; road verges and lease pads; historic seismic lines on limestone slopes	6.5
Total		131.5

Source: Adapted from Astron Environmental Services 2010a

Table 4-9 Significant Features Identified during CO_2 Baseline Seismic Vegetation Survey to be Avoided

Restricted Vegetation Classification	Number of Vegetation Associations*	Approximate Area (ha)*
RD1: Vegetation is restricted in areal coverage on Barrow Island, based on total land area on Barrow Island	72	8.6
RD3: Vegetation with a restricted areal coverage and fragmented distribution on Barrow Island	1	5.5
RF: Vegetation containing typically >25% cover of flora that are either Declared Rare, Priority, EPBC Act Listed or Specially Protected, and that are used to define the vegetation	91	30.8
RDF: Vegetation that satisfies one of the four categories of distribution restricted vegetation plus contains >2% cover of flora that are either Declared Rare, Priority, EPBC Act Listed or Specially Protected	15	1.5
RBR1: Relict Vegetation	4	0.7
RBR2: Relict Vegetation with Restricted Distribution	15	3.2
RBR3: Relict Vegetation with Restricted Flora	1	0.1
RBR4: Relict Vegetation with restricted Distribution and Flora	2	0.6
Fauna Habitat	**Number Identified***	
Termite Mound	595	-
Ficus Stand	689	-
Boodie warrens	2	-
Sinkhole	1	-

*Note: * within vegetation surveyed seismic line corridors (Astron Environmental Services 2010a)*

4.2.2.2 Vegetation and Soils

Vegetation has a distinct relationship with landforms and soils on Barrow Island (Mattiske 1993). Although approximately 75% of species on Barrow Island have been recorded on more than one landform type, there are plant species that are characteristic of landforms due to their increased relative dominance/abundance on particular landforms. The plant species that are characteristic of landforms on Barrow Island are listed in Table 4-10 and the distributions of significant plant species on Barrow Island are shown in Map 3.

Table 4-10 Plant Species Characteristic of Landforms on Barrow Island

Landform	Substrate	Characteristic/ Abundant Grass Species[1]	Other Characteristic Species
Coastal Dunes and Cliffs	White Sand	*Spinifex longifolius*	*Ipomoea pes-caprae* *Salsola tragus*
	Red Sand	*Triodia pungens*	*Acacia coriacea*
	Limestone	-	*Frankenia pauciflora*
Drainage Lines and Creeklines	Red Sand and Red Sandy Clay	*Triodia angusta*	*Hakea lorea* *Acacia bivenosa* *Gossypium robinsonii* *Petalostylis labicheoides*
Flats			
Ridges and Slopes	Limestone	*Triodia wiseana*	*Melaleuca cardiophylla* *Ficus brachypoda* *Ficus virens* *Erythrina vespertilio* *Pittosporum phylliraeoides*
Valley Slopes and Escarpment Slopes			
Claypans	Clay	*Mixed grasses*	*Mixed forbs*
Marine Flats	Sand	*Sporobolus virginicus*	*Avicennia marina*
Tidal Flats	Clays with Shallow Limestone Outcrops		*Tecticornia halocnemoides* *Frankenia pauciflora*

Note: 1 Most abundant species listed, other grass species also usually present

4.3 Fauna

4.3.1 Overview

There is substantial information on the fauna of Barrow Island. An Annotated Bibliography of the Natural History of Barrow Island 1622–2004 (Smith *et al.* 2006) identified 41 reports and publications on the invertebrate fauna of Barrow Island, and 217 reports and publications on the vertebrate fauna of Barrow Island.

The locations of fauna sampling and surveying are shown on Map 5i and the distribution of selected significant species are shown on Map 6. Map 6 includes the location of turtle beaches for completeness. For information related to marine turtles, refer to the Long-term Marine Turtle Management Plan (Chevron Australia 2013b), which is required under Condition 16 of Statement No. 800 and Condition 12 of EPBC Reference: 2003/1294 and 2008/4178.

To aid readability, this section is divided into:

- mammals
- reptiles and amphibians
- birds

- terrestrial invertebrates
- subterranean fauna.

4.3.1.1 Definition of Significant Fauna

The fauna assemblages of Barrow Island are significant because the Island has not been colonised by non-indigenous terrestrial mammals that could alter ecological processes, and because direct interactions with humans have been strictly controlled.

Specific fauna species are considered significant if they are:

- listed under the EPBC Act (Cth)
- listed under the *Wildlife Conservation Act 1950* (WA)
- listed as Priority species by DPaW
- short-range endemics (SREs)

  or

- top-level predators on the Island and therefore critical to ecological processes.

The ability of populations to recover after disturbance (recolonise disturbed or depopulated areas) has not been directly considered in determining fauna significance. This is because there are difficulties in applying this principle consistently across fauna groups due to varying levels of documented responses to disturbance. However, species with low reproduction rates, such as subterranean fauna and raptors, are identified as significant for other reasons.

Fauna inventories and species of significance are listed in Appendix 4 to Appendix 8.

4.3.2 Mammals

4.3.2.1 Methodology

Extensive mammal surveys have been undertaken on Barrow Island, as indicated by the number of trapping grids and transects shown in Map 5i.

DPaW has collected information on terrestrial vertebrates on Barrow Island since 1998 using spotlighting transects and five grids (increased to six in 2007) of traps in representative areas around the Island. These data have been captured in a number of reports including: Burbidge *et al.* (1998); Morris *et al.* (1999); Morris *et al.* (2001); Morris *et al.* (2002); Burbidge *et al.* (2003); and Burbidge and Holmes (2006).

The mammal (and reptile) surveys in the vicinity of the Gas Treatment Plant site in November and December 2003, and in October 2004 are detailed in the Draft EIS/ERMP (Chevron Australia 2005). The Feed Gas Pipeline routes, airport extension, and road-widening areas were also surveyed in 2004 for signs of mammal activity, in particular, Boodie warrens.

Since completion of the Draft EIS/ERMP studies in 2005 (Chevron Australia 2005), terrestrial fauna surveys were conducted in 2005 and 2006 to support realignments in the Onshore Feed Gas Pipeline and the location of the HDD Shore Crossing laydown area (RPS BBG 2006b). A survey of sensitive habitats (warrens) in the area was also undertaken for the CO_2 seismic monitoring area by Astron Environmental Services (2009) and for the Additional Support Area by Biota Environmental Sciences (2013).

The methodology used in the mammal (and reptile) survey for the Gorgon Gas Development and Jansz Feed Gas Pipeline replicated the grid alignment of the DEC surveys. Results from the mammal (and reptile) survey collected within the Development area were compared with DEC data from similar habitats elsewhere on the Island to determine the importance of different vegetation and landform types for fauna. Each trap site contained 25 pitfalls (15 cm diameter and 40 cm deep with 7 m of aluminium wire drift nets approximately 20 cm high), 25 medium-sized Elliott traps (32.5 cm × 8.5 cm × 9.5 cm), and 25 Sheffield wire cage traps (20 cm × 20 cm

× 50 cm), deployed at 20 m spacing in 5 m × 5 m regular grids. Six layouts were established in six main vegetation types within the development area. All specimens caught were measured, weighed and marked.

A total of 658 ha surrounding the Gas Treatment Plant site near Town Point and 550 ha around North Whites Beach were surveyed for Boodie warrens. Boodie warren surveillance was conducted using transects spaced 50 m apart. If a warren was observed, the position, number of entrances, significant vegetation, and soil type were plotted. Transects totalling 131 km in length were surveyed for Boodie warrens. A PhD student from the University of Western Australia (UWA) working on Boodies also surveyed for active and inactive warrens across a large section of the Island in 2002, and provided updated data that have been incorporated into Chevron Australia's Geographical Information System (GIS).

4.3.2.2 Results

The mammals of Barrow Island, along with their conservation status, are listed in Appendix 4. Barrow Island supports 13 species of resident terrestrial mammals (taxonomy follows Strahan 2004), with a further two species of bats recorded as vagrants to the Island. The six significant species of resident mammals are:

- Water-rat (*Hydromys chrysogaster*)
- Black-flanked Rock-wallaby (*Petrogale lateralis lateralis*)
- Barrow Island Euro (*Macropus robustus isabellinus*)
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus conspicillatus*)
- Barrow Island Golden Bandicoot (*Isoodon auratus barrowensis*)
- Boodie (*Bettongia lesueur*).

All known terrestrial mammals of Barrow Island were found to occur in the vicinity of at least portions of the Gorgon Gas Development Footprint. However, the Black-flanked Rock-wallaby only occurs on the west coast of Barrow Island and does not reside in the vicinity of the Gorgon Gas Development Footprint.

There are no fauna habitats unique to the Gorgon Gas Development Footprint; therefore, it is considered highly unlikely that unusual concentrations of mammals should be present. Golden Bandicoots and Northern Brushtail Possums were well-represented throughout the vicinity of the Gas Treatment Plant site, as they are across much of Barrow Island. The abundance of other mammals was lower in the vicinity of the Gas Treatment Plant site than in other areas with similar vegetation. This may have been a reflection of mammal trapping grids being influenced by the surrounding habitats for animals with large home ranges (Chevron Australia 2005).

An indication of the number of mammals captured in the six trapping grids within 1 km of the Gas Treatment Plant site is provided in Table 4-11. Species richness and abundance on these trapping grids varied between 2003 and 2004, which may reflect the interannual variation in mammal distribution.

Table 4-11 Abundance and Distribution of Mammals on Barrow Island

Species	Barrow Island Population	Barrow Island Distribution/ Habitat Preferences[5]	Diet[5]
Barrow Island Euro	528–914[2] to 1500[3]	Widely observed in habitats including within existing oilfield operations.	Spinifex and shrubs
Barrow Island Spectacled Hare-wallaby	5700–8600[2]	Wide range of habitats including existing oilfield operations – uses tall spinifex as daytime refuges from predators and heat.	Spinifex, and wide range of shrubs and grasses
Black-flanked Rock-wallaby	150–200[1,2]	Rocky habitats, mainly on western coast of Barrow Island. Shelters amongst cliffs, caves and rocks. Not often observed using artificial environments.	Plants
Barrow Island Boodie	2900[2]	Burrows usually in well-drained limestone cap-rock or caves. Often associated with fig trees (which provide food).	Figs, seeds, roots, termites, insects and fungi. Food scraps if available.
Barrow Island Golden Bandicoot	60 000–80 000[1]	Shelter in limestone crevices, spinifex tussocks and termite mounds across most of Barrow Island. Quickly occupy artificial habitats.	Includes, ants, moths, roots, tubers, turtle eggs, small reptiles and Common Rock Rat
Northern Brushtail Possum	650–1468[2]	Widespread across Barrow Island. Shelters in termite mounds, caves and limestone crevices.	Figs, spinifex and insects
Pseudantechinus sp.	Not estimated	Probably widely distributed on Barrow Island. Recorded in wattle thickets in coastal dunes, termite mounds and artificial habitat.	Insects and lizards
Planigale species	Not estimated	Collected along limestone cliffs and caves on western side of Barrow Island, termite mounds, *Triodia angusta* dominated vegetation associations and among coastal vegetation.	Insects. Eggs, meat and honey in captivity.
Western Chestnut Mouse	Not estimated	Occurs across Barrow Island in spinifex areas and in artificial habitats.	Plants. Food scraps if available.
Common Rock-rat	>1000[4]	Any areas of broken rock fragments such as sandstone formations and scree slopes. Occur in beach foredunes and regularly visit artificial habitats such as store and accommodation rooms.	Seeds and leaf material. Food scraps if available.
Water Rat	>50[4]	Marine beaches and mangroves.	Turtle eggs, aquatic insects, fish, crustaceans, molluscs, frogs, lizards, small mammals, waterbirds, fresh carrion
Common Sheathtail Bat	>70 recorded in one cave[5]	On Barrow Island, main permanent residence is the limestone cliff caves along west coast.	Range of insects

Species	Barrow Island Population	Barrow Island Distribution/ Habitat Preferences[5]	Diet[5]
Finlayson's Cave Bat	20 recorded in one roost[5]	Caves, crevices and solution pipes.	Small insects especially mosquitoes, flies and moths

Notes: * *total captures from six trapping grids*
1. *Strahan (2004)*
2. *Burbidge* et al. *(2003)*
3. *Short* et al. *(1989)*
4. *Butler (1970)*
5. *WAPET (1989)*

The Black-flanked Rock-wallaby population on Barrow Island is remote from the Gorgon Gas Development Footprint. Black-flanked Rock-wallabies shelter in rocky cliffs along approximately 13 km of the west coast of Barrow Island and up to 3 km inland (Butler 1970). The total extent over which they range on Barrow Island has not been determined, but they have been recorded 1.4 km from cliff habitat on Barrow Island (Burbidge 2008a). The closely related taxon *Petrogale lateralis* MacDonnell Ranges race, in central Australia, has been reported as moving up to 4 km from rock piles but largely foraging within 200 m of shelter (Burbidge 2008a). This restricted foraging range may reflect altered behaviour due to predation by foxes and dogs, which are not present on Barrow Island (Burbidge 2008a).

The Water-rat was recorded along the coast near Town Point where tracks were seen and one specimen opportunistically trapped (Chevron Australia 2005). Its preferred habitat is where sandy and rocky coastline alternate (WAPET 1989). This species has been recorded on Barrow Island beaches (Chevron Australia 2005). Whilst widespread on Barrow Island, it may not be plentiful (Butler 1970). Water-rats are 'consistently located at Biggada Creek, Whites Beach and John Wayne Country beach as well as the mangrove areas' (WAPET 1989). Water-rats have not been quantified in the vicinity of the Gas Treatment Plant site, and numbers are expected to be low given there is no free water at the Plant site, and rocky areas (habitat) forming Town Point are extensive beyond this geological formation.

Spotlighting from roads has inherent limitations (such as variable vegetation height and thus opportunity to see animals, bias in oversampling abundance for a landscape, etc.). However, unpublished DEC data (1972 to 1997) from five mammal species combined for 1998, 2000–2003, and 2007 reveals gross differences in densities of larger mammals between the spotlighting transects in the north of the Island compared to transects in the south where clearing is greater along roads and well-pads. However, this statistical difference should be treated with caution as the distance sampling analysis output comes from a less-than-optimal design (road bias). Differences observed should be viewed as indicative and interpreted with this limitation in mind.

The two mammals previously introduced to Barrow Island are the:

- Black Rat (*Rattus rattus*), which was recorded on Boomerang, Middle, Boodie, Pasco, and North and South Double Islands prior to WAPET's presence on Barrow Island in the 1960s (WAPET 1989). Black Rats were eradicated from the small islands and from the southern end of Barrow Island in the 1980s. No Black Rats have been recorded on Barrow Island since May 1991
- House Mouse (*Mus domesticus*), which was inadvertently introduced Barrow Island on several occasions since the 1960s, but has been eradicated through poison-baiting and trapping.

The mammals of Barrow Island are well documented and there are voucher specimens lodged with the Western Australian Museum for all mammal species recorded on Barrow Island. As

indicated in Appendix 4, only one additional mammal has been recorded on Barrow Island since 1974, and none since 1988. This indicates that the inventory of mammals on Barrow Island is relatively comprehensive.

4.3.3 Reptiles and Amphibians

4.3.3.1 Methodology

Records of reptiles and amphibians on Barrow Island have been compiled from a number of sources including:

- pitfall traps used for mammal surveys (detailed in Section 4.3.2.1)
- 18 pitfall traps, flushing by burning of spinifex, examination of rubbish sites and 'stalking' (Smith 1976)
- flushing by burning of spinifex over an area of 1175 m^2 (Heatwole and Butler 1981)
- targeted surveys with method not recorded (Butler 1970).

Targeted reptile surveys were conducted at the existing Chevron Australia camp accommodation blocks, airport, Barge (WAPET) Landing, existing oilfield operations base, and the terminal tanks on Barrow Island in April 2006 (Biota Environmental Sciences 2006).

4.3.3.2 Results

The 45 reptiles and one amphibian recorded on Barrow Island are listed in Appendix 6. This Barrow Island reptile assemblage includes, as would be expected, fewer species than the mainland, but is represented by species from all families that occur there except the snake family Colubridae. A single species of burrowing frog is found on the Island.

Heatwole and Butler (1981) noted that the lizard fauna of Barrow Island is unusual in its equitability (i.e. individuals are equally apportioned between species). Although there are relatively few species, the density of individuals is relatively high. The phenomenon of high density (called density compensation) is not unusual on islands. It may be due to reduced predation intensity, greater insect productivity, reduced competitive interference, or a combination of these factors.

Heatwole and Butler (1981) measured a density of 324 individual lizards per hectare (equating to 3.11 kg/ha) amongst *Triodia angusta* on Barrow Island after a period of 18 months without rain. The three most abundant species (*Diplodactylus taeniatus, Cyclodomorhpus melanops melanops* and *Proablepharus reginae*) had densities of 50 individuals per hectare.

Table 4-12 summarises the relative abundances of reptiles collected using two methods:

- flushing reptiles by burning spinifex on Barrow Island (Heatwole and Butler 1981)
- pitfall traps from 2003 to 2005 in the vicinity of the Gas Treatment Plant Site (Chevron Australia 2005).

Table 4-12 Relative Abundance of Reptiles on Barrow Island

Species	Habitat Preferences[1]	Abundance & Distribution on Barrow Island[2]	% Total Captures (pitfall traps)[3]	% Total Captures (flushing)[4]
Agamidae (lizards)				
Ctenophorus caudicinctus caudicinctus	R & S	W	0.0	2.6
Lophognathus gilberti gilberti	S	U		
Pogona minor minor	S	U	2.1	2.6

Species	Habitat Preferences[1]	Abundance & Distribution on Barrow Island[2]	% Total Captures (pitfall traps)[3]	% Total Captures (flushing)[4]
Pygopodidae (legless lizards)				
Delma borea	S	R	0.2	
Delma nasuta	S	W	0.7	7.9
Delma tincta	R	U		
Lialis burtonis	S	W	0.5	7.9
Pygopus nigriceps	S	R		
Gekkonidae (geckos)				
Diplodactylus stenodactylus	S	U		15.8
Gehyra pilbara	R	C		
Gehyra variegata	R & S	C		
Heteronotia binoei	R & S	W	2.8	2.6
Strophurus jeanae	-	U	0.8	
Scincidae (skinks)				
Carlia triacantha	S	C	0.2	
Cryptoblepharus carnabyi	R & S	C	0.3	
Ctenotus duricola	R	U	0.2	
Ctenotus grandis	S	W	10.6	
Ctenotus hanloni	S	R		
Ctenotus pantherinus acripes	R	W	1.6	10.5
Ctenotus saxatilis	R & S	W	3.3	13.2
Ctenotus serventyi	S	U		2.6
Cyclodomorphus melanops melanops	-	W	2.3	15.8
Eremiascincus richardsonii	R	U		
Glaphyromorphus isolepis	-	W	0.7	
Lerista bipes	S	W	50.1	
Lerista elegans	S	U		2.6
Lerista muelleri	S	W	10.6	
Menetia greyii	-	R	5.9	
Morethia lineoocellata	S	R		
Morethia ruficauda exquisita	R & S	C	1.3	
Notoscincus ornatus ornatus	R & S	C	2.9	
Proablepharus reginae	S	W	2.0	15.8
Typhlopidae (blind snakes)				
Ramphotyphlops ammodytes	S	R	0.2	
Ramphotyphlops longissimus	-	-		
Ramphotyphlops grypus	-	-		
Varanidae (goannas)				
Varanus acanthurus	S	R	0.7	
Varanus brevicauda	-		0.2	
Varanus giganteus	R & S	W		
Boidae (pythons)				
Antaresia stimsoni stimsoni	S	W		
Elapidae (fanged snakes)				
Brachyurophis approximans	-	R		
Demansia rufescens	S	U		
Furina ornata	S	R		

Species	Habitat Preferences[1]	Abundance & Distribution on Barrow Island[2]	% Total Captures (pitfall traps)[3]	% Total Captures (flushing)[4]
Pseudechis australis	S	W		
Suta monachus	-	-		
Hylidae (frogs)				
Cyclorana maini	-	-		

Notes: 1 Smith 1976; R = rocky area; S = sandy area (80% and 20% of Barrow Island respectively)
2 WAPET 1989; W = widespread and abundant; C = relatively common but possibly restricted; U = uncommon and/or restricted; R = rarely observed/collected
3 Chevron Australia 2005
4 Heatwole and Butler 1981

A total of 24 reptile species have been recorded in the Gorgon Gas Development Footprint. The most species-rich areas were habitats with a mixture of shrub species and *Triodia* on coastal primary and secondary dunes. No reptiles were considered restricted to the Gorgon Gas Development Footprint, and whilst relative population sizes were not assessed across the Island, there is no indication that any habitats in the Gorgon Gas Development Footprint would support higher herpetofauna diversity than elsewhere on the Island (Chevron Australia 2005).

None of the terrestrial reptile species on Barrow Island are listed as Threatened Species under the *Wildlife Conservation Act 1950* (WA) or the EPBC Act.

A number of reptile taxa are restricted to Western Australian islands, including *Ramphotyphlops longissimus*, *Ramphotyphlops yampiensis*, *Aprasia rostrata*, *Ctenotus lancelini*, *Egernia pulchra longicauda*, and *Lerista praefrontalis*. Reptile populations on Barrow Island are likely to show unique genetic characteristics as a result of their relatively long isolation (Chevron Australia 2005). Smith (1976) noted the following species on Barrow Island have apparent divergences from the mainland populations:

- *Pseudechis australis* (dwarfism)
- *Ctenotus grandis* (fewer mid-body scales)
- *Ctenotus pantherinus acripes* (endemic to Barrow Island, and has spiny soles on the feet, and more mid-body scales that *Ctenotus pantherinus pantherinus*)
- *Proablepharus reginae* (smaller and darker, more subdigital lamellae, and most upper periocular granules not hidden).

The Subterranean Blind Snake (*Ramphotyphlops longissimus*) is listed by DPaW as a Priority 2 species and is likely to be endemic and restricted to Barrow Island since it is known from only one specimen collected on Barrow Island. It is not known to occur within the areas coinciding with the Gorgon Gas Development Footprint. This is the only known troglobitic snake anywhere in the world and there are no effective survey techniques for this species. Additional specimens of this species opportunistically captured in monitoring on Barrow Island are to be recorded and, if practicable to do so, be submitted to the Western Australian Museum. This Subterranean Blind Snake is also referred to in Section 4.3.6.3.

The Leopard Skink (*Ctenotus pantherinus acripes*) appears to be restricted to Barrow Island and has been recorded within the Gorgon Gas Development Footprint. The species was recorded by Smith (1976) as inhabiting the 80% of the Island occupied by rocky areas of *Triodia* steppe. It has also been captured in a wide range of habitats on Barrow Island (Chevron Australia 2005), and WAPET (1989) reported this species as 'abundant and widespread' on Barrow Island. Heatwole and Butler (1981) recorded Leopard Skink at densities of 34 individuals per hectare in *Triodia angusta* habitat, representing approximately 10% of individual lizards and lizard biomass. Applying this density of individuals to approximately 80%

of Barrow Island would equate to a population in excess of 625 000 individuals. This is not presented as an accurate population estimate, but does indicate the likely order of magnitude of the population size. This data was collected in summer, when there had been no rain for the previous 18 months.

On this basis, Heatwole and Butler (1981) concluded that it was 'probable that at the time lizard populations were at relatively low densities and that under more favourable conditions, populations densities would be greater'. Capture rates for the Leopard Skink in pitfall traps used for mammal monitoring are low, and not informative as to relative densities of individuals between habitat types on Barrow Island. Most studies consider *Ctenotus* species unspecialised generalist foragers, although this is not true of all species (Craig *et al.* 2006). The stomach contents of Leopard Skinks on Barrow Island examined by Smith (1976) were found to include a range of invertebrates (Crustacea, Aranedia, Chilopoda, Isoptera, Hemiptera and Coleoptera).

The single frog species (*Cyclorana maini*) on Barrow Island breeds in seasonal watercourses in the Town Point area, in Airport Creek to the south of the Gas Treatment Plant site, along the Feed Gas Pipeline routes, and in other areas across the Island. Single individuals of the Desert Tree Frog (Litoria rubella) and the Water-holding Frog (*Cyclorana platycephala*) have both been recorded as having been introduced to Barrow Island and were both removed from Barrow Island.

The Perentie (*Varanus giganteus*) is ecologically significant on the Island as it is an abundant top-level predator. It is the largest Australian lizard and a dominant predator with few natural enemies (Vincent and Wilson 1999). The Perentie is a generalist carnivore and scavenger. A Perentie of average weight captured on Barrow Island is 5.6 kg; it would typically consume 41 g to 180 g of prey per day (Green *et al.* 1986). Butler (1970) recorded Perenties in excess of 17 kg, and, based on consumption by body weight, this would equate to 124 g to 620 g of prey per day.

The Perentie's diet includes turtle eggs and hatchlings, small to medium mammals (including Bandicoots, Boodie, Northern Brushtail Possums and juvenile Euros), lizards (including other Perenties), snakes, birds (including Silver Gulls), bats, spiders and grasshoppers (King *et al.* 1989). The activity areas of Perenties have been recorded on Barrow Island as ranging from 2.9 ha to 21.5 ha (King *et al.* 1989). The population of Perenties on Barrow Island is estimated to be about 3000 individuals.

The majority of the reptile species on Barrow Island have been documented; a flattening of the species accumulation curve in Appendix 1 shows that only three additional reptiles have been recorded since 1977. More species of reptiles have now been recorded on Barrow Island than the predictions of Thompson *et al.* (2003). Thompson *et al.* (2003) concluded that the species accumulation curve 'most probably' plateaued at 25 species and predicted species richness for reptiles on Barrow Island as being between 22 and 33 species, on the basis of 11 models using data from 2198 pit-trap days on Barrow Island.

4.3.4 Avifauna

4.3.4.1 Overview

Birds regularly travel between the Pilbara mainland and the offshore islands within the Montebello/Lowendal/Barrow Island groups. Consequently, many of the birds on Barrow Island represent vagrants rather than resident populations.

4.3.4.2 Methodology

Quantitative surveys of landbirds across Barrow Island were undertaken by Sedgwick (1978) and Pruett-Jones and O'Donnell (2004). Sedgwick (1978) surveyed across Barrow Island in August 1976 in eight 0.5 ha quadrats. Pruett-Jones and O'Donnell (2004) surveyed across Barrow Island in September and October 2001 at 178 two-hectare quadrats in six major vegetation zones.

Landbirds and littoral birds were also surveyed monthly from September 2003 to October 2004 as part of the Draft EIS/ERMP for the Gorgon Gas Development (Chevron Australia 2005). Further littoral bird surveys were conducted along the entire Barrow Island coastline in October 2005, and in February and March 2006 (RPS BBG 2006c). These surveys collected data from the 12 regions shown in Figure 4-1.

Source: RPS BBG 2006c

Figure 4-1 Regions of Coastline Used for Littoral Bird Surveys 2003–2006

The breeding colonies of the Wedge-tailed Shearwater and Bridled Tern were visited on Double Island in October and November 2003.

A more intensive survey of the White-winged Fairy-wren (Barrow Island) was conducted in October 2004 to examine habitat preferences. Further surveys of the nesting habitat preferences of White-winged Fairy-wrens (Barrow Island) were conducted during their breeding season, August to September 2005, in the Gorgon Gas Development and Jansz Feed Gas Pipeline areas between the existing Chevron Australia Camp and the Terminal Tanks site just north of the Gas Treatment Plant site (RPS BBG 2006d).

4.3.4.3 Results

The avifauna of Barrow Island and their conservation status are listed in Appendix 5. Of the 119 bird species recorded on Barrow Island, 68 are protected under the EPBC Act (Cth) (39 species are listed under the JAMBA, CAMBA or ROKAMBA migratory treaties, 54 are listed as marine species under the Act, and one species is listed under the Bonn Convention for Migratory Species). Of these 68 protected species, 47 are residents or regular migrants to the Island. The remainder are vagrants from the nearby mainland.

4.3.4.3.1 Littoral Birds

A minimum of 32 119 littoral birds were counted on Barrow Island over a 12-month period by RPS BBG (2005a). The highest monthly count of 20 428 individuals was recorded in September 2004. The counts for the entire Barrow Island coastline of the most abundant littoral avifauna species are summarised in Table 4-13.

Table 4-13 Total Counts of Most Abundant Littoral Avifauna on Barrow Island

Bird Species	Average Monthly Count[1]	Maximum Monthly Count[1]	Minimum Monthly Count[1]
Bar-tailed Godwits	555	1070	71
Ruddy Turnstones	1065	2173	108
Silver Gulls	509	892	206
Red-necked Stints	4161	7933	822
Grey-tailed Tattlers	1599	2719	428
Common Terns	409	1818	0
Greater Sand Plovers	523	1151	164
Lesser Sand Plovers	501	902	224

Note: 1 RPS BBG 2005a

Barrow Island is a regionally significant site for Grey-tailed Tattlers, Ruddy Turnstones, and Red-necked Stints. The portion of the East Asian–Australasia Flyway populations recorded on Barrow Island for these species is 6.6%, 5.5%, and 2.4% respectively (RPS BBG 2005a). Fairy Terns have declined significantly in eastern Australia, and Western Australia now harbours the majority of the total population. Fairy Terns are reported from Barrow Island throughout the year and primarily from the south-east to south-west of the Island, with high counts between November and April (RPS BBG 2005a).

The counts of Sanderlings, Greater Sand Plovers and Lesser Sand Plovers during the southward migration period (September to November) met the staging criterion (0.25% of a species' population in the East Asian–Australasia Flyway) of the Ramsar Convention. Counts of Roseate Terns over adjacent waters in August 2002 may also be significant for this species (Astron Environmental Services 2002). Population estimates for Common Terns in the north-west of Australia are uncertain, and therefore the significance of over 1708 Common Terns sighted on Barrow Island in November 2003 is unknown. The maximum count of 83 Sooty Oystercatchers on the Island represents 1.1% of the known population of the distinctive northern race (*Ophthalmicus*) of the species (Wetlands International 2002).

Littoral birds are widely distributed around Barrow Island, in particular mudflats and rocky intertidal pavements (RPS BBG 2006c). The highest abundances of littoral avifauna on Barrow Island (over two-thirds of records of most species) are associated with the extensive tidal mudflats in the south and south-east of the Island, from south of the proposed Construction Village to Bandicoot Bay (RPS BBG 2006d). Bandicoot Bay is the focus of the Bandicoot Bay Conservation Area that extends from Stokes Point on Barrow Island around Bandicoot Bay to the easternmost point on Middle Island. This area includes the largest intertidal sand/mudflat community in the Montebello/Barrow Islands Marine Conservation Reserves, is high in invertebrate diversity, and encompasses representative areas of macroalgal, seagrass and rocky shore/intertidal reef platform communities (DEC 2007). The littoral birds in these areas appear to predominately roost near their foraging sites (RPS BBG 2006c).

Only a small portion of the littoral avifauna in Barrow Island forage on the reef platforms around Town Point near the Gas Treatment Plant site (RPS BBG 2005a), and impacts within 200 m of the existing Barge (WAPET) Landing and causeway equate to approximately 0.35% of littoral avifauna habitat of Barrow Island (Chevron Australia 2005).

The typical habitats of the EPBC Act listed littoral birds considered residents or regular migrants to Barrow Island are listed in Table 4-14.

Table 4-14 Typical Habitats of EPBC Act Listed Resident/Regular Migrant Littoral Birds

	Habitat Types[1 & 2]						
	Sandy Beach (large areas at western end of Bandicoot Bay)	**Mudflat** (on Barrow Is. largest area on Bandicoot Bay)	**Saltmarsh** (not present on Barrow Island)	**Estuary** (not present on Barrow Island)	**Mangrove** (on Barrow Is. mainly on east coast)	**Rock Platform** (on Barrow Is. largest areas on west coast)	**Freshwater** (intermittent on Barrow Island)
Australian Pelican	x	x					
Eastern Reef Egret	x	x			x	x	
Nankeen Night Heron				x	x		x
Black-tailed Godwit		x					x
Bar-tailed Godwit		x					
Whimbrel		x		x	x		
Eastern Curlew	x		x	x	x		
Common Greenshank		x					x
Terek Sandpiper	x	x		x	x		
Common Sandpiper					x		x
Grey-tailed Tattler		x			x	x	
Ruddy Turnstone	x					x	
Great Knot	x	x					
Red Knot	x	x		x			
Sanderling Calidris	x						
Red-necked Stint		x		x			x
Sharp-tailed Sandpiper							x
Curlew Sandpiper		x					x
Pacific Golden Plover	x	x	x	x		x	
Grey Plover	x	x		x			
Lesser Sand Plover	x	x		x			
Greater Sand Plover	x	x					
Silver Gull	x						x
Gull-billed Tern	x	x					x
Caspian Tern	x	x		x			x
Lesser Crested Tern	x						
Crested Tern	x						x
Roseate Tern	x	x					
Common Tern	x	x	x	x			x
Little Tern		x		x			x
Fairy Tern		x		x		x	x
White-winged Black Tern		x	x	x			x
Lesser Noddy					x		
Sacred Kingfisher		x			x		x

Notes: 1 Geering, Agnew and Harding 2007
2 Pizzey and Knight 1998

The relative distribution of these EPBC Act listed littoral birds is indicated in Table 4-15, which shows the percentage of individuals recorded in each region, as shown in Figure 4-1.

Table 4-15 Distribution of EPBC Act Listed Resident/Regular Migrant Littoral Birds around Barrow Island

	Percent of Individuals Recorded in Region of Barrow Island Coastline[1]												
	Lower East	Lower West	Mid East	Mid West	North	North East	North West	South	South East	South West	Upper East	Upper West	Total Number of Individuals Observed
Australian Pelican	9		6	1	8	3	4	**36**	4	**26**	4		228
Eastern Reef Egret	**11**	**11**	9	3	**16**	6	2	7	**22**	6	5	2	776
Black-tailed Godwit													No records
Nankeen Night Heron	6					1			**94**				233
Bar-tailed Godwit	**17**	5	4	1	6	3	3	**37**	7	14	2		9653
Whimbrel	**16**	**20**	1	3	6	6	4	**19**	15	5	4	1	979
Eastern Curlew	4							**71**	18	7			45
Common Greenshank	20	3	4	1	1	7		**34**	**24**	4	3		2153
Terek Sandpiper	14				1			**60**	23	2			100
Common Sandpiper	11	**16**	2	3	8	**23**	2	13	**17**	1	5		395
Grey-tailed Tattler	**13**	3	6	1	4	12	5	**28**	**18**	4	5		26607
Ruddy Turnstone	**13**	**10**	4	3	7	9	9	**16**	**17**	6	5		17885
Great Knot	18		2			1		**40**	13	**26**	1		3434
Red Knot	**28**		5					**36**	21	9	1		80
Sanderling		6		6			5	17		**65**			983
Red-necked Stint	**22**	3	3	1	2	6	1	**31**	**22**	6	3		65188
Sharp-tailed Sandpiper						3		3	**94**				35
Curlew Sandpiper	24		1					**33**	13	**29**			1254
Pacific Golden Plover	2	**19**		**19**	2	**36**	8	2	6	3	2		247
Grey Plover	**35**	2	4	1	5	4	4	**23**	11	5	5		1550
Lesser Sand Plover	15	1	4		2	6		**46**	**19**	3	3		7521
Greater Sand Plover	**18**	4	4	1	5	9	2	**32**	14	6	5		9569
Silver Gull	7	**12**	3	**16**	**15**	4	**12**	4	6	10	4	5	8133
Gull-billed Tern	4	16	2	4		2		**25**		**48**			56
Caspian Tern	**14**	1	**26**	2	4	4		7	**20**	10	11		1374
Lesser Crested Tern	**30**	5	15	4	**27**		2		5	2	10	1	2028
Crested Tern	**15**	**16**	9	**13**	12	1	4		4	**16**	8	2	10292
Roseate Tern		4			**89**		6			1			8902
Common Tern	**24**	1		14	11	2	1	18		**29**			6544
Little Tern	2	1			2	2	1	**68**		23			239
Fairy Tern	5	3			6	1	1	**32**	2	**48**	1		7926
White-winged Black Tern				19				7		**74**			791
Lesser Noddy													No records
Sacred Kingfisher													No records

Notes: 1 RPS BBG 2006c
Values of zero omitted for clarity
Minimum number of regions to capture >50% records for species in bold font (if either of two regions could be included to reach 50%, as both contain same value, then both in bold)

A total of 36 Black-tailed Godwits were recorded at two localities in the south-west region of Barrow Island by Sedgwick (1978).

The Lesser Noddy is likely to be in low abundance as it was not recorded by either Sedgwick (1978) or RPS BBG (2006c).

A total of 12 Sacred Kingfisher were recorded, predominately in association with mangroves along the east coast of Barrow Island in the Upper East, Mid East, Lower East and South East regions, by Sedgwick (1978).

4.3.4.3.2 Sea Birds

Wedge-tailed Shearwaters and Bridled Terns nest on Double Island, off the east coast of Barrow Island and 4 km from the Gas Treatment Plant site.

Bridled Terns are offshore fish foragers that generally nest in limestone crevices or under low bushes (Nicholson 2002). Wedge-Tailed Shearwaters are offshore squid and fish foragers that excavate burrows up to 1.5 m long (Nicholson 2002). These burrows may be in sand or limestone crevices. On Double Island, Bridled Terns and Wedge-Tailed Shearwaters live in burrows located in sand and solution cavities in the surface limestone.

Two surveys have been undertaken that provide an indication of population size, but neither was sufficiently intensive or comprehensive to provide definitive estimates.

In November 2003, RPS BBG (2005a) estimated 4000 Bridled Terns were circling North and South Double Island. Morris *et al.* (2002) recorded approximately 20 to 50 Wedge-tailed Shearwater nesting burrows on North Double Island and approximately 300 on South Double Island, (approximately 250 on the west side of Main Beach, 15 behind East Beach, 20 on the flat sandy area in the middle of the Island and adjacent to East Beach, and 20 under cap rock). Chevron Australia (2005) provided an estimate of 500 burrows over a 2 ha portion of the north-eastern corner of South Double Island, supporting 5000 to 10 000 pairs of Wedge-tailed Shearwaters.

Other species that may intermittently nest on North and/or South Double Islands include Caspian Tern, Roseate Tern, Fairy Tern, Crested Tern and Lesser Crested Tern (Burbidge pers. comm. 2008).

4.3.4.3.3 Landbirds

The most common landbirds on Barrow Island are the Spinifexbird, White-winged Fairy-wren (Barrow Island), Singing Honeyeater, White-breasted Wood Swallow and the Welcome Swallow. The population estimates for these species on Barrow Island are listed in Table 4-16. Pruett-Jones and O'Donnell (2004) found there was no significant correlation between any of the habitat variables and species richness, or total number of individuals, but there were relationships between habitats and individual bird species. These population estimates are summarised in Table 4-16.

Table 4-16 Estimates of Landbird Populations on Barrow Island

Species	Habitat Preferences and Comments for Barrow Island (Pruett-Jones and O'Donnell 2004)	Sedgwick (1978)	Pruett-Jones and O'Donnell (2004)
Spotted Harrier	Uncommon, scattered along coast	180	162
Brahminy Kite	Rare, scattered along coast but occasionally seen inland	15	23
Osprey	Regularly spaced along coast, nesting pairs observed using artificial structures	180	73

Species	Habitat Preferences and Comments for Barrow Island (Pruett-Jones and O'Donnell 2004)	Sedgwick (1978)	Pruett-Jones and O'Donnell (2004)
White-bellied Sea-eagle	Along coast, anecdotal information indicates that it hunts in inland areas	3	73
Australian Kestrel	Rare, occasionally seen inland and reported to be on coast	1650	69
Bar-shouldered Dove	Common on Barrow Island in central limestone ridges in valleys, less so on flats and in coastal areas. Known to nest on limestone ledges, caves, in mangroves and Acacia species along coast.	180	692
Black-eared Cuckoo	Irregular migrant. Rare but scattered throughout Island, associated with emergent shrubs and trees.	No estimate	67
Horsfield's Bronze Cuckoo	Regular migrant. Uncommon but scattered throughout Island, associated with emergent shrubs and trees	910	102
Sacred Kingfisher	Likely regular migrant. Rare and only seen along creeks and drainage lines. Sedgwick (1978) noted preference for mangroves.	12	6
Welcome Swallow	Common and widespread, and more common in disturbed areas	8500	1077
Tree Martin	Rare. Sedgwick (1978) noted preference for coastal areas (but not actual beaches) with some extension into claypan areas.	7050	6
Spinifexbird	Most abundant bird on Barrow Island and in habitats with spinifex	17 800	24 623
White-winged Fairy-wren (Barrow Island)	Abundant in most habitats on Barrow Island, especially those with complex vegetation structure	9336	7519
Singing Honeyeater	Abundant in habitats on Barrow Island with dense vegetation or with emergent shrubs and trees	3050	3920
Zebra Finch	Regular migrant. Common on claypans, uncommon elsewhere.	No estimate	1152
White-breasted Woodswallow	Common and most abundant where vegetation is dense or there are emergent shrubs and trees	3450	1945

Pruett-Jones and O'Donnell (2004) compared the differences in birds between natural areas, around well-pads and along roadsides, within habitat types. They concluded that current oilfield operations have a relatively minor impact on landbird populations on Barrow Island. A markedly lower number of Tree Martins, Welcome Swallows and White-breasted Woodswallows were recorded in 2004 than in 1978, but it is unclear whether this reflects difference in survey and population estimate techniques, or short- or long-term fluctuations.

The number of individual birds is greatest along roadsides. Landbirds commonly roost in the scattered emergent shrubs along the side of the roads and may occur at higher densities on roadsides than in adjacent habitats (Pruett-Jones and O'Donnell 2004).

As indicated in Appendix 5, White-winged Fairy-wrens (Barrow Island) are the only Barrow Island bird species listed under the *Wildlife Conservation Act 1950* (WA), but not listed under the CAMBA, JAMBA or ROKAMBA international treaties for migratory birds.

White-winged Fairy-wrens (Barrow Island) are listed as a Schedule 1 species under the *Wildlife Conservation Act 1950* (WA) and as Vulnerable under the EPBC Act (Cth). The population of White-winged Fairy-wrens (Barrow Island) on Barrow Island appears to have remained relatively stable between the 1978 and 2004 surveys (Pruett-Jones and O'Donnell 2004).

The Draft EIS/ERMP stated this species' preferred habitat was vegetation with emergent shrubs such as *Melaleuca cardiophylla* and *Acacia bivenosa* (Chevron Australia 2005). White-winged Fairy-wrens (Barrow Island) have subsequently been found to occur and breed in a range of plant species including *Melaleuca cardiophylla*, *Acacia bivenosa*, *Acacia coriacea*, *Hakea lorea*, *Grevillea pyramidalis* and *Triodia* species (RPS BBG 2006d). White-winged Fairy-wrens (Barrow Island) have also been observed nesting in the tall *Triodia angusta* along the roadways on Barrow Island in areas without *Melaleuca cardiophylla*. This is consistent with the observations of Sedgwick (1978) and Pruett-Jones and Tarvin (2001) and is supported by the comparison of distributions of White-winged Fairy-wrens (Barrow Island) and *Melaleuca cardiophylla* in Figure 4-2.

The White-winged Fairy-wren (Barrow Island) is a relatively territorial and sedentary species. Therefore, the significant number of records outside the distribution of the main populations of *Melaleuca cardiophylla* may reflect that there are individuals of this bird species that do not use this shrub on Barrow Island at all.

Four bird species were regularly observed by RPS BBG (2005a) during the survey of six transects over a 12-month period in the vicinity of the Gas Treatment Plant site. These transects (each 50 m wide and 1 km long) were surveyed twice each month. The mean densities recorded for these bird species in each of the six vegetation types that these transects passed through are shown in Table 4-17.

Table 4-18 lists estimates of the direct impact on these four species of clearing for the Gas Treatment Plant site. These estimates were calculated based on the densities of birds in vegetation types (Table 4-17) and the areas of these vegetation types to be cleared (Table 4-7).

For landbirds, there are no avifauna habitats at the Gas Treatment Plant site of higher ecological significance than those of surrounding areas. The abundance and distribution of landbirds are well documented on Barrow Island. As indicated in Appendix 5, no additional bird species have been recorded for the Island since 1963.

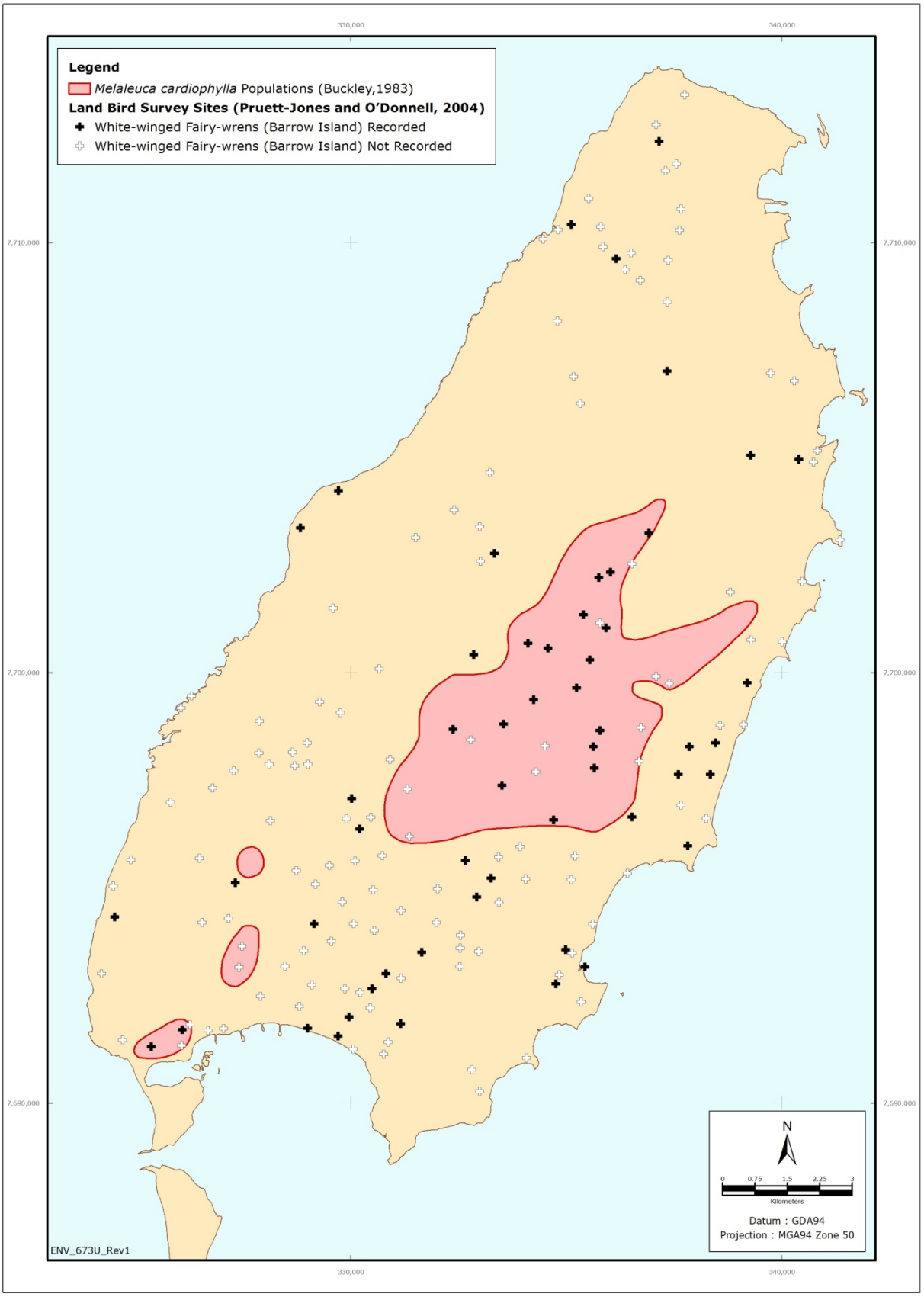


Figure 4-2 Comparison of White-winged Fairy-wren (Barrow Island) and *Melaleuca cardiophylla* Distribution

Table 4-17 Mean Densities (per hectare) of Bird Species Regularly Observed Near the Gas Treatment Plant Site

Vegetation Types	Total Distance in Transects (m)	Equivalent vegetation formation[1]	Bar-shouldered Dove	Spinifexbird	White-winged Fairy-wren (Barrow Island)	Singing Honeyeater
Acacia coriacea over *Triodia angusta* on coastal red, sandy dunes	400	C2	0.15	0.10	0.02	0.29
Acacia bivenosa over mixed *Triodia* species on red sandy-loam plain	1700	F1	0	0.19	0.23	0.03
Melaleuca cardiophylla over mixed *Triodia* species on shallow soils of limestone rises and ridges	2600	L7	0	0.15	0.52	0.03
Triodia angusta forming dense stands with or without emergent shrubs in red sandy-loam	200	D2	0	0.12	0.29	0
Triodia wiseana occasionally with shrubs <1% cover on shallow soils of limestone	300	C3	0	0.16	0.81	0
Low *Acacia bivenosa* over mixed *Triodia* species on shallow soils of limestone slopes	800	V1	0	0.25	0.38	0.04

Source: RPS BBG 2005a
Notes: 1 Refer to Appendix 3 for description

Table 4-18 Abundance of Birds at the Gas Treatment Plant Site

Species Regularly Observed Near Gas Treatment Plant Site	Barrow Island Population	Estimated No. at Site	Estimated % at Site
Bar-shouldered Dove	180[1] – 692[2]	0	0%
Spinifexbird	17 800[1] – 24 623[2]	25	0.1%
White-winged Fairy-wren (Barrow Island)	7 519[2] – 9 336[1]	50	0.7–0.5%
Singing Honeyeater	3 050[1] – 3 920[2]	5	0.1–0.2%

Notes: 'Site' is the Gas Treatment Plant Site
% is percent of Barrow Island population
1 Sedgwick 1978
2 Pruett-Jones and O'Donnell 2004

4.3.5 Terrestrial Invertebrates

4.3.5.1 Methodology

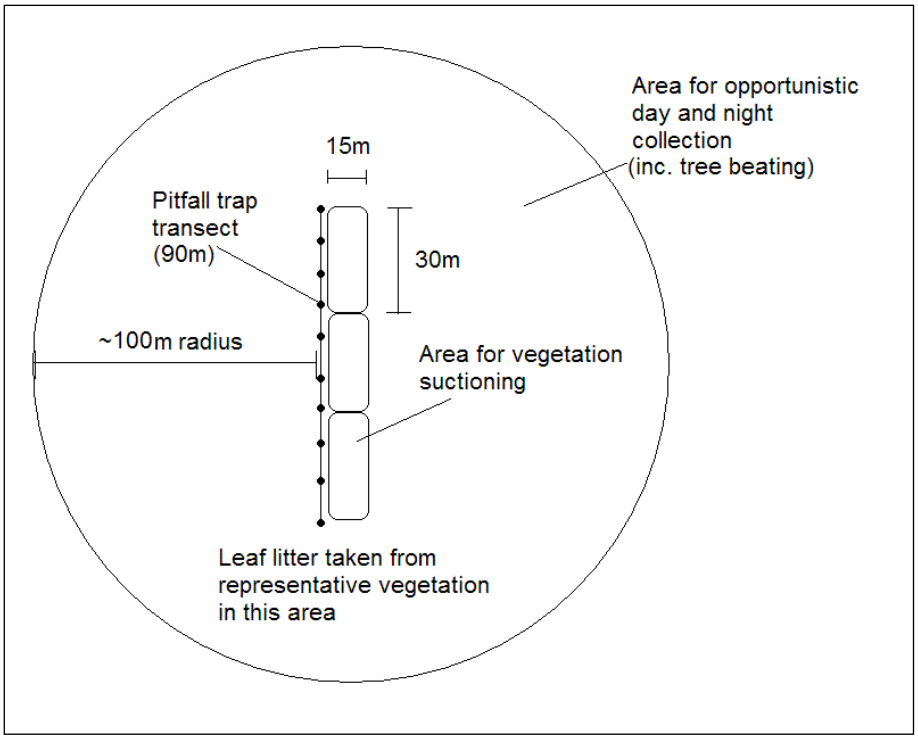
In one of the largest invertebrate surveys in Australia for a single locality, up to 26 taxonomists were consulted for the identification of invertebrates. The invertebrate, groups that were targeted during surveys in 2003 and 2004 for input into the Draft EIS/ERMP (Chevron Australia 2005) were:

- *Araneae* (spiders, in particular trapdoor and wolf spiders)
- *Pseudoscorpionida* (pseudoscorpions)
- *Scorpionida* (scorpions)
- *Diplopoda* (millipedes)
- *Pulmonata* (camaenid land snails).

The Draft EIS/ERMP (Chevron Australia 2005) documented the method for the 2003 and 2004 surveys as consisting of pitfall trapping and hand foraging, including head-torching, burrow excavation, lifting rocks, peeling bark, and foraging through leaf litter and under *Triodia* hummocks. Leaf litter and other debris found beneath *Triodia* clumps were collected and later sieved for cryptic invertebrates. Voucher specimens were collected, preserved, and lodged with the Western Australian Museum for ongoing taxonomic studies.

Various survey methods were again used during surveys in 2006, including pitfall traps, litter searches, plant beating, and night searches with light traps (Majer, Callan, Graham and Edwards 2008). The locations of the 12 undisturbed and 27 disturbed sites and nine light traps sites surveyed are shown in Map 5ii in Section 10.0.

The 2006 invertebrate survey used a standard sampling protocol developed during the preliminary survey of 2005. A 90 m transect formed the focal point for pitfall trapping, vegetation-based sampling, leaf litter collection and hand collection techniques (Figure 4-3).



Source: Majer, Callan, Graham, and Edwards. 2008

Figure 4-3 Standard Sampling Site for Invertebrate Survey

The method for the survey was described by Majer *et al*. (2008) as follows:

> *At the commencement of each sampling period, 10 pitfall traps, comprising 43 mm internal diameter plastic vials, half-filled with ethylene glycol were installed at 10 m intervals. To avoid digging-in effects, these were opened after a 12-hour period, and then left in operation for five days while the other sampling methods were undertaken.*
>
> *Vegetation-based sampling consisted of vacuum sampling and tree beating. Three vacuum samples were run parallel to the pitfall trap transect, up to a distance of 30 m long and to a maximum of 15 m to one side of the pitfall trap line. Vacuuming was performed using a modified leaf blower/vacuum, with two layers of nylon stocking material in the intake, which filtered invertebrates and debris from the air. Shrubs and herbs shorter than head height were passed over with the suction device, which was then emptied into a funnel, leading into a vial of 90% ethanol.*

If present, up to ten small trees or large shrubs (taller than head height) were flagged for beat sampling in each study location. Beating was performed by jarring each tree with a stout stick, the dislodged animals being collected into a sampling net, which was moved around the canopy during the exercise in order to ensure adequate sampling. Invertebrates were hand-picked from the net using forceps or a paintbrush and placed in containers of 90% ethanol.

Leaf litter from each site was collected by hand and coarse-filtered using purpose-built litter sieves. The sieved litter was placed in three vertical mesh nets within each Winkler sack (one sack per site), for a period of four days. Cups half-filled with ethylene glycol were placed in the bottom of each sack to catch invertebrates as they crawled out of the litter and fell below.

Nocturnal hand collections were undertaken for two person-hours per site, using head torches and forceps to gather invertebrates into 90% ethanol. Some invertebrates, such as moths, mosquitoes, larger orthopterans, mantids and phasmids (which were to be pinned) were kept in dry vials and put on ice to sedate. During diurnal collections, which were conducted for one person-hour per site, personnel used a net for capturing flying insects, and explored cryptic habitats by opening termite mounds, lifting shrubs and bushes, and overturning rocks.

The light trap was custom-made from a 20 L bucket with a funnel over the opening, and a fluorescent light source that emitted a mix of visible and ultraviolet light. Insects attracted to the light found their way into the bucket via the funnel, and were anaesthetised by chloroform, which was wick-evaporated from a bottle inside the apparatus. The trap was assembled shortly after dark and operated for two hours at a time. The sealed assembly was placed overnight in a chest freezer, and specimens were removed from the bucket the following day. Moths and mosquitoes were refrozen for storage in containers lined with paper towelling or immediately pinned, while beetles, wasps, hemipterans, and other non-scaly invertebrates were placed in 90% ethanol for storage.

In the laboratory, pitfall trap and Winkler sack samples were transferred to 80% ethanol for storage. Material from all samples was sorted by order and separated for subsequent identification. Some specimens were kept dry (frozen, or stored with paper towelling and Chloro-m-cresol) and later pinned for the reference collection. It was ensured that duplicates were sent away for identification where this was the case.

Frequency as well as species presence was recorded at each site and Majer, Callan, Graham, and Edwards (2008) undertook the following analyses of these data to determine relative abundance of species as well as identify any habitat limitations on Barrow Island:

- Richness values for each invertebrate group were compiled for each sampling period. One ordination method and one classification method were used to assess the variation in assemblage composition of each taxonomic group across the sites surveyed.
- Detrended Correspondence Analysis (DCA) was used to investigate trends in the invertebrate assemblages of each sample.
- Where possible, site groups were visually identified from the clustering of points on the ordination diagrams. These were compared with groupings produced using the TWINSPAN technique, which is a divisive, polyphyletic classification procedure that separates samples into groups of similar species composition.

Rhagada sp. 2 land snails were collected after rain events from a wide range of sites on Barrow Island during 2004 (Chevron Australia 2005). These snails were transported live to the School of Animal Biology at UWA for genetic analyses. Electrophoresis was used to determine levels of polymorphism in *Rhagada* sp. 2 and the degree of genetic connection between snails from different parts of Barrow Island.

Two sites (the Terminal Creek sandpit area and B Pumping station) were selected for field investigation of scorpions (*Urodacus* sp.), based upon reported sightings from Chevron Australia staff on Barrow Island (Majer *et al.* 2006). Searching was undertaken during the day and at night. Day searching involved looking for burrows. Dry pitfall traps were dug into the ground at the entrance of suspect scorpion burrows and were removed at the end of each night. Night searches were undertaken in the week leading into the new moon phase and involved scanning for scorpions using a portable black light under which scorpions fluoresce.

A dedicated Barrow Island reference collection and a relational database have been developed as part of these surveys by the Department of Environmental Biology at Curtin University (Majer, Callan, Graham, and Edwards 2008).

4.3.5.2 Results

Seasonal factors appear to have a greater influence on invertebrate assemblages than geography, vegetation complexes or soil types, and unique invertebrate assemblages have not been identified within the Gorgon Gas Development Footprint (Majer, Callan, Graham and Edwards 2008).

In excess of 1900 species from 26 orders of terrestrial invertebrates have been collected on Barrow Island. Prominent (for readability) aspects of the records for these taxa are summarised in Appendix 7. Whilst results and analysis for some invertebrate groups (e.g. mites, wasps, flies and moths) are not complete, no terrestrial invertebrates so far identified on the Island are listed as requiring special protection under the EPBC Act (Cth), *Wildlife Conservation Act 1950* (WA), or DPaW lists

The species identified as short-range endemics (SREs) on Barrow Island in the Draft EIS/ERMP (Chevron Australia 2005) and which are therefore significant:

- mygalomorph (trapdoor) spiders
- pseudoscorpions *Synsphronus* sp. nov. *'barrow', Angarypus heatwolei*, *Austrohorus* sp. 1, *Xenolpium* sp. 1 and *Xenolpium* sp. 2
- scorpion *Urodacus* sp. nov. *'barrow'*
- land snails *Rhagada* sp. 1 and sp. 2, Q*uistrachia barrowensis*, *Pupoides contrarius* and *P. beltianus*.

Most terrestrial invertebrate species appear to be more abundant on Barrow Island during the wet season when there is a flush of growth in dominant plant forms. This is likely to be due to the majority of invertebrates sampled being highly mobile (readily dispersing for food, shelter, and mating) and vegetation being relatively similar in structure and floristics across the Island (Majer, Callan, Graham and Edwards 2008). Ephemeral creeks and claypans were not targeted during invertebrate surveys and therefore no comment can be made on any aquatic invertebrate assemblages that may occur on Barrow Island.

SREs identified in the Gorgon Gas Development Footprint or highly likely to occur there include the pseudoscorpion *Synsphronus* sp. nov. *'barrow'*, the scorpions *Urodacus* sp. nov. *'barrow'*, '*Aops' 'ops'* , the trapdoor spider *Idiommata* sp., and the snail *Rhagada* sp. 1 (the smaller of the two *Rhagada* species on Barrow Island).

With the exception of *Idiommata* sp., subsequent surveys have proven that these species are widespread on Barrow Island. Whilst this may reduce the level of impact on these species due to the Gorgon Gas Development Footprint, it does not change the status of these species as short-range endemics. The trapdoor spider is the subject of further surveys to locate and confirm its distribution on Barrow Island, under Condition 11 of Statement No. 800.

The distributions of the pseudoscorpion *Synsphronus* sp. nov. *'barrow'*, and scorpion *Urodacus* sp. nov. *'barrow'* are detailed in the Short Range Endemics and Subterranean Fauna Monitoring Plan (Chevron Australia 2012c) required under Condition 11 of Statement No. 800.

The scorpion '*Aops' 'ops'* has only been recorded on Barrow Island and has poor dispersal capabilities and may possibly be confined to disjunct habitats (Majer, Edwards, and Callan 2008). The locations of the 17 specimens collected are listed in Table 4-19.

Table 4-19 Collections of Scorpion *'Aops' 'ops'*

Specimen	Site Name	Site Description	Easting[1] (m)	Northing[1] (m)	Landform	Survey Method	Date
1	SS7.08	B Station West Side	330920	7695107	Limestone Ridge	Walking	04/02/08
2	SS7.08	B Station West Side	330920	7695107	Limestone Ridge	Walking	04/02/08
3	SS7.08	B Station West Side	330920	7695107	Limestone Ridge	Walking	04/02/08
4	SS7.08	B Station West Side	330920	7695107	Limestone Ridge	Walking	04/02/08
5	SS7.08	B Station West Side	330920	7695107	Limestone Ridge	Walking	04/02/08
6	SS7.08	B Station West Side	330920	7695107	Limestone Ridge	Walking	04/02/08
7	SS7.08	B Station West Side	330836	7695025	Limestone Ridge	Walking	25/02/08
8	SS7.08	B Station West Side	330827	7695091	Drainage Line	Walking	25/02/08
9	SS7.08	B Station West Side	330946	7695133	Limestone Ridge	Walking	25/02/08
10	SS08.5	Barrow Island Biggada Creek Rd	328999	7701391	Drainage Line	Walking	25/02/08
11	SS08.5	Barrow Island Biggada Creek Rd	329011	7701397	Drainage Line	Walking	25/02/08
12	SS08.4	Barrow Island R Block	330528	7702158	Valley	Walking	25/02/08
13	SS08.4	Barrow Island R Block	330573	7702173	Valley	Driving	25/02/08
14	SS08.4	Barrow Island R Block	330571	7702182	Valley	Driving	25/02/08
15	SS08.4	Barrow Island R Block	330585	7702191	Limestone Ridge	Walking	25/02/08
16	SS08.4	Barrow Island R Block	330566	7702188	Valley	Walking	25/02/08
17	SS08.6	Barrow Island Airport Rd	334665	7692842	Flat	Driving	25/02/08

Note: 1 Datum: GDA94, Projection: MGA 50
Source: Majer, Edwards, and Callan (2008)

As shown in Map 6 in Section 10.0, collections are from sites near the east and west coasts, and in the interior of Barrow Island. Sixteen of the 17 '*Aops' 'ops'* specimens were collected in sites remote from the Gorgon Gas Development Footprint (either near the central portion of the west coast or the southern interior of the Island). One specimen was collected in the vicinity of the Gorgon Gas Development and Jansz Feed Gas Pipeline, along the Airport Road. The scorpion appears to be able to co-inhabit in areas of current oilfield operations on Barrow Island. Whilst specimens have been collected from four different landforms, the species appears to be associated with rocky habitats composed of limestone (Majer, Edwards, and Callan 2008).

As shown in Map 6, the land snail *Rhagada* sp. 1 (the smaller of the two *Rhagada* species on Barrow Island) occurs in the north-west of the Island.

There are 20 invertebrate taxa from seven orders identified on Barrow Island that are considered non-indigenous terrestrial invertebrates. Majer, Callan, and Graham (2008) divided these into two categories: confirmed and putative (which remain under suspicion of being non-

native to Barrow Island until the appropriate issues are resolved and the species can be confirmed as either native or non-native).

The 13 confirmed and seven putative (presumed) non-indigenous terrestrial invertebrates to Barrow Island are listed in Table 4-20.

Table 4-20 Confirmed and Putative Non-indigenous Terrestrial Invertebrates

Category	Common Name	Species Name
Confirmed: Organisms that have been positively identified as species not native to Barrow Island, and there are no reasons to doubt that they have become naturalised on Barrow Island.	Giant Daddy Long-legs Spider	*Artema Atlanta*
	Daddy long-legs Spider	*Crossopriza lyoni*
	Spitting Spider	*Dictis striatipes*
	Urban Wall Spider	*Oecobius navus*
	Slater	*Porcellionides pruinosus*
	American Cockroach	*Periplaneta americana*
	Dermistid Beetle	*Dermestes haemorrhoidalis*
	Red-legged Ham Beetle	*Necrobia rufipes*
	Beetle	*Leucohimatium arundinaceum*
	Tomato Mirid	*Nesidiocoris tenuis*
	Tomato Thrip	*Frankliniella schultzei*
	Ant	*Cerapachys longitarsus*
	Black Crazy Ant	*Paratrechina longicornis*
Putative: Organisms (or species) that have been identified as possible non-indigenous terrestrial invertebrates to Barrow Island, although there is a level of doubt concerning either the identity of the organism, or the taxonomy, origin, or natural range of the species.	Red-backed Spider	*Latrodectus hasseltii*
	Springtail	*Hemisotoma* sp. cf. *thermophila* grp. (voucher #3)
	Springtail	*Hypogastrura* sp. cf. *vernalis* (voucher #44)
	Springtail	cf. *Isotoma viridis* (voucher #34)
	Springtail	*Mesaphorura* sp. (voucher #37)
	Sneaking Ant	*Cardiocondyla nuda*
	Bug	*Montandoniola* sp.

Source: Majer, Callan, and Graham (2008)

4.3.6 Subterranean Fauna

4.3.6.1 Overview

Two broad categories of fauna 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.

4.3.6.2 Methodology

Subterranean fauna has been studied on Barrow Island since 1991. Surveys by the Western Australian Museum at 43 sites focused largely on cave fauna. Sampling was undertaken by Chevron Australia in 2002 and 2003 to support the Environmental, Social and Economic Review of the Gorgon Gas Development on Barrow Island (ChevronTexaco Australia 2003). Subsequent to this, Chevron Australia commissioned a 19-month four-phase survey between November 2004 and July 2006. The last two phases were undertaken after the release of the

Draft EIS/ERMP in 2005 (Chevron Australia 2005). This sampling was undertaken at 46 sites for troglofauna and 37 sites for stygofauna. The number of bores sampled during each phase is summarised in Table 4-21 and also shown in Map 5iii.

Four types of boreholes were installed and sampled as part of the survey:

- **Halocline bores**: Cased holes drilled to the halocline (the interface between the superficial aquifer and deeper saline groundwater) plus 5 m – aimed primarily at stygofauna sampling.
- **Subterranean fauna bores**: Drilled to 5 m below the top of the superficial fresh water aquifer – primarily stygofauna sampling holes, but the portion of the casing above the watertable was also fully slotted (3 mm slots) to allow for troglofauna sampling. These were the core component of the sampling program and a grid of reference site bores (S1 to S9) was installed to provide transects of data inland from shore.
- **Opportunistic troglofauna bores**: Uncased holes drilled primarily for geotechnical work (top few metres cased and capped to enable sampling access and prevent blockages) – varying depth (generally less than 5 m), sampled only for troglofauna in this superficial portion of the karst.
- **Opportunistic bores (other)**: Bores of undetermined origin.

Stygofauna were sampled using the established technique of groundwater bailing with haul nets. Troglofauna were sampled by means of custom-built litter traps containing leaf litter material left in the ground for a minimum of six weeks to allow sufficient time for colonisation.

Table 4-21 Number of Bores Successfully Sampled in Phases I to IV

Phase	Area	Troglofauna	Stygofauna
Phase I: Nov – Dec 2004	In Gas Treatment Plant site	24	16
	Outside Gas Treatment Plant site	19	18
Phase II: March 2005	In Gas Treatment Plant site	24	14
	Outside Gas Treatment Plant site	19	18
Phase III: March 2006	In Gas Treatment Plant site	22	14
	Outside Gas Treatment Plant site	20	17
Phase IV: May – June 2006	In Gas Treatment Plant site	22	11
	Outside Gas Treatment Plant site	21	18

Source: Biota Environmental Sciences 2007

4.3.6.3 Results

A total of 13 troglobitic and 43 stygofauna taxa have been recorded on Barrow Island (Biota Environmental Sciences 2007). Of these, five troglobitic and five stygofauna taxa have been recorded under the Gas Treatment Plant site. Subterranean fauna taxa, along with their conservation status and whether they are located within the Gorgon Gas Development Footprint, are listed in Appendix 8. The locations of troglofauna and stygofauna recorded on Barrow Island are shown in Map 6ii.

Ten subterranean fauna species recorded on Barrow Island are listed as Schedule 1 species (species that are rare or likely to become extinct) under the *Wildlife Conservation Act 1950* (WA). These are the troglobites *Draculoides bramstokeri* and *Speleostrophus nesiotes*; and seven species of stygobite (*Nedsia fragilis*, *Nedsia humphreysi*, *Nedsia hurlberti*, *Nedsia macrosculptilis*, *Nedsia sculptilis*, *Nedsia straskraba*, and *Nedsia urifimbriata*). This number of listings reflects that:

- there are unresolved taxonomic issues with valid species delineations within the *Nedsia* genus
- there is a relatively small number of occurrences recorded for subterranean fauna in WA.

Two stygal vertebrates have been recorded on Barrow Island – the Barrow Cave Gudgeon (*Milyeringa justitia*) and the Blind Eel (*Ophisternon sp.*)

The Barrow Cave Gudgeon is a subterranean fish listed as a Schedule 1 species under the *Wildlife Conservation Act 1950* (WA) and as Vulnerable under the EPBC Act (Cth) (i.e. the Barrow Cave Gudgeon is a matter of NES)[1]. Two individuals of this fish species were collected from the Borehole L8 (GDA94 coordinates 332664m E, 7697031m N), located in the centre of Barrow Island approximately 6 km east of the Gorgon Gas Development Construction Village. One individual was collected from a Borehole SF-RD10-02 (338057m E, 7699178m N) on the Administration and Operations Complex site.

There is one unconfirmed report of the Blind Eel on Barrow Island, with a single individual recovered from a seismic drill hole on the west coast of the island, approximately 10 km from the Gas Treatment Plant site. The single Blind Eel found on Barrow Island was not identified to species level. Given the wide range of *Ophisternon candidum* in stygal ecosystems in the Pilbara, the Blind Eel record from Barrow Island is taken to be *Ophisternon candidum* for the purposes of conservation status (Humphreys et al. 2013). *Ophisternon candidum* is listed as Vulnerable under the EPBC Act.

The Barrow Island Cave Gudgeon and the Blind Eel can be assumed to be widespread on Barrow Island due to the extensive freshwater aquifer (characterised in Section 4.6) that provides habitat.

The low capture rate for the Barrow Cave Gudgeon and Blind Eel is likely to be a result of stygofauna traps excluding larger individuals. Whilst the species grows to 4.5 cm long, the boreholes have an internal diameter of only 6 cm.

As discussed previously in this Report, the Subterranean Blind Snake (*Ramphotyphlops longissimus*) is listed by DPaW as a Priority 2 species and is likely to be endemic and restricted to Barrow Island as this species is known from only one specimen, which was collected on Barrow Island.

4.3.6.3.1 Stygofauna

Stygofauna were recorded from 59% of bores. Approximately 24 taxa have been identified on Barrow Island to date. The dominant taxa, both numerically and spatially, were the cyclopoid copepods and the 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 Environmental Sciences 2007). The stygal taxa recorded are representative of the stygofaunal groups recorded at mainland locations, including Cape Range and the Robe Valley.

The proportion of the stygofauna recorded on the Island cannot yet be determined with any certainty. Meaningful species accumulation curves cannot be constructed for stygofauna until most specimens have been identified at the species level.

To date, two stygal taxa have not been located outside the disturbance area associated with the Gas Treatment Plant site (Appendix 8). Subsequent sampling and taxonomic investigations have been conducted in relation to these species and a summary is provided below.

[1] The sightless Gudgeon found on Barrow Island has previously been reported as *M. veritas* but has been reclassified as *M. justitia* (Larson *et al.* 2013). At the time of writing, this taxonomic revision had yet to be adopted under the EPBC Act. However, for the purposes of this report *M. justitia* has been included as a matter of NES consistent with *M. veritas*, which is listed as Vulnerable under the EPBC Act.

- Amphipoda

  A mitochondrial deoxyribonucleic acid (DNA) genetic analysis of the collected amphipods (*Nedsia* sp.) was undertaken by the School of Animal Biology at UWA in 2007 to evaluate the variation of this taxon across Barrow Island and within the Gas Treatment Plant site (Finston 2007). A morphological study was commissioned in 2007 to provide a context for evaluating whether these genetic differences represent variation within a population or unique taxa. These results are presented in the Gorgon Project Subterranean Fauna Survey report 2009 (Biota Environmental Sciences 2009). The DNA suggests that there are six distinct species of amphipods, of which two belong to the genus *Nedsia*. Two amphipod species are only known from the Gas Treatment Plant site and these are identified in Appendix H (Biota Environmental Sciences 2007).

  One species of *Nedsia* is widespread and was recorded in all bores sampled. The second species of *Nedsia* is less common. It was recorded in five bores, all outside the Gorgon Gas Development Footprint. Given the wider distribution of the other, better-collected species in the same genus, it is likely these two restricted species may be found elsewhere, with further sampling effort required under Condition 11 of Statement No. 800.

- Bathynellacea

  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 now been classified to species level as *Notobathynella* sp. nov. 1 (Biota Environmental Sciences 2008). This species has been collected from reference bores outside the Gas Treatment Plant site and is therefore no longer considered restricted to this site.

4.3.6.3.2 Troglofauna

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

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 restricted to the underground environment (i.e. most individuals were not true troglobites). On this basis, only 13 of the 21 taxonomic groups collected were classified as representing troglobitic taxa. Within the nine taxonomic groups, ten troglobitic taxa were identified. Troglofauna were recorded from 56% of bores. Schizomids were the most abundant, accounting for approximately 71% of the total collection of troglobites; they were collected from 50% of the bores sampled (Biota Environmental Sciences 2007). At order level, the troglobitic taxa recorded are representative of the troglofaunal taxa recorded at mainland locations, including Cape Range and the Robe Valley.

To date, one troglobitic taxon (*Symphyla* sp.) has not been located outside the Gorgon Gas Treatment Plant site and Additional Support Area (Appendix 8). As presented in Appendix 1, sample-based and individual-based rarefaction and taxa accumulation curves prepared by Biota Environmental Sciences (2007) indicate that the total number of troglobitic taxa on Barrow Island is approximately 14, suggesting that approximately five troglobitic taxa remain uncollected. Given that sampling Phases III and IV did not collect additional species, undetected taxa may require considerable sampling effort to detect them elsewhere.

4.4 Habitat

4.4.1 Overview

Habitat is defined by DPaW (DEC 2008b) as the area or areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography) and the biotic factors.

As stated in Section 3.1.4, the ecological element of 'habitat' is restricted to Boodie warrens, termite mounds, and raptor nests in this Report. Other aspects of habitat will be captured through the characterisation of other ecological elements.

Significant habitat needs to be identified so that potential impacts on taxa and features are identified. Habitat was considered significant in the Draft EIS/ERMP (Chevron Australia 2005) where it was identified as:

- supporting an unusually high species richness or abundance compared to other parts of Barrow Island
- containing faunal habitats not well represented in other parts of the Island
- containing habitat for site-restricted fauna of high conservation significance
- being 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.

Applying these criteria, the habitats identified as being significant on Barrow Island are:

- Boodie warrens – habitat for Boodies, which are fauna of high conservation significance
- termite mounds that support high species richness
- nests of raptors (birds of prey), which are not represented on the Island in high numbers and which provide habitat for fauna of high conservation significance.

Shrubland of *Melaleuca cardiophylla* has not been included as a significant habitat although it was indicated in the Draft EIS/ERMP that it may be critical habitat for the White-winged Fairy-wren (Barrow Island) (*Malurus leucopterus edouardi*) on Barrow Island (Chevron Australia 2005). As discussed in Section 4.3.4, the White-winged Fairy-wren (Barrow Island) on Barrow Island nests in tall spinifex and a range of shrubs, and they occur and breed in vegetation associations where this species is not present.

Boodie Warrens

Boodies are dependent upon their warrens and are expected to have limited ability to disperse into surrounding areas (Chevron Australia 2005).

Termite Mounds

Under the Conservation and Land Management Regulations 2002 (WA), termite mounds are listed as a protected 'naturally occurring feature' on the conservation estate (of which Barrow Island is a part).

The termites *Nasutitermes triodiae* perform an important function in the organic matter cycle, and the termite mounds provide valuable shelter for reptiles, birds, and mammals on Barrow Island (Chevron Australia 2005). The potential for nutrient cycling is reflected in elevated levels of organic matter and phosphorus, iron, and manganese in material collected from a termite mound on Barrow Island (Lewis and Grierson 1990).

Other fauna recorded on or using termite mounds on Barrow Island include the Northern Brushtail Possum (T*richosurus vulpecula arnhemensis*), geckos (*Gehyra* species and *Heteronotia binoei*), skinks (*Cryptoblepharus carnabyi*), and dragon lizards (*Ctenophorus caudicinctus caudicinctus*) (Chevron Australia 2005). Other fauna recorded on or in termite mounds on Barrow Island include pythons (*Liasis stimsoni stimsoni*), insects (bristletails, beetles

and cockroaches), mice, the Golden Bandicoot (*Isoodon auratus barrowensis*), bats, and birds (WAPET 1989). The Perentie (*Varanus giganteus*) also lays eggs in termite mounds.

Raptor Nests

There are few substantial trees on Barrow Island and the importance of nests for raptors is recognised through the requirement for exclusion zones around them in Clearing Permit CPS 123/2 issued to Chevron Australia by the DEC.

4.4.2 Boodie Warrens

4.4.2.1 Methodology

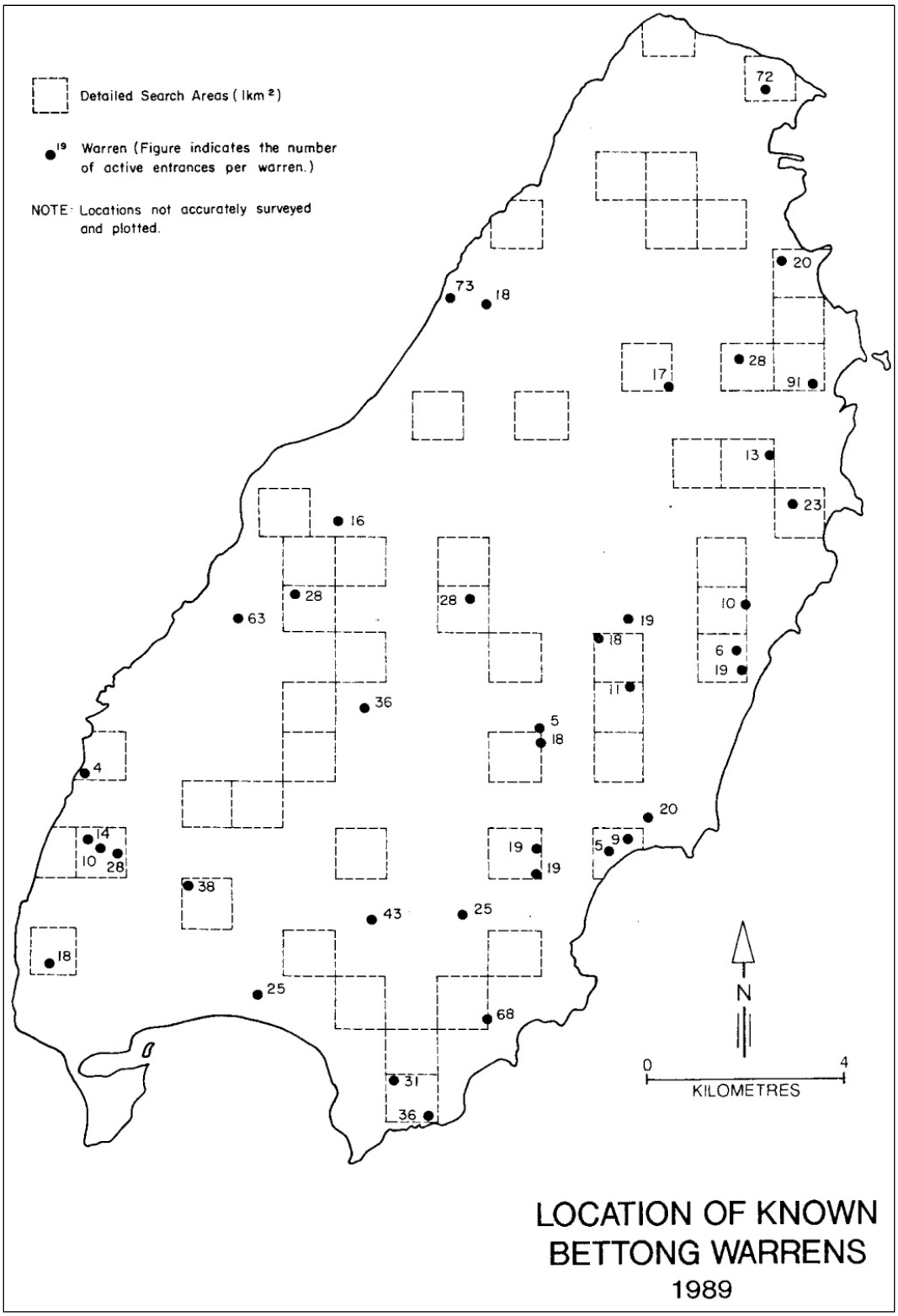
Boodie warrens across Barrow Island were surveyed within fifty 1 km^2 blocks across Barrow Island by Short *et al.* (1989). The Draft EIS/ERMP presented the method for surveying for Boodie warrens in the vicinity of the Gorgon Gas Development Footprint and the Onshore Feed Gas Pipeline (Chevron Australia 2005). The survey areas are shown in Map 5i. Transects totalling 131 km (spaced 50 m apart in an east–west direction) were surveyed in the vicinity of the Gas Treatment Plant site. The locations of warrens are recorded in Chevron Australia's GIS.

4.4.2.2 Results

The 62 active and seven inactive Boodie warrens recorded since 2003 are shown in Map 7. There appear to be more suitable sites for warrens than active warrens (Short *et al.* 1989). One Boodie warren was located within the area cleared for the Gas Treatment Plant site.

Surveying of over 5000 ha of Barrow Island, as indicated in Figure 4-4, demonstrates active Boodie warrens are dispersed widely and evenly across the Island at low density (approximately 0.43 per km^2).

Warrens are generally located on well-drained sites (often on or near the crests of ridges), usually located in cap rock, and often associated with the fig *Ficus platypoda*. No warrens were located in dune habitats or drainage lines in the absence of rocks, as cap rock most likely provides structural stability as well as insulation for the burrows.



Source: Short et al. 1989

Figure 4-4 Approximate Locations of Boodie Warrens

4.4.3 Termite Mounds

4.4.3.1 Methodology

Termite mounds have been mapped by Chevron Australia within 500 m of the Gorgon Gas Development Footprint based on the interpretation of 2005 aerial photo imagery at scale of 1:1000.

4.4.3.2 Results

The distribution of the 6772 termite mounds identified in aerial imagery over an area of 3777 ha is shown in Map 7. The average density of termite mounds in this area was 2 mounds per hectare. There are large variations in mound density within each of the vegetation formations mapped by Mattiske (1993), ranging from 0.01 to 18.5 mounds per hectare between communities, with no robust correlations evident.

Perry (1972) noted that termite mounds were not distributed uniformly across Barrow Island, and even in areas where they typically occur (such as red sand dunes and limestone ridges), they are absent over large areas. Termite mounds on Barrow Island are most abundant on the flats south of the geological fault between Junction Beach and Eagles Nest Point, and north of the geological fault between Ant Point on the east coast and North Whites Beach on the west coast (Butler pers. comm. 2008). The Gorgon Gas Development Footprint is therefore located in the portion of Barrow Island where termite mounds are less abundant.

Perry (1972) concluded that factors other than food (spinifex) and mound-building material resulted in the absence of mounds in large areas of suitable habitat. Lewis and Grierson (1990) suggested that termite mound distribution may reflect soil types since large amounts of iron and manganese were present in the mounds and iron is a useful cementing agent. Butler (pers. comm. 2008) suggested that mounds generally occur where there is clay in the soil, except in drainage lines subject to flooding.

4.4.4 Raptor Nests

4.4.4.1 Methodology

Raptor nests have been mapped by Chevron Australia on the basis of expert knowledge of the Island and global positioning system (GPS) coordinates supplied by field staff in 2006.

4.4.4.2 Results

Raptors establish nests along the Barrow Island coastline. Of the 54 raptor nests recorded, 35 nests are more than 2 km from the Gorgon Gas Development Footprint; these are detailed in Table 4-22 and are shown in Map 7. The quadrat-based population estimates in Table 4-22 were considered overestimates due to sighting of individuals at habitats they rarely frequented, and, taking this into account, Pruett-Jones and O'Donnell (2004) revised these population estimates downward.

The distribution of nests is likely to be reflected in the observed distributions of these birds. The observations of Pruett-Jones and O'Donnell (2004) were that:

- Brahminy Kites are scattered along the coast
- Ospreys are regularly spaced along the coast
- White-bellied Sea-eagles are occasional visitors (and nesting pairs were seen on the southern coast).

The only raptor nests within 2 km of the Gorgon Gas Development Footprint are two Osprey nests.

Table 4-22 Summary of Raptor Nests

Species	Quadrat-based Island Population (individuals)	Revised Population Estimates	Confirmed Nests	Unconfirmed Nests	Old Records/ Nest Absent	Location Approx	Total Nests
Brahminy Kite	15[1]–23[2]	23[2]	3	1	0	0	4
Osprey	73[2]–180[1]	50[2]	18	10	7	1	36
Sea-eagle	3[1]–73[2]	10–12[2]	6	8	0	0	14
Total			**27**	**19**	**7**	**1**	**54**

Notes: 1 Sedgwick (1978)
2 Pruett-Jones and O'Donnell (2004)

4.5 Ecological Communities

4.5.1 Overview

DPaW (DEC 2008c) defines an ecological community as '[a] naturally occurring biological assemblage that occurs in a particular type of habitat'. DPaW defines ecological communities at varying scales as a reflection of the varying levels of detail in information sources.

In the context of this broad definition, focus is required to characterise ecological communities on Barrow Island in a practicable manner (as per Section 3.1.1). As stated in Section 3.1.4, the ecological element of 'ecological communities' is restricted to ecological communities listed in DPaW's Threatened Ecological Communities Database (DEC 2006). Other aspects of ecological communities will be captured through the characterisation of other ecological elements.

Ecological communities are considered significant on Barrow Island if they are:

- listed under the EPBC Act (Cth); or
- listed by DPaW as a TEC or a PEC.

No ecological communities listed under EPBC Act (Cth) are recorded or are known to occur on Barrow Island. No TECs, as listed in DPaW's Threatened Ecological Database (DEC 2006), have been recorded or are known to occur on Barrow Island. The two Priority 1 PECs listed by DPaW that occur on Barrow Island are:

- Barrow Island Subterranean Fauna: Barrow Island stygofauna and troglofauna
- Barrow Island Creekline Vegetation: General cover of *Triodia angusta* with shrubs principally *Hakea suberea*, *Petalostylis labicheoides*, *Acacia bivenosa* and *Gossypium robinsonii*. Mangrove thickets (*Avicennia marina*) at the creek mouths.

Both these PECs are listed by DPaW as Priority 1 ecological communities. By definition, this means that DPaW has identified them as meeting the following overall description:

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

These PECs are further discussed below. The creeklines and mangroves are discussed separately as this more accurately reflects their distinctly different natures, and in recognition that they are separate ecological communities.

4.5.2 Subterranean Fauna

4.5.2.1 Methodology

Subterranean fauna has been studied on Barrow Island since 1991. Surveys during the 1990s decade were conducted by the Western Australian Museum and focused largely on cave fauna. Sampling of bores for subterranean fauna was undertaken in 2002, 2003, and in a 19-month four-phase survey, spanning from 2004 to 2006 (refer to Section 4.3.6.1.

4.5.2.2 Results

The Gorgon Gas Development Footprint overlies only a very small portion of the subterranean fauna habitat on Barrow Island. The geology of Barrow Island (shown on Map 8) is conducive to supporting highly rich subterranean fauna with widespread distributions (EPA 2007). Preliminary geological reviews suggest that strata on the Island (e.g. interbedded sand/limestone) are relatively continuous (Biota Environmental Sciences 2007) and subterranean fauna have been recorded at every sampled site except one. The locations of subterranean fauna records on Barrow Island are shown in Map 8.

The Trealla Limestone, recorded as being up to 83 m thick, is exposed over about 80% of Barrow Island, with the exception of low-lying areas in the north, a narrow strip in the east, and south of the Barrow Fault (Groundwater Consulting Services 2005). The Giralia Calcarenite, which is up to 142 m thick, is exposed only in the bottom of deeply incised gullies (Groundwater Consulting Services 2005).

Biota Environmental Sciences (2007) interprets the geological evidence available as suggesting the area of the Gas Treatment Plant site contains a range of habitats suitable for utilisation by stygofauna and troglofauna in the form of:

- air and water-filled cavities, with size ranges including sub-metre dimensions
- abundant fractures in the more brittle, high-strength lithologies
- solution cavities in competent lithologies
- voids developed in uncompacted sands
- detrital sediment.

The lower limestone at the Gas Treatment Plant site has a higher incidence of cavities and is expected to be more permeable, but cavity development declines sharply about 60 m below ground level (about -50 m AHD) (Chevron Australia 2007a).

Biota Environmental Sciences (2007) considers Barrow Island has a high conservation value for subterranean fauna at national, state, and regional scales on the basis that the Island supports a range of subterranean species that are specially protected at both State and Commonwealth statutory levels.

The values of the subterranean fauna ecological community represented in the area of the Gas Treatment Plant site are that it includes:

- subterranean fauna endemic to Barrow Island
- at least three Schedule 1 fauna species
- three taxa yet to be recorded elsewhere on the Island.

The Gas Treatment Plant site is considered to be of high conservation value in a regional context but of moderate conservation significance compared to other parts of Barrow Island, taking into account the overall extent of subterranean fauna habitat (Biota Environmental Sciences 2007).

Sampling effects can play a large role in the apparent distribution of subterranean fauna. Biota Environmental Sciences (2007) suggests that data from species that are physically largest, and

those species that have been collected in higher numbers, indicates that stygal and troglobitic species are likely to have widespread distributions across the Island. That said, differences in species biology could also reduce a species' distribution and should not be discounted, and many species exhibit strong habitat preferences and are likely to have spatially patchy distributions that match the distribution of their preferred habitat.

4.5.3 Creeklines

4.5.3.1 Overview

The listing of Barrow Island creeklines as a PEC is a reflection of the level of creekline disturbance as a result of past land use management practices; the PEC does not include creeklines that have been previously disturbed (Van Leeuwen pers. comm. 2008).

The creeklines of Barrow Island were subject to considerable disturbance in the early years of WAPET's operations in the 1960s because they provided ready access to sources of gravel. In addition, many roads were built along watercourses because they were easier to construct on the alluvial substrates than on limestone areas. This disturbance was exacerbated by road duplication, water erosion, and an absence of initial active rehabilitation (WAPET 1989).

Vegetation along creeklines is potentially important in providing feed for animals during drought periods because the soils take longer to dry out. Vegetation also slows water flow, which decreases erosion, sediment loss, turbidity at outflows into the ocean, and increases water recharge (WAPET 1989).

4.5.3.2 Methodology

A desktop study of the level of disturbance of creeklines (mapped by Mattiske [1993]) has been prepared by Chevron Australia on the basis of:

- undisturbed drainage systems that are entirely intact regardless of size and contain no roads or quarries whatsoever
- disturbed but large and relatively unfragmented drainage systems that contain at least one portion of totally undisturbed creekline vegetation greater than five hectares and no breaks in vegetation of more than ten metres
- disturbed drainage systems that are small and/or relatively fragmented (all other areas).

4.5.3.3 Results

There is no definitive delineation of the Barrow Island creekline PEC, but an indication of the least disturbed creeklines is provided in Map 8.

Desktop estimates show there is approximately 888 ha of uncleared creekline vegetation on Barrow Island. This uncleared creekline vegetation can be classified as follows:

- Undisturbed 11.5 ha
- Continuous 631 ha
- Discontinuous 245 ha.

An overlay of GIS datasets indicates that 11.5 ha of creeklines are defined as totally undisturbed, of which there is less than 0.007 ha that may be cleared for the Gorgon Gas Development and Jansz Feed Gas Pipeline. In addition, of the 631 ha of creeklines defined as continuous, approximately 22.4 ha of these may be cleared for the Gorgon Gas Development and Jansz Feed Gas Pipeline. It should be noted that the ecological functioning of every other creekline has not necessarily been diminished as even a single road crossing across an extensive creekline resulted in it being classified as being fragmented.

4.5.4 Mangroves

4.5.4.1 Overview

The EPA (2001) recognises the intrinsic value of tropical arid zone mangroves and the need to protect their distribution and function along the Pilbara coastline. Mangroves are highly productive systems supporting a wide variety of fauna (State of Western Australia 2003). On Barrow Island, they provide important habitat for birds such as the Mangrove Heron, Yellow Silver-eye, Brahminy Kite, White-breasted Woodswallows, and Sacred Kingfishers (WAPET 1989), as well as a variety of marine fauna.

The EPA (2001) recognises mangroves along the Pilbara coastline as the largest single unit of relatively undisturbed tropical arid zone habitats in the world. The mangroves on Barrow Island are considered by DPaW to be relatively intact examples of this vegetation type along the north-west coastline. In particular, they have intact faunas as a consequence of negligible access by the public and little disturbance from land-based activities that may promote changes in freshwater hydrological regimes and nutrient flows (Van Leeuwen pers. comm. 2008). The significance of the mangroves on the Island is supported by their inclusion in the Bandicoot Bay Conservation Area (Van Leeuwen pers. comm. 2008).

4.5.4.2 Methodology

Mangroves were mapped on Barrow Island by Chevron Australia based on interpretation of 2005 aerial photography at a scale greater than 1:5000.

4.5.4.3 Results

Mangroves typically occur in relatively protected intertidal zones of brackish and marine shores (State of Western Australia 2003). The most common mangrove species of the Pilbara are *Avicenna marina* and *Rhizophora stylosa*.

On Barrow Island, mangroves occur in localised pockets in more protected portions of the southern and eastern coastlines. These mangroves generally consist of narrow bands only a few trees in width, in contrast to mangroves on the nearby mainland that extend up to 1 km from the coast (Chevron Australia 2005). The mangroves on Barrow Island are dominated by *Avicennia marina* subsp. *marina*, with *Ruppia maritima* also present at some localities (Mattiske 1993).

Buckley (1983) described two types of mangroves on Barrow Island. They are stands of *Avicennia marina* subsp. *marina* in mud pockets in limestone and rocky beach, and old *Avicennia marina* subsp. *marina* stands swamped by sand, with a ground cover of halophytes (*Neobassia astrocarpa*, *Sclerolaena spinosa*, *Halosarcia* species, *Frankenia pauciflora*, *Threkeldia difussa*, *Enchylaena tomentosa*, and *Sporobolus virginicus*) toward inland margins.

Mangroves cover a total of approximately 23.8 ha and occupy 7% of the Barrow Island coastline. The 39 occurrences of mangroves range from approximately 0.02 ha to 2.4 ha, with an average extent of 0.6 ha; these are shown in Map 8. Mangroves on Barrow Island are relatively intact and there are no occurrences within the Gorgon Gas Development Footprint.

4.6 Groundwater

4.6.1 Overview

Significant groundwater is identified so that potential impacts on taxa and features can be identified. On Barrow Island, the entire shallow relatively fresh groundwater aquifer is considered significant. This aquifer provides habitat for significant subterranean fauna (stygofauna). Terrestrial Groundwater Dependent Ecosystems (GDEs) may occur where root depths are within one to two metres of watertables, with a decreasing likelihood of groundwater dependency of terrestrial vegetation within increasing groundwater depth (Sinclair Knight Merz 2007).

4.6.2 Methodology

4.6.2.1 Barrow Island

A number of desktop reviews and geotechnical investigations have been conducted on the hydrogeology and groundwater resources of Barrow Island. Fifteen hydrogeological studies were completed on Barrow Island between 1995 and 2003 by Chevron Australia (IT Environmental 2003). An assessment of the hydrogeology and groundwater of Barrow Island was undertaken by Groundwater Consulting Services in 2005 (Groundwater Consulting Services 2005).

4.6.2.2 Gas Treatment Plant Site

Geotechnical investigations were conducted in 2004 and 2006 in the vicinity of the Gas Treatment Plant site and other areas, and monitoring wells were installed for stygofauna and groundwater. Geotechnical investigations conducted at (or near) the Gas Treatment Plant site have used various techniques including:

- geophysical surveying (including electrical resistivity, ground-penetrating radar, cross-hole seismic)
- diamond core drilling
- hydraulic testing and groundwater electrical conductivity profiling
- groundwater sampling for field or laboratory chemical analyses to assess groundwater levels and water quality.

In 2007, a coastal land-based hydrogeological assessment was undertaken to improve understanding of the hydrogeology of the Island (Chevron Australia 2007a); this assessment included groundwater levels recorded at ten-minute intervals at nine sites around the Gas Treatment Plant site and at the Barge (WAPET) Landing over nine days.

4.6.3 Results

4.6.3.1 Barrow Island

Two aquifers are located below Barrow Island. A deep confined, saline aquifer known as the Flacourt Sands Aquifer is situated at depths between 900 m and 1200 m, and a shallow unconfined aquifer (watertable) ranges in depth from nil at the coast to over 50 m at the centre of the Island (Groundwater Consulting Services 2005). The discussion below focuses on the shallower aquifer. The salinity and elevation of the groundwater of Barrow Island is shown in Map 10.

The shallow unconfined aquifer forms a shallow fresher groundwater mound (up to 0.6 m high) as a lens floating upon denser, more saline seawater (Groundwater Consulting Services 2005). The watertable is typically between 9 m and 53 m below ground level in the Tertiary limestone (Fluor Daniel GTI 1997). Groundwater Consulting Services (2005) estimated that there is about 38 GL of fresher groundwater in the 75 km^2 central part of the Island.

The Gorgon Gas Development Footprint overlies only a very small portion of the shallow unconfined aquifer. The freshwater lens extends across the Island to within 200 to 500 m of the coast (Groundwater Consulting Services 2005) where tidal influences prevent the formation of a stable low salinity lens (Chevron Australia 2007a). The extent of the aquifer across the Island is reflected by the fact that almost all the wells drilled on the Island have recorded total loss of mud circulation between 50 m and 110 m below the surface (WAPET 1989).

The thickness of the lens of fresher water increases from zero to 25 m between 200 and 500 m and one to two kilometres from the coast, but whether the thickening is abrupt or gradual is variable depending upon local groundwater flow, Lithology, and recharge (Groundwater Consulting Services 2005). The lens of fresher water is on average 20 m thick (Groundwater

Consulting Services 2005), but in most areas where groundwater abstraction has occurred, it appears to occur as a relatively thin lens up to six metres deep (WAPET 1989).

Recharge to the aquifer is principally from direct infiltration of rainfall and to a lesser extent by indirect enhanced recharge in drainage lines such as the Donald River (Groundwater Consulting Services 2005). It is considered conservative to estimate that 10% of rainfall enters the groundwater regime based on similar areas of Trealla Limestone in the Cape Range (Groundwater Consulting Services 2005).

Recharge occurs most rapidly in areas of highly permeable soils overlying porous karst limestone. Lower salinities occur in areas where recharge is rapid along the easiest paths for rainfall to enter the groundwater regime (Groundwater Consulting Services 2005). Higher salinities occur where recharge is slower, represented by clays and silts overlying massive limestone, and in areas where the freshwater/seawater interface is close to the surface of the watertable.

Discharge occurs where water levels are shallower than three to four metres (Groundwater Consulting Services 2005) and at the seeps, which are discussed as surface water landforms in Section 4.7.

Groundwater salinity rates from the upper aquifer vary considerably across the Island. It has been recorded as ranging from 28 600 mg/L Total Dissolved Solids (TDS) near the coast to 55 mg/L 600 m inland (Fluor Daniel GTI 1998). The large variations in salinity reflect variable recharge rates and the interface of fresh groundwater and seawater (WAPET 1989). The salinity of seawater is about 35 000 mg/L TDS, and the higher ranges of groundwater salinities (above 25 000 mg/L TDS) represent areas of significant seawater intrusion.

A relationship between tidal fluctuations and groundwater levels has been observed on some parts of Barrow Island. The influence of tidal fluctuations generally decreases with increasing distance from the coast, but this has not been consistently observed at Barrow Island, most likely because of the low hydraulic gradient of the watertable and the significant effects of karstic limestone that enables strong hydraulic connection with the ocean (Chevron Australia 2005).

The response of the groundwater to tidal changes generally decreases exponentially with distance from the coast (Chevron Australia 2007a). Close to the coast, a 0.67 m watertable level was recorded in response to a 2.77 m tide compared to a 0.01–0.84 m tide 550 m from the coast (Fluor Daniel GTI 1998). Hydraulic gradient and direction of groundwater flow has also been found to be influenced by tides, with a reversal of gradient recorded at the airport (Fluor Daniel GTI 1998a). The tidal lag (the time between high or low tide and corresponding groundwater responses) generally increases linearly with distance from the coast (Chevron Australia 2007a) and varies from two to three hours near the coast to six hours near the centre of the Island (Groundwater Consulting Services 2005).

The temperature of the groundwater has been recorded as ranging between 19.3 °C and 32.8 °C (Fluor Daniel GTI 1997), and pH is generally neutral to slightly alkaline (Groundwater Consulting Services 2005). In ten boreholes sampled in the area of the Gas Treatment Plant site in September 2008, the temperature of the groundwater ranged from 27.5 °C to 30.1 °C (Golder Associates 2008a).

The watertable is highest toward the centre of the Island with a north–south oriented watertable mound along the length of the Island. Groundwater flow is approximately radially outward from the centre of the Island towards the coast, although the Barrow Island Fault may provide a localised hydraulic barrier in the south of the Island (Groundwater Consulting Services 2005). Natural groundwater flows are likely to be in the order of 0.00003 m per second (m/s), but probably range up to 0.001 m/s in cavities during peak recharge events (Groundwater Consulting Services 2005). The vertical component of groundwater flow is insignificant except in response to recharge events (Groundwater Consulting Services 2005), and storm surges have the potential to temporarily increase the groundwater levels by several metres (Fluor Daniel GTI 1998a).

Extensive drilling on the Island has continually confirmed that the superficial aquifer is highly fractured and cavernous. Monitoring of salinity levels indicates variable recharge rates and preferred groundwater flow pathways, which are consistent with a cavernous aquifer in a fractured limestone matrix (WAPET 1989). Whilst the aquifer exhibits local variability, it is regionally uniform (Groundwater Consulting Services 2005).

4.6.3.2 Gas Treatment Plant Site

The depth of the watertable below the site of the Gas Treatment Plant is around five metres (Chevron Australia 2005). Hydraulic gradients are low, ranging from 0.001 to about 0.01 (or a drop in water level of between three centimetres and 30.5 cm over a 30.5 m distance) (Chevron Australia 2005).

In the area of the Gas Treatment Plant, the 'fresh' groundwater lens is about 10 m thick (Chevron Australia 2005). The boundary between the 'fresh' and saline water is not a sharp boundary line, but instead consists of a transition zone of brackish water caused by seasonal fluctuations in rainfall, tidal action, and the amount of water extraction and discharge. In the area of the Gas Treatment Plant, this halocline is five to ten metres thick (Chevron Australia 2005). The saline zone is thinner to the north of the Gas Treatment Plant site (Chevron Australia 2007a). Whilst salinity generally increases with depth, an exception to this was observed at one bore where karst features result in lower salinity groundwater flowing preferentially beneath stagnant higher salinity water (Chevron Australia 2007a).

There is typically an oxygenated zone (Dissolved Oxygen >3 mg/L) several metres thick at the watertable overlying anoxic conditions (Dissolved Oxygen <1 mg/L). This is probably due to biotic activity, which grades back into more oxygenated conditions (Chevron Australia 2007a).

The chemical composition of the groundwater supports the hydrogeological model of the site. It is consistent with a well-mixed aquifer (with no isolation of groundwater of different salinity levels); dominated by sea water, with input of low salinity rainfall which dissolves carbonate (Chevron Australia 2007a).

There are no indications of groundwater contamination from current operations in the Gorgon Gas Development Footprint (ChevronTexaco Australia 2000). However, groundwater has been impacted by hydrocarbons at a site associated with the existing oilfield operations about one kilometre north of the Gas Treatment Plant site. This is currently being monitored by Chevron Australia and it is unlikely that any plume of contamination could extend far enough southwards to affect the Gas Treatment Plant site.

4.7 Surface Water Landforms

4.7.1 Overview

In addition to characterising surface water landforms on Barrow Island to the degree practicable (as per Section 3.1.1), significant surface water landforms are also identified so that potential impacts on taxa and features (as discussed in Section 6.4) are identified.

Surface water landforms are important on Barrow Island due to the scarcity of water in this semiarid environment. Surface water features are considered to be significant on Barrow Island if they are:

- wetlands listed under the EPBC Act (Cth)
- catchments listed under the *Country Areas Water Supply Act 1947* (WA)
- expressions of groundwater (permanent and ephemeral seeps)
- areas where standing water typically accumulates for more than a few days after rainfall (claypans)

  or

- areas identified as typically having flowing water after rainfall (some major drainage lines).

4.7.2 Methodology

Claypans and major drainage lines have been mapped across Barrow Island by Mattiske (1993) at scales between 1:10 000 and 1:25 000. The topography of Barrow Island has been mapped and characterised by Chevron Australia using a Digital Terrain Model (DTM) that was modelled using Airborne Laser Scanning (ALS) data acquired in 2005 from a fixed-wing aircraft with a horizontal accuracy of less than 0.40 m and a vertical accuracy of 0.067 m.

Seeps have been mapped on the basis of expert knowledge of the Island by Chevron Australia through the use of aerial photography. Golder Associates' (2008) Assessment of Erosion Protection Measures [on] Barrow Island incorporated observations from an inspection of the entire length of the Onshore Feed Gas Pipeline in November 2007.

4.7.3 Results

The surface water landforms of Barrow Island are shown on Map 9. The surface hydrology on Barrow Island is characterised by:

- unpredictable, but sometimes very intense, rainfall resulting in significant run-off 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 aquifers.

There are no wetlands listed under the EPBC Act (Cth) or catchments listed under the *Country Areas Water Supply Act 1947* (WA) on Barrow Island.

The only permanent surface water on the Island are seeps that discharge into near-coastal (brackish to saline) pools of water (WAPET 1989). Three of these are known. The largest is located near the mouth of Biggada Creek where fauna concentrates and marine fish and Green Turtles have been observed. These seeps are on the west coast, remote from the Gas Treatment Plant site and more than 5 km from the nearest pipeline alignment.

Other seeps are ephemeral and generally only appear after rain events. The nearest ephemeral freshwater seep to any Gorgon infrastructure is located approximately 500 m south of the North Whites Beach Shore Crossing.

There is an additional saline water pool relatively remote from the beach near 'the Chair' on the west coast of Barrow Island, which fluctuates with tides and in which fish have been observed occasionally (WAPET 1989). This pool is remote from the Gorgon Gas Development Footprint.

Areas where standing water typically accumulates for more than a few days after rainfall events are designated by Mattiske (1993) as claypans (vegetation types S1 and S2). Following rainfall events, claypans temporarily attract water-frequenting birds, such as Zebra Finches. Claypans support species of *Eragrostis* grasses rather than *Triodia* grasses, which are favoured by Richard's Pipits (WAPET 1989). There are 22 claypans on Barrow Island covering a total 193 ha. Two claypans are currently intersected by the road between the Gorgon Gas Development Construction Village and the existing Airport. This road will be used by the Gorgon Gas Development and Jansz Feed Gas Pipeline but is not currently planned to be widened or realigned.

The drainage lines of Barrow Island are highly ephemeral, usually dry, and primarily flow in response to very short, intense rainfall rather than long duration rainfall events (Golder Associates 2008). This is typical of Pilbara rivers, which are highly variable and typically flow in response to large, highly variable, rainfall events (Ruprecht and Ivanescu 2000). There was no evidence of recent flooding in watercourses along the Feed Gas Pipeline route during November 2007, and in many locations along this alignment, watercourses are only discernible by the increased presence of vegetation (Golder Associates 2008).

The 34 closed micro catchments identified in the Draft EIS/ERMP cover a total of 21 530 ha or approximately 92% of the Island (Chevron Australia 2005). These micro catchments range in size from 27 ha to 1880 ha, with an average size of 633 ha. The Gorgon Gas Development Footprint intersects 22 micro catchments, ranging in size from 55 ha to 2322 ha, with an average size of 836 ha. The micro catchments intersecting with the Gorgon Gas Development Footprint total 18 392 ha (79% of the Island).

Most of the drainage lines identified by Mattiske (1993) are largely aligned in an east–west orientation on either side of a central, elevated ridge running north–south. These drainage lines are largely valley floors where soil moisture is higher, rather than channels with flowing water.

An indication of the size of peak discharge events can be measured by the dimension of outfall channels. These are generally very small. An example is one catchment that covers 26 km^2 or 11% of Barrow Island, discharging through a channel approximately 15 m wide just north of Shark Point (Blandford 1996).

Areas identified as typically having flowing water after rainfall events are the naturally bare centrelines of drainage lines mapped by Mattiske (1993). Map 9 shows possible creeklines based on modelled valley centrelines, with the centrelines of broad valleys with no discrete centreline visible on aerial photos removed. Of the 14 drainage lines intersected by the Gorgon Gas Development and Jansz Feed Gas Pipeline, 13 were identified as major drainage lines (Vegetation Types D1, D2, and D3) by Mattiske (1993).

Where water does flow along drainage lines, a water depth of 1 m is not likely to be uncommon on Barrow Island, as Mattiske (1993) noted that litter is often high in creeks or seasonal drainage lines after flooding with leaves and branches building up against shrubs and trees to a height of 1 m.

During the anticipated two years of the Feed Gas Pipeline construction, the estimated flood heights and widths in the 14 watercourse crossings is expected to range between 0.1 m and 0.5 m high (with an average of 0.24 m), and 12 m and 201 m wide (with an average of 77.5 m) (Golder Associates 2008). Golder Associates (2008) estimate the flood heights and widths of the four largest watercourse crossings during a 1-in-100 year event as being:

- 0.2 m high by 82 m wide
- 0.4 m high by 105 m wide
- 0.2 m high by 150 m wide
- 0.5 m high by 60 m wide.

Blandford (1996) suggested sediment yields on Barrow Island are generally low in the absence of clearing, and in 2007 Golder Associates (2008) found no evidence of erosion along creeklines crossed by the Feed Gas Pipeline route.

4.8 Physical Landforms

4.8.1 Overview

The landforms identified as significant on Barrow Island are:

- coastal foredunes
- fossil beds
- cliffs and gorges
- caves, rock shelters and sinkholes.

All these landforms are shown in Map 11. The significance of these landforms is explained immediately below, and the methodology, results and data gaps detailed below that.

Coastal Foredunes

The scenic and ecological values of coastal foredunes, as well as their importance in protecting infrastructure from coastal processes (by accommodating the impacts of severe storms, shoreline movement, global sea level rise, and natural fluctuations) is recognised in the Western Australian State Coastal Planning Policy (Western Australian Planning Commission 2003). Although no bird species are restricted to coastal dunes, dunes are favoured for foraging by Kites and provide nesting and foraging for Bar-shouldered Doves and Ospreys (WAPET 1989). Coastal dunes also need to be considered for their vulnerability to erosion on Barrow Island (Mattiske 1993).

Fossil Beds

Fossils are important because they contribute to our knowledge of the history of life on Earth and to our understanding of the evolution of the groups of organisms whose remains they represent. When fossils of terrestrial (as opposed to marine) organisms occur in deposits on islands, they can have the added importance of contributing to the scientific understanding of species–area relations and island biogeography.

Cliffs and Gorges

Cliffs and gorges are refuges for fauna. They provide shade and shelter from the sun and wind, which is critical given the aridity of Barrow Island. The importance of this habitat type is recognised in Clearing Permit CPS 123/2. The importance of cliffs and gorges to Black-flanked Rock-wallabies (*Petrogale lateralis lateralis*), which use screes and rock piles for shelter, is reflected in the fact that this species is almost totally confined to the western side of the Island where there are limestone cliffs (WAPET 1989).

Northern Brushtail Possums (*Trichosurus arnhemensis*) and Barrow Island Euros (*Macropus robustus isabellinus*) are widespread over the Island, but they tend to be more numerous in the vicinity of cliffs, which provide shade and windbreaks (WAPET 1989). This is supported in the Draft EIS/ERMP (Chevron Australia 2005) in that Northern Brushtail Possums were caught in higher numbers close to a cliff, which probably provided shelter for them in the form of cavities, screes and rock piles.

Cliffs are important habitat for kestrels, Ospreys, and White-bellied Sea-eagles, and the wave-cut platforms at their base provide habitat for oystercatchers and Eastern Reef Herons (WAPET 1989).

Caves, Sinkholes and Fissures

Caves provide a refuge for animals from the Barrow Island heat. King *et al.* (1989) found that the temperature in caves on Barrow Island varied by 3.5 °C compared to a 15.5 °C variation in the shade over a seven-day period in November. The maximum temperature in the cave was also 11.5 °C cooler than the maximum temperature in the shade and on average had 18% higher humidity.

Caves provide daytime roosts for Finlayson's Cave Bat (*Eptesicus finlaysoni*) and the Common Sheathtail-bat (*Taphozous georgianus*). They are used for shelter by Black-flanked Rock-wallabies (*Petrogale lateralis lateralis*) (WAPET 1989), particularly where there are narrow cavities and fissures. Sinkholes and fissures potentially function as preferential pathways for the recharge of the groundwater regime from rainfall.

4.8.2 Coastal Foredunes

4.8.2.1 Methodology

The frontal faces of coastal foredunes were mapped as vegetation units C1 and C2 and the back slopes mapped as C3, C4, C6 and C7 by Mattiske (1993) based on aerial photo interpretation (C5 represents cliffs). Detailed vegetation mapping in the vicinity of the Gorgon Gas Development and Jansz Feed Gas Pipeline is described in Section 4.2.2.

4.8.2.2 Results

Approximately two-thirds of the Island's coastline is occupied by the exposed frontal slopes of coastal foredunes, which cover approximately 790 ha and extend up to 1.4 km inland. Only 3.3 ha of coastal dunes are in the Gorgon Gas Development Footprint, which equates to 0.4% of coastal dunes on Barrow Island. Land clearing of coastal foredunes for the Gorgon Gas Development and Jansz Feed Gas Pipeline only occurs at Town Point on the east coast and North Whites Beach on the west coast.

In addition to the mapping of foredunes, the stability of the beaches adjacent to Town Point has been examined and historical aerial photographs between 1976 and 2001 show little overall change in either beach morphology or vegetation lines. Geotechnical information indicates that the immediate coastal waters at Town Point are shallow, low energy in nature, and feature a rock/reef substrate therefore limiting the amount of mobile sediment.

4.8.3 Fossil Beds

4.8.3.1 Methodology

Marine fossils from the Miocene limestones, and bones from red fill deposits and caves were collected by Harry Butler in the 1960s and 1970s, and Dr Ken McNamara and Mr George Kendrick of the Western Australian Museum who visited Barrow Island in 1982 on a WAPET Environmental Grant to study fossils.

Dr Ken Aplin and Dr Alex Baynes, both of the Western Australian Museum, and Prof Ernest Lundelius of the University of Texas at Austin conducted field trips to Barrow Island in 1994, 1995, 1996, and 1999. During some field seasons they were accompanied by geomorphologist, Prof John Chappell, and magnetic polarity dating expert, Dr Brad Pillans, both from the Australian National University. In the course of these field seasons, visits were made to various parts of Barrow Island, including the cliffed sections of practically the whole coast of the Island in search of red fills. The results that follow are based on advice from the Western Australian Museum (Baynes pers. comm. 2008).

4.8.3.2 Results

Overview

There are no significant fossil sites in the Gorgon Gas Development Footprint. The high land represented by Barrow Island and the Montebello Islands contains one of the longest and most diverse fossil records of terrestrial mammals on any Australian island group. Both Tasmania and Kangaroo Island have more and larger deposits, but only the fossils known from Tasmania cover a greater time span than those discovered to date on Barrow Island.

Limestone underlies most of Barrow Island, and forms the western uplands and the west coast cliffs. This limestone, which was uplifted as part of the Barrow Island anticline, was laid down in a shallow tropical sea in the Middle Miocene, approximately 16 to 11 million years ago (McNamara and Kendrick 1994). Remains of abundant marine invertebrates living on and in the bed of that sea became incorporated in the limestone; in the case of some burrowing sea urchins, this is probably where they died. Subsequent weathering has caused chemical changes in the limestone, including the fossils (McNamara and Kendrick 1994), and the development of caves, solution pipes, fissures and other spaces within the limestone. Collectively, such spaces are known as karst features.

The coastal exposures of Miocene deposits extend from Cape Malouet to Eagles Nest on the western side of the Island, and from Ant Point to Stokes Point on the east side, and the northern and southern coast is covered by Pleistocene deposits and Holocene dunes.

The eastern lowlands of Barrow Island are largely covered by red Quaternary dune sands, but in the south-east of the Island these are underlain by Pleistocene marine deposits, which outcrop at the coast or have been revealed by excavations associated with oil wells, and also contain marine fossils (McNamara and Kendrick 1994). They lie about 2.5 m above present sea

levels, and this situation, and the fossil faunas they contain, are consistent with a Last Interglacial (marine isotope Stage 5e) age of 130 000 to 125 000 years ago (McNamara and Kendrick 1994).

Important palaeontological sites on Barrow Island are discussed below as invertebrate fossil sites and vertebrate fossil sites.

Invertebrate Fossil Sites

The significant invertebrate fossil beds of Barrow Island are shown in Map 11 and described in Appendix 9.

A preliminary fossil survey on Barrow Island was conducted by McNamara and Kendrick (1994), surveying 17 different localities and resulting in the collection of 270 registered specimens, comprising 70 species of mollusc, nine species of echinoids, one species of calcareous worm, one species of cephalopod, and a number of undescribed coral species.

McNamara and Kendrick (1994) found that the distribution of echinoids, particularly the infaunal ones, is closely related to the grain size of the sediment. The best source of fossil material was found along coastal cliffs. The localities containing the most diverse and best preserved fossils are found along the north-west coast. Inland sites yielded a limited quality of poorly preserved specimens.

Vertebrate Fossil Sites

The vertebrate fossil sites are detailed in Appendix 9. In accordance with a request from the Western Australian Museum, their locations are not shown on Map 11 as this Report is a public document. DEC (now DPaW) has been notified of the locations. The 13 vertebrate fossil sites found to date are on or close to the west coast. Most deposits have formed within the Miocene limestone.

Where the spaces have opened to the surface, soil has since fallen in. As this soil is rich in iron, the fills have a dark reddish brown colour. The Western Australian Museum has termed these ‘red fills’. Red fills are common in the limestone along both the east and west coasts, but most do not contain fossils. However, a few along the west coast contain teeth and bones of vertebrates. These remains were probably accumulated by predators in large caves, with an air space above the red sediment accumulating in the bottom of the cave. Such large caves may only have developed where the limestone had been raised sufficiently high above sea level, as, for example, on the west coast. The ages of the bones discovered so far in the red fills and caves vary from about four million years to no more than hundreds of years for the owl-accumulated bones that are found on the floors of some of the present west coast caves.

It is not possible to rank the vertebrate sites in importance because each group is of a different age and therefore its contribution is of equal value to the overall history of terrestrial mammal and reptile species in the area that is currently Barrow Island.

4.8.4 Cliffs and Gorges

4.8.4.1 Methodology

Significant cliffs and gorges were mapped by Chevron Australia across the entire island using the DTM developed using ALS data acquired in 2005 with a horizontal accuracy of less than 0.40 m and a vertical accuracy of 0.067 m. The following thresholds were applied:

- a minimum slope of threshold angle of 20°
- either a minimum size of 0.05 ha or separated by less than 20 m from areas greater than 0.05 ha
- not mapped as coastal foredunes by Mattiske (1993).

These thresholds were based on expert knowledge of the Island, in conjunction with the known distribution of Black-flanked Rock-wallabies, which largely reside in the vicinity of this habitat type.

4.8.4.2 Results

There are no cliffs or gorges in the Gorgon Gas Development Footprint. Cliffs and gorges occupy approximately 76 ha of Barrow Island. These landforms are predominantly located in the western third of the Island, with limestone cliffs also occurring on some of the more prominent headlands of the east coast.

4.8.5 Caves, Sinkholes and Rock Shelters

4.8.5.1 Methodology

Caves and rock shelters have been mapped by Chevron Australia on the basis of expert knowledge of the Island. Sinkholes have not been mapped and it was concluded that they could not be mapped on the basis of Chevron Australia's DTM.

4.8.5.2 Results

A total of 24 caves have been mapped and are shown in Map 11. There are no documented caves, sinkholes or rock shelters in the Gorgon Gas Development Footprint.

4.9 Climate

Barrow Island is characterised by an arid, subtropical 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 temperatures 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 the 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 3500 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 between 6 and 8 m/s.

4.10 Soils

Lewis and Grierson (1990) described the soils of Barrow Island as varying from duplex to coarse textural uniform depending upon their topographic position and geological parent rock. On the western side of the Island, soil texture is influenced by tertiary limestone and characterised as typically silty clay with alluvial watersheds dominated by silty clays and clayey loam textures (Lewis and Grierson 1990). In the larger alluvial flats, soils have prolific root growth in the upper horizons and high organic matter content, which would reduce the erosiveness of the soil.

The eastern soils are generally more prone to erosion due to their greater coarseness. On the eastern slopes, the soils were influenced by Quaternary material and, as such, the soils are much coarser, with coarse clayey sands, sandy loams and sandy clays dominating. In the lower-lying areas, duplex soils are present (Lewis and Grierson 1990). Blandford (1996) observed that sediment or soil with a composition similar to that in the drainage line discharging

to the north of Shark Point (21% clay, 30% silt, and 49% sand), is highly erodible in a disturbed state.

The south-east slopes are strongly influenced by aeolian processes, and in the north-east stranded relic dunes are present, underlain by calcareous cemented coarse sandy hard pans and surrounded by a mixture of coarse and fine soils influenced by past marine inundation (Lewis and Grierson 1990).

4.11 Information Gaps

There are more than 474 documents relating to the natural history of Barrow Island (Smith *et al.* 2006) and there is sufficient information presented in this Report on which to assess the impacts associated with the Terrestrial Facilities on Barrow Island. The Terrestrial Facilities are adequately characterised to determine the associated pathways of stressors that may impact on the environment, and their associated time frames and locations.

There is sufficient contextual information to determine the significance and vulnerability of taxa and features occurring in the Gorgon Gas Development Footprint. This includes relatively comprehensive species lists for Barrow Island. A number of species accumulation curves for Barrow Island data are now available and are presented in Appendix 1. Decreasing slopes in these curves over time, or over the number of sampling events, indicates that few species remain undocumented on Barrow Island.

Remaining gaps in knowledge about the risks of the stressors from the Gorgon Gas Development on the environment of Barrow Island are few. Table 4-23 summarises these information gaps for the Terrestrial Facilities on Barrow Island.

Table 4-23 Information Gaps to be Addressed by Chevron Australia

Element	Timing	Action	Information Gap Category
Flora	In progress	Targeted surveys to determine proportions on Barrow Island of the following that may be impacted: *Acacia synchronicia, Erythrina vespertilio, Grevillea pyramidalis, Jasminum calcarium, Melaleuca cardiophylla* and *Whiteochloa airoides*	Design
	In progress	Baseline monitoring of air quality including Total and insoluble matter (dust), $NO/NO_2/NOx$, SO_2, PM10, CO, Volatile Organic Compounds, and H_2S	Monitoring
Vegetation	In progress	A review of the mapping of disturbed areas subsequent to establishing definitions of cleared and uncleared areas for the Vegetation Clearing and Audit Common User Procedure (Chevron Australia 2012b)	Monitoring
	In progress	Additional vegetation surveys at sites to be disturbed for seismic data acquisition	Design
Fauna	In progress	Pilot a study for estimating Perentie abundance or activity levels on Barrow Island	Monitoring
	In progress	Establish a quantitative baseline for Wedge-tailed Shearwaters and Bridled Terns on Double Island, off the eastern coastline of Barrow Island in the form of replicable counts of breeding performance	Monitoring

Element	Timing	Action	Information Gap Category
Short Range Endemics including Subterranean Fauna	In progress	Survey for, and locate, terrestrial and subterranean taxa currently only found in the Gas Treatment Plant site and Additional Support Area.	Monitoring
Habitat	In progress	Surveys for Boodie warrens in the vicinity of the CO_2 injection sites and seismic monitoring sites	Design
	In progress	A survey of raptor nests along the Barrow Island coastline	Monitoring
	Ongoing	A quantitative assessment/ground truthing of the accuracy of aerial photo interpretation. Initial on-ground observations indicate the interpretation is likely to be accurate.	Monitoring
Ecological Communities	In progress	For creekline and mangrove vegetation, refer to Vegetation in this table	-
Surface Water Landforms	In progress	Accurate mapping of creeklines likely to carry flowing water through the surrounds of the Gorgon Gas Development and Jansz Feed Gas Pipeline as part of developing surface water baseline information. The modelled valley centrelines do not always match likely flowlines.	Monitoring and Design
Groundwater	In progress	Groundwater baseline monitoring in the vicinity of the Gas Treatment Plant site and waste disposal bores to gather site-specific data. This includes the installation of groundwater monitoring boreholes to gather baseline data on groundwater quality and water levels. A subset of these will be used for subterranean fauna sampling. Soil sampling will also be undertaken to characterise baseline levels of analytes in the area.	Monitoring
Physical Landforms	In progress	Map sinkholes, caves and rock shelters avoided during seismic monitoring, as required	Design
	In progress	Further geophysical investigations for potential voids and caves beneath the Gas Treatment Plant site	Design

5.0 Baseline State of Ecological Elements on the Mainland

This section describes and discusses the ecological elements, including significant ecological elements, that occur along the mainland route of the Onshore Domestic Gas Pipeline. This information is not required to meet the conditions of Statements No. 800 and 769 or EPBC Reference: 2003/1294 and 2008/4178; however, it has been included in this Report as background information and has been used to establish the Onshore Domestic Gas Pipeline TDF.

5.1 Flora

The 43 taxa recorded along the Onshore Domestic Gas Pipeline by Dames and Moore (1998) and Chevron Australia (2005), and the 66 taxa for which voucher specimens from the locality of Mardie Station are held at the Western Australian Herbarium (Western Australian Herbarium 2008) are listed in Appendix 2.

DPaW's Threatened (Declared Rare) Flora database, the Western Australian Herbarium Specimen database for priority species, and DPaW's Declared Rare and Priority Flora List were searched to identify rare and priority plant taxa that could potentially occur along the Onshore Domestic Gas Pipeline. The rare and priority plant taxa identified by DEC (now DPaW) (2008d) in a search area defined by a rectangle (with a top-left and bottom-right corner of 114.086318, -19.471616 and 116.424744, -21.743771 respectively in decimal degrees GDA94) are listed in Table 5-1.

An Acacia species was collected by Dames and Moore (1998) along the Onshore Domestic Gas Pipeline that was potentially *Acacia glaucocaesia*, but this could not be confirmed. No Priority taxa were recorded in the preliminary vegetation survey of the Onshore Domestic Gas Pipeline, but voucher specimens of three Priority 3 taxa have been collected in the locality of Mardie Station:

- *Acacia glaucocaesia*
- *Goodenia nuda*
- *Owenia acidula*.

Voucher specimens of three weed taxa have been collected in the locality of Mardie Station:

- *Aerva javanica*
- *Prosopis glandulosa* x *velutina*
- *Tamarindus indica*.

Cenchrus ciliaris occurs in sand dunes in the vicinity of the Onshore Domestic Gas Pipeline (Dames and Moore 1998). The potential for Mesquite (*Prosopis glandulosa* x *velutina*) to occur along the Onshore Domestic Gas Pipeline was identified in 2009. This was based on previous records of 17 juvenile Mesquite plants occurring along Apache Energy's Second Sales Gas Pipeline (Dames and Moore 1998). Vegetation surveys conducted in 2010 later confirmed the presence of Mesquite (*Prosopis* spp. and hybrids) along the Onshore Domestic Gas Pipeline (Astron Environmental Services 2010; Chevron Australia 2011).

Table 5-1 Rare and Priority Plants Potentially in Vicinity of Onshore Domestic Gas Pipeline

Species	Conservation Significance	Sites	Vegetation	Life Form	Flowering Time
Acacia glaucocaesia	P3	Red loam, sandy loam, clay. Floodplains.	-	Dense, glabrous shrub or tree, 1.8–6 m high	July – September
Abutilon uncinatum	P1	Red sand. Flat plain.	Hard hummock grassland of *Triodia lanigera* with an overstorey of *Acacia xiphophylla*	Prostrate perennial, herb, 0.2–1 m high	-
Goodenia pascua	P3	• Red sandy soils • Basaltic plains	Annual grassland, *Acacia* shrub steppe	Ascending to erect herb, to 0.5 m high	May – August
Goodenia pallida	P1	Red soils	-	Erect herb, to 0.5 m high	August
Goodenia nuda	P3	Plain. Dry, red sand.	Mesquite scrub	Erect to ascending herb, to 0.5 m high	April – August
Gunniopsis sp. Fortescue (M.E. Trudgen 11019)	P1	-	-	-	-
Owenia acidula	P3	Clay near creek	Shrub steppe	Tree, 3 to 8 m high	August
Rhynchosia bungarensis	P3	• Slightly elevated area between two minor drainages • Floodplain of Robe River • Sandstone rocks • Cobble bed of large river • Pebbly, shingly coarse sand amongst boulders. Banks of flowline in the mouth of a gully in a valley wall.	• *Acacia bivenosa, Acacia trachycarpa* open shrubland over scattered *Tephrosia rosea* var. *glabrior* low shrubs. • Hummock–tussock grassland • *Eucalyptus camaldulensis* woodland • *Melaleuca argentia* and *Eucalyptus camaldulensis* gallery woodland	Compact, prostrate shrub, to 0.5 m high	-

Sources: DEC 2008d; Western Australian Herbarium 2008

5.2 Vegetation

No significant vegetation was identified on the mainland by applying:

- Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, No. 51 (EPA 2004)
- Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. (EPA 2002).

As shown in Map 12, the Onshore Domestic Gas Pipeline passes through these two vegetation associations defined by Shepherd *et al.* (2001):

- Bare areas; mudflats
- Mosaic: sedgeland; various sedges with very sparse snakewood/hummock grasslands, shrub-steppe; kanji over soft spinifex.

The Onshore Domestic Gas Pipeline passes through these land systems defined by Van Vreeswyk *et al.* (2004a):

- Littoral (bare coastal mudflats with mangroves on seaward fringes, samphire flats, sandy islands, coastal dunes and beaches)
- Onslow (sand plains, dunes and claypans)
- Horseflats (gilgaied clay plains).

The Onshore Domestic Gas Pipeline runs predominantly through the stocked (cattle) lands of Mardie Station along degraded to heavily degraded grasslands (Chevron Australia 2005). On Mardie Station, the perennial vegetation is in good or better condition in 57% of the Horseflat Land System, 30% of the Onslow Land System, and 100% of the Littoral Land System (Van Vreeswyk *et al.* 2004a).

The preliminary vegetation assessment of the route, documented by Chevron Australia (2005), identified the following vegetation types:

- **Mangrove Forests** of *Avicennia marina* subsp. *?eucalyptifolia*, *Bruguiera exaristata* and *Rhizophora stylosa*. Scattered *Ceriops tagal* and *Aegiceras corniculatum* are also present. The inland edge of the mangroves comprises scattered small *Avicennia marina* and patches of samphire
- **Samphires** consisting of a low shrubland of *Tecticornia halocnemoides* subsp. *Tenuis*, *Tecticornia indica* and *Suaeda arbusculoides* and unvegetated tidal flats
- **Grassland** of *Triodia epactia* and *Cenchrus species* with *Eragrostis dielsii* and *Eragrostis falcata* with occasionally emergent *Acacia farnesiana*, *Acacia trachycarpa*, *Lawrencia viridigrisea* and *Neobassia astrocarpa* shrubs on raised red earth mounds
- **Low Open Shrubland** including *Acacia* species over grassland with *Dicanthium sericeum* subsp. *Humilius*, *Eriachne flaccida*, *Aristida holathera* var. *holathera* and *Eriachne benthamii* over a Very Open Herbland including *Rhynchosia minima* and *Neptunia dimorphantha* on red earth flats
- **Open Shrubland to Tall Open Shrubland** of *Acacia trachycarpa*, *Acacia ancistrocarpa*, *Acacia elachantha*, *Acacia victoriae* and *Acacia xiphophylla* over a Grassland of *Triodia epactia* and *?Cenchrus* sp. (likely to be the weed *Cenchrus ciliaris*) over mixed herb species on red sandy flats. This community was recorded at the eastern end of the proposed mainland pipeline route, near the existing compressor station.

Dames and Moore (1998) noted that the distribution of hummock and bunch grasses is influenced by minor topographic variations. Bunch grasses such as *Eragrostis* sp. dominate

lower-lying cracking clays in shallow sheet-wash drainage lines and hollows. Hummock grasses such as *Triodia pungens* dominate higher areas of non-cracking clays.

Initial flora and vegetation surveys, including recognition of major vegetation units along the Onshore Domestic Gas Pipeline, were undertaken in May 2003 using aerial photography and site inspection. The vegetation types mapped during this survey are shown in Figure 5-1. The length of the Onshore Domestic Gas Pipeline and area to be cleared in each of the vegetation types are summarised in Table 5-2.

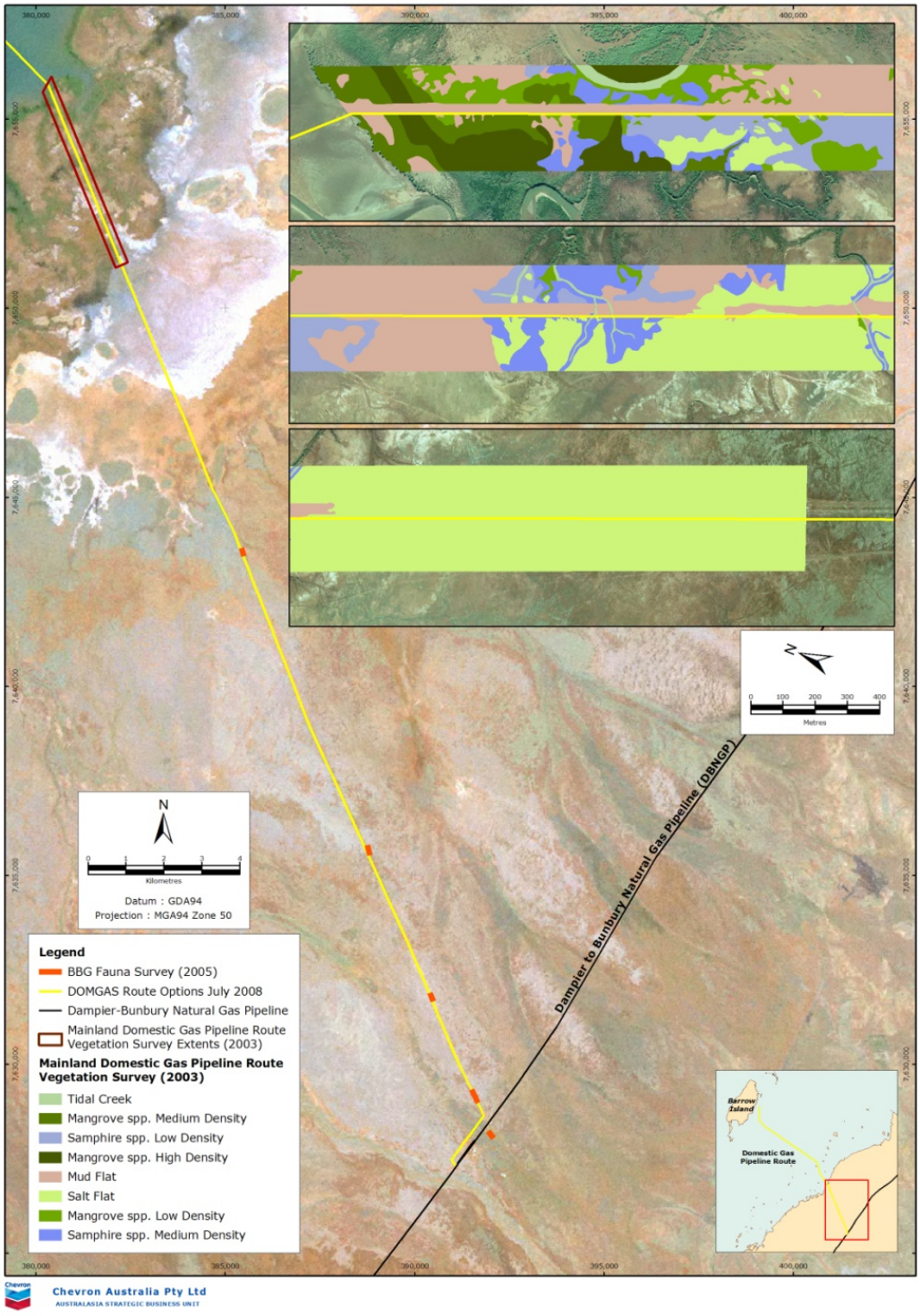


Figure 5-1 Vegetation along the Onshore Domestic Gas Pipeline

Table 5-2 Vegetation along the Onshore Domestic Gas Pipeline

Description	Length of Pipeline (m)	Area to be Cleared (ha)
Mudflat	1383	4.15
Mangrove	643	1.93
Salt flat	9207	27.62
Samphire	939	2.82
Tidal creek	25	0.08
Grassland/shrubland	17803	53.41
Total	**30000**	**90.00**

5.3 Fauna

5.3.1 Overview

A total of 268 species of terrestrial or semi-aquatic vertebrates was identified as potentially occurring in the vicinity of the Onshore Domestic Gas Pipeline. These comprised 5 frogs, 63 reptiles, 170 birds, and 30 mammals.

RPS BBG (2006e) concluded that few conservation-significant fauna are likely to occur in the area of the proposed pipeline route, and that the majority of conservation-significant species were shorebirds. The distribution of these species is restricted to the tidal flats, mangroves, and ocean at the northern end of the pipeline route.

5.3.2 Method

An assessment of the terrestrial fauna of the Onshore Domestic Gas Pipeline was undertaken in 2006 from a literature review, site inspection, and brief field survey (RPS BBG 2006e). This represents a Level 1 survey (desktop study, reconnaissance survey) according to the EPA Position Statement No. 3 (EPA 2002).

A list of fauna expected to occur in the area of interest was generated by searching available databases and literature. Databases were searched by RPS BBG (2006e) for the one degree grid block that surrounds the proposed pipeline route (21° to 22° S, and 115° to 116° E (Figure 5-2). These databases included the:

- Western Australian Museum database (http://www.museum.wa.gov.au/faunabase)
- Birds Australia database for the second Atlas of Australian Birds (records of bird observations in Australia, 1998–1995 from http://www.birdsaustralia.com.au)
- information and species distribution maps provided by Aplin and Smith (2001), How *et al.* (2001), Tyler *et al.* (2000), Storr *et al.* (1983, 1990, 1999, 2002), Wilson and Swan (2003), Cogger (2000), Johnstone and Storr (1998, 2005), Strahan (2004), Menkhorst and Knight (2004), and Churchill (1998).

Additional information and records on threatened species and threatened communities were derived from threatened fauna databases maintained by the DEC (now DPaW) and SEWPaC (now DotE). The DEC database was searched for the area between Onslow and Dampier (bounded by 20° 49’ 36” S, and 21° 38’ 41” S, 115° 05’ 46” E, and 116° 29’ 38” E). The search area for the EPBC database was a 20 km buffer area around the line between the points 21° 11’ 44” S, 115° 50’ 49” E and 21° 31’ 52” S, 115° 59’ 03” E, which approximates the ends of the pipeline route (Figure 5-2).

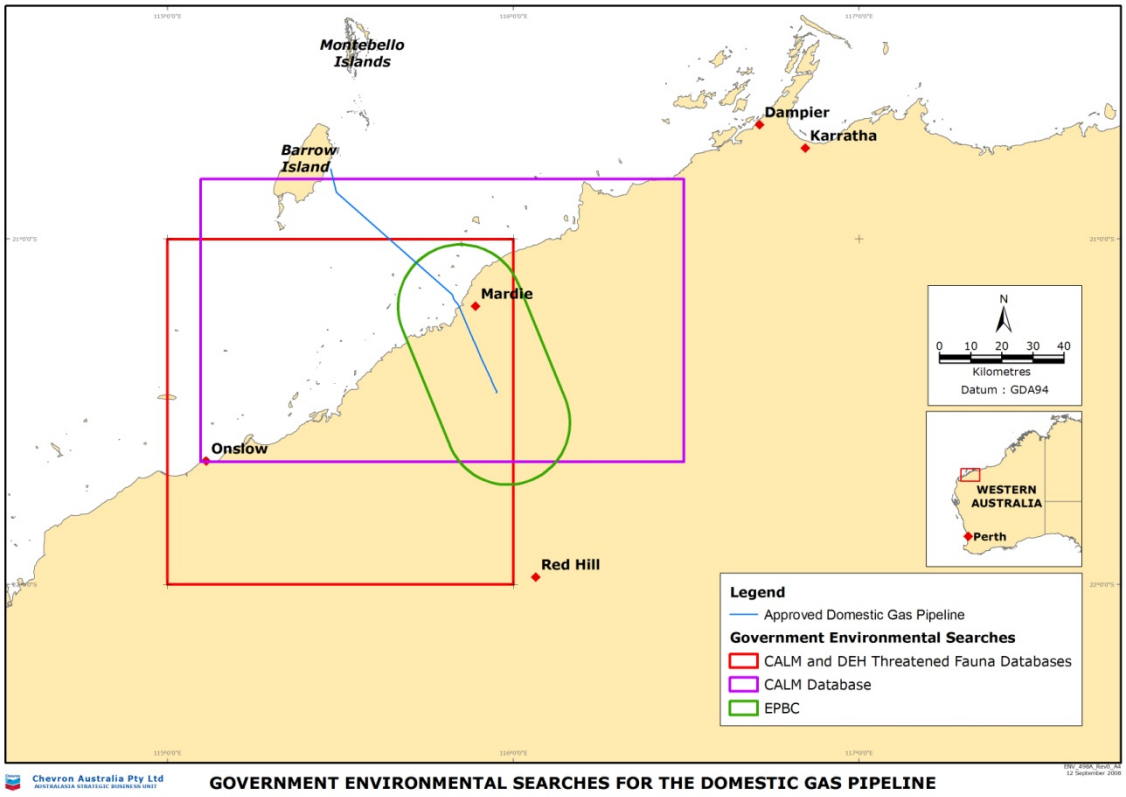


Figure 5-2 Database Search Areas to Identify Fauna along the Onshore Domestic Gas Pipeline

Some species returned by the database searches were omitted from expected species lists by RPS BBG (2006e) because of their ecology, lack of habitat, or range limitations. These omissions included 19 reptiles and amphibians, 22 birds, and nine mammals.

There is no freshwater habitat in the area and therefore no freshwater fish are expected to be present (RPS BBG 2006e).

Field surveys were conducted at the locations indicated in Figure 5-1; the survey methods included:

- helicopter surveys to record bird species in the mangrove, samphire and tidal flat areas
- small box (Elliott) traps to sample small vertebrate fauna, targeting *Mulgara*
- hand searching around logs and leaf litter for invertebrates, amphibians, reptiles, and small mammals
- spotlighting for nocturnal mammals such as owls and larger mammals.

Elliott traps (approx. 80 × 100 × 325 mm) were used to sample the vertebrate fauna of the pipeline route, with the aim of targeting *Mulgara*, a listed threatened mammal species under the EPBC Act (Cth). Traps were deployed in five lines of ten traps, with the traps 20 m apart within each line. Elliott traps were placed under vegetation and baited with a mixture of rolled oats, peanut butter, and tinned sardines. Each line was operated for two nights for a total effort of 100 trap-nights. The trap lines were set across the range of vegetation and soil associations in the area, as summarised in Table 5-3.

Spotlighting for nocturnal animals was undertaken along the existing pipeline route from Compressor Station 1 to the edge of the tidal flats. Helicopter bird surveys were conducted on 18 October 2005 when migratory shorebirds would be expected to be present. The areas of mangrove, samphire and tidal flats in the vicinity of the pipeline route were surveyed twice,

between approximately 0920 and 0950 hours, and between 1300 and 1320 hours. The number and general location of each species observed during these aerial surveys were recorded. In addition, the mangrove and surrounding areas at the north-west end of the proposed pipeline route were inspected on foot after helicopter set down.

Opportunistic hand searching for terrestrial invertebrates, small reptiles, and small mammals was conducted at Elliott trapping lines and at other locations along the pipeline route. In between the two aerial surveys, the survey team was set down in the mangroves and surveyed a 100 m wide strip for 500 m along the pipeline route.

Table 5-3 Fauna Trapping Sites along the Onshore Domestic Gas Pipeline

Line	Start (GDA94)	End (GDA94)	Description
1	392 090 m E 7 628 045 m N	391 940 m E 7 628 230 m N	*Acacia* shrubland/open *Eucalyptus* woodland over *Triodia* grassland on firm red loam with some gravel
2	391 680 m E 7 628 975 m N	391 510 m E 7 629 330 m N	*Acacia* shrubland over grasses growing on cracking red-brown clay with some gravel
3	390 490 m E 7 631 660 m N	390 400 m E 7 631 890 m N	Annual grassland on cracking red-brown clays
4	388 820 m E 7 635 520 m N	388 750 m E 7 635 790 m N	*Acacia* shrubs over grasses growing on cracking red-brown clay with some gravel
5	385 490 m E 7 643 432 m N	385 426 m E 7 643 652 m N	*Triodia* hummock grassland on red-brown clay, near the coast

5.3.3 Mammals

The mammals expected to be in the vicinity of the Onshore Domestic Gas Pipeline and their conservation status are listed in Appendix 4 and summarised in Table 5-4.

Table 5-4 Number of Mammal Species along the Onshore Domestic Gas Pipeline

Mammals	**Recorded** (along pipeline)	**May Occur** (along pipeline)	**Conservation-significant Species** (either recorded or may occur along pipeline)
Dasyuridae (dasyurids)	0	7	2
Macropodidae (kangaroos, wallabies and tree kangaroos)	1	1	0
Pteropodidae (fruit bats)	1	1	0
Emballonuridae (sheathtail bats)	0	2	0
Vespertilionidae (vespertilionid bats)	0	4	1
Muridae (rats and mice)	0	6	1
Canidae (dogs and foxes)	1	1	0
Felidae (cats)	0	0	0
Total	**3**	**22**	**4**

The mammal assemblage is expected to be typical of near-coastal environments in the region (RPS BBG 2006e). RPS BBG (2006e) concluded that the four conservation-significant fauna species that may occur along the Onshore Domestic Gas Pipeline are the:

- Mulgara (*Dasycercus cristicauda*): Listed as Vulnerable under the EPBC Act (Cth). None were trapped and its typical sandy habitat is absent from the route. If this species is present, it is likely to be sparsely distributed and very uncommon (RPS BBG 2006e)
- Northern Quoll (*Dasyurus hallucatus*): Listed as Endangered under the EPBC Act (Cth). This species typically inhabits rocky eucalypt woodland within 200 km of the coast. This species is unlikely to be present due to lack of suitable habitat (RPS BBG 2006e)
- Little Western Freetail-bat (*Mormopterus* sp.): Listed as a Priority 4 species by DPaW. This species may be present in the mangrove forests and adjacent areas
- Lakeland Downs Mouse or Kerakenga (*Leggandina lakedownensis*): Unlikely to be present due to lack of moist tussock grassland, tropical savannah, or stony hummock grassland. Although the preferred habitat listed by RPS BBG (2006e) is not present, this species is widespread and also occurs in seasonally-inundated samphire, sedgelands, and tussock grasslands on red or white sandy clay soils, as well as hummock grassland (Burbidge 2008a).

5.3.4 Reptiles and amphibians

The herpetofauna (reptiles and amphibians) expected to be present along the Onshore Domestic Gas Pipeline and their conservation status are listed in Appendix 6 and summarised in Table 5-5. The high number of herpetofauna species that may occur along the Onshore Domestic Gas Pipeline is typical of the high biodiversity of reptiles in the semi-arid regions of Western Australia (RPS BBG 2006e).

Table 5-5 Number of Herpetofauna Species along the Onshore Domestic Gas Pipeline Route

Herpetofauna	**Recorded** (along pipeline)	**May Occur** (along pipeline)	**Conservation-significant Species** (either recorded or may occur along pipeline)
Agamidae (lizards)	5	3	0
Pygopodidae (legless lizards)	0	5	0
Gekkonidae (geckos)	1	9	0
Scincidae (skinks)	3	11	0
Typhlopidae (blind snakes)	0	3	3
Varanidae (goannas)	5	2	0
Boidae (pythons)	0	3	0
Colubridae (colubrid snakes)	0	1	0
Elapidae (fanged snakes)	1	10	0
Hylidae (frogs)	0	5	0
Total	**15**	**52**	**3**

5.3.5 Birds

A high number of birds are expected to occur in the area due to the presence of several distinct vegetation and soil associations (e.g. mangroves, spinifex hummocks, Acacia woodlands and open *Eucalyptus* woodlands). At least 56 of the bird species (e.g. cormorants, herons, scolopacids, charadrids, gulls, and terns) are generally dependent on wetland, tidal, or oceanic

habitats and are only likely to occur in the mangroves or along the coast at the north-west end of the pipeline route. There are also several species of passerine (perching birds) that are mangrove-dependent (e.g. Dusky Gerygone [*Gerygone tenebrosa*], Mangrove Robin [*Eopsaltria pulverulenta*] and White-breasted Whistler [*Pachycephala lanioides*]).

The results of both helicopter surveys of the mangroves and mudflats in the vicinity of the proposed Onshore Domestic Gas Pipeline found 11 species of littoral avifauna: Darter (*Anhinga melanogaster*), Australian Pelican (*Pelecanus conspicillatus*), White-faced Heron (*Ardea (Egretta) novaehollandiae*), Eastern Reef Egret (*Ardea (Egretta) sacra)*, Osprey (*Pandion haliaetus*), Brahminy Kite (*Haliastur indus*), Bar-tailed Godwit (G*odwit Limosa lapponica*), Whimbrel (*Numenius phaeopus*), Eastern Curlew (*Numenius madagascariensis*), Common Greenshank (*Tringa nebularia*), and Mangrove Grey Fantail (*Rhipidura phasisana*).

The mangroves and surrounding areas at the north-west end of the proposed Onshore Domestic Gas Pipeline were inspected on foot (after helicopter set down). Waterbirds roosting through the mangroves and samphire included 12 species of littoral avifauna: Eastern Curlew (*Numenius madagascariensis*), Whimbrel (*Numenius phaeopus*), Bar-tailed Godwit (*Limosa lapponica*), Common Greenshank (*Tringa nebularia*), Ruddy Turnstone (*Arenaria interpres*), Common Sandpiper (*Tringa hypoleucos*), Terek Sandpiper (*Xenus cinerea [Tringa terek])*, Grey-tailed Tattler (*Tringa brevipes*), Greater Sand Plover (*Charadrius leschenaultia*), Red-capped Plover (*Charadrius ruficapillus*), Grey Plover (*Pluvialis squatarola*), and White-faced Heron (*Ardea (Egretta) novaehollandiae*).

RPS BBG (2006e) identified the two most likely species of conservation significance to occur along the terrestrial component of the Onshore Domestic Gas Pipeline as:

- Australian Bustard (*Ardeotis australis*), which is listed as a Priority 4 species by DPaW; it inhabits grasslands, spinifex, open scrublands and pastoral lands
- Rainbow Bee-Eater (*Merops ornatus*), which is listed as Migratory under the EPBC Act (Cth); it inhabits open woodlands, sand ridges, sand pits, riverbanks, beaches, dunes, cliffs, mangroves, and man-made grassed fields.

The abundance, habitat, and distribution of EPBC Act listed bird species identified along the Onshore Domestic Gas Pipeline are listed in Table 5-6.

Table 5-6 Habitat and Distribution of EPBC Act Listed Birds along the Onshore Domestic Gas Pipeline

	Species	Distribution in Australia[1,2,3,4]	Portion of Australia Included in Distribution[1]	Typical Habitat[2,3] (only those present along the route are listed)
Land-birds	Rainbow Bee-eater	All of Australia except Tasmania and arid interior of Western Australia. One of the 40 bird species most commonly recorded breeding in Australia.	76%	Shrublands, riverbanks, mangroves and grassland
	Nankeen Kestrel	Abundant and widespread. May have increased due to clearing and introduction of prey species. One of the 40 most commonly recorded bird species in Australia.	93%	Grasslands
	Pallid Cuckoo	Widespread throughout, except Nullarbor Plain.	78%	Shrublands, mangroves, pasture
	Richard's Pipit	Widespread. One of the 40 most commonly recorded bird species in Australia.	81%	Grasslands

	Species	Distribution in Australia[1,2,3,4]	Portion of Australia Included in Distribution[1]	Typical Habitat[2,3] (only those present along the route are listed)
Littoral Birds	Osprey	Generally common and secure in Australia, particularly in northern Australia. Distributed along almost all Australian coastline but rare in Victoria and absent from Tasmania	20%	Coastlines
	Brahminy Kite	Widespread, and common to abundant in northern Australia	13%	Mudflats, mangroves
	Australian Pelican	Only absent in arid interior	56%	Mudflats
	Eastern Reef Egret	Widespread along coast except Victoria and Tasmania	17%	Mudflats and mangroves
	Bar-tailed Godwit	Widespread along coast. Australian population estimate: 185 000 individuals	15%	Mudflats
	Whimbrel	Widespread along coast. Australian population estimate: 10 000 individuals	15%	Mudflats and mangroves
	Eastern Curlew	Widespread along coast, except Nullarbor Plain. Australian population estimate: 28 000 individuals.	16%	Salt flat / samphire and mangrove
	Common Greenshank	Widespread along coast and also in southern interior	30%	Mudflats

Notes: 1 Barrett et al. *2003; percentage based on number of 809 one degree grids across Australia*
2 Geering, Agnew and Harding 2007
3 Pizzey and Knight 1998
4 Debus 2001

5.3.6 Invertebrates

No invertebrates of conservation significance were identified as potentially occurring in the vicinity of the Onshore Domestic Gas Pipeline in the database searches (RPS BBG 2006e). Furthermore, no invertebrate data has been collected or collated for the Onshore Domestic Gas Pipeline as the pipeline is not expected to significantly impact upon invertebrates, although it is noted that the lower tidal flats of the Pilbara region support rich epibenthic and burrowing invertebrate fauna communities (Dames and Moore 1998).

While there is scope for short-range endemics to be restricted at small spatial scales, terrestrial habitats along the Onshore Domestic Gas Pipeline are extensive and are not subdivided; the habitats remain unfragmented and there are no mesas along the pipeline route that could signify isolated subterranean habitats. Based on the EPA Guidance Statement No. 20 (EPA 2009), the Onshore Domestic Gas Pipeline is unlikely to support habitat to reflect a divergence of populations of short-range endemics, and further short-range endemic surveys are unwarranted (RPS BBG 2006e).

5.3.7 Subterranean Fauna

No subterranean fauna data has been collected or collated for the Onshore Domestic Gas Pipeline as the pipeline is not expected to impact upon stygofauna or troglofauna.

The EPA's position (2007) is that the Pilbara is a global hot spot for subterranean biodiversity and it should be assumed that sites in the Pilbara will support significant stygofauna and troglofauna assemblages (unless there is strong evidence that subterranean habitats lack pore spaces, are completely anoxic, or contain hypersaline water).

The Onshore Domestic Gas Pipeline is expected to be trenched up to 1.8 m depth, and is not anticipated to reach the groundwater; therefore, stygofauna habitat will not be directly impacted by construction. Troglofauna have been recorded from as shallow as 4 m, down to 40 m below ground level in sampling by Biota Environmental Sciences (2006a) in Mesa A and the Robe Valley. Shallow excavation to 1.8 m depth will intersect little, if any, of the vertical portion of troglofauna habitat.

The protection of stygofauna or troglofauna is not a relevant environmental factor for assessing the environmental impact of the Onshore Domestic Gas Pipeline. In accordance with EPA Guidance Statement No. 54 (EPA 2003a), the construction of the pipeline is not predicted to have an impact on stygofauna or troglofauna habitat. The proposal is not predicted to:

- lower the watertable sufficiently to dry out the zone in which some species live, or otherwise artificially changing watertables
- change water quality (e.g. increasing salinity levels or altering haloclines)
- increase nutrient levels or the availability of organic matter, or introducing other pollutants

  or

- destroy or damage caves (including changing their temperature and humidity).

5.4 Habitat

Within Mardie Station, the terrestrial habitats are generally extensive and, whilst not fragmented, they are degraded (RPS BBG 2006e). The stocked and degraded grasslands of Mardie Station appear to be of low conservation significance for native fauna (RPS BBG 2006e).

Mangroves and coastal tidal flats are important habitat for conservation-significant migratory shorebirds. Both habitats are extensive and only very small areas of these habitats will be disturbed. Mangroves are extensive along the Pilbara coast and the area to be cleared represents less than 1% of the surrounding 5000 ha of mangroves in the region (Chevron Australia 2005). The loss of such a small proportion of the mangrove habitat will have little effect on local terrestrial fauna populations.

5.5 Ecological Communities

As stated in Section 3.1.4, the ecological element of ‘ecological communities’ is restricted to ecological communities listed in DPaW’s Threatened Ecological Database (DEC 2006). Other aspects of ecological communities will be captured through the characterisation of other ecological elements.

DEC (now DPaW) (2008a) conducted a search of its TEC database in an area defined by a rectangle (with a top-left and bottom-right corner of 114.086318, -19.471616 and 116.424744, -21.743771 respectively in decimal degrees GDA94).

The closest TECs or PECs to the Onshore Domestic Gas Pipeline are two Priority 1 PECs, approximately 20 km to the south. These PECs are:

- Robe Valley mesas (subterranean invertebrate community of pisolitic mesas in the Robe Valley)
- Robe Valley pisolitic hills (subterranean invertebrate community of pisolitic hills in the Robe Valley).

These PECs will not occur along the Onshore Domestic Gas Pipeline, which is not located in the Robe Valley and does not intersect any pisolitic hills or mesas.

There is the potential that the Priority 1 PEC, Roebourne Plains coastal grasslands, occurs along the proposed Onshore Domestic Gas Pipeline. Mapping of vegetation associations along the proposed Onshore Domestic Gas Pipeline will identify whether this PEC occurs there.

DPaW (2008d) has characterised this PEC as:

> *coastal grasslands with gilgai microrelief of deep cracking clays are self-mulching cracking clays that emerge on depositional surfaces. The Roebourne Plains gilgai grasslands occur on microrelief of deep cracking clays, surrounded by clay plains/flats and sandy coastal and alluvial plains. The gilgai depressions supports ephemeral and perennial tussock grasslands dominated by* Sorghum *[species] and* Eragrostis xerophila *(Roebourne Plains Grass) along with other native species including* Astrebla pectinata *(Barley Mitchell Grass),* Eriachne benthamii *(Swamp Wanderrie Grass),* Chrysopogon fallax *(Golden Beard Grass) and* Panicum decompositum *(Native Millet). It differs from the surrounding clay flats of the Horseflat land system which are dominated by* Eragrostis xerophila *and other perennial tussock grass species (*Eragrostis *[species] mostly).*

The threats to this PEC have been identified by DPaW (2008d) as grazing and clearing for mining and infrastructure.

5.6 Groundwater

Groundwater in the vicinity of the Onshore Domestic Gas Pipeline is contained within a shallow alluvium and colluvium aquifer (Dames and Moore 1998). The proposed pipeline route is expected to be trenched up to 1.8 m depth and is not anticipated to reach the groundwater as the freshwater aquifer lens is situated at a depth of between 9 m and 53 m; therefore, groundwater data has not been collected or collated for the Onshore Domestic Gas Pipeline.

5.7 Surface Water Landforms

There is no freshwater habitat along the Onshore Domestic Gas Pipeline (RPS BBG 2006e). Outside the coastal mangrove and samphire vegetation units, the Onshore Domestic Gas Pipeline does not cross any lakes or water bodies; however, it does cross ten drainage lines mapped by Geoscience Australia (1992) at a scale of 1:50 000. All these drainage lines are small and ephemeral (Dames and Moore 1998).

The four drainage lines crossed at the south-east end of the pipeline route near Compressor Station 1, feed into Peters Creek, which discharges into the Indian Ocean. The other drainage lines have indistinct outflows in floodplains.

5.8 Physical Landforms

The Onshore Domestic Gas Pipeline rises gently and consistently from sea level to approximately 42 m above sea level over 30 km (Geoscience Australia 1992). The Onshore Domestic Gas Pipeline is located in geomorphic/geological units that can be characterised as a coastal plain of red gravel and sand sediments and extensive tidal flats of mud and muddy sand deposits, with a sand ridge between the plain and the flats (Semenuik 1993). No unusual, discontinuous, restricted, or otherwise significant landforms such as cliffs, gorges or caves are apparent along the Onshore Domestic Gas Pipeline.

5.9 Information Gaps

There is sufficient information presented in this Report on which to assess the impacts associated with the Gorgon Gas Development Onshore Domestic Gas Pipeline, and so no information gaps have been identified. The Onshore Domestic Gas Pipeline is adequately characterised to determine the associated pathways of stressors that may impact on the environment, and their associated time frames and locations.

There is sufficient information to indicate that the alignment of the Onshore Domestic Gas Pipeline will not have potential impact on regional conservation values, and that it is highly unlikely that realignment of the pipeline will significantly reduce any impacts.

6.0 Terrestrial Disturbance Footprint

6.1 Introduction

This section describes and discusses the Terrestrial Disturbance Footprint (TDF) that will apply during the construction period, including the period of simultaneous construction and operations activities (SIMOPs), of the Gorgon Gas Development, and the ecological elements deemed to be significant and at risk on Barrow Island. This information is provided to satisfy the conditional requirements of Statement No. 800 (Conditions 6.5iii, 6.5iv, 6.5viii, 6.5ix, 6.5x, 6.6), and EPBC Reference: 2003/1294 and 2008/4178 (Conditions 5.4iii, 5.4iv, 5.4v, 5.4vi, 5.4viii, 5.4ix).

6.1.1 Definition of Terrestrial Disturbance Footprint

The TDF includes the Gorgon Gas Development Footprint and a zone beyond this that contains the area disturbed by the construction or operations activities associated with the terrestrial facilities. Table 6-6 shows the TDF dimensions for the Gorgon Gas Development and Jansz Feed Gas Pipeline.

The TDF does not relate to the impacts arising from unplanned emergency responses such as:

- fires
- oil spills
- explosions
- pipeline ruptures
- preventing danger to human life, health, or irreversible damage to a significant portion of the environment
- seepage of injected carbon dioxide to surface or near-surface environments
- preventing or reducing imminent damage to Gorgon Gas Development and Jansz Feed Gas Pipeline infrastructure in response to the impact of a destructive natural event such as a storm, lightning strike, fire, or flood

  or

- where reasonably necessary to immediately respond to an accident such as a leak, fire or medical emergency or to repair any associated damage.

Chevron Australia will aim to reduce Material and Serious Environmental Harm from the construction and operation of the terrestrial facilities as far as practicable inside the TDF (excluding the Gorgon Gas Development Footprint), noting that Chevron Australia shall reduce adverse impacts from the construction and operation of the terrestrial facilities as far as practicable inside the TDF (in accordance with Condition 7.4i of Statement No. 800) and shall

not cause or allow Material or Serious Environmental Harm outside the TDF (in accordance with Condition 6.6 of Statement No. 800).

6.1.2 Methodology for Defining TDF

The process by which the TDF is determined is summarised in Figure 6-1. In determining the TDF, the following were considered:

- the Gorgon Gas Development Footprint as shown in Map 1; the TDF is measured out from this boundary
- stressors and significant ecological elements – these provide broad direction for the assessment and are summarised in Section 6.2
- the qualitative ecological risk assessment – this identifies specific ecological elements (as listed in Condition 6.1) and provides a specific focus, if required, when assessing broad impacts to elements
- the methodology/modelling to indicate the likely extent of boundary effects that define the TDF – this is based upon modelling of noise contours, literature reviews and field observations, and includes reference to the precedents discussed in Section 6.1.2.1
- mitigation/management measures – these have been implicitly considered to limit the extent of, and impacts within, the TDF
- location – the TDF relates to habitat area where ecological elements occur. Therefore, the TDF does not relate to ecological elements that occur in habitat beyond the influence of the Gorgon Gas Development (e.g. on offshore islands).

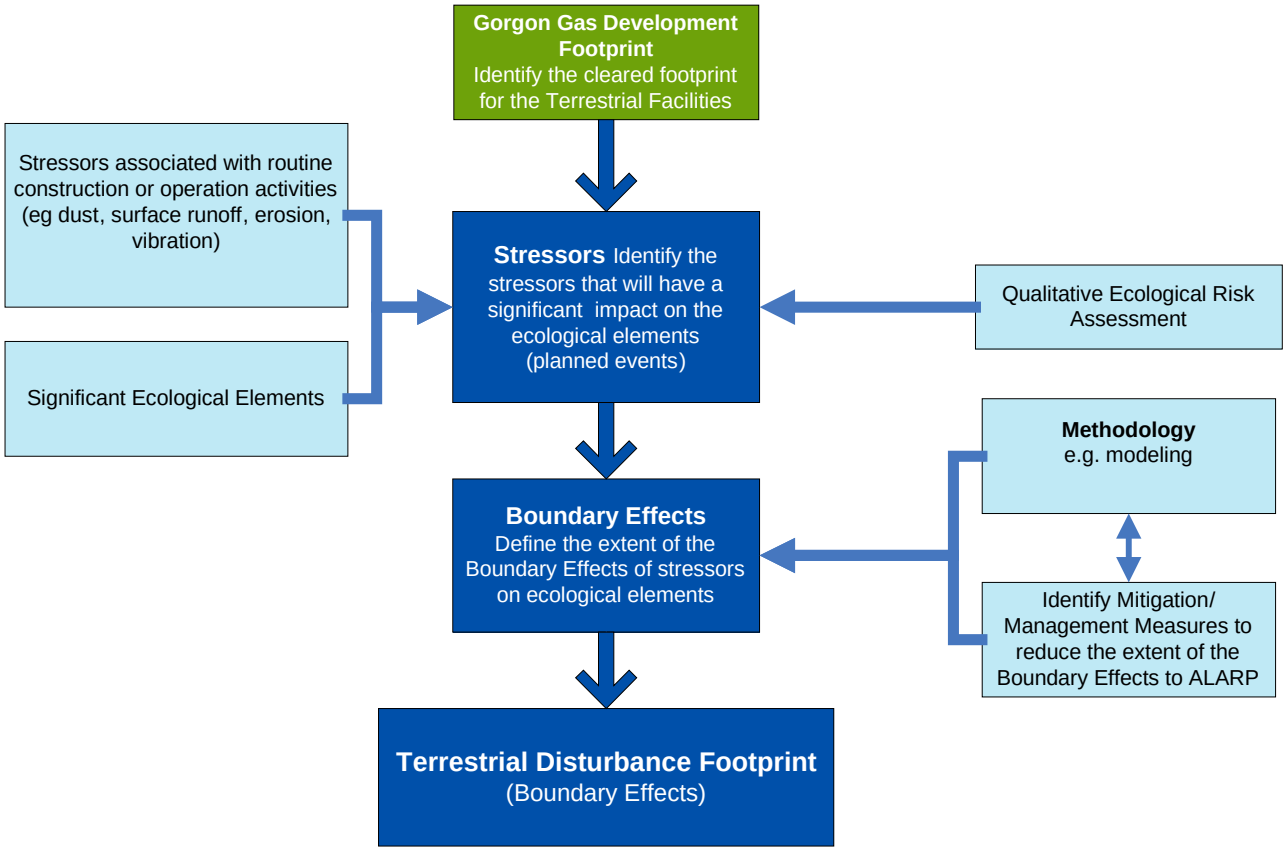


Figure 6-1 Process for Delineating the Terrestrial Disturbance Footprint

Uniformity in the distance between the Gorgon Gas Development Footprint and the extent of the TDF is desirable as it reduces confusion over the TDF boundary in the field. Therefore, the TDF has been based on the largest distance for combinations of stressors and their effects on ecological elements for planned activities. The TDF is three-dimensional and distances are specified in the three dimensions.

The boundary effects of seismic activities are sufficiently different to other activities to be considered separately. Subterranean seismic activities involve the interaction between explosions below the watertable and stygofauna; surface seismic activities (vibroseis and clearing of pads for shot holes) involve low intensity and infrequent disturbance with a very high perimeter-to-area ratio.

The total extent of the TDF was then considered to ensure that:

- the TDF **does not** contain a sufficiently large portion of any significant ecological element (such that any harm contained within the TDF **could not** threaten the survival/viability/functioning of an element)
- boundary effects from stressors can be contained within the TDF (design/engineering requirements are practicable/feasible).

6.1.2.1 Precedents

An indication of the distance over which the physical stressors could result in boundary effects is provided by the distance used for exclusion zones to protect sensitive receptors on Barrow Island as documented in Clearing Permit CPS 123/2 issued to Chevron Australia for Barrow Island by the DEC (now DER).

These distances were developed for, and are therefore appropriate for, the following infrastructure maintenance, pipelines, minor works, and emergency stressors:

- maintaining and operating wells, roadside bollards, main camp infrastructure, sewage lines, airport beacons, perimeter fencing
- maintaining and grading existing graded roads
- operating and carrying out works within hardstand areas
- driving on access roads
- repairing and maintaining power poles
- active rehabilitation
- assessing, monitoring and removing dead vegetation at leak sites to allow for rehabilitation
- maintaining conduits passing under roads
- installing roadside bollards
- taking material at borrow pits
- reducing fire risk
- installing and modifying existing infrastructure
- accessing any infrastructure
- constructing bores
- monitoring biodiversity
- clearing at the base of overhead powerlines
- installing, constructing, replacing, and maintaining airport perimeter beacons, water-source wells, and other similar minor works.

Caution should be exercised in applying generic distances for boundary effects that may not be appropriate for the Pilbara region in general and Barrow Island in particular. However, the exclusion zones created around rare flora and wetlands, established through their inclusion in the definition of Environmentally Sensitive Areas in Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA) provide a general indication of the distance beyond which clearing should not have a significant indirect impact on these receptors. The DEC (now DER) has also previously assumed the boundary effects of dust on vegetation extend 50 m beyond clearing envelopes when assessing the impacts of mining operations in the mid-west of Western Australia.

The distance within which the specific receptors could be impacted by maintenance, minor works, and emergency response activities are indicated in Table 6-1.

Table 6-1 Buffers Previously Used to Protect Significant Ecological Elements

Receptor	Stressor	Exclusion Zone	Applicable Area	Source
Boodie warren (point)*	Maintenance and minor works	150 m	Barrow Island	Clearing Permit CPS 123/2
Boodie warren (polygon)	Maintenance and minor works	100 m	Barrow Island	Clearing Permit CPS 123/2
Boodie warren	Maintenance and minor works	100 m	Barrow Island	Draft EIS/ERMP page 360 (Chevron Australia 2005)
Caves, sinkholes, fissures	Maintenance and minor works	100 m	Barrow Island	Clearing Permit CPS 123/2
Sea-eagle nest	Maintenance and minor works	70 m	Barrow Island	Clearing Permit CPS 123/2
Osprey nest	Maintenance and minor works	70 m	Barrow Island	Clearing Permit CPS 123/2
Brahminy Kite nest	Maintenance and minor works	50 m	Barrow Island	Clearing Permit CPS 123/2
Declared Rare Flora	Vegetation clearing	50 m	Western Australia	Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)
Wetlands	Vegetation clearing	50 m	Western Australia	Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)

*Note * Additional 50 m over polygon provides buffer to allow for extent of warrens which Short* et al. *(1989) noted ranged from 8 m × 5 m to 120 m × 20 m*

6.2 Stressors and Receptors Used to Define the TDF

6.2.1 Barrow Island

While the direct stressors are predicted to impact on the Gorgon Gas Development Footprint, it is the indirect stressors for which boundary effects were considered to manifest beyond the Footprint and thus in determining the TDF; these are summarised in Table 6-3. Three categories of activities were considered on Barrow Island because of the distinctly different type, intensity, and frequency of associated impacts.

The eight ecological elements considered in developing the TDF were those listed in Condition 6.1 of Statement No. 800 and Statement No. 769. The ecological elements that are receptors for combinations of stressors and activities are shown in Table 6-3.

Table 6-2 Planned Activities Considered in TDF Determination on Barrow Island

Construction and Operation	Surface Seismic Activities	Subsurface Seismic Activities
• abrasive blasting • burning of vegetation • clearing and earthworks • concrete batching • waste generation, storage, transport and disposal • drilling and blasting • hot work, welding, grinding • land use change • operation of machinery, plant and equipment • pipeline installation, operation, inspection, maintenance and site reinstatement • pipeline pressure testing, flooding and gauging • vehicle movements • winning and crushing of material • chemical and fuel transportation, storage, use and disposal • operation of Gas Treatment Plant.	• vibroseis (using 3 m-wide cleared lines for vehicles) • subsurface explosives (with 6 m × 6 m drill pads and heliportable air/sonic drill rigs that do not require drilling mud used to prepare the shot holes)	• 4 kg charges exploded at approximately 15 m below sea level (below the watertable)

Table 6-3 Indirect Stressors, and Receptors, Contributing to TDF Determination

Activities / Stressors	Construction and Operation	Surface Seismic Activities	Subsurface Seismic Activities
Dust	Vegetation		
Erosion	Vegetation	Vegetation	
Sedimentation	Vegetation		Groundwater
Noise and Vibration	Fauna	Fauna	
Shockwaves			Fauna
Change to Subsurface Water Regime	Groundwater		
Heat and Fire	Fauna Vegetation		
Light	Fauna		
Shade	Fauna		
Spills	Vegetation Groundwater Fauna		Groundwater

Chemical and biological stressors are not expected to arise as indirect effects of routine activities. Neither the discharge of chemicals into the terrestrial environment nor any introduction or spread of biological elements will typically result from routine activities.

There should be no significant indirect flooding or drought as a result of the Gorgon Gas Development and Jansz Feed Gas Pipeline, given the limited amount of flowing water on the Island and provided that the extent of the TDF is developed with consideration of:

- the indicative distance of 100 m used to protect caves/fissures/sinkholes from pollution in Clearing Permit CPS 123/2
- the 50 m buffer applied to limit indirect impacts of clearing on wetlands in the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA).

Procedures in place to limit the flyrock for human safety purposes are planned to limit any impacts on fauna and habitat (termite mounds) to within the boundaries of the TDF determined by other factors.

6.2.1.1 Construction and Operations Stressors

Dust

Dust can directly impact plants by covering photosynthetic structures, blocking stomata, interfering with plant gas exchange mechanisms, and indirectly via nutrient inputs and induced toxicity (Gleason *et al.* 2007).

Gleason *et al.* (2007) assessed the effects of windblown soil on rare and common vegetation in a low rainfall, high altitude part of Hawaii in field trials that measured windblown soil mass, response to sandblasting, and plant germination and growth rates. They concluded the direct effects of windblown soil on plants were negligible in terms of germination and growth rates. Gleason *et al.* (2007) concluded that abrasion of plants from soil saltation had an effect below a height of 20 cm up to 40 m from 4 m-wide roads and 1 ha clearings during severe wind conditions (7 m/s).

The site studied by Gleason *et al.* (2007) is similar to Barrow Island in that rainfall is relatively low and highly seasonal (with most of the 430 mm of annual rainfall falling over a four-month period); and the soils are poorly aggregated sandy loams. Barrow Island receives most of its average rainfall of 320 mm during the cyclone season, which lasts for six months.

The site studied by Gleason *et al.* (2007) is dissimilar in having an average annual temperature of 13 °C with little variation, compared to Barrow Island, which is significantly warmer.

Dust has been noted on Barrow Island in significant levels up to 20 m either side of the existing road to the Construction Village, but an effect on the vegetation is not evident beyond several metres from the road.

On the evidence above, the boundary effects of dust should be containable within a proposed TDF extent of 100 m.

Erosion

McTainsh and Boughton (1993) list the direct impacts of erosion as including the loss of soil, organic matter and nutrients. The magnitude of any erosion will be influenced by the soil types subject to clearing, as well as slopes and rainfall.

Erosion of coarse soils in drainage lines is expected to occur when the detachment threshold of 0.15 m/s is exceeded, and extensive erosion expected when a threshold of 0.5 m/s is exceeded (Blandford 1996).

Soils previously identified by Mattiske (1993) as having been subject to wind erosion in disturbed areas are those associated with coastal dunes (associations C1, C2, C3, C4, C6, and C7). Clearing procedures at the HDD site is expected to be contained within 100 m of the Gorgon Gas Development and Jansz Feed Gas Pipeline Footprint. Mattiske (1993) also noted

that claypans (associations S1 and S2) are vulnerable to vehicle traffic, but no new roads are planned through claypans.

There are few drainage lines at elevated risk from water erosion. Most areas mapped as 'major drainage lines' in vegetation maps are areas of water accumulation rather than areas of significant flowing water, and surface water on Barrow Island flows after significant (typically cyclonic) rainfall events.

The areas of potential creeklines are shown on Map 9. A number of these areas have been impacted by erosion as a result of roads being constructed through or along drainage lines up to 40 years ago, prior to the development of the industry standards that would be currently applied. Whilst sedimentation extends more than 100 m from the road in the worst cases, erosion outside previously cleared areas is negligible, and, given current industry standards, erosion should be containable within a TDF of 100 m.

Sedimentation

Sediment can be produced as a result of clearing and any retardation of normal stream flow, which results in an increased water detention time.

Sediment deposition can change the capacity of drainage lines by scouring creek banks or increasing the base level of the drainage line (Blandford 1996). In addition, seed can be buried, which Ren *et al.* (2002) found can influence the number of days to first emergence and germination and seedling emergence rates for many plant species.

Blandford (1996) estimated post-development sediment yields in the Airport, Terminal, and Dove Point Creeks as being in the order of two, six, and 0.3 t/ha/year respectively. Blandford (1996) suggested that previous clearing in the Airport Creek catchment may have increased sediment delivery by at least an order of magnitude. Many cyclones since 1968 would have been sufficiently intense to move sediment into drainage lines and lowlands. However, the number of extreme rainfall run-off events associated with cyclones capable of moving sediment into the marine environment (crudely defined as 24-hour rainfall exceeding 150 mm or an average intensity of 6.25 mm/h for 24 hours) are relatively infrequent and in the order of one every six years (Blandford 1996).

There are few drainage lines at elevated risk from increased sedimentation as most of the areas mapped as 'major drainage lines' in vegetation maps are areas of water accumulation rather than areas of significant flowing water. The potential creeklines are shown on Map 9. A number of these areas have been impacted in the form of sedimentation by roads constructed through or along drainage lines up to 40 years ago, prior to the development of the industry standards that would be currently applied. Whilst increased sedimentation extends more than 100 m from roads in the worst cases, given changes in industry marine environment practices, these effects should be containable within a TDF of 100 m.

Sediment transported into near-shore areas should be limited given the surface water management strategies, the small number of creeklines within the Gorgon Gas Development Footprint, the distance of these creekline disturbances from the coast, and that surface water on Barrow Island flows after significant (typically cyclonic) rainfall events. The dispersion zone of the fine silt and clay fraction of eroded sediment in the near-shore environment of previous works associated with the airport were expected to be within an area measuring 400 m by 400 m at a rate of 3 kg/m^2, with this being larger under near-shore conditions of high turbulence (Blandford 1996). However, whilst suspended solids may be high when streams are discharging into the marine environment, this is when wave-generated turbidity from cyclonic events will also be high (Blandford 1996).

The issue of coastal erosion and sedimentation is more likely to arise from the construction of the MOF; any such impacts are addressed in the Coastal Stability Management and Monitoring Plan (Chevron Australia 2009c), which is required under Condition 25 of Statement No. 800.

The effects of any sedimentation in near-shore areas arising from the Gorgon Gas Development should not be discernible from that resulting from oceanic processes, and a TDF should not need to extend into the marine environment.

Noise

The EPA (2007a) has stated that there are limited studies available regarding the impacts of noise on terrestrial and marine animals, and many of these studies show that animal populations appear to habituate or to avoid man-made noise. The EPA (2007a) qualified this by also stating that there may be less-obvious impacts that research has not revealed to date. Less-obvious impacts could include behavioural changes such as heightened alertness, physiological stress, abandonment of young, reduction in time feeding, and retreat from favourable habitat (Larkin *et al.* 1996).

Although noise generated from construction and general operations activities may result in the disturbance of some fauna, it unlikely to have a significant adverse effect on the identified significant ecological element (fauna) to locate prey, hunt prey, or avoid predators in the vicinity of the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island.

None of the fauna that are significant ecological elements on Barrow Island are thought to have a critical reliance on hearing to either avoid predators, or locate or hunt prey because:

- there are few carnivores on Barrow Island
- all mammals (except the Barrow Island Euro and Black-flanked Rock-wallaby) are primarily nocturnal
- the top-level predators (the varanids and raptors) are primarily diurnal
- raptors rely predominantly on sight to locate prey. Noise is unlikely to directly affect their hunting ability (Kamien pers. comm. 2008), and reduced prey (due to animals vacating an area due to noise) is unlikely to be an issue given that these raptors typically prey upon marine species
- the ability of varanids to locate and hunt prey is unlikely to be compromised by noise. Kamien (pers. comm. 2008) indicates that reptiles typically hunt using chemoreception and vision, and King and Green (1999) state that varanids primarily use smell for detecting food
- the Leopard Skink, which is also a significant reptile on Barrow Island, preys upon invertebrates (Smith 1976). Its prey is unlikely to be adversely affected by noise as invertebrates generally use sight, tactile sensory organs or chemoreception to hunt prey or avoid predators (Kamien pers. comm. 2008).

Euros, Boodies, Golden Bandicoots, Spectacled Hare-wallabies, Brushtail Possums and other small mammals persist close to the existing Barrow Island airport. Chevron Australia (2005) documented that planes and helicopters land and take off from this airstrip at least four days per week, with noise levels of approximately 80 dB(A) at 100 m. Additional significant animals that persist close to existing operations include the White-bellied Sea-eagle, Osprey, and Perentie. A raptor nest has persisted for a considerable time (several years) approximately 70 m from the Barge (WAPET) Landing.

Noise can potentially interfere with communications used to maintain the social structure within populations of animals that are significant on Barrow Island. For example:

- Olfactory and visual cues are more important forms of communication for mammals such as Euros, which have limited vocalisations (Croft 1981).
- Reptiles are not highly vocal and not often communal.
- Most invertebrates are not heavily reliant on hearing, apart from some groups that call to attract mates (e.g. crickets, grasshoppers, cicadas) (Kamien pers. comm. 2008).

- Seabirds (the Wedge-tailed Shearwater and Bridled Tern) have their breeding colonies on Double Island. Therefore, noise from the construction at the Gas Treatment Plant site 4 km away should not be significant. Aircraft noise should also not impact breeding seabirds. It was concluded that seabirds habituated to helicopters flying within 200 m of colonies at the Lowendal Islands, where changes in the flight paths of birds, or mass panic flights of the nesting colony were rarely observed (Nicholson 2002).
- Shorebirds (including the Lesser Crested Tern) concentrate along the southern shores of Barrow Island, well away from Gorgon Gas Development Footprint.
- Raptors (Osprey, Brahminy Kite, and White-bellied Sea-eagle) have limited vocalisations and are relatively solitary (Debus 2001).

Passerine birds (or songbirds) appear to be the most sensitive type of animal. Noise can potentially interfere with communications of passerine birds, such as the White-winged Fairy-wren (Barrow Island), which rely on calling to establish and maintain territories and to attract mates. White-winged Fairy-wren (Barrow Island) communications incorporate at least five distinct calls to maintain social structure (establish territory and maintain group cohesion, raise alarm, establish contact, indicate hunger or subordination) (Tidemann 1980).

Dooling and Popper (2007) suggest that in the absence of empirical data for birds, levels of (highway) noise known to annoy humans provide a useful interim guideline for the potential to cause physiological stress and behavioural disturbance in birds. They found:

- Birds are more resistant to both temporary and permanent hearing loss or to hearing damage than humans and other mammals, as birds are able to regenerate the sensory cells of the inner ear.
- Generally humans have better auditory sensitivity (lower auditory thresholds) than does the ‘typical’ bird.
- Birds, like humans and other animals, employ a range of short-term behavioural strategies, or adaptations, for communicating in noise. This results in a doubling to quadrupling of the efficiency of hearing in the presence of noise.

Dooling and Popper (2007) suggest that masking of bird communication could impact behavioural or physiological effects in the area included in the 50 to 60 dB(A) continuous noise contour (impulse noise does not mask communication). It is therefore reasonable to incorporate a 50 dB(A) contour into the area potentially impacted by noise impacts. The Draft EIS/ERMP indicates that the 50 dB(A) contour for normal plant operations with a wind speed of 3 m/s, a temperature of 15 °C, and no thermal inversion is approximately 850 m from the edge of the Gorgon Gas Development Footprint (Chevron Australia 2005). Noise effects are therefore expected to be contained within 1 km from the Gorgon Gas Development and Jansz Feed Gas Pipeline Footprint.

The application of the ambient noise level of a quiet suburban area as used by Dooling and Popper (2007) is appropriate for Barrow Island. The ambient noise on Barrow Island is 24 to 50 db(A) (Chevron Australia 2005).

Vibration

Whilst a Boodie warren persists within 10 m of the Barge (WAPET) Landing, the distance at which the effects of blasting associated with earthworks are experienced could be expected to be significantly larger.

All Boodie warrens on Barrow Island are supported by limestone cap rock, with one exception being a Boodie warren dug into sand. This cap rock likely provides structural stability, and, given that Short *et al.* (1989) recorded a mean cap rock depth at entrances of 50 cm, the warrens should be able to withstand vibrations 100 m from a blasting location.

The Draft EIS/ERMP (Chevron Australia 2005) identifies that the collapse of karst formations may arise as a result of blasting and vibration during construction. Subsequent geotechnical

investigation of the Gas Treatment Plant site has shown that it is reasonable to assume that there will be no significant disturbance of the subterranean fauna's habitat, as a result of construction or plant operations.

No significant unstable areas are anticipated beneath the Gas Treatment Plant site. This is based on observations and data collected during the drilling of 68 boreholes across the site, and the use of electrical resistivity imaging and microgravity surveying (geophysics).

Whilst nearly all the underground rock openings encountered during drilling investigations contained at least some soil infill, most were either totally filled or empty. Any such infill must be generally of a flocculating nature rather than being dispersive, since any such latter materials would have already dispersed and the groundwater would be naturally cloudy (which is not the case).

The energy levels induced in the subsoil by construction activities will be generally very low (except perhaps in the immediate vicinity of blasting). It is therefore concluded that there is very little scope for sedimentation of the groundwater, except in very localised areas, where some very short-term sedimentation might occur.

Based on the results of the subsurface conditions encountered by the geotechnical studies carried out across the Gas Treatment Plant site area, structures will have shallow foundations consisting of spread footings and strip footings. Any net uplift loads applied to the foundations will be carried by ground anchors, if necessary. Therefore, there are no planned requirements to install any piles or other deep foundations beneath the site.

A 100 m extent of the TDF incorporates, and is consistent with, the indicative distance of 100 m used to protect Boodie warrens from vibration in Clearing Permit CPS 123/2 and the Draft EIS/ERMP (Chevron Australia 2005).

Fire and Heat

Radiated and/or exhaust heat from the Gorgon Gas Development and Jansz Feed Gas Pipeline will be associated with:

- power generation gas turbine generators
- refrigeration compressors, gas turbines, and air coolers
- ground flare burners
- boil-off gas flares
- burning of vegetation during site clearance.

Modelling has been cited by URS (2002) related to heat plumes associated with the combustion of LNG in compressors and heat generated by air fin coolers at the proposed Wickham Point LNG Plant. This modelling indicates that the associated heat would be diluted by a factor of 1000 within tens of metres from the plant, and by more than 10 000 times within a few hundred metres from the plant.

Temperature is not expected to be significantly elevated above ambient temperatures beyond the Gorgon Gas Development Footprint. Significant heat plumes from boil-off gas flares could reach up to 50 m above the flare outlet during worst-case scenarios. Therefore, a TDF which aligns with the boundary to the Gorgon Gas Development Footprint (designated clearing area) is appropriate for fire, with the vertical extent of the TDF being measured from the top of infrastructure.

Burning of vegetation associated with site clearance will follow procedures established in the Fire Management Plan (Condition 12 of Statement No. 800). This includes fire risk reduction measures to be implemented in order to manage proposal-related prescribed fire and minimise the risk of escape from the designated clearing area. The detailed TDF for fire is defined in the Fire Management Plan..

Light

Artificial light may potentially provide an attractant or repellent to fauna, interrupt natural behaviours, expose individuals to higher predation levels, and disrupt navigational abilities.

Terrestrial fauna should not be exposed to significantly higher predation levels due to changes in light levels. Whilst most Barrow Island mammals (except the Barrow Island Euro and the Black-flanked Rock-wallaby) and a significant portion of reptiles are nocturnal, the top-level predators (the varanids and raptors) are not.

A light modelling study for the routine operation of the Gas Treatment Plant indicates a 0.1 lux light contour (which corresponds to full moonlight levels) extending approximately 120 m.

The possible impacts of an attraction of birds to artificial lighting can include birds circling lights until exhaustion, or disorientated birds colliding with other birds or structures (Imber 1975). The effects of light have been shown to manifest at much larger distances for nocturnal birds than 100 m:

- De Molenaar *et al.* (2000) found the density of Black-tailed Godwit nests in wet grasslands was statistically lower up to 300 m away from lighting sources.
- Gauthreaux and Belser (2006) demonstrated that the flight behaviour of migrating nocturnal birds could be influenced by a strong searchlight up to 1 km away, although the effects tended to decline with the distance from light sources.
- Fledging Wedge-tailed Shearwaters have been documented as being attracted to the night lighting of the Gas Treatment Plant on nearby Varanus Island (Nicholson 2002).

The management of the potential impact of light on turtles is addressed in the Long-term Marine Turtle Management Plan (Chevron Australia 2013b), in accordance with Condition 16 of Statement No. 800.

The scale of a 100 m TDF would be appropriate for terrestrial animals and is appropriate for some insects, as lamps have been demonstrated to elicit flight-to-light behaviour for moths from 3 m to 130 m (Frank 2006).

While the concept of a TDF does not relate to offshore islands, the extent of the effect of light is considered to potentially manifest on Double Island, 4 km from the Gas Treatment Plant on Barrow Island, where there are breeding colonies of Wedge-tailed Shearwaters and Bridled Terns. These species will be monitored as part of an impact assessment in the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a), but they will not be monitored in relation to a TDF.

Shade

Shade is critical to animals in providing a refuge from the Barrow Island heat.

Reptiles regulate their temperature by moving between areas of different ambient temperatures. Perenties have been observed to shelter from direct sunlight during the middle of the day (King *et al.* 1989).

Macropods can regulate body temperature via increased respiratory rates as this increases evaporative cooling. Due to subsequent water loss, this would often be a last resort if shade was not available to reduce body temperatures (Main and Bakker 1981). The importance of cliffs and gorges for shade (and protection from wind) is reflected in the almost total confinement of Black-flanked Rock-wallabies (*Petrogale lateralis lateralis*) to the western side of the Island where there are limestone cliffs (WAPET 1989).

Northern Brushtail Possums (*Trichosurus arnhemensis*) and Barrow Island Euros (*Macropus robustus isabellinus*) are widespread over the Island, but they tend to be more numerous in the vicinity of cliffs (WAPET 1989), and Northern Brushtail Possums were caught in higher numbers close to a cliff (Chevron Australia 2005).

The longest midday shadows produced by structures (on the winter solstice) at the latitude of Barrow Island are approximately the same as the height of the structure. The design of the Gas Treatment Plant has yet to be finalised, but with the possible exception of emission stacks, buildings and structures are expected to be less than 100 m high. The midday shade produced by structures less than 100 m high is expected to extend less than 100 m from their base.

Therefore, the area potentially impacted by shade is expected to be contained within a 100 m TDF.

Turbidity

Turbidity is a measure of water clarity or cloudiness as a result of suspended particulates held in solution. The potential impacts associated with increased turbidity can include reduced visibility for fauna, reduced light for photosynthesis, reduced temperatures, clogging of fish gills, and blocking invertebrate feeding membranes (Dunlop *et al.* 2005).

Fine particulates can remain in suspension when there is enough water turbulence to keep them in suspension; otherwise, they tend to settle out on the streambed with the rate of resuspension proportional to particle size and the volume and velocity of water. Finer particulates will enter into suspension and remain in suspension at lower velocities. Therefore, sections of drainage lines passing through coastal foredunes are expected to have a greater sand fraction in the surface soil, thus a lower relative contribution to turbidity.

In flowing water bodies, turbidity typically increases with increases in stream flows. Turbidity levels in Pilbara rivers are generally relatively low during average flows, and extremely high during flood events (Ruprecht and Ivanescu 2000). The flow-weighted turbidity of the major gauged rivers of the Pilbara ranges from nine Nephelometric Turbidity Units (NTU) at Deep Reach Pool on the Fortescue River to 1075 NTU at Nanutarra on the Ashburton River (Ruprecht and Ivanescu 2000).

Turbidity is not factored into defining a TDF because:

- there are no significant terrestrial receptors affected by turbidity on Barrow Island given that there is no submerged aquatic vegetation in creeklines, and the only identified aquatic animal is the frog, *Cyclorana maini*, which breeds in seasonal watercourses but would not be exposed to first flush events in creeklines
- particulates would not remain in suspension for any significant time given that there are no permanent streams or rivers on Barrow Island, and creeks do not tend to flow for more than one week after rainfall.

Change in Subsurface Hydrology

There are no forecasted indirect impacts on the groundwater of Barrow Island due to the Gorgon Gas Development and Jansz Feed Gas Pipeline as no abstraction from or injection into the groundwater is planned. Recharge points may be displaced by small distances as a result of surface water management across cleared and compacted areas. As the aquifer across the entirety of the Island is connected, then substantially the same recharge will occur. Therefore, no significant changes in watertable levels or groundwater dynamics are expected.

Gaseous Emissions

Air emissions modelling of existing and planned emissions sources (NO_x, SO_2, H_2S and particulates), dispersal contours, and ground concentrations were presented in Chapters 7 and 10 and Technical Appendix B1 of the Draft EIS/ERMP for the Gorgon Gas Development (Chevron Australia 2005).

Acid gas venting containing CO_2 and traces of H_2S, BTEX, and other hydrocarbons could potentially result in fauna mortality if fauna get trapped in the gas cloud, but stacks will be designed to facilitate fast dispersion of the pollutant stream and CO_2 venting should not occur for more than 20% of the operational plant time. The modelling predicts negligible impacts to

local and regional receiving environments, with impacts to flora and fauna being unlikely. Therefore, air emissions were not considered in developing a TDF.

6.2.1.2 Seismic Surface Activity Stressors

Erosion, Sedimentation and Changes in Surface Water Regimes

Erosion, sedimentation, and changes in surface water regimes should not be significant given that the source lines will be established by either raised blade grading or slashing. Minor localised erosion or sedimentation from surface seismic activities should be contained within a TDF of 5 m.

Noise and Vibration

The vibrations associated with a vibroseis operation are barely perceptible to people within metres of the vibroseis truck; the most disruptive aspect is the noise from the truck. An examination in May 2008 of the proximity of intact termite mounds to vibroseis lines (established in 2006 as part of a pilot study) indicates that termite mounds survive within several metres of multiple vibroseis operations.

No impact on termite mounds from vibration is evident, based on the considerable traffic that currently exists along the road between the existing Barrow Island airport and the Gorgon Gas Development Construction Village site, where intact mounds persist within metres of the road.

An active Boodie warren persists within 10 m of the Barge (WAPET) Landing, indicating that noise and vibrations from vehicles are not sufficient to displace individuals from their warren. The noise and vibration generated by vehicles and equipment for seismic data acquisition is not expected to have a Significant Impact on Boodies or their habitat.

Minor or Irrelevant Stressors

Given that planned seismic data acquisition activities will occur infrequently over short periods and with no permanent structures established, the effects of dust, heat, light, and shade are not predicted to be significant.

Gaseous emissions (vehicle and portable generator exhaust) are not expected to have any detectable impact and will be less than those for other operations. Therefore, impacts associated with gaseous emissions are not considered to be significant.

6.2.1.3 Subsurface Seismic Activity Stressors

Shock Waves

The subterranean fish, the Barrow Cave Gudgeon, is considered to be the key receptor for shock waves. Whilst invertebrates are typically highly resistant to shock, fish may be vulnerable to shock waves due to the presence of swim bladders.

In the absence of data on maximum shock wave levels for subterranean fauna and their habitat, the 100 kPa overpressure for lethal effects on fish proposed by Wright (1982) was used to calculate the likely extent of the impacts of shock waves. Using peak particle velocities ranging from 7 to 40 mm/s^{-1}, impact zones between 15 and 40 m were calculated. Shock waves should be contained within a TDF of 40 m.

Minor or Irrelevant Stressors

The extent of the effects of sedimentation and gaseous emissions (from explosions) is expected to be significantly less than those related to shock waves.

6.2.2 Onshore DOMGAS Pipeline

The following planned activities associated with construction and operation of the onshore DOMGAS facilities have been considered in defining the Onshore DOMGAS Pipeline TDF:

- abrasive blasting

- clearing and earthworks
- waste generation, storage, transport and disposal
- hot work, welding, grinding
- operation of machinery, plant and equipment
- pipeline installation, operation, inspection, maintenance and site reinstatement
- pipeline pressure testing, flooding and gauging
- vehicle movements

The stressors associated with Onshore DOMGAS Pipeline construction and operation applicable to ecological receptors include:

- dust
- erosion
- sedimentation
- noise and vibration
- heat and fire
- light
- spills
- introduction/spread of weeds.

6.2.3 Dimensions of the TDF

The rationale for determining the dimensions of the TDF in relation to stressors and their potential effects on ecological elements is summarised in Table 6-4. Indicative territory or home range of a variety of fauna on Barrow Island are presented in Table 6-5. This information shows that in considering the size of a TDF, the area that animals use also needs to be considered when determining the area of a TDF where stressors may manifest.

Table 6-4 Basis of TDF Dimensions

Stressor	Ecological Element (Receptor)	Manifestation of Boundary Effect	Rationale of Extent of Boundary Effect
Dust	Vegetation	• Plant mortality (photosynthetic structures covered, stomata blocked, cuticle abraded)	• 50 m DRF and wetlands (Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)) • Significant abrasion of plants 40 m from 4 m wide roads and 1 ha clearings during severe winds (Gleason *et al.* 2007) • Dust depositions noted 20 m from roads on Barrow Island
Erosion	Vegetation	• Topsoil loss/ reduction in plant germination	• Basis of design
Turbidity	None	• Elevated particulate loads	• No submerged aquatic vegetation and the only aquatic (vertebrate) animal is a frog that emerges after rainfall

Stressor	Ecological Element (Receptor)	Manifestation of Boundary Effect	Rationale of Extent of Boundary Effect
Sedimentation	Vegetation	• Suppression of plant germination	• Basis of design
Vibration	Fauna habitat	• Collapse of mounds/ burrows	• 100 m for Boodie warrens (Barrow Island Clearing Permit) • 100 m for Boodie warrens (Chevron Australia 2005).
Change to Surface Water Regime	Vegetation	• Plant death (induced flooding/ drought)	• 50 m DRF and wetlands (Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)) • 100 m caves/fissures/sinkholes (Barrow Island Clearing Permit)
Change to Subsurface Water Regime	Groundwater	• Change in watertable height • Contamination	• Watertable not applicable as one aquifer occurs across Barrow Island and total recharge/discharge unchanged (no groundwater abstraction planned) • Contaminants can be dispersed through groundwater. On the basis of expert opinion (Reeves pers. comm. 2008), the possible extent of a plume of any groundwater pollution five years (the period for the review of plans) after initial contamination from within the Gas Treatment Plant site should remain within 200 m of the Gorgon Gas Footprint
Noise	Fauna	• Distribution of social structure	• 850 m from footprint edge for 50 dB noise contour.
Fire	Vegetation Fauna habitat	• Plant death • Animal death	• The detailed TDF for fire is defined in the Fire Management Plan

Table 6-5 Indicative Territory or Home Range of Species

Group	Species	Indicative Territory/ Home Range/ Recorded Movement	Location where Data Derived from	Scale of Core Habitat
Large Highly Mobile Mammal	Barrow Island Euro	10 – 37 ha *M. robustus erubescens* 10 ha *M. robustus woodwardii*	Fowlers Gap, NSW[1] Adelaide River, NT[1]	300 – 600 m
	Spectacled Hare-wallaby	8 – 10 ha *Lagorchestes conspicillatus*	Barrow Island[2]	280 – 320 m
Large Highly Mobile Reptile	Perentie	3 – 22 ha, 900 m *Varanus giganteus*	Barrow Island[3]	170 – 900 m
Medium Mammal	Golden Bandicoot	4 – 10 ha *Isoodon auratus barrowensis* 750 m *Isoodon auratus barrowensis* 10 – 35 ha *Isoodon auratus*	Barrow Island[4] Barrow Island[4] Marchinbar Island, NT[5]	200 – 750 m

Group	Species	Indicative Territory/ Home Range/ Recorded Movement	Location where Data Derived from	Scale of Core Habitat
	Boodie	1 – 2 km *Bettongia lesueur* 29 – 35 ha *Bettongia lesueur*	Barrow Island[6] Arid Recovery Reserve, SA[7]	0 – 2000 m
Small Mammal	Western Chestnut Mouse	0.5 ha *Pseudomys nanus*	Purnululu National Park, WA[8]	70 m
Small Reptile	Leopard Skink	40 – 60 m max. recapture distance over 6 years of five *Ctenotus* species	Olympic Dam, SA[9]	40 – 60 m
Raptors	Osprey	Territory-immediate surrounds of nest, 100 km^2 home range Recorded 1 km inland	Generalisation[10] Barrow Island[11]	1000 m
	White-bellied Sea-eagle	3 km^2 territory, 150 km^2 home range	Generalisation[12]	1700 m
Resident Landbird	White-winged Fairy-wren (Barrow Island)	1.3 – 8.3 ha *Malurus leucopterus edouardi* 0.6 – 4.8 ha *Malurus leucopterus*	Booligal, NSW[13] Barrow Island[14]	40 – 110 m

Notes:
1 Dawson (2002)
2 WAPET (1989)
3 King, Green and Butler (1989)
4 Morris and Dickman (1991)
5 Southgate et al. *(1996)*
6 Donaldson (pers. comm. 2008)
7 Finlayson and Moseby (2004)
8 Partridge (2006)
9 Read (1999)
10 University of Michigan Museum of Zoology (2008)
11 Pruett-Jones and O'Donnell (2004)
12 State of Tasmania (2003)
13 Tidemann (1980)
14 Pruett-Jones and Tarvin (2001) and Pruett-Jones and O'Donnell (2004)

Consequently, for the purposes of defining a TDF that reflects the nature of the ecological element, three construction and operations related TDFs are defined in terms of area where the Gorgon Gas Development may potentially impact (Table 6-6):

- A TDF of 100 m, reflecting an area within which potential impacts from planned stressors may manifest on non-mobile ecological elements (e.g. plants, surface water landforms).
- A TDF of 200 m, reflecting an area within which potential impacts to groundwater may manifest.
- A TDF of 1000 m, reflecting an area within which potential impacts to mobile ecological elements (e.g. fauna) may manifest.

Table 6-6 Dimensions of TDF

Activities	**Horizontal Dimension**[1] (outside Gorgon Gas Development and Jansz Feed Gas Pipeline footprints)	**Vertical Above-ground Dimension** (above top of infrastructure)	**Vertical Below-ground Dimension** (below earthworks and excavations)
Construction and operations	100 m (non-mobile elements e.g. plants) 200 m (groundwater) 1000 m (mobile elements e.g. fauna)	100 m	1 m
Surface Seismic	5 m	0 m	0 m
Subsurface Seismic	40 m	Not applicable	40 m

Note: 1 Distance is from the external periphery of footprint

A TDF of 200 m, extending 100 m either side of the Onshore Domestic Gas Pipeline ROW, is considered an appropriate area for which to identify any new establishment of Mesquite or other weed species during construction or operations activities. This also applies to any potential impacts from planned stressors that may manifest on surface water landforms.

Measurements for the TDF during construction/operations activities and surface seismic activities are as follows:

- horizontal distances are measured from outside edges of any disturbance or cleared areas to be used for the Gorgon Gas Development and Jansz Feed Gas Pipeline
- vertical above-ground distances are measured above ground level or the top of any infrastructure, whichever is higher at that point
- vertical below-ground distances are measured below any disturbed surfaces (even if the finished surface is above any temporarily disturbed surfaces such as in excavations).

The extent of the TDF does not mean that the impacts associated with the Gorgon Gas Development and Jansz Feed Gas Pipeline represent impacts to the Barrow Island terrestrial environment because:

- the TDF includes areas previously cleared and currently used by the existing oilfield operation
- the TDF has been based on the largest distance of boundary effects for combinations of stressors and receptors, and therefore not all receptors within the TDF are potentially impacted
- management practices of stressors in cleared areas will seek to limit stressors within in the TDF.

Therefore, using the TDF concept as a management and monitoring tool should not present a threat to the survival, viability, and functioning of any ecological element on Barrow Island.

6.3 Application of the TDF in other Ministerial Deliverables

The concept of a TDF, as amended from time to time, applies to other Ministerial Deliverables required under Statement No. 769 and 800. These are listed below for information and referral:

- Terrestrial and Subterranean Environment Protection Plan (Condition 7): One of this Plan's objectives is to ensure that construction and operation of the terrestrial facilities does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint.
- Terrestrial and Subterranean Environment Monitoring Program (Condition 8): The objective of this Program 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.
- Fire Management Plan (Condition 12): One of this Plan's objectives is that the Proposal does not cause Material or Serious Environmental Harm outside the Terrestrial Disturbance Footprint due to fire. The TDF for fire is defined in the Fire Management Plan (Chevron Australia 2009b). Aboriginal Cultural Heritage Management Plan (Condition 31): The TDF aligns with the Gorgon Gas Development Footprint and is not discussed further in this Report.
- Post-Construction Rehabilitation Plan (Condition 32): The TDF relates to those areas that will be disturbed as part of construction and areas that are part of the TDF, but which are not required for the future construction and operation. A TDF of 100 m applies to rehabilitation.
- Horizontal Directional Drilling Management and Monitoring Plan (Condition 22): One of this Plan's objectives is to ensure that the impacts of HDD activities on the TDF are reduced as far as practicable. Three TDFs, as outlined in this Report, apply to the HDD Plan.
- Offshore Gas Pipeline Installation Management Plan (Condition 23): One of this Plan's objectives is to ensure that the impacts of the offshore gas pipeline installation activities on the TDF are reduced as far as practicable. Three TDFs, as outlined in this Report, apply to the Offshore Gas Pipeline Installation Management Plan.

6.4 Significant Ecological Elements and Areas at Risk

6.4.1 Overview

Applying the risk concepts of Woodman Environmental Consulting (2007), impacts are of regional significance when there is an impact to a local population of a species, and that population is significant to the overall/regional conservation of the species (e.g. the number of individuals in a local population is a significant portion of the total number of individuals of the species in the world).

As distribution, fragmentation, and abundance have been considered in determining the significance of elements, the elements of most concern in impact assessment should be the subset of these significant elements. The fauna of Barrow Island includes a number of migratory and vagrant species. Vagrant species are not considered to be at risk from the Gorgon Gas Development and Jansz Feed Gas Pipeline. The risk to migratory species is assessed on the same basis as resident species on Barrow Island.

Species that do not hold habitat on Barrow Island (e.g. seabirds occupying offshore islands) will not have a TDF related to them; however, these are recognised as taxa that may be at risk by the Gorgon Gas Development and are recognised as significant and requiring monitoring.

Species or features that are at risk:

- have restricted or uneven distribution on Barrow Island and are potentially disproportionately over-represented in the Gorgon Gas Development TDF

and/or

- are vulnerable to a stressor, the scale of which may be disproportionate or not determined by the extent of land clearing (e.g. noise, light, vehicle strikes) on Barrow Island.

The terrestrial stressors identified in the Draft EIS/ERMP (Chevron Australia 2005) as potentially impacting upon ecological elements, which includes significant ecological elements, are summarised in Table 6-7. Clearing and earthworks is only a significant stressor if ecological elements are restricted in distribution, and therefore this stressor is considered in terms of the distribution of ecological elements. Other stressors are considered in terms of the vulnerability of the ecological elements.

Table 6-7 Summary of Terrestrial Stressors Identified in the EIS/ERMP

	Ecological Element in this Report			
	• Surface Water Landforms • Physical Landforms • Groundwater	• Flora • Vegetation • Ecological Communities	• Fauna • Ecological Communities • Habitat	• Fauna • Ecological Communities
	Factors in Draft EIS/ERMP			
	Physical Environment	**Flora and Vegetation**	**Terrestrial Fauna**	**Subterranean Fauna**
Clearing and earthworks	x	x	x	x
Physical presence	x			x
Waste disposal	x			x
Leaks or spills	x	x		x
Fire		x	x	
Physical interaction			x	
Noise and vibration			x	x
CO_2 leak				x

Source: Chevron Australia 2005.

Light was considered in the marine section of the EIS/ERMP, as the likely receptors (turtles and seabirds) are marine species. The potential impact of light on turtles is addressed in the Long-term Marine Turtle Management Plan (Chevron Australia 2013b), in accordance with Condition 16 of Statement No. 800 and Condition 12 of EPBC Reference: 2003/1294 and 2008/4178. Seabirds are likely to be less sensitive to lights than turtles. Light impacts on seabirds are expected to be mitigated through management for turtles.

No taxa or features have been identified as restricted or over-represented in the vicinity of the Onshore Domestic Gas Pipeline. Therefore, no taxa or features are considered potentially impacted from the construction or operation of the Onshore Domestic Gas Pipeline.

6.4.2 Ecological Elements Impacted Due to Localised Distribution

For distribution to be the reason that an element is considered at risk, the element should occur in the Gorgon Gas Development TDF. The occurrence of significant ecological elements in the TDF on Barrow Island is summarised in Table 6-8.

Table 6-8 Summary of Occurrences of Significant Ecological Elements in Gorgon Gas Development TDF on Barrow Island

Ecological Elements		No. Species/ Extent Present on Barrow Island	Significant	Significant and in TDF	No. Species/ Elements Over-represented in TDF
Flora	Plant species	397	40	6	5
Vegetation	Subformations	38	20	7	5
Fauna	Mammal species	15	6	6	0
	Reptile and amphibian species	45	4	4	0
	Bird species	119	67	6	0
	Terrestrial invertebrate species	1261	157	4	0
	Subterranean fauna species	56	56	10	4
Habitat	Raptor nests	54	54	1	No
	Termite mounds	>6700 mounds[1]	1680 mounds	1680 mounds	No
	Boodie warrens	>62[2]	8	8	No
Ecological Communities	Subterranean fauna community species	56	56	10	4
	Undisturbed drainage lines	1134.4 ha	1134.4 ha	30.3 ha	No
Surface Water Landforms	Major drainage lines	1134.4 ha	1134.4 ha	30.3 ha	No
	Claypans	193 ha	193 ha	0.2 ha	No
	Seeps	3 sites	3 sites	0	No
Groundwater	Superficial aquifer	23 800 ha	23 800 ha	332 ha	No
Physical Landforms	Coastal foredunes	1329 ha	1 329 ha	3.7 ha	No
	Fossil beds	>18 sites	18 sites	0	No
	Cliffs and gorges	76 ha	76 ha	0 ha	No
	Caves, rock shelters and sinkholes	24	24	0	No

Notes: 1 Approximately 15% of Barrow Island mapped
2 Approximately 3% of Barrow Island mapped

The baseline information presented in this Report indicates that the following are not at risk from activities associated with the Gorgon Gas Development due to distribution:

- significant littoral avifauna, including the Lesser Crested Tern, as they are concentrated on the south coast of Barrow Island
- termite mounds and Boodie warrens, as they are widespread and well-represented outside the Gorgon Gas Development Footprint
- physical landforms, as they are generally absent within the Gorgon Gas Development Footprint
- groundwater, as it is widespread and relatively homogenously distributed across Barrow Island

- significant terrestrial invertebrate species, as they are predicted to be well-represented outside the Gorgon Gas Development TDF (as no terrestrial short-range endemics have been identified as being restricted to the Gorgon Gas Development Footprint).

The baseline information presented in this Report indicates that the following may be at risk due to distribution:

- one troglobitic taxon (Symphyla sp.) that has yet to be located outside the disturbance area associated with the Gas Treatment Plant site and the Additional Support Area
- three stygobitic taxa (*?Bogidomma* sp. 1,Melitidae unknown sp. 1, and *Pilbaracandona* sp. nov.) that have yet to be located outside the disturbance area associated with the Gas Treatment Plant site and the Additional Support Area
- five significant plant species (*Jasminum calcarium*, *Grevillea pyramidalis*, *Erythrina vespertilio*, *Acacia synchronicia*, *Whiteochloa airoides*) that are restricted within Barrow Island, for which the total abundance or extent on Barrow Island is unknown at the time of writing this Report
- two vegetation subformations (F5, L9) at risk due to vulnerability.

6.4.3 Vulnerability of Ecological Elements

6.4.3.1 Ecological Elements that are Vulnerable

The following significant ecological elements may be at risk from the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island; they are summarised in Table 6-9:

- White-winged Fairy-wren (Barrow Island) may be at risk due to its vulnerability to noise (as discussed in Section 6.2.1.1)
- highly mobile terrestrial animals are more likely to be disproportionately impacted by physical interactions (vehicle strikes and trenches); populations of larger mammals and large reptiles (Perentie) are more affected by roads than populations of small mammals (Spellerberg 2002) and roadkill rates are generally higher for large animals with large home ranges (e.g. Klocker *et al.* 2006)
- raptors may be impacted by vehicle traffic disproportionately larger than the land clearing associated with the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island as a result of attraction to infrastructure for roosting, and potential inclusion of basking reptiles, roadkill, and carrion on roads as a component of their diet
- *Melaleuca cardiophylla* is considered more vulnerable to impacts as it has been identified as potentially having low regeneration rates (Mattiske 1993)
- coastal foredunes, and associated vegetation, from wind erosion
- undisturbed drainage lines and surface water landforms (claypans), and associated vegetation, from water erosion and sedimentation
- terrestrial invertebrate SRE (trapdoor spider) in the Gas Treatment Plant site
- subterranean fauna beneath the LNG plant site
- groundwater beneath and near the LNG plant site where recharge patterns may be altered.

Table 6-9 Significant Ecological Elements At Risk due to Vulnerability

Ecological Element	Taxa/Feature	Characteristic Determining Impact Status
Surface Water Landforms	Major drainage lines Claypans	Vulnerability to water erosion and sedimentation
Groundwater	Superficial aquifer	Vulnerability to groundwater pollution
Vegetation	Relict inland dunes with coastal flora (F5d, F5e, L9)	Restricted distribution
	Claypans (S1, S2b)	Vulnerability to sedimentation
	Drainage lines (D1, D2)	Vulnerability to water erosion and sedimentation
	Coastal dunes (C1, C2, C3, C4)	Vulnerability to wind erosion
Plants	*Jasminum calcarium* *Grevillea pyramidalis* *Erythrina vespertilio* *Acacia synchronicia* *Whiteochloa airoides*	Species with restricted distribution*
	Melaleuca cardiophylla	Species with low regeneration rate
Fauna	Subterranean fauna (*Pilbaracandona* sp. nov., *?Bogidomma* sp. 1, *Melitidae* unknown sp. 1, Symphyla sp.)	Species with restricted distribution**
	Terrestrial invertebrate (*Idiommata* sp.)	Species with restricted distribution***
	Barrow Island Euro Perentie Spectacled Hare-wallaby Barrow Island Golden Bandicoot Boodie	Vulnerability to vehicle strike
	Brahminy Kite Osprey White-bellied Sea-eagle	Vulnerability to vehicle strike
	White-winged Fairy-wren (Barrow Island)	Vulnerability to noise
	Bridled Tern Wedge-tailed Shearwater	Vulnerability to light
Physical Landforms	Coastal foredunes	Vulnerability to wind erosion

*Notes: * Restricted within Barrow Island*
***Restricted within Gas Treatment Plant site footprint and Additional Support Area footprint on Barrow Island*
**** Restricted within Gas Treatment Plant site footprint on Barrow Island*

6.4.3.2 Ecological Elements that are not Vulnerable

Species that do not hold habitat on Barrow Island (e.g. seabirds occupying offshore islands) will not have a TDF related to them. However, seabirds nesting on offshore islands in the vicinity of the Gas Treatment Plant, in particular Wedge-tailed Shearwaters and Bridled Terns, have been documented as being attracted to construction and vessel rigging and the night lighting of the Gas Treatment Plant on nearby Varanus Island (Nicholson 2002). Therefore, while not linked to a TDF, seabirds are recognised as taxa that may be at risk from the Gorgon Gas Development and are recognised as significant, and thus require monitoring.

The Draft EIS/ERMP (Chevron Australia 2005) identified several fauna species as key receptors to the stressor of vehicle strikes. Whilst individuals of some of these species may be at risk from vehicle strikes and are useful in considering risk level, their populations are not considered at risk from road traffic. This applies to the following three species due to their relatively broad distributions on Barrow Island, high abundances, and small home ranges:

- Leopard Skink (*Ctenotus pantherinus acripes*)
- Barrow Island Chestnut Mouse (*Pseudomys nanus ferculinus*) (now confirmed as the Western Chestnut Mouse (*Pseudomys nanus*)
- White-winged Fairy-wren (Barrow Island) (*Malurus leucopterus edouardi*).

The following are ecological elements that were considered not to be at risk due to vulnerability to stressors:

- troglofauna and subterranean blind snakes: any spills would have only a small impact area within their habitat as liquids will pass through the soil profile and enter the watertable before spreading significantly
- stygofauna: any groundwater pollution arising from the Gas Treatment Plant would not be expected to spread more than 200 m over a five-year period. This does not represent degradation of a large portion of the stygofauna habitat on Barrow Island.

Introduction of non-indigenous species was identified as a risk associated with the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island by Chevron Australia (2005). Quarantine breaches were not considered as a stressor against which the vulnerability of individual species could be appropriately assessed. This is consistent with the advice of the Quarantine Expert Panel (QEP) and, although the consequences of some introductions could be very serious, no species have been individually identified as being at risk from this stressor through the significant public consultation process or the ongoing environmental baseline studies of Barrow Island flora and fauna (Gorgon Quarantine Expert Panel 2003). Introduction of non-indigenous species is not addressed in this Report as it is addressed in detail in the Terrestrial and Marine Quarantine Management System (required under Condition 10 of Statement No. 800 and Statement No. 769, and Condition 8 of EPBC Reference: 2003/1294 and 2008/4178).

Chevron Australia believes that under planned activities, the stressors will not manifest outside the TDF due to management measures outlined in the Environment Management Plans required under Statement No. 800, Statement No. 769, and EPBC Reference: 2003/1294 and 2008/4178.

In accordance with Condition 6.6 of Statement No. 800, Chevron Australia does not predict there will be ecological elements that, under planned activities, will be at risk outside the TDF under the EPBC Act (Cth), or Material or Serious Environmental Harm under the EP Act (WA). Therefore, these are not further described or mapped in this Report beyond those described and mapped in Section 4.0 and Section 5.0.

6.5 Reference Sites

Reference sites shall not be at risk of being affected by the Gorgon Gas Development and Jansz Feed Gas Pipeline or existing developments, and can be used to determine the natural state, including natural variability, of environmental attributes of ecological elements. Reference sites shall therefore be located beyond the TDF, i.e. beyond areas that Chevron Australia predict will, under planned activities, be at risk of Material or Serious Environmental Harm. Reference Sites will, where reasonably practicable, be comparable to those sites in the areas at risk.

There are expected to be minimal boundary effects associated with planned surface seismic activities due to the low intensity and frequency of disturbance. Therefore, the areas beyond which ecological elements are considered at risk are only defined in terms of construction and operation activities and not surface seismic activities.

The terrestrial monitoring locations for at risk sites and reference sites are identified and discussed in the Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a).

6.6 Review of Risk Assessment in the Draft EIS/ERMP

This section reviews the results of the qualitative ecological risk assessments of the likelihood and consequence of Gorgon Gas Development and Jansz Feed Gas Pipeline impacts on the ecological elements, to satisfy Condition 6.5i of Statement No. 800 and Statement No. 769.

6.6.1 Barrow Island

A summary of residual risk levels associated with the construction and commissioning of the Gorgon Gas Development was included in the Draft EIS/ERMP. In addition, impacts from the Jansz Feed Gas Pipeline on Barrow Island and the surrounding State territorial waters were assessed in the Draft EIS/ERMP (Chevron Australia 2005). This original assessment was reviewed as part of the development of the Gorgon Gas Development Revised and Expanded Proposal PER (Chevron Australia 2008) and the Gorgon Gas Development Additional Construction Laydown and Operations Support Area Environmental Review (Chevron 2013a) in light of the changes to the Gorgon Gas Development (described in Section 1.4). The outcomes of these assessments have been reviewed and are provided in Table 6-10. More detailed information is provided in Appendix 11. There is no evidence that any ecological element is more restricted or vulnerable than previously presented.

The assessed level of risks presented in both the Draft EIS/ERMP (Chevron Australia 2005) and this Report are based on residual risk (that is, after mitigation measures are implemented). Mitigation measures can significantly influence the level of residual risks, and, without mitigation measures, the impacts of planned activities such as construction trenches and vehicle strikes would be higher. The Terrestrial and Subterranean Fauna Environment Protection Plan (Chevron Australia 2010) documents the framework to safeguard risks to significant ecological elements.

The majority of the risks associated with the Gorgon Gas Development and Jansz Feed Gas Pipeline on Barrow Island are not significantly changed by the consideration of additional information, the extent of boundary effects or changes in design, and detailed mitigation strategies, with the exception of subterranean fauna.

The risks presented in the Draft EIS/ERMP for restricted subterranean fauna represent a worst-case scenario. The associated risks have been reassessed in the PER (Chevron Australia 2008) due to additional information such as:

- further sampling strategy has resulted in only three, rather than eight, subterranean fauna yet to be confirmed outside the Gas Treatment Plant site
- the three subterranean fauna taxa yet to be confirmed outside the development area are not ‘listed/threatened’ taxa as defined in the Draft EIS/ERMP risk assessment (Chevron Australia 2005)
- the apparent restrictions in distributions of the three species yet to be confirmed outside the Gas Treatment Plant site may be a consequence of limited sampling
- data from species that have been collected in higher numbers (e.g. *D. bramstokeri*, *S. nesiotes*, *H. Tulki*, and *S. stylifera*) indicate that stygofauna and troglofauna species may have widespread distributions across the Island (Biota Environmental Sciences 2007)

- preliminary geological reviews suggest that strata on the Island (e.g. interbedded sand/limestone) are relatively continuous (Biota Environmental Sciences 2007)
- assuming no subterranean fauna species are restricted to the Gas Treatment Plant site, the greatest possible consequence would be the reduction in viability of a local population, but not a reduction in the viability of the Barrow Island population as previously assumed.

Seabirds and marine turtles have been discussed in this Report as potentially subject to impacts from terrestrial lights. However, they were risk assessed as part of the marine environment in the Draft EIS/ERMP (Chevron Australia 2005). The risk assessment framework has not been modified between the Draft EIS/ERMP and this Report, and therefore they are not considered in the risk review.

Table 6-10 Summary of the Review of Residual Risk Levels for Barrow Island

Environmental Factor/Stress	Construction and Commissioning		Operations	
	Risk in Draft EIS/ERMP	Reviewed Risk	Risk in Draft EIS/ERMP	Reviewed Risk
Soil and Landform				
Clearing and earthworks	M	M	L	L
Liquid and solid waste disposal	M	M	L	L
Leaks or spills	M	M	M	M
Surface and Groundwater				
Clearing and earthworks	M	M	L	L
Physical presence	M	M	M	M
Liquid and solid waste disposal	M	M	L	L
Leaks or spills	M	M	M	M
Air Quality				
Atmospheric emissions	L	L	L	L
Clearing and earthworks	L	L	L	L
Flora and Vegetation Communities				
Clearing and earthworks (restricted flora and vegetation communities)	H	H	L	L
Clearing and earthworks (general flora and vegetation communities)	L	L	L	L
Fire	M	M	M	M
Atmospheric emissions	L	L	L	L
Light/shading/heat/cold	L	L	L	L
Dust	L	L	L	L
Unpredicted CO_2 migration			L	L
Leaks or spills	L	L	L	L
Terrestrial Fauna				
Clearing and earthworks	M	M	L	L
Physical interaction	M	M	M	M
Leaks or spills	L	L	L	L
Light or shade	L	L	L	L
Atmospheric emissions	L	L	L	L
Dust	L	L	L	L

Environmental Factor/Stress	Construction and Commissioning		Operations	
	Risk in Draft EIS/ERMP	Reviewed Risk	Risk in Draft EIS/ERMP	Reviewed Risk
Unpredicted CO_2 Migration				
Heat and/or cold	L	L	L	L
Noise and vibration	L	M	M	M
Fire	M	M	M	M
Subterranean Fauna				
Clearing and earthworks	H*	L	L	L
Physical presence	-	H*	M	M
Wastewater discharge	H*	M	-	-
Noise and vibration	H*	M	-	-
Leaks or spills	M	M	M	M
Unpredicted CO_2 migration	-	-	M*	L

*Notes: * Worst-case scenario in absence of final sampling results*
H = High, m = Medium, L = Low.

7.0 Risk Assessment

7.1 Overview

Risk assessment provides the basis for the targeted management and monitoring as detailed in the Terrestrial and Subterranean Fauna Environment Protection Plan (Chevron Australia 2010) and Terrestrial and Subterranean Environment Monitoring Program (Chevron Australia 2012a).

Condition 6.5 i of Statement No. 800 and Statement No. 769 and Condition 5.4 i of EPBC Reference: 2003/1294 and 2008/4178 require '[a] review of the results of the existing qualitative ecological risk assessments of the likelihood and consequence of Proposal impacts on the ecological elements…'.

The risk assessment in the Draft EIS/ERMP (Chevron Australia 2005) is reviewed using the same risk assessment framework. Risks are only reassessed where additional information results in a significant discrepancy with assumptions used in the risk assessment in the Draft EIS/ERMP with regards to the following:

- the TDF, which is defined as the area to be disturbed by construction activities associated with the Terrestrial Facilities listed in Condition 6.3 of Statement No. 800 and Statement No. 769, and Condition 5.2 of EPBC Reference: 2003/1294 and 2008/4178, and as further described in this Report.
- reference sites that are not at risk of Significant Impact under the EPBC Act (Cth) or Material or Serious Environmental Harm under the EP Act (WA).

Impacts from the Jansz Feed Gas Pipeline on Barrow Island and the surrounding State territorial waters have been assessed in the Draft EIS/ERMP (Chevron Australia 2005).

Some clarifications in design have occurred since the release of the Draft EIS/ERMP by Chevron Australia in 2005, but these have not had a significant influence on the review of the assessed risks. Mitigation strategies, whilst having been refined, are consistent with and not significantly different in intent from those presented in the Draft EIS/ERMP (Chevron Australia 2005). Any significant changes to the Gorgon Gas Development are considered as part of additional environmental approvals. Such changes are assessed in the Gorgon Gas Development Revised Proposal PER (Chevron Australia 2008) and the Gorgon Gas Development Additional Construction Laydown and Operations Support Area Environmental Review (Chevron 2013a).

7.2 Risk Assessment Framework

7.2.1 Overview

Chevron Australia has prepared the HES Risk Management: ASBU – Standardized OE Process (Chevron Australia 2007b) to assess and manage health, environment, and safety (HES) risks, which it internally requires its employees, contractors, etc. to comply with.

The methodology for the environmental risk assessments undertaken during the EIS/ERMP assessment process is documented in Chapter 9 of the EIS/ERMP (Chevron Australia 2005). The risk assessments were undertaken in accordance with the following standards:

- AS/NZS 4360:2004 Risk Management (Standards Australia/Standards New Zealand 2004b)
- AS/NZS Handbook 203:2006 Environmental Risk Management – Principles and Process (Standards Australia/Standards New Zealand 2006)
- AS/NZS 3931:1998 Risk Analysis of Technological Systems – Application Guide (Standards Australia/Standards New Zealand 1998).

The risks associated with Environmental Factors/Stressors were assessed in the Draft EIS/ERMP as either low, medium, or high (Chevron Australia 2005). These three risk levels are

based on the combinations of likelihood and consequence as detailed in Section 9 of the Draft EIS/ERMP and are summarised in Table 7-1.

Table 7-1 Environmental Risk Matrix

		Consequence				
		Minor	**Moderate**	**Serious**	**Major**	**Critical**
Likelihood	**Almost Certain**	Low	Medium	High	High	High
	Likely	Low	Medium	High	High	High
	Possible	Low	Medium	Medium	High	High
	Unlikely	Low	Low	Medium	Medium	Medium
	Remote	Low	Low	Low	Medium	Medium

Significant Impacts under the EPBC Act (Cth) and Material or Serious Environmental Harm under the EP Act (WA) are defined in terms of consequences rather than likelihood or risk. The consequences that constitute Significant Impact under the EPBC Act (Cth) or Material or Serious Environmental Harm under the EP Act (WA) may change over time, as the status (e.g. abundance of species) changes.

Therefore, these terms are not defined in the ecological framework of this Report; however, a conservative approach has been applied in the Terrestrial and Subterranean Environment Protection Plan (Chevron Australia 2010) where triggers for further investigation and management are applied well below impacts of these magnitudes. The consequence definitions used in the Draft EIS/ERMP for fauna and flora and vegetation communities are provided in Appendix 10.

8.0 Review of this Report

Chevron Australia is committed to conducting activities in an environmentally responsible manner and aims to implement best practice environmental management as part of a program of continuous improvement. This commitment to continuous improvement means that Chevron Australia will review this Report as required (e.g. in response to any Project scope changes that come online and have not been previously covered in this report).

If the Report no longer meets the aims, objectives or requirements of the Report, if works are not appropriately covered by the Report, or measures are identified to improve the Report, Chevron Australia may submit an amendment or addendum to the Report to the Minister for approval under Condition 36.2 of Statement No. 800,Condition 21 of Statement No. 769 and Condition 2-3 of Statement No. 965. The State Minister for Environment may also direct Chevron Australia to revise the Report under Condition 36.2 of Statement No. 800.

If Chevron Australia wishes to carry out an activity other than in accordance with the Report, Chevron Australia will update the Report and submit it for approval to the Commonwealth Minister for Environment in accordance with Condition 25 of EPBC Reference: 2003/1294 and 2008/4178, and Condition 6 of EPBC Reference: 2005/2184. The Commonwealth Minister for Environment may request Chevron Australia to revise the Report under Condition 26 of EPBC Reference: 2003/1294 and 2008/4178.

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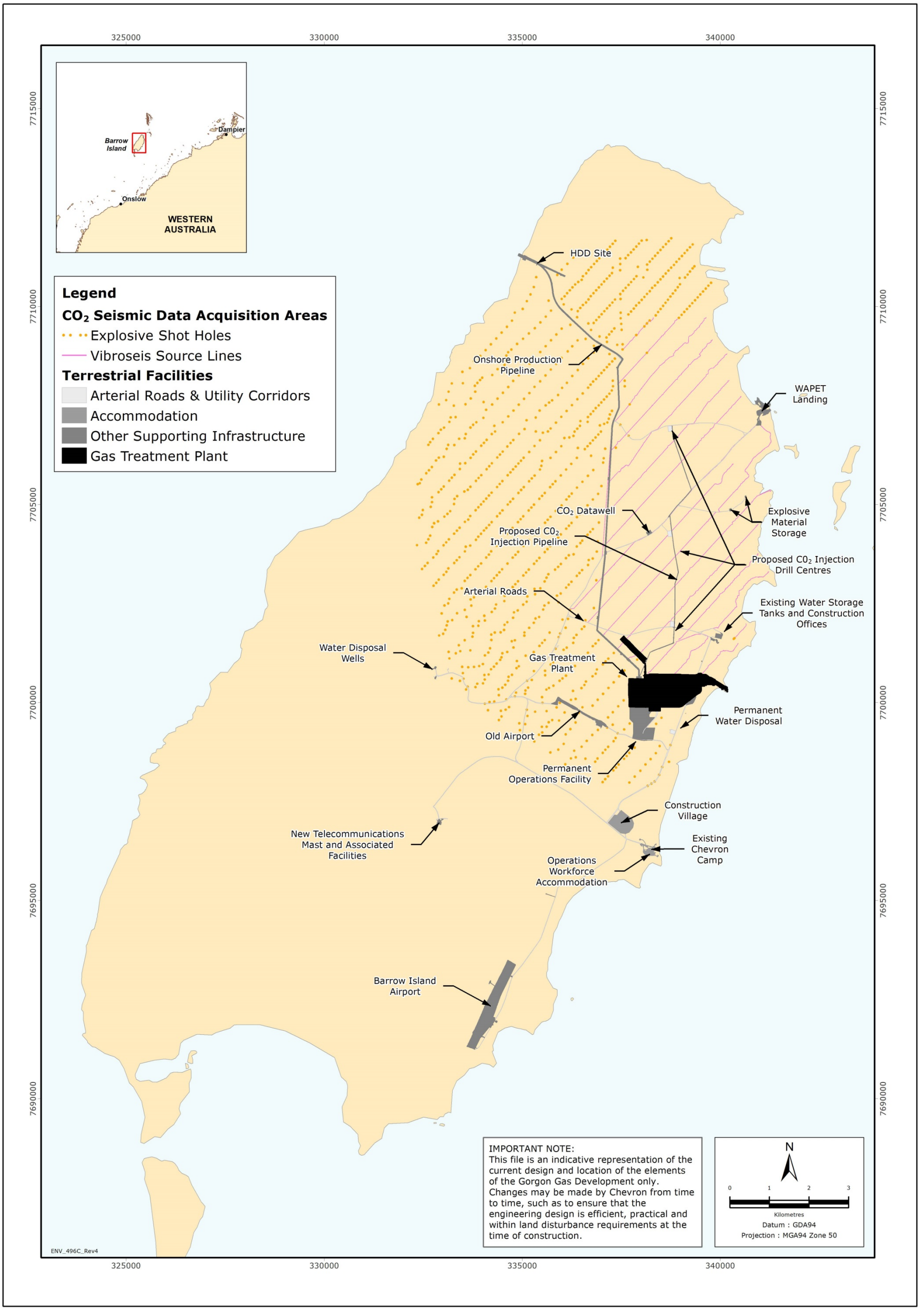
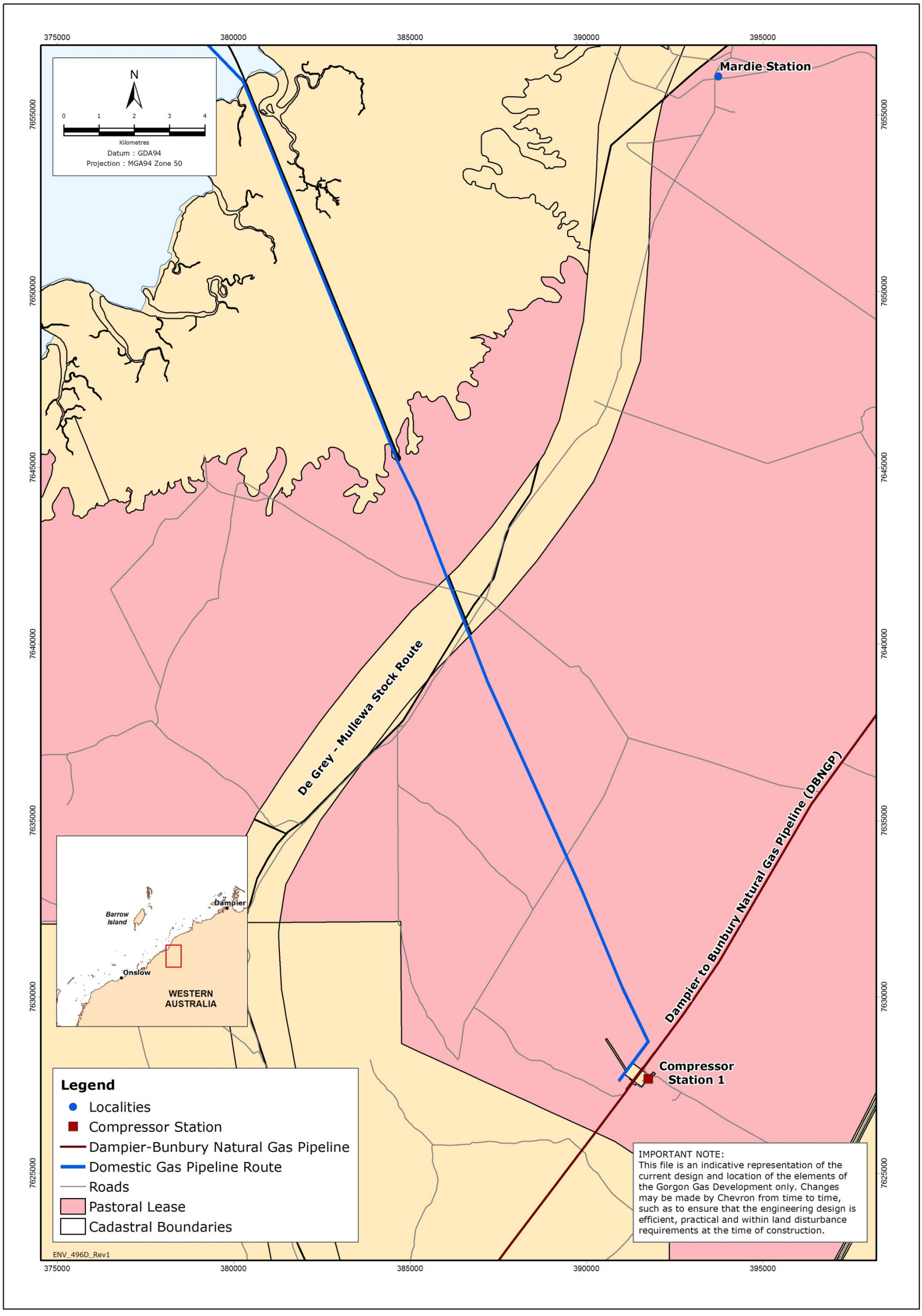
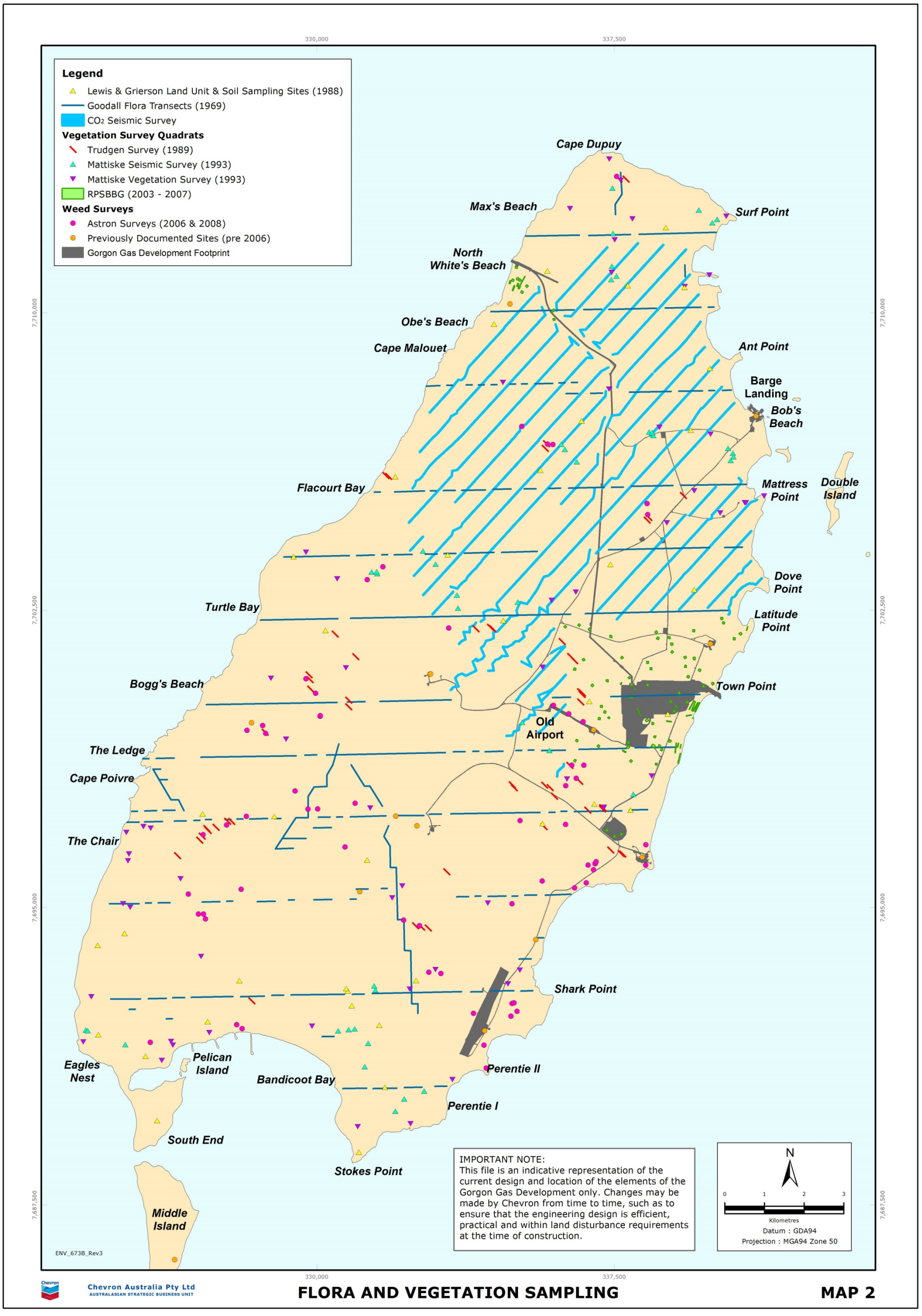
10.0 Maps

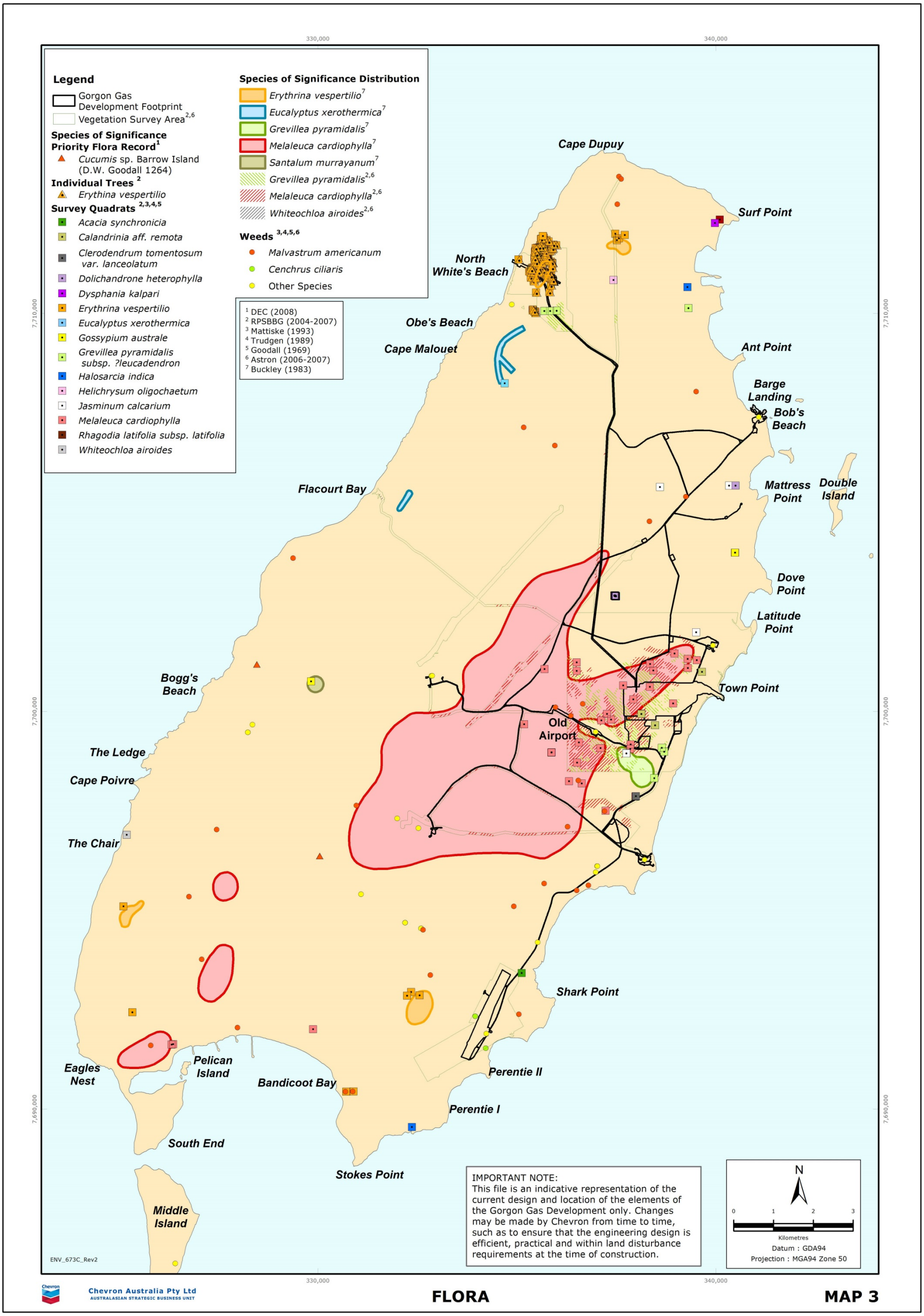


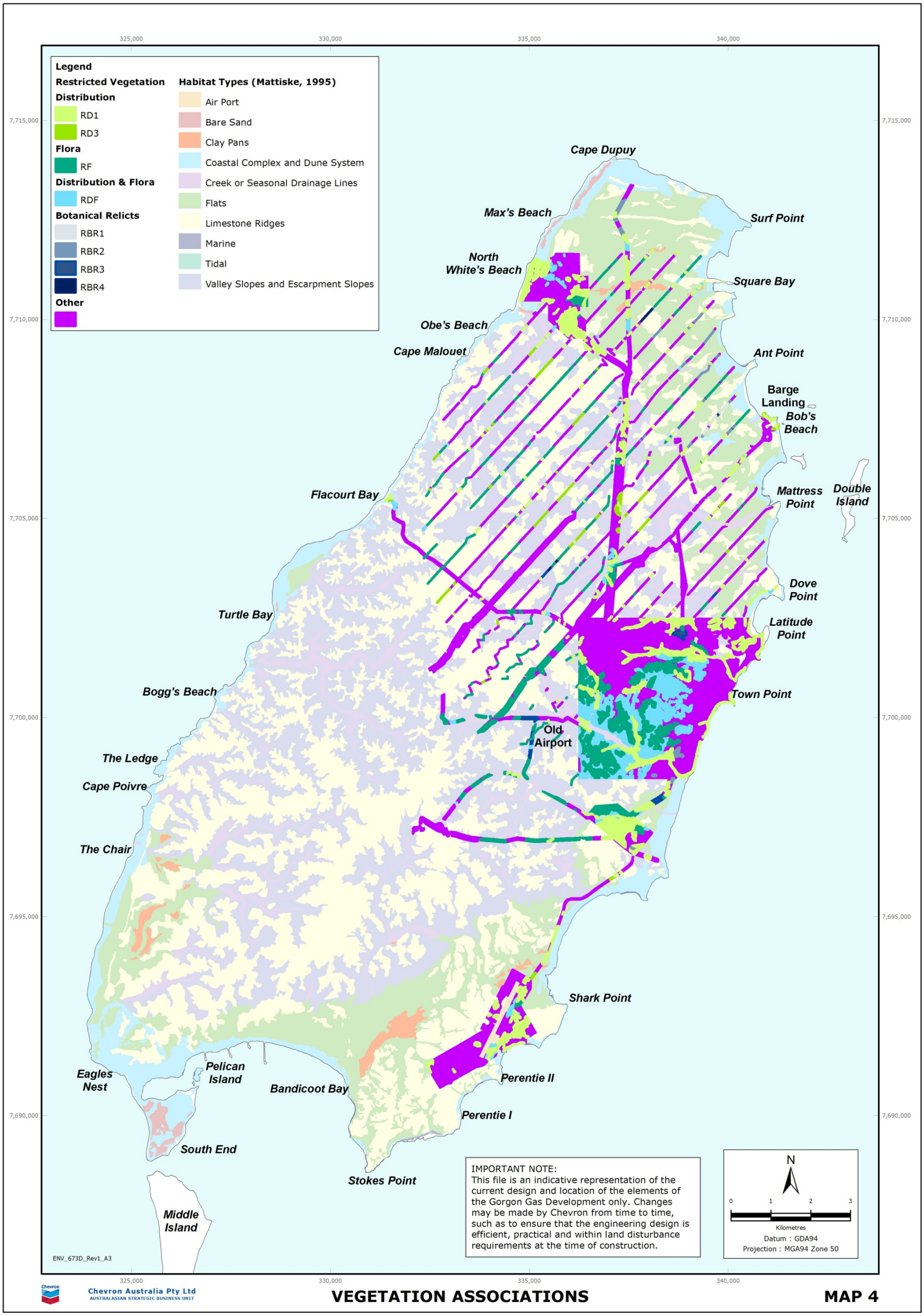
Map 1i

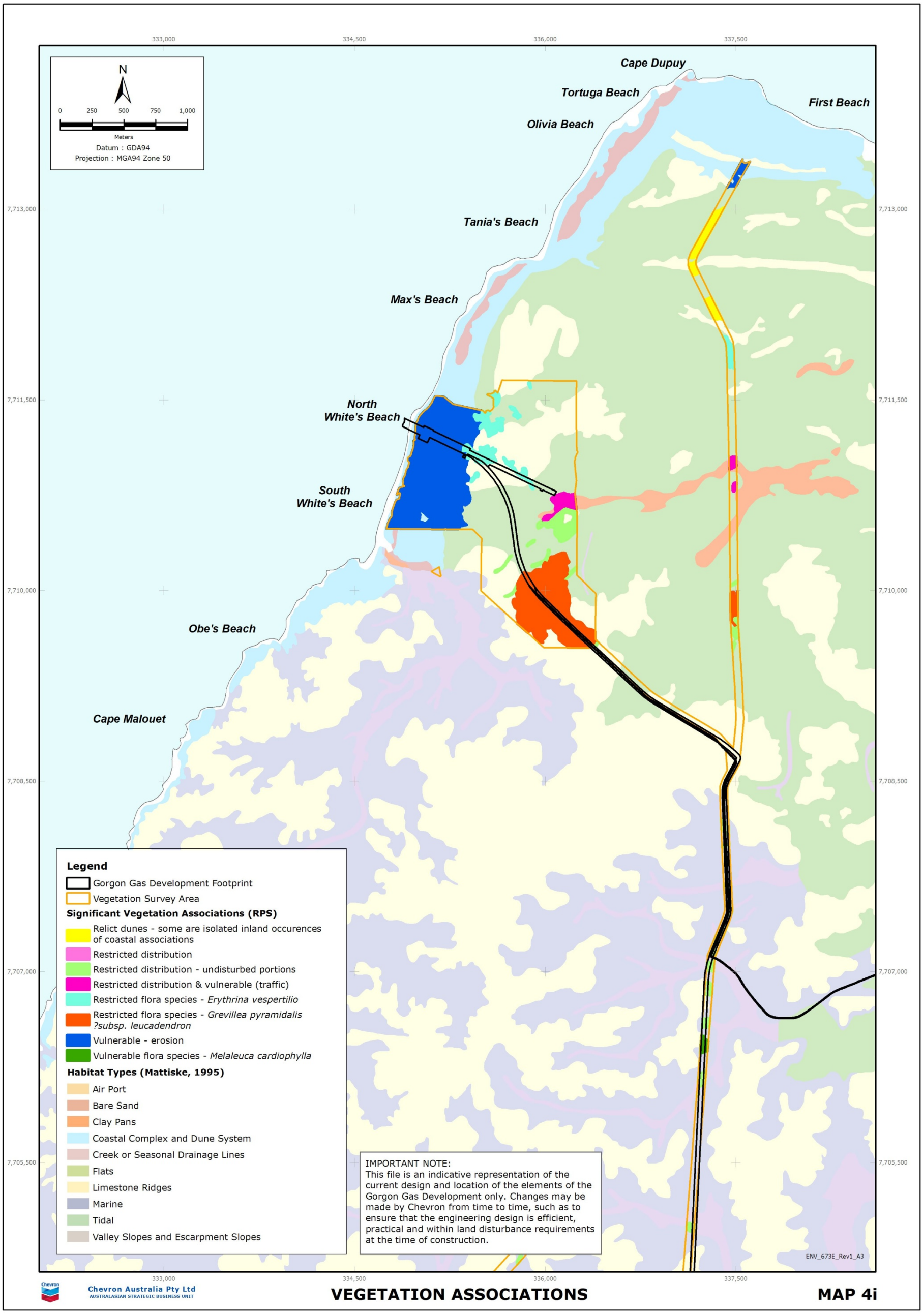


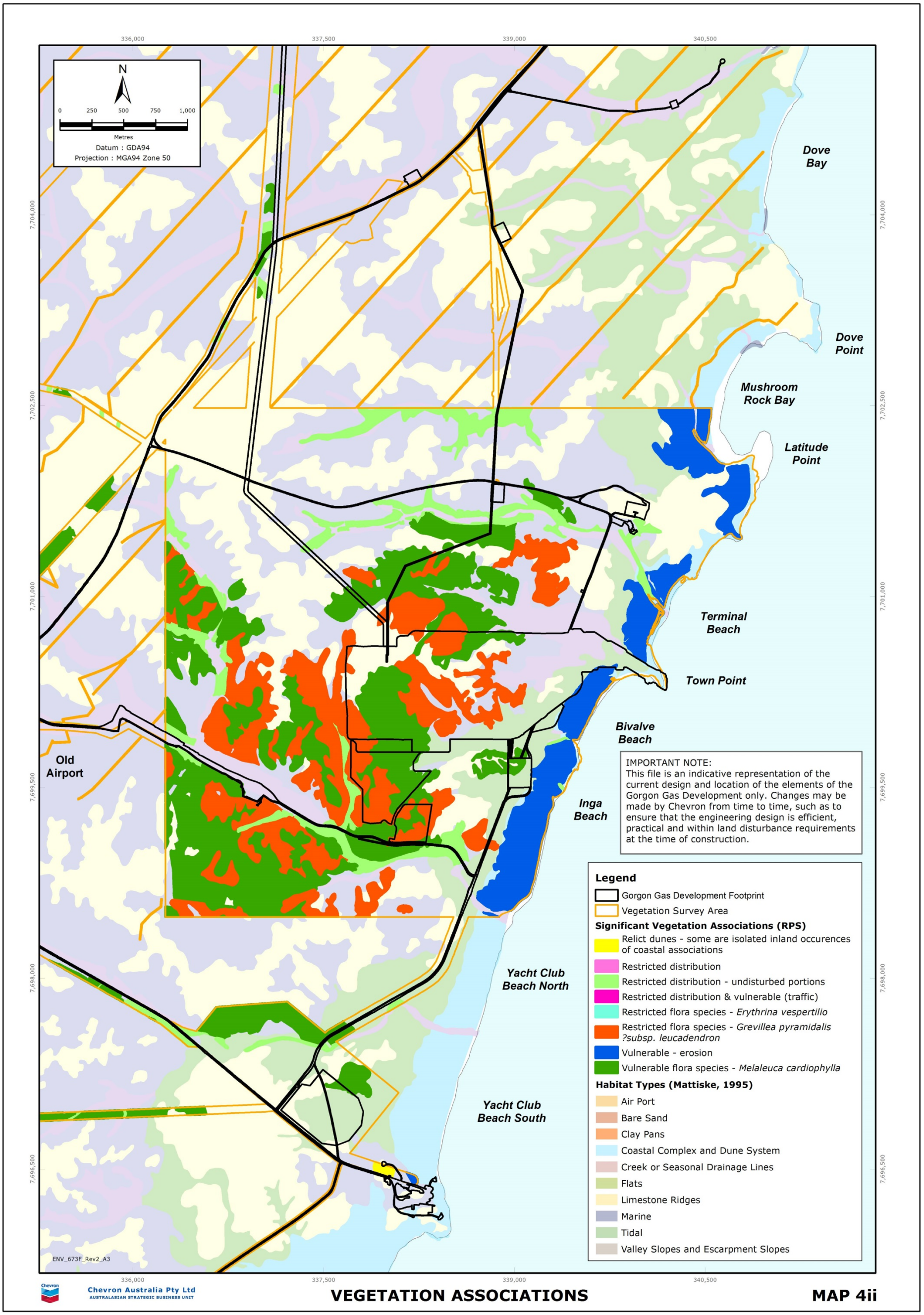
Map 1ii

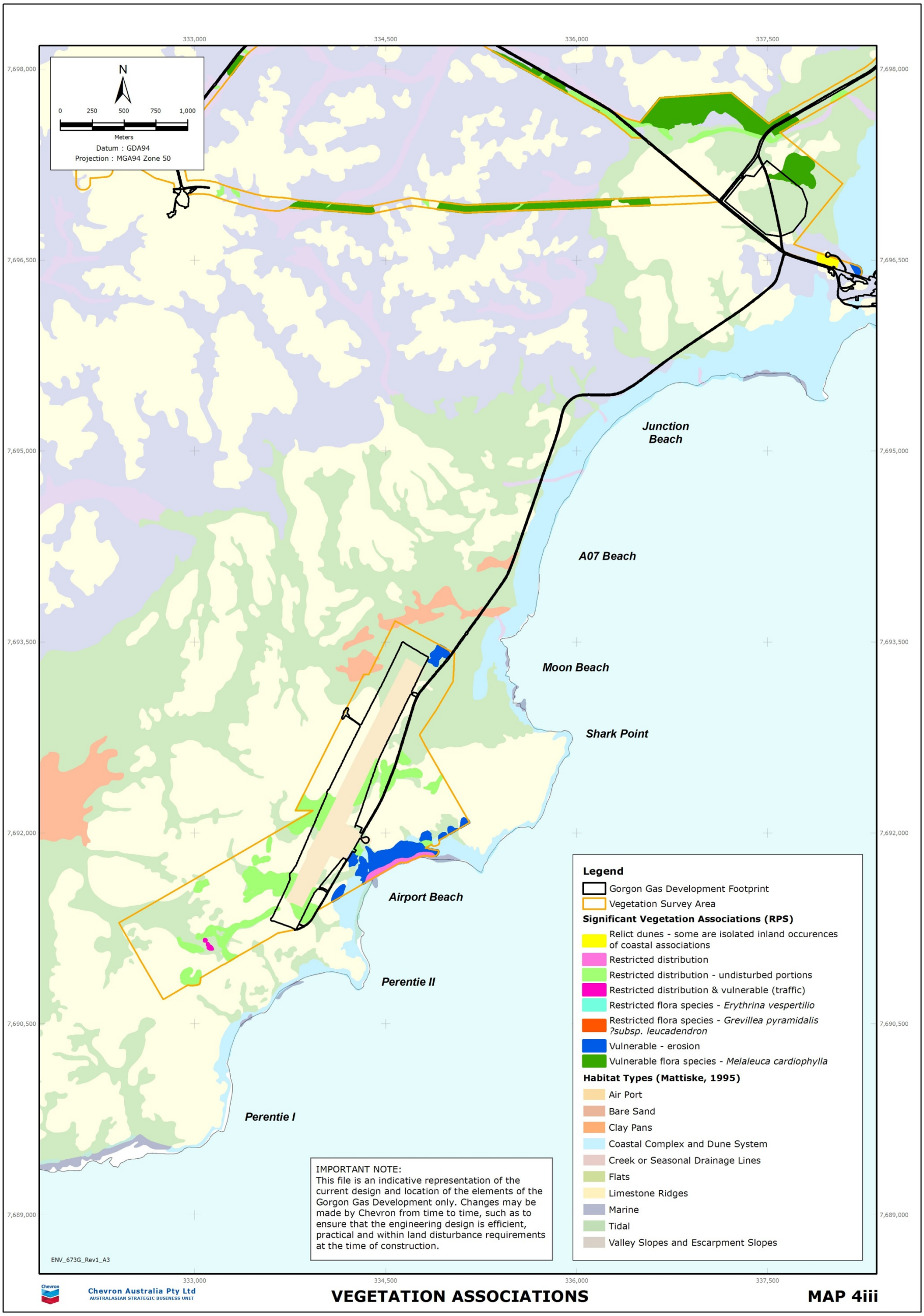

Legend
Lewis & Grierson Land Unit & Soil Sampling Sites (1988)
Goodall Flora Transects (1969)
CO2 Seismic Survey
Vegetation Survey Quadrats
Trudgen Survey (1989)
Mattiske Seismic Survey (1993)
Mattiske Vegetation Survey (1993)
RPSBBG (2003 - 2007)
Weed Surveys
Astron Surveys (2006 & 2008)
Previously Documented Sites (pre 2006)
Gorgon Gas Development Footprint
330,000
337,500
7,710,000
7,702,500
7,695,000
7,687,500
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Bob's Beach
Flacourt Bay
Mattress Point
Double Island
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0 1 2 3
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673B_Rev3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
FLORA AND VEGETATION SAMPLING
MAP 2

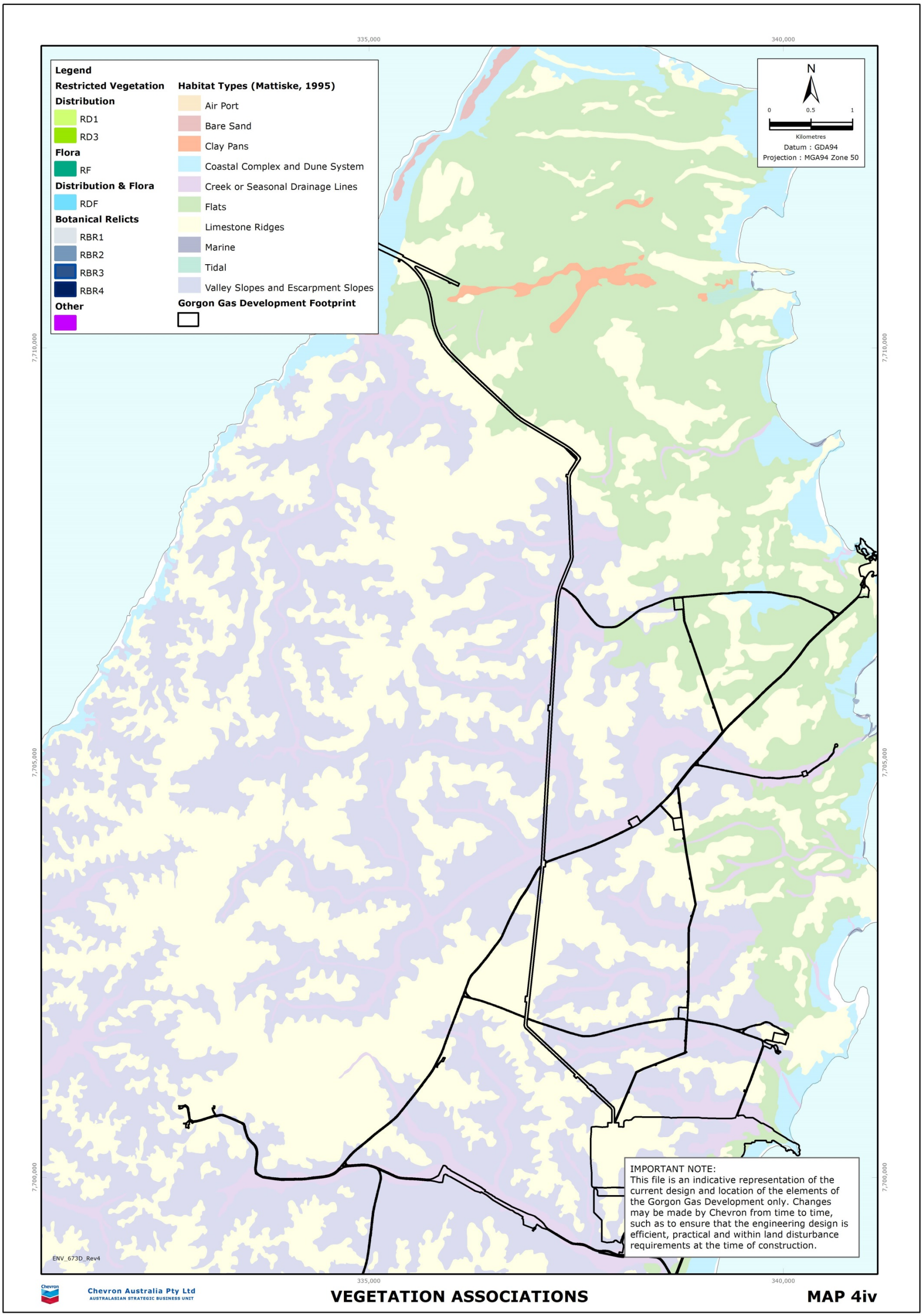



Legend
Restricted Vegetation Distribution
RD1
RD3
Flora
RF
Distribution & Flora
RDF
Botanical Relicts
RBR1
RBR2
RBR3
RBR4
Other
Habitat Types (Mattiske, 1995)
Air Port
Bare Sand
Clay Pans
Coastal Complex and Dune System
Creek or Seasonal Drainage Lines
Flats
Limestone Ridges
Marine
Tidal
Valley Slopes and Escarpment Slopes
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Bob's Beach
Flacourt Bay
Mattress Point
Double Island
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0 1 2 3
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673D_Rev1_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
VEGETATION ASSOCIATIONS
MAP 4




N
0 250 500 750 1,000
Metres
Datum : GDA94
Projection : MGA94 Zone 50
336,000
337,500
339,000
340,500
7,704,000
7,702,500
7,701,000
7,699,500
7,698,000
7,696,500
Dove Bay
Dove Point
Mushroom Rock Bay
Latitude Point
Terminal Beach
Town Point
Bivalve Beach
Inga Beach
Old Airport
Yacht Club Beach North
Yacht Club Beach South
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
Legend
Gorgon Gas Development Footprint
Vegetation Survey Area
Significant Vegetation Associations (RPS)
Relict dunes - some are isolated inland occurences of coastal associations
Restricted distribution
Restricted distribution - undisturbed portions
Restricted distribution & vulnerable (traffic)
Restricted flora species - Erythrina vespertilio
Restricted flora species - Grevillea pyramidalis ?subsp. leucadendron
Vulnerable - erosion
Vulnerable flora species - Melaleuca cardiophylla
Habitat Types (Mattiske, 1995)
Air Port
Bare Sand
Clay Pans
Coastal Complex and Dune System
Creek or Seasonal Drainage Lines
Flats
Limestone Ridges
Marine
Tidal
Valley Slopes and Escarpment Slopes
ENV_673F_Rev2_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
VEGETATION ASSOCIATIONS
MAP 4ii

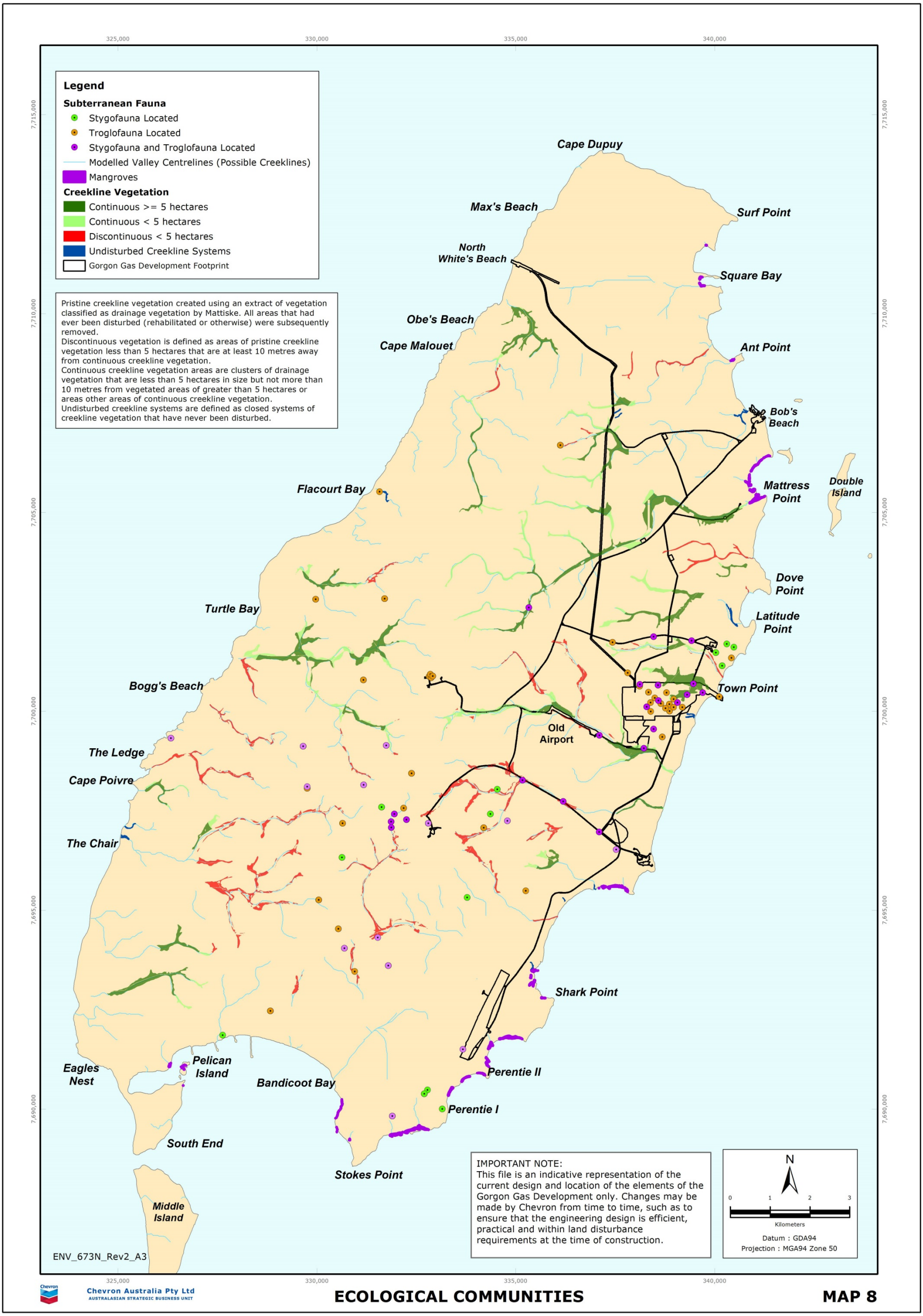



Legend
Restricted Vegetation Distribution
RD1
RD3
Flora
RF
Distribution & Flora
RDF
Botanical Relicts
RBR1
RBR2
RBR3
RBR4
Other
Habitat Types (Mattiske, 1995)
Air Port
Bare Sand
Clay Pans
Coastal Complex and Dune System
Creek or Seasonal Drainage Lines
Flats
Limestone Ridges
Marine
Tidal
Valley Slopes and Escarpment Slopes
Gorgon Gas Development Footprint
N
0
0.5
1
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
335,000
340,000
7,710,000
7,705,000
7,700,000
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
ENV_673D_Rev4
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
VEGETATION ASSOCIATIONS
MAP 4iv

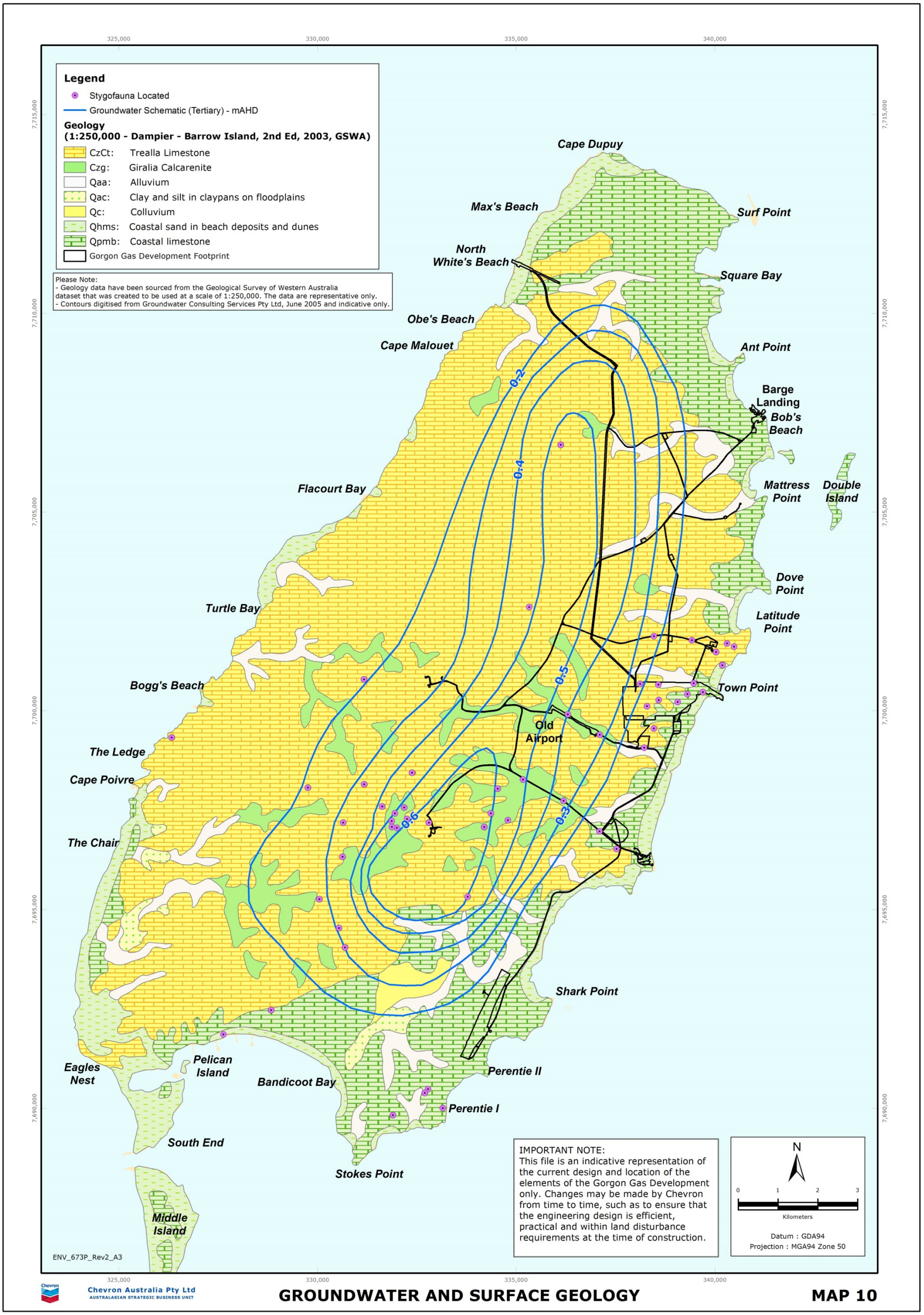

Legend
Invertebrates Surveys
Baseline Invertebrates Survey - Light Trapping (2006)
Baseline Non-Indigenous Invertebrates Survey (2006)
Rhagada Snails Survey (2004)
Baseline Invertebrates Survey Transects (2005-06)
Gorgon Gas Development Footprint
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Flacourt Bay
Mattress Point
Double Island
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0 1 2 3 4
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673I_Rev2_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
TERRESTRIAL INVERTEBRATE SAMPLING
MAP 5ii

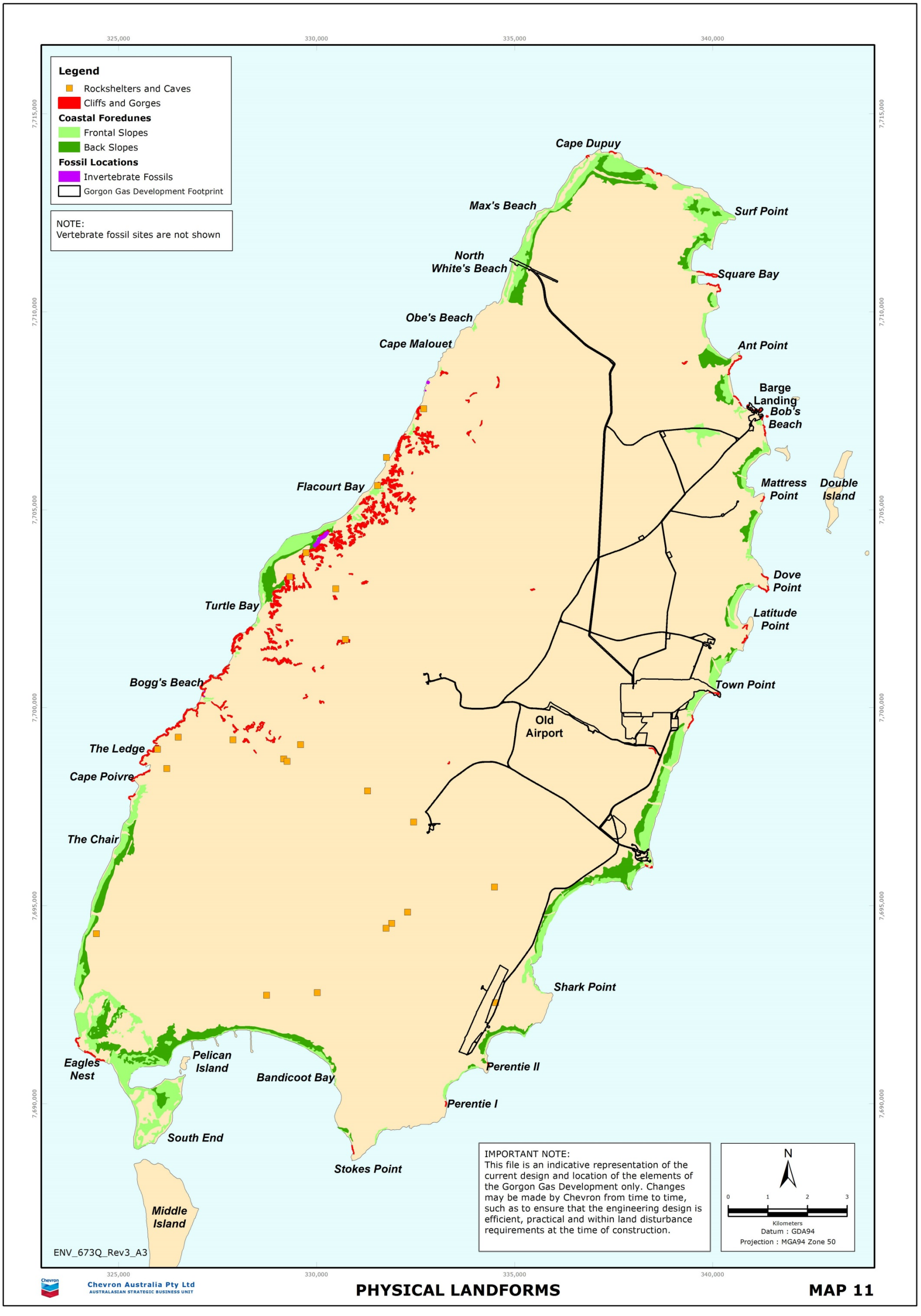

Legend
Small Rhagada Snail
Turtle Nesting Beaches
Shorebird and Wading Bird Concentrations
Bridled Tern and Wedge-tailed Shearwater Colony
White-winged Fairy-wrens (Barrow Island)
Rock Wallaby Confirmed (November 2004)
Gorgon Gas Development Footprint
Please Note: Only significant species with uneven distribution are shown.
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Double Island
Mattress Point
Flacourt Bay
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0 1 2 3 4
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673K_Rev2_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
TERRESTRIAL FAUNA
MAP 6i

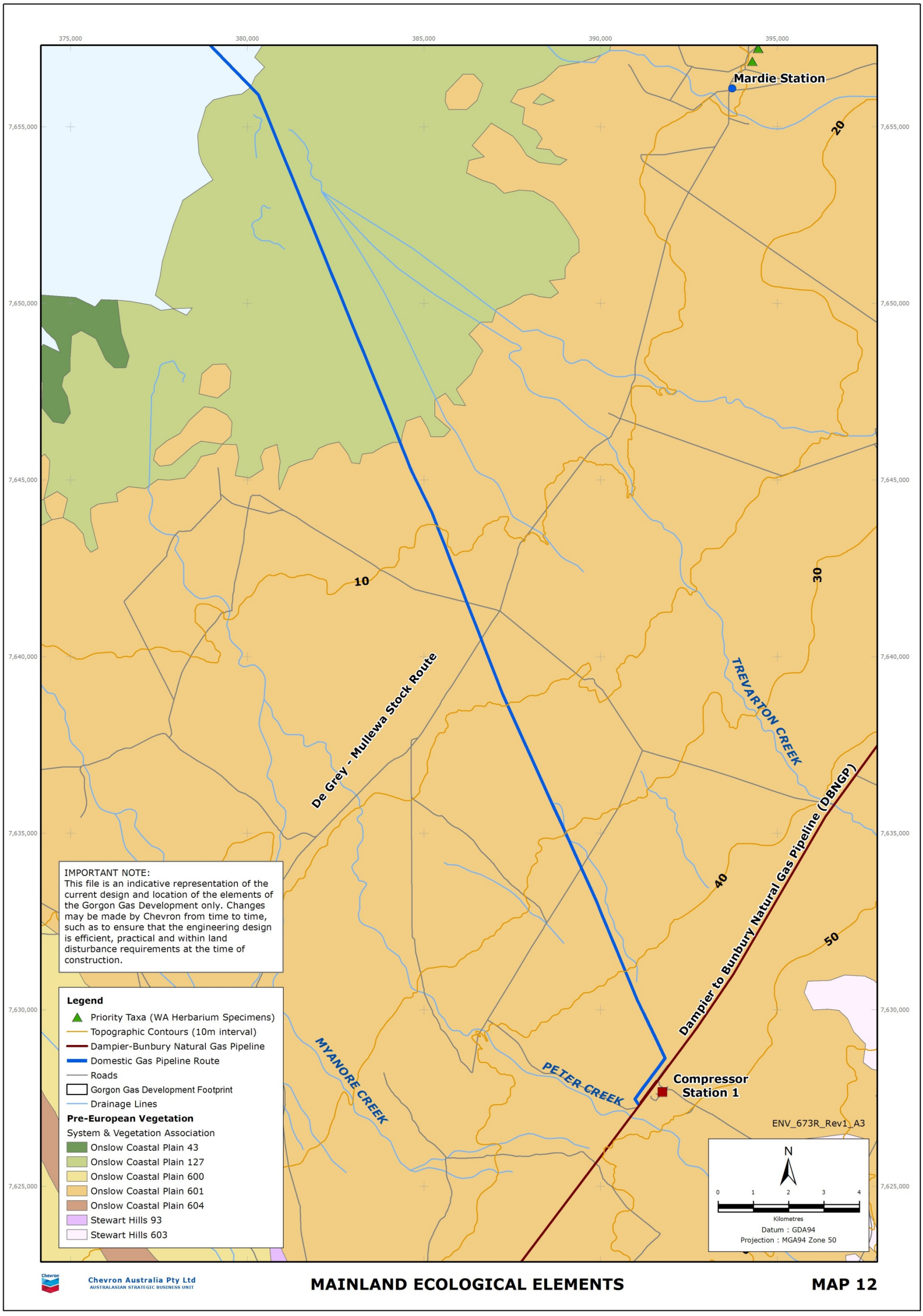

Legend
Boodie Warrens
Raptor Nest Locations
Confirmed Raptor Nest
Unconfirmed Raptor Nest
Termite Mounds (2012)
Extent of Aerial Interpretation
Individual Termite Mounds
Gorgon Gas Development Footprint
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Bob's Beach
Flacourt Bay
Mattress Point
Double Island
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0 1 2 3
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673M_Rev4_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
HABITAT
MAP 7

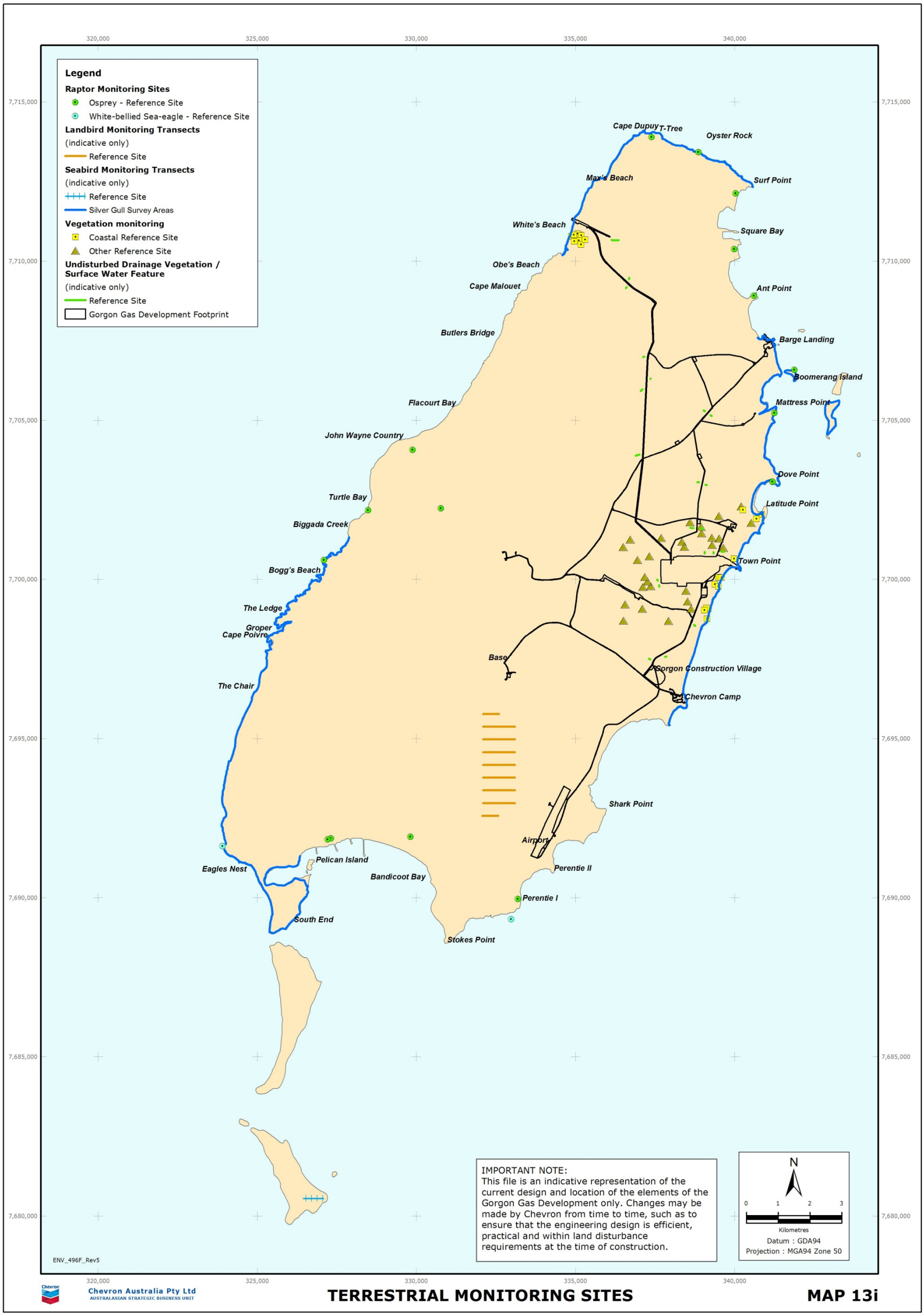



Legend
Potential Surface Water Flowlines
Modelled Valley Centrelines (Possible Creeklines)
Areas of Water Accumulation
Areas of Water Accumulation
Freshwater Seep
Gorgon Gas Development Footprint
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Bob's Beach
Flacourt Bay
Mattress Point
Double Island
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0
1
2
3
Kilometers
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673O_Rev2_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
SURFACE WATER LANDFORMS
MAP 9

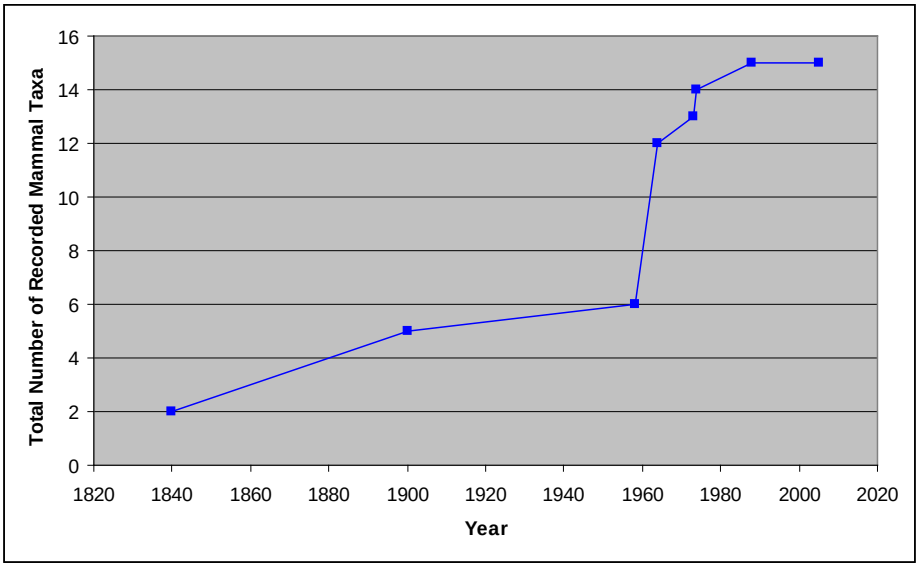



Legend
Rockshelters and Caves
Cliffs and Gorges
Coastal Foredunes
Frontal Slopes
Back Slopes
Fossil Locations
Invertebrate Fossils
Gorgon Gas Development Footprint
NOTE:
Vertebrate fossil sites are not shown
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
Cape Dupuy
Max's Beach
Surf Point
North White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Barge Landing
Bob's Beach
Flacourt Bay
Mattress Point
Double Island
Dove Point
Turtle Bay
Latitude Point
Bogg's Beach
Town Point
Old Airport
The Ledge
Cape Poivre
The Chair
Shark Point
Eagles Nest
Pelican Island
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
Middle Island
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0
1
2
3
Kilometers
Datum : GDA94
Projection : MGA94 Zone 50
ENV_673Q_Rev3_A3
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
PHYSICAL LANDFORMS
MAP 11



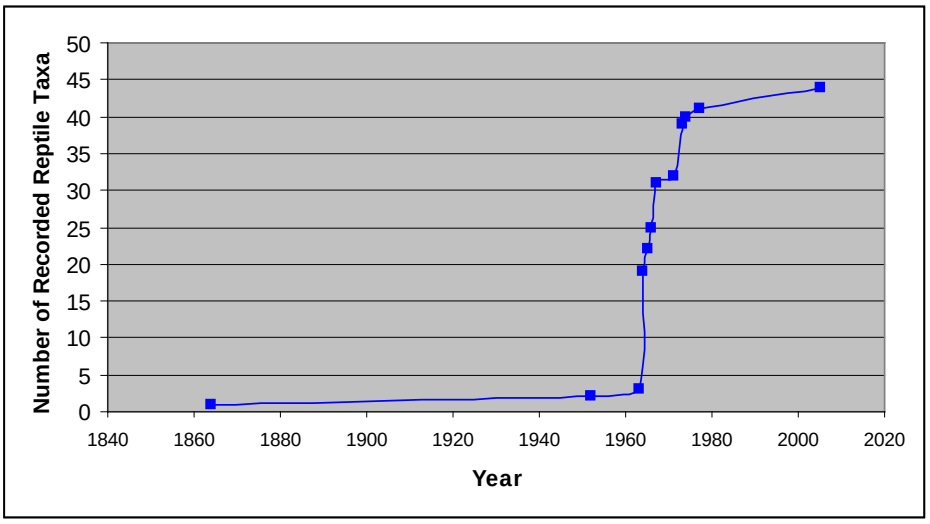

Legend
Raptor Monitoring Sites
Osprey - Reference Site
White-bellied Sea-eagle - Reference Site
Landbird Monitoring Transects
(indicative only)
Reference Site
Seabird Monitoring Transects
(indicative only)
Reference Site
Silver Gull Survey Areas
Vegetation monitoring
Coastal Reference Site
Other Reference Site
Undisturbed Drainage Vegetation / Surface Water Feature
(indicative only)
Reference Site
Gorgon Gas Development Footprint
320,000
325,000
330,000
335,000
340,000
7,715,000
7,710,000
7,705,000
7,700,000
7,695,000
7,690,000
7,685,000
7,680,000
Cape Dupuy
T-Tree
Oyster Rock
Max's Beach
Surf Point
White's Beach
Square Bay
Obe's Beach
Cape Malouet
Ant Point
Butlers Bridge
Barge Landing
Boomerang Island
Flacourt Bay
Mattress Point
John Wayne Country
Dove Point
Turtle Bay
Latitude Point
Biggada Creek
Town Point
Bogg's Beach
The Ledge
Groper
Cape Poivre
Base
Gorgon Construction Village
The Chair
Chevron Camp
Shark Point
Airport
Pelican Island
Eagles Nest
Bandicoot Bay
Perentie II
Perentie I
South End
Stokes Point
IMPORTANT NOTE:
This file is an indicative representation of the current design and location of the elements of the Gorgon Gas Development only. Changes may be made by Chevron from time to time, such as to ensure that the engineering design is efficient, practical and within land disturbance requirements at the time of construction.
N
0
1
2
3
Kilometres
Datum : GDA94
Projection : MGA94 Zone 50
ENV_496F_Rev5
Chevron Australia Pty Ltd
AUSTRALASIAN STRATEGIC BUSINESS UNIT
TERRESTRIAL MONITORING SITES
MAP 13i

Appendix 1 Species Accumulation Curves



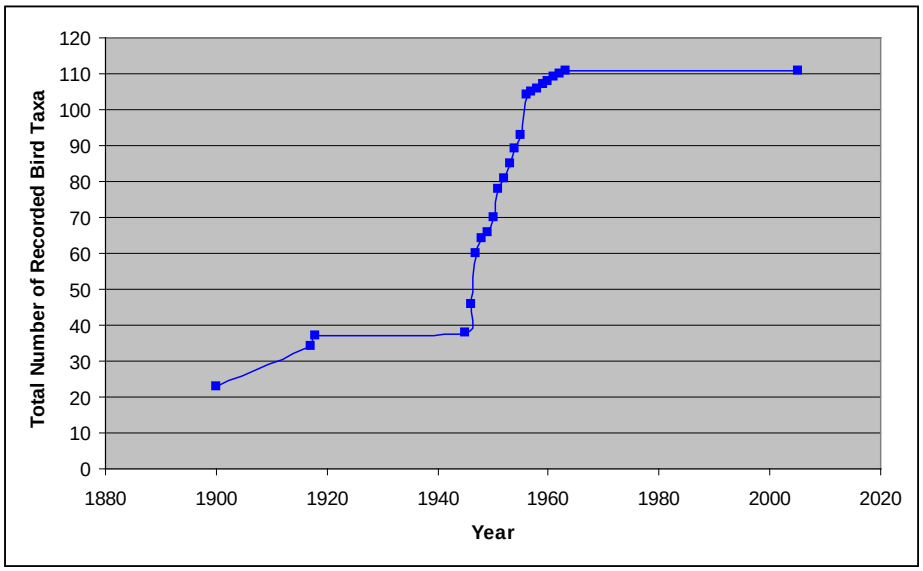
Source: West Australian Petroleum Pty Ltd 1989, Chevron Australia 2005

Appendix 1 Figure 1: Number of Mammal Taxa Recorded on Barrow Island



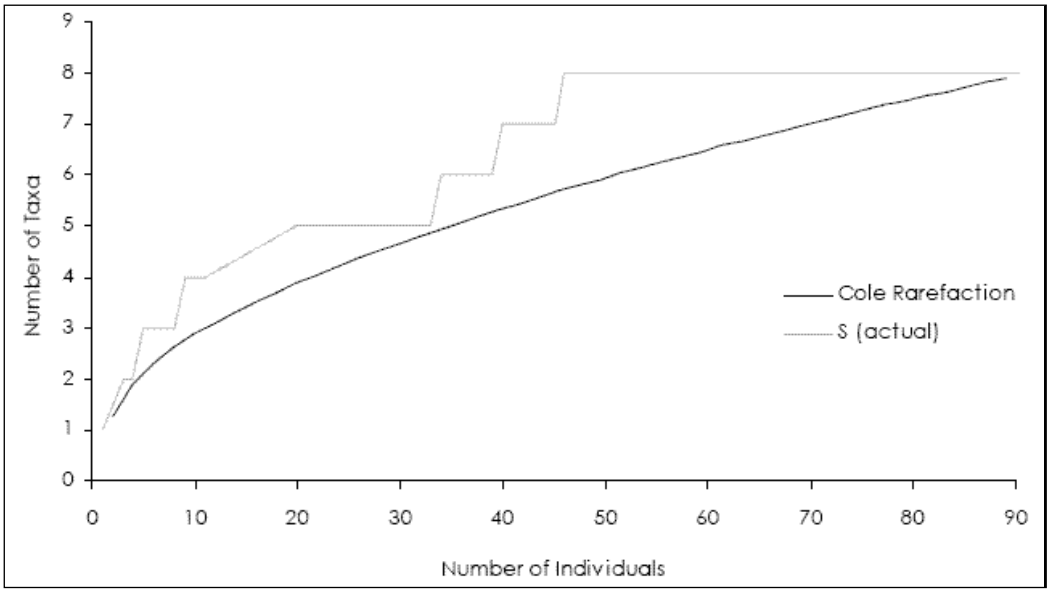
Source: West Australian Petroleum Pty Ltd 1989, Chevron Australia 2005

Appendix 1 Figure 2: Number of Reptile Taxa Recorded on Barrow Island



Source: West Australian Petroleum Pty Ltd 1989, Chevron Australia 2005

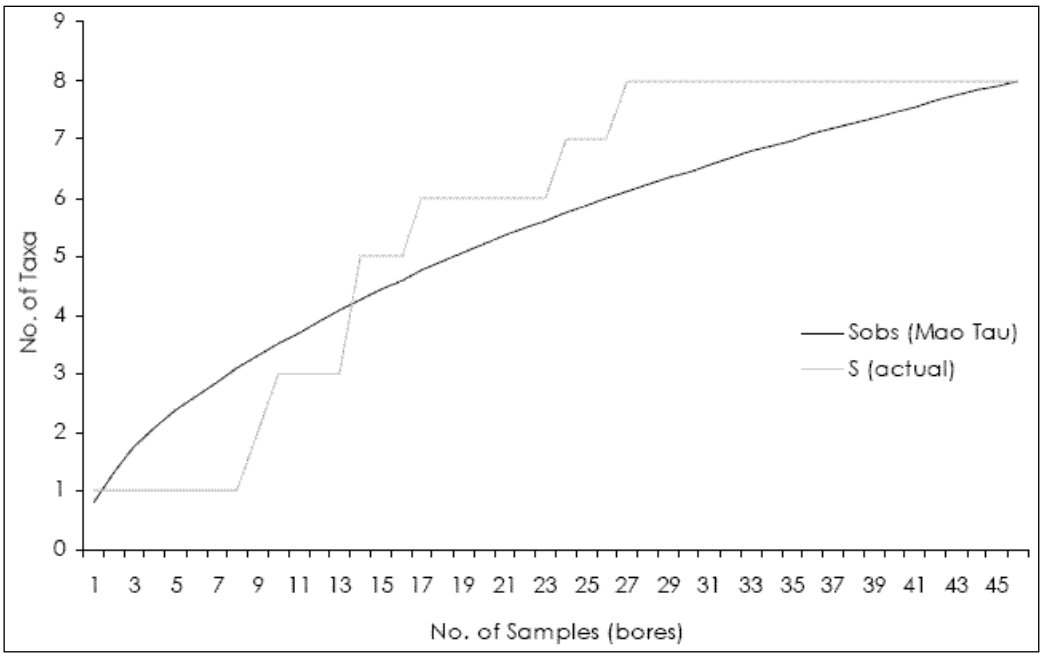
Appendix 1 Figure 3: Number of Bird Taxa Recorded on Barrow Island



Source: Biota Environmental Sciences 2007

Appendix 1 Figure 4: Individual-based Taxa Accumulation Curve for Troglobitic Fauna on Barrow Island

Note: Data pooled for Phases I to IV of sampling and taxa collected opportunistically not included.



Source: Biota Environmental Sciences 2007

Appendix 1 Figure 5: Sample-based Taxa Accumulation Curve for Troglobitic Fauna on Barrow Island

Note: Data pooled for Phases I to IV of sampling and taxa collected opportunistically not included.

Appendix 2 Flora Inventory

Appendix 2 Table 1: Barrow Island Flora Inventory

Only taxa for which voucher specimens are held at the Western Australian Herbarium are included.

Significant Ecological Elements are shaded in grey

Family		Species	In Footprint	DPaW Priority Taxa	Restricted Distribution on Barrow Island	At or near Geographical Extent	Low Regeneration Rate	Rarely Collected on Barrow Island
023	Potamogetonaceae	*Ruppia maritima*						
023C	Cymodoceaceae	*Halodule uninervis*						
029	Hydrocharitaceae	*Thalassia hemprichii*						
031	Poaceae	*Aristida contorta*						x
031	Poaceae	*Aristida holathera* var. *holathera*						x
031	Poaceae	*Bothriochloa bladhii*						x
031	Poaceae	*Cenchrus ciliaris*						
031	Poaceae	*Chrysopogon fallax*						x
031	Poaceae	*Cymbopogon ambiguus*	x					
031	Poaceae	*Cymbopogon procerus*						
031	Poaceae	*Cynodon dactylon*						
031	Poaceae	*Dactyloctenium radulans*						x
031	Poaceae	*Dichanthium sericeum* subsp. *humilius*						
031	Poaceae	*Enneapogon caerulescens*						
031	Poaceae	*Enneapogon lindleyanus*						
031	Poaceae	*Enneapogon oblongus*						
031	Poaceae	*Enneapogon polyphyllus*						x
031	Poaceae	*Eragrostis cumingii*						
031	Poaceae	*Eragrostis falcata*						
031	Poaceae	*Eragrostis xerophila*						x
031	Poaceae	*Eriachne flaccida*						
031	Poaceae	*Eriachne mucronata*	x					
031	Poaceae	*Eulalia aurea*						
031	Poaceae	*Iseilema dolichotrichum*						
031	Poaceae	*Paspalidium clementii*						
031	Poaceae	*Paspalidium tabulatum*	x					
031	Poaceae	*Setaria dielsii*						x
031	Poaceae	*Spinifex longifolius*						
031	Poaceae	*Sporobolus australasicus*						
031	Poaceae	*Sporobolus virginicus*						
031	Poaceae	*Triodia angusta*	x					
031	Poaceae	*Triodia epactia*						
031	Poaceae	*Triodia pungens*						
031	Poaceae	*Triodia wiseana*	x					
031	Poaceae	*Triraphis mollis*						x
031	Poaceae	*Yakirra australiensis*						x
032	Cyperaceae	*Bulbostylis barbata*	x					x
032	Cyperaceae	*Cyperus cunninghamii* subsp. *cunninghamii*						
047	Commelinaceae	*Commelina ensifolia*						x
054C	Dasypogonaceae	*Acanthocarpus robustus*				x		
054C	Dasypogonaceae	*Acanthocarpus verticillatus*	x					
054F	Anthericaceae	*Corynotheca flexuosissima*						x
087	Moraceae	*Ficus brachypoda*	x					
087	Moraceae	*Ficus virens* var. *virens*			x	x		
090	Proteaceae	*Hakea lorea* subsp. *lorea*	x					

	Family	Species	In Footprint	DPaW Priority Taxa	Restricted Distribution on Barrow Island	At or near Geographical Extent	Low Regeneration Rate	Rarely Collected on Barrow Island
105	Chenopodiaceae	*Atriplex isatidea*						
105	Chenopodiaceae	*Atriplex semilunaris*						x
105	Chenopodiaceae	*Chenopodium melanocarpum* forma *leucocarpum*						x
105	Chenopodiaceae	*Dysphania plantaginella*						
105	Chenopodiaceae	*Dysphania rhadinostachya* subsp*. inflata*						x
105	Chenopodiaceae	*Enchylaena tomentosa* var*. tomentosa*						
105	Chenopodiaceae	*Eremophea spinosa*						
105	Chenopodiaceae	*Neobassia astrocarpa*						
105	Chenopodiaceae	*Rhagodia latifolia*				x		
105	Chenopodiaceae	*Rhagodia preissii* subsp*. obovata*						
105	Chenopodiaceae	*Salsola tragus*						
105	Chenopodiaceae	*Tecticornia halocnemoides*						
105	Chenopodiaceae	*Tecticornia indica* subsp*. leiostachya*						
105	Chenopodiaceae	*Tecticornia pterygosperma* subsp*. denticulata*						
105	Chenopodiaceae	*Threlkeldia diffusa*						
106	Amaranthaceae	*Amaranthus pallidiflorus*	x					
106	Amaranthaceae	*Amaranthus sp. Barrow Island* (R. Buckley 6884)						
106	Amaranthaceae	*Gomphrena sordida*						x
106	Amaranthaceae	*Hemichroa diandra*						x
106	Amaranthaceae	*Ptilotus appendiculatus*						
106	Amaranthaceae	*Ptilotus appendiculatus* var*. appendiculatus*						
106	Amaranthaceae	*Ptilotus clementii*	x					
106	Amaranthaceae	*Ptilotus exaltatus* var*. exaltatus*						
106	Amaranthaceae	*Ptilotus fusiformis*						
106	Amaranthaceae	*Ptilotus fusiformis* var*. fusiformis*						x
106	Amaranthaceae	*Ptilotus obovatus*						
106	Amaranthaceae	*Ptilotus obovatus* var*. obovatus*	x					
106	Amaranthaceae	*Ptilotus villosiflorus*						
107	Nyctaginaceae	*Boerhavia burbidgeana*						
107	Nyctaginaceae	*Boerhavia coccinea*						
107	Nyctaginaceae	*Commicarpus australis*						
108	Gyrostemonaceae	*Codonocarpus cotinifolius*	x					
110	Aizoaceae	*Sesuvium portulacastrum*						
111	Portulacaceae	*Calandrinia remota*	x			x		
111	Portulacaceae	*Portulaca intraterranea*						
111	Portulacaceae	*Portulaca pilosa*						
113	Caryophyllaceae	*Polycarpaea longiflora*	x					
122	Menispermaceae	*Tinospora smilacina*						
135	Papaveraceae	*Papaver somniferum*						
137A	Capparaceae	*Capparis lasiantha*						x
137A	Capparaceae	*Capparis spinosa*						
137A	Capparaceae	*Capparis spinosa* var*. nummularia*						
137A	Capparaceae	*Cleome viscosa*	x					
138	Brassicaceae	*Lepidium platypetalum*						x
152	Pittosporaceae	*Pittosporum phylliraeoides*	x					
160	Surianaceae	*Stylobasium spathulatum*	x					
163	Mimosaceae	*Acacia bivenosa*	x					
163	Mimosaceae	*Acacia colei* var*. colei*			x			
163	Mimosaceae	*Acacia coriacea*						

	Family	Species	In Footprint	DPaW Priority Taxa	Restricted Distribution on Barrow Island	At or near Geographical Extent	Low Regeneration Rate	Rarely Collected on Barrow Island
163	Mimosaceae	*Acacia coriacea* subsp. *coriacea*	x					
163	Mimosaceae	*Acacia gregorii*	x					
163	Mimosaceae	*Acacia pyrifolia* var. *pyrifolia*	x					
163	Mimosaceae	*Acacia robeorum*						
163	Mimosaceae	*Acacia synchronicia*			x			
163	Mimosaceae	*Acacia trudgeniana*			x			
164	Caesalpiniaceae	*Petalostylis labicheoides*						
164	Caesalpiniaceae	*Senna artemisioides* subsp. *oligophylla*						
164	Caesalpiniaceae	*Senna glutinosa* subsp. *pruinosa*						
164	Caesalpiniaceae	*Senna notabilis*						
165	Papilionaceae	*Canavalia rosea*						x
165	Papilionaceae	*Crotalaria cunninghamii*						
165	Papilionaceae	*Crotalaria medicaginea* var. *neglecta*						
165	Papilionaceae	*Cullen lachnostachys*						
165	Papilionaceae	*Cullen leucanthum*						
165	Papilionaceae	*Cullen pogonocarpum*						x
165	Papilionaceae	*Erythrina vespertilio*			x			
165	Papilionaceae	*Indigofera boviperda*						
165	Papilionaceae	*Indigofera colutea*						
165	Papilionaceae	*Indigofera linifolia*						
165	Papilionaceae	*Indigofera linnaei*						x
165	Papilionaceae	*Indigofera monophylla*	x					
165	Papilionaceae	*Indigofera trita*						
165	Papilionaceae	*Indigofera trita* subsp. *trita*						
165	Papilionaceae	*Lotus cruentus*						
165	Papilionaceae	*Rhynchosia australis*						
165	Papilionaceae	*Rhynchosia minima*	x					
165	Papilionaceae	*Sesbania cannabina*						x
165	Papilionaceae	*Swainsona kingii*						x
165	Papilionaceae	*Swainsona pterostylis*						x
165	Papilionaceae	*Tephrosia rosea*						
165	Papilionaceae	*Tephrosia rosea* var. *clementii*	x					
165	Papilionaceae	*Tephrosia rosea* var. *glabrior*						
173	Zygophyllaceae	*Tribulus cistoides*						
173	Zygophyllaceae	*Tribulus terrestris*						
185	Euphorbiaceae	*Adriana urticoides* var. *urticoides*	x					
185	Euphorbiaceae	*Euphorbia alsiniflora*						
185	Euphorbiaceae	*Euphorbia australis*	x					
185	Euphorbiaceae	*Euphorbia coghlanii*	x					
185	Euphorbiaceae	*Euphorbia drummondii* subsp. *drummondii*	x					x
185	Euphorbiaceae	*Euphorbia myrtoides*						
185	Euphorbiaceae	*Euphorbia tannensis* subsp. *eremophila*						
185	Euphorbiaceae	*Mallotus nesophilus*	x					
185	Euphorbiaceae	*Phyllanthus maderaspatensis*	x					
202	Stackhousiaceae	*Stackhousia muricata*	x					
207	Sapindaceae	*Diplopeltis eriocarpa*	x					
207	Sapindaceae	*Dodonaea lanceolata*						
207	Sapindaceae	*Dodonaea lanceolata* var. *lanceolata*	x					
215	Rhamnaceae	*Ventilago viminalis*			x			
220	Tiliaceae	*Corchorus congener*	x	x				
220	Tiliaceae	*Corchorus parviflorus*						
220	Tiliaceae	*Corchorus walcottii*	x					

	Family	Species	In Footprint	DPaW Priority Taxa	Restricted Distribution on Barrow Island	At or near Geographical Extent	Low Regeneration Rate	Rarely Collected on Barrow Island
220	Tiliaceae	*Triumfetta clementii*						
220	Tiliaceae	*Triumfetta ramosa*						
221	Malvaceae	*Abutilon cunninghamii*	x					
221	Malvaceae	*Gossypium robinsonii*	x					
221	Malvaceae	*Hibiscus leptocladus*						
221	Malvaceae	*Hibiscus sturtii* var. *platychlamys*			x			
221	Malvaceae	*Lawrencia viridigrisea*						x
221	Malvaceae	*Malvastrum americanum*						
221	Malvaceae	*Sida fibulifera*						
223	Sterculiaceae	*Hannafordia quadrivalvis* subsp. *recurva*	x					
223	Sterculiaceae	*Melhania oblongifolia*						x
223	Sterculiaceae	*Waltheria indica*						
236	Frankeniaceae	*Frankenia ambita*						
248	Passifloraceae	*Passiflora foetida* var. *hispida*						
273	Myrtaceae	*Eucalyptus xerothermica*			x			
273	Myrtaceae	*Melaleuca cardiophylla*	x				x	
276	Haloragaceae	*Haloragis gossei*	x					
276	Haloragaceae	*Haloragis gossei* var. *gossei*						
294	Plumbaginaceae	*Muellerolimon salicorniaceum*						
294	Plumbaginaceae	*Plumbago zeylanica*						
301	Oleaceae	*Jasminum calcarium*			x			
301	Oleaceae	*Jasminum sp. Exmouth* (G. Marsh 77)						
303	Gentianaceae	*Centaurium clementii*						
305	Asclepiadaceae	*Cynanchum floribundum*	x					
305	Asclepiadaceae	*Sarcostemma viminale* subsp. *australe*	x					
305	Asclepiadaceae	*Tylophora flexuosa*						x
307	Convolvulaceae	*Convolvulus clementii*						
307	Convolvulaceae	*Evolvulus alsinoides*						
307	Convolvulaceae	*Evolvulus alsinoides* var. *decumbens*						x
307	Convolvulaceae	*Polymeria ambigua*	x					
310	Boraginaceae	*Cordia subcordata*						
310	Boraginaceae	*Heliotropium crispatum*						
310	Boraginaceae	*Heliotropium cunninghamii*						
310	Boraginaceae	*Heliotropium glanduliferum*	x					
310	Boraginaceae	*Heliotropium inexplicitum*				x		
310	Boraginaceae	*Trichodesma zeylanicum*	x					
312	Avicenniaceae	*Avicennia marina* subsp. *marina*						
313	Lamiaceae	*Clerodendrum tomentosum*			x			
313	Lamiaceae	*Clerodendrum tomentosum* var. *lanceolatum*						
313	Lamiaceae	*Clerodendrum tomentosum* var. *mollissima*						
315	Solanaceae	*Nicotiana occidentalis* subsp. *occidentalis*	x					
315	Solanaceae	*Nicotiana rosulata* subsp. *rosulata*				x		
315	Solanaceae	*Solanum diversiflorum*	x					
315	Solanaceae	*Solanum ellipticum*	x					
315	Solanaceae	*Solanum esuriale*				x		
315	Solanaceae	*Solanum lasiophyllum*	x					
315	Solanaceae	*Solanum nigrum*						
325	Acanthaceae	*Dicladanthera forrestii*						x
325	Acanthaceae	*Dipteracanthus australasicus* subsp. *corynothecus*						x
326	Myoporaceae	*Eremophila forrestii* subsp. *forrestii*				x		

	Family	Species	In Footprint	DPaW Priority Taxa	Restricted Distribution on Barrow Island	At or near Geographical Extent	Low Regeneration Rate	Rarely Collected on Barrow Island
326	Myoporaceae	*Myoporum montanum*	x					
331	Rubiaceae	*Oldenlandia crouchiana*						
331	Rubiaceae	*Psydrax latifolia*						
331	Rubiaceae	*Synaptantha tillaeacea*						
331	Rubiaceae	*Synaptantha tillaeacea* var. *tillaeacea*						
337	Cucurbitaceae	*Cucumis sp. Barrow Island* (D.W. Goodall 1264)	x	x				
341	Goodeniaceae	*Goodenia microptera*						
341	Goodeniaceae	*Scaevola amblyanthera* var. *amblyanthera*						
341	Goodeniaceae	*Scaevola amblyanthera* var. *centralis*						
341	Goodeniaceae	*Scaevola crassifolia*						x
341	Goodeniaceae	*Scaevola cunninghamii*	x					
341	Goodeniaceae	*Scaevola sericophylla*						x
341	Goodeniaceae	*Scaevola spinescens*	x					
345	Asteraceae	*Centipeda minima*						
345	Asteraceae	*Centipeda minima* subsp. *macrocephala*						
345	Asteraceae	*Flaveria australasica*						
345	Asteraceae	*Olearia dampieri* subsp. *dampieri*	x					
345	Asteraceae	*Pentalepis trichodesmoides*	x					
345	Asteraceae	*Pluchea dentex*	x					
345	Asteraceae	*Pluchea dunlopii*						x
345	Asteraceae	*Pluchea ferdinandi-muelleri*						
345	Asteraceae	*Pluchea rubelliflora*						
345	Asteraceae	*Pluchea sp. B Kimberley Flora* (K.F. Kenneally 9526A)						x
345	Asteraceae	*Pterocaulon sphacelatum*	x					
345	Asteraceae	*Pterocaulon sphaeranthoides*	x					
345	Asteraceae	*Streptoglossa bubakii*	x					
345	Asteraceae	*Streptoglossa decurrens*	x					
345	Asteraceae	*Streptoglossa macrocephala*						
345	Asteraceae	*Vittadinia arida*				x		
345	Asteraceae	*Vittadinia obovata*				x		

Sources: Western Australian Herbarium 2008; RPS BBG 2006b; Astron Environmental Services 2008a

Appendix 2 Table 2: Mainland Flora Inventory

Significant Ecological Elements shaded in grey

Family	Species	Recorded on Alignment[1, 2]	Vouchered in Locality of Mardie Station[3]	Weed[3]	Conservation Significance[3]
AIZOACEAE	*Trianthema triquetra*		x		
AIZOACEAE	*Zaleya galericulata* subsp. *galericulata*		x		
AMARANTHACEAE	*Achyranthes aspera*		x		
AMARANTHACEAE	*Aerva javanica*		x	x	
AMARANTHACEAE	*Amaranthus undulatus*		x		
AMARANTHACEAE	*Ptilotus axillaris*		x		
AMARANTHACEAE	*Ptilotus divaricatus*	x			
AMARANTHACEAE	*Ptilotus gomphrenoides*		x		
AMARANTHACEAE	*Ptilotus helipteroides* var. *helipteroides*		x		
AMARANTHACEAE	*Ptilotus macrocephalus*		x		
AMARANTHACEAE	*Ptilotus murrayi*		x		
APIACEAE	*Trachymene oleracea* subsp. *oleracea*		x		
ASCLEPIADACEAE	*Sarcostemma viminale* subsp. *australe*		x		
ASTERACEAE	*Angianthus acrohyalinus*		x		
ASTERACEAE	*Calotis multicaulis*		x		
ASTERACEAE	*Pterocaulon sphaeranthoides*	x			
AVICENNIACEAE	*Avicennia marina* subsp. *?eucalyptifolia*	x			
BORAGINACEAE	*Heliotropium ovalifolium*		x		
CAESALPINIACEAE	*Senna notabilis*		x		
CAESALPINIACEAE	*Tamarindus indica*		x	x	
CHENOPODIACEAE	*Dysphania rhadinostachya*subsp. *rhadinostachya*		x		
CHENOPODIACEAE	*Enchylaena tomentosa* var. *tomentosa*		x		
CHENOPODIACEAE	*Neobassia astrocarpa*	x			
CHENOPODIACEAE	*Salsola tragus*	x			
CHENOPODIACEAE	*Sclerolaena glabra*		x		
CHENOPODIACEAE	*Suaeda arbusculoides*	x			
CHENOPODIACEAE	*Tecticornia halocnemoides subsp. tenuis*	x			
CHENOPODIACEAE	*Tecticornia indica*	x			
CONVOLVULACEAE	*Ipomoea coptica*		x		
CONVOLVULACEAE	*Ipomoea costata*		x		
CONVOLVULACEAE	*Ipomoea muelleri*	x			
CUCURBITACEAE	*Cucumis maderaspatana*		x		
CYPERACEAE	*Cyperus vaginatus*		x		
CYPERACEAE	*Schoenoplectus subulatus*		x		
EUPHORBIACEAE	*Euphorbia boophthona*		x		
EUPHORBIACEAE	*Euphorbia coghlanii*		x		
EUPHORBIACEAE	*Euphorbia drummondii*		x		
EUPHORBIACEAE	*Phyllanthus maderaspatensis*		x		
FRANKENIACEAE	*Frankenia ambita*	x			
FRANKENIACEAE	*Frankenia pauciflora*	x			
GOODENIACEAE	*Goodenia nuda*		x		P3
MALVACEAE	*Lawrencia viridigrisea*	x			
MELIACEAE	*Owenia acidula*		x		P3
MIMOSACEAE	*Acacia ampliceps*	x			
MIMOSACEAE	*Acacia ancistrocarpa*	x	x		
MIMOSACEAE	*Acacia bivenosa*	x			
MIMOSACEAE	*Acacia cowleana*	x			
MIMOSACEAE	*Acacia elachantha*	x			
MIMOSACEAE	*Acacia farnesiana*	x			
MIMOSACEAE	*Acacia glaucocaesia*		x		P3
MIMOSACEAE	*Acacia pyrifolia* var. *pyrifolia*		x		

Family	Species	Recorded on Alignment[1,2]	Vouchered in Locality of Mardie Station[3]	Weed[3]	Conservation Significance[3]
MIMOSACEAE	*Acacia trachycarpa*	x			
MIMOSACEAE	*Acacia victoriae*	x			
MIMOSACEAE	*Acacia xiphophylla*	x			
MIMOSACEAE	*Neptunia dimorphantha*	x	x		
MIMOSACEAE	*Prosopis glandulosa x velutina*	x	x	x	
MYOPORACEAE	*Eremophila longifolia*		x		
MYOPORACEAE	*Myoporum montanum*		x		
MYRSINACEAE	*Aegiceras corniculatum*	x			
PAPILIONACEAE	*Indigofera colutea*		x		
PAPILIONACEAE	*Indigofera linifolia*		x		
PAPILIONACEAE	*Lotus cruentus*		x		
PAPILIONACEAE	*Rhynchosia minima*	x			
PAPILIONACEAE	*Swainsona kingii*		x		
PAPILIONACEAE	*Swainsona pterostylis*		x		
POACEAE	*?Cenchrus* sp. *(*likely to be *Cenchrus ciliaris)*	x			
POACEAE	*Aristida contorta*	x			
POACEAE	*Aristida holathera* var. *holathera*	x			
POACEAE	*Astrebla pectinata*		x		
POACEAE	*Cenchrus ciliaris*	x			
POACEAE	*Dichanthium sericeum* subsp. *humilius*	x			
POACEAE	*Enneapogon caerulescens*		x		
POACEAE	*Eragrostis dielsii*	x			
POACEAE	*Eragrostis falcata*	x			
POACEAE	*Eragrostis setifolia*	x	x		
POACEAE	*Eragrostis tenellula*		x		
POACEAE	*Eragrostis xerophila*	x	x		
POACEAE	*Eriachne benthamii*	x	x		
POACEAE	*Eriachne flaccida*	x			
POACEAE	*Eulalia aurea*		x		
POACEAE	*Panicum decompositum*	x			
POACEAE	*Setaria dielsii*		x		
POACEAE	*Sorghum plumosum*		x		
POACEAE	*Sorghum* sp.		x		
POACEAE	*Sorghum timorense*		x		
POACEAE	*Sporobolus australasicus*		x		
POACEAE	*Tragus australianus*		x		
POACEAE	*Triodia epactia*	x			
POACEAE	*Triodia pungens*	x			
PORTULACACEAE	*Calandrinia ptychosperma*		x		
PROTEACEAE	*Hakea lorea*subsp. *lorea*		x		
RHIZOPHORACEAE	*Bruguiera exaristata*	x			
RHIZOPHORACEAE	*Ceriops tagal*	x			
RHIZOPHORACEAE	*Rhizophora stylosa*	x			
SCROPHULARIACEAE	*Mimulus uvedaliae*		x		
SCROPHULARIACEAE	*Stemodia floribunda*	x			
SCROPHULARIACEAE	*Stemodia kingii*		x		
SOLANACEAE	*Nicotiana occidentalis* subsp. *obliqua*		x		
SOLANACEAE	*Solanum gabrielae*		x		
TILIACEAE	*Corchorus laniflorus*		x		
TILIACEAE	*Corchorus trilocularis*		x		
TILIACEAE	*Corchorus walcottii*		x		
TILIACEAE	*Triumfetta appendiculata*		x		

Sources: *1 Chevron Australia 2005*
2 Dames and Moore 1998
3 Western Australian Herbarium 2008

Appendix 3 Barrow Island Vegetation Summary

Appendix 3 Table 1: Summary of Vegetation Formations

Significant Ecological Elements shaded in grey

Formation[1]	Description[1]	Soils[1]	Avg. Total % Cover undisturbed sites[2]	[3]	Avg. number of taxa (100 m^2)[3]	Significance[1]	Total Extent[1] (ha)
C1	Coastal Complex dominated by *Spinifex longifolius* on white foredunes; including Coastal Complex of *Ipomoea pes-caprae* subsp. *brasiliensis* and *Spinifex longifolius* on strand line foredunes	Deep coarse light coloured soils	17	24	2.34	Vulnerable (erosion)	257.4
C2	Open Scrub of *Acacia coriaea* - *Rhagodia* subsp. *obovata* - *Olearia dampieri* subsp. *dampieri* on elevated dunes on fringes of island	Deep coarse light coloured sands	59	60	4.64	Vulnerable (erosion)	535.2
C3	Hummock Grassland of *Triodia pungens* with dense shrubs including *Acacia bivenosa* on back-slopes of foredunes	Deep coarse red sands	83	-		Vulnerable (erosion)	414.0
C4	Mixed Hummock Grassland of *Triodia angusta* - *Triodia pungens* with dense shrubs including *Acacia bivenosa* on back-slopes of foredunes	Deep coarse red sands	-	-		Vulnerable (erosion)	69.6
C5	Low Mixed Shrubland of *Frankenia pauciflora* and *Oldenlandia crouchina* on exposed cliff faces around edge of island	Shallow limestone outcrops	5	6	6.45		205.4
C6	Hummock Grassland of *Triodia pungens* with dense pockets of *Melaleuca cardiophylla* on sandy valley systems in the south-western corner of the island	Deep coarse red sands	84	-		Vulnerable (erosion)	14.2
C7	Hummock Grassland of *Triodia pungens* with dense pockets of *Olearia dampieri* subsp. *dampieri* on sandy soils behind foredune in south-western corner of island.	Deep coarse red sands	96	-		Vulnerable (erosion)	38.2
D1	Mixed Hummock Grassland of *Triodia pungens* with pockets of dense shrubs along major creeklines	Variable but generally sandy	-	72	6.73	Restricted distribution - undisturbed portions	37.1
D2	Hummock Grassland of *Triodia angusta* along minor creek-lines and drainage lines	Variable but generally sandy	50	-		Restricted distribution - undisturbed portions	1096.7
D3	Hummock Grassland of *Triodia angusta* along minor creek-line with emergent *Santalum murrayanum*	Variable but generally sandy	-	-		Restricted distribution - undisturbed portions	0.6
F1	Hummock Grassland of *Triodia angusta* on red earths and drainage lines	Deep coarse red sands	58	-			1567.2
F2	Hummock Grassland of *Triodia angusta* with emergent *Acacia synchronicia* on red earth flat	Red sandy-clays	106	-		Restricted distribution	9.0
F3	Hummock Grassland of *Triodia angusta* with emergent shrubs of *Gossypium robinsonnii* on red earth flats	Red sandy-clays	65	-		Restricted distribution	36.9
F4	Hummock Grassland of *Triodia angusta* - *Triodia* species with emergent pockets of *Erythrina vespertilio* on flats	Red sandy-clays	60	-		Restricted species - *Erythrina vespertilio*	42.2

Formation[1]	Description[1]	Soils[1]	Avg. Total % Cover undisturbed sites		Avg. number of taxa (100 m^2)[3]	Significance[1]	Total Extent[1] (ha)
			2	3			
F5	Mixed Hummock Grassland of *Triodia pungens* - *Triodia angusta* on fringes of main red earth flats and drainage lines	Red sands	47	-			1374.3
F6	Hummock grassland of *Triodia pungens* on slopes of escarpments on fringes of red earth flats	Red sands	69	-			137.5
F7	Hummock Grassland of *Triodia pungens* - *Triodia angusta* - *Triodia wiseana* on slopes of escarpments on fringes of red earth flats	Red sands	42	-			856.2
F8	Open Low Shrubland of *Acacia bivenosa* over Hummock Grassland of *Triodia wiseana* - *Triodia angusta* on flats, valleys floors and loams fringing claypans	-	-	82	4.33		NA
L1	Hummock Grassland of *Triodia wiseana* with *Ficus brachypoda* on central limestone ridges	Shallow limestone	47	-			2727.8
L2	Hummock Grassland of *Triodia wiseana* with *Ficus virens* var. *virens* on escarpments on west coast and southern edge of limestone ridges	Shallow limestone	-	-		Restricted species - *Ficus virens* var. virens	19.6
L3	Hummock Grassland of *Triodia wiseana* with low mixed shrubs, including *Acacia gregorii* on limestone ridges	Shallow limestone	42	64	5.29		2782.5
L4	Hummock Grassland of *Triodia wiseana* with dense emergent shrubs of *Acacia pyrifolia*, *Acacia gregorii* and *Petalostylis labicheoides* on dense limestone ridges	Shallow limestone	49	60	3.60		322.7
L5	Hummock grassland of *Triodia wiseana* with emergent *Hakea lorea* subsp. *lorea* on limestone ridges	Shallow limestone	70	57	8.88		105.7
L6	Hummock Grassland of *Triodia wiseana* with emergent *Grevillea pyramidalis* on limestone ridges	Shallow limestone	69	65	7.40		93.7
L7	Hummock Grassland of *Triodia wiseana* with dense pockets of *Melaleuca cardiophylla* on limestone ridges	Shallow limestone	48	56	4.93		1583.4
L8	Hummock Grassland of *Triodia wiseana* with pockets of *Eucalyptus xerothermica* on limestone ridges	Shallow limestone	76	-		Restricted species - *Eucalyptus xerothermica*	8.8
L9	Hummock Grassland of *Triodia wiseana* - *Triodia angusta* with emergent *Sarcostemma viminale* subsp. *australe* and *Ficus brachypoda* on coastal limestone flats and low ridges with localised pockets of *Frankenia pauciflora*	Shallow limestone	50	54	4.36		1747.3
L10	Hummock Grassland of *Triodia pungens* - *Triodia angusta* with emergent *Hakea lorea* subsp. *lorea* on exposed small limestone hills on southern coastal area	Shallow limestone	89	-		Restricted distribution	47.5
M1	Aquatic Complex supporting stands of *Avicennia marina* and *Ruppia maritima* on fringes of maritima on fringes of the island	Coarse sand	-	-		Restricted distribution	23.9
S1	Mixed Herbfield and Grassland of *Eragrostis xerophila* - *Eriachne flaccida* - *Sporobolus virginicus* on claypans	Clay	-	-		Restricted distribution & vulnerable (traffic)	192.2
S2	Mixed Herbfields with *Streptoglossa bubakii* and *Pterocaulon sphacelatum* on fringes of tidal halophytic areas and flood channels on clay soils near coast	Clay	-	-		Restricted distribution & vulnerable (traffic)	0.9

Formation[1]	Description[1]	Soils[1]	Avg. Total % Cover undisturbed sites		Avg. number of taxa (100 m^2)[3]	Significance[1]	Total Extent[1] (ha)
			2	3			
T1	Halophytic Complex dominated by *Halosarcia halocnemoides* and *Halosarcia indica* on tidal flats	Clay with limestone outcrops	33	-		Restricted distribution	12.2
T2	Mixed Chenopod and Halophytic Complex with low *Frankenia pauciflora* shrubs on high tide areas usually associated with stands of *Avicennia marina*	Clay with limestone outcrops	77	-		Restricted distribution	3.6
V1	Hummock Grassland of *Triodia wiseana* with emergent shrub species on valley slopes	Shallow limestone	45	60	4.39		6822.9
V2	Hummock Grassland of *Triodia wiseana* with *Pentalepis trichodesmoides* on southern escarpment	Shallow limestone	38	-			144.6
V3	Scattered *Acacia pyrifolia* shrubs over Hummock Grassland of *Triodia wiseana* on valley slopes and minor drainage lines	-	-	52	4.05		NA
Bare Rock							NA
Bare Sand							81.8
Disturbed							NA
Unvegetated							39.7
Total							**23452.6**

Note: *'NA' indicates extent not mapped as defined subsequent to Mattiske (1993)*

Sources: *1 Mattiske 1993*
2 Mattiske Consulting 1999

Appendix 3 Table 2: Summary of Flora Taxa in Vegetation Formations

Formation →	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	F1	F2	F3	F4	F5	F6	F7	F8	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	M1	S1	S2	T1	T2	V1	V2	V3
Taxa ↓ No. 'unique' Taxa →	1	3	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	3	0	0	0	1	1	2	0	1	2	0	2	1	4	0	0
Abutilon cunninghamii		x	x				x														x															
Acacia bivenosa	x	x	x	x			x	x			x	x		x	x			x			x	x	x	x	x			x		x				x		x
Acacia coriacea subsp. *coriacea*	x	x	x	x		x		x			x				x	x		x			x			x			x					x		x		
Acacia gregorii								x										x			x	x	x	x	x									x	x	x
Acacia pyrifolia var. *pyrifolia*									x												x	x			x									x		x
Acacia synchronicia												x																								
Acanthocarpus verticillatus		x				x		x	x		x							x			x			x												
Adriana urticoides var. *urticoides*	x	x	x				x					x			x	x		x						x			x	x		x		x		x		
Amaranthus pallidiflorus		x			x																x															
Atriplex isatidea		x																																		
Avicennia marina subsp. *marina*																													x			x				
Boerhavia gardneri		x																					x											x		
Bonamia media var. *villosa*																					x													x		
Bulbostylis barbata																											x							x		
Calandrinia polyandra													x														x									
Calandrinia remota																					x													x		
Capparis spinosa var. *nummularia*					x																x						x									
Chrysopogon fallax																		x																		
Cleome viscosa		x	x																								x									
Clerodendrum tomentosum																																		x		
Codonocarpus cotinifolius																					x			x										x	x	
Commicarpus australis		x	x												x												x									
Corchorus congener		x			x			x										x			x	x	x	x	x		x							x		
Corchorus sidoides													x											x													
Corchorus parviflorus															x												x									
Corchorus sp.		x						x										x			x		x	x	x									x		
Corchorus walcottii	x	x	x	x			x	x	x		x			x	x	x	x	x			x		x	x		x	x			x				x	x	
Cullen lachnostachys																	x																			
Cullen leucantha												x																		x				x		
Cullen pustulatum								x										x																		
Cymbopogon ambiguus					x				x		x			x	x		x				x	x	x			x	x	x						x	x	
Cynanchum floribundum		x						x										x			x		x	x			x							x		
Cyperus cunninghamii subsp. *cunninghamii*					x								x		x		x										x							x		

Formation →	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	F1	F2	F3	F4	F5	F6	F7	F8	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	M1	S1	S2	T1	T2	V1	V2	V3
Dichanthium sericeum subsp. *humilis*																											x									
Diplopeltis eriocarpa		x						x										x			x				x								x		
Diplopeltis intermedia var. *intermedia*		x																					x	x				x					x		
Dipteracanthus australasicus ssp. *corynothecus*																							x				x									
Dodonaea lanceolata var. *lanceolata*								x	x												x					x								x	
Dysphania rhadinostachya subsp. *rhadinostachya*																																		x		
Enneapogon oblongus																											x									
Eragrostis dielsii					x																						x							x		
Eragrostis xerophila																														x						
Eremophea spinosa																															x	x				
Eremophila forrestii subsp. *forrestii*											x																									
Eriachne flaccida																														x				x		
Eriachne mucronata									x		x				x						x	x	x	x	x	x								x		
Erythrina vespertilio														x			x											x							
Eucalyptus xerothermica																										x										
Euphorbia australis	x	x	x	x	x	x	x						x	x	x						x	x		x			x							x	x	
Euphorbia coghlanii																								x											x	
Euphorbia drummondii subsp. *drummondii*					x																x			x	x								x		
Euphorbia myrtoides	x	x																																		
Euphorbia tannensis subsp. *eremophila*		x					x										x																	x		
Evolvulus alsinoides var. *decumbens*																									x											
Ficus brachypoda						x											x				x						x	x						x		x
Flaveria australasica		x																																		
Frankenia pauciflora var. *pauciflora*	x	x		x	x																						x					x	x			
Gossypium robinsonii									x		x		x								x				x									x		
Grevillea pyramidalis subsp. *leucadendron*												x												x												
Hakea lorea subsp. lorea								x									x	x			x	x	x	x			x	x						x		x
Haloragis gossei		x						x										x			x		x	x	x									x		
Halosarcia halocnemoides																															x	x	x			
Halosarcia indica																																	x			
Halosarcia indica subsp. *julacea*																																x				
Hannafordia quadrivalvis subsp. *recurva*								x			x							x			x		x	x	x									x	x	
Heliotropium crispatum			x																																	
Heliotropium glanduliferum		x			x			x										x			x		x	x	x									x		
Heliotropium ovalifolium	x	x		x	x										x		x				x			x			x							x		
Hybanthus aurantiacus																					x		x		x									x		
Indigofera boviperda						x	x								x	x																				

Formation →	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	F1	F2	F3	F4	F5	F6	F7	F8	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	M1	S1	S2	T1	T2	V1	V2	V3
Indigofera monophylla		x		x	x		x	x	x		x							x			x	x	x	x	x	x	x	x						x	x	
Isotropis atropurpurea																																		x		
Jasminum calcarium						x		x																		x										
Lipocarpha microcephala																																		x		
Mallotus nesophilus																	x									x										
**Malvastrum americanum*														x																x						
Melaleuca cardiophylla						x		x			x				x			x			x				x									x		
Muellerolimon salicorniaceum																																x				
Mukia maderaspatana																											x							x		
Myoporum montanum	x	x	x	x	x	x	x	x	x						x			x			x			x			x			x		x		x		
Neobassia astrocarpa																																x	x			
Nicotiana occidentalis subsp. *occidentalis*		x																x			x															
Oldenlandia crouchiana					x																				x		x							x		
Olearia dampieri subsp. *dampieri*	x	x		x	x	x	x									x		x																x		
Paspalidium tabulatum					x								x	x							x	x	x		x		x							x		
Pentalepis trichodesmoides		x						x						x			x	x			x	x	x	x			x							x	x	
Petalostylis labicheoides		x						x	x		x						x				x	x	x		x			x						x		x
Phyllanthus maderaspatensis																							x	x			x									
Pittosporum phylliraeoides var. *phylliraeoides*						x		x							x											x	x							x		
Pluchea dentex					x																		x		x											
Pluchea rubelliflora					x																						x				x					
Pluchea tetranthera											x																			x	x					
Plumbago zeylanica																					x					x										
Polycarpaea longiflora		x			x								x		x		x				x			x			x							x		
Polymeria ambigua		x															x				x													x	x	
Pterocaulon sp.	x	x																			x		x													
Pterocaulon sphacelatum		x			x													x			x		x		x		x				x			x		
Pterocaulon sphaeranthoides	x	x	x	x	x	x	x		x		x	x	x		x	x					x	x	x	x	x		x			x	x	x		x	x	
Ptilotus clementii																					x													x		
Ptilotus gomphrenoides var. *gomphrenoides*	x																																			
Ptilotus obovatus var. *obovatus*							x				x	x	x	x			x				x						x									
Rhagodia preissii subsp. obovata		x		x																																
Rhynchosia minima	x	x	x			x		x			x				x	x		x																x		
Ruppia maritima																													x							
Salsola tragus	x	x		x																											x					
Sarcostemma viminale subsp. *australe*		x			x						x						x	x			x						x	x								
Scaevola cunninghamii			x		x			x							x						x			x										x		

Formation →	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	F1	F2	F3	F4	F5	F6	F7	F8	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	M1	S1	S2	T1	T2	V1	V2	V3
Scaevola spinescens		x																			x						x	x						x		
Senna artemisioides subsp. *oligophylla*																					x															
Senna glutinosa subsp. *pruinosa*																					x															
Senna notabilis													x																					x		
Senna species																														x						
Sida fibulifera						x								x													x			x						
Sida micracantha							x																											x		
Solanum diversiflorum						x								x		x	x	x			x			x	x										
Solanum ellipticum		x	x	x	x	x	x		x		x	x		x	x		x				x		x	x			x						x		
Solanum lasiophyllum	x	x	x		x		x	x				x	x	x	x		x	x			x		x	x	x		x	x		x				x		
Spinifex longifolius	x	x		x	x																															
Sporobolus virginicus											x																				x	x				
Stackhousia muricata																					x															
Stemodia species											x																			x						
Streptoglossa adscendens						x			x		x																			x				x		
Streptoglossa bubakii								x													x				x											
Streptoglossa decurrens		x			x													x			x		x	x	x		x			x				x		
Streptoglossa macrocephala		x																																		
Stylobasium spathulatum	x	x	x				x	x	x		x	x	x	x			x	x			x	x	x		x	x		x		x		x		x		x
Synaptantha tillaeacea	x														x																					
Tephrosia rosea var. *clementii*									x								x	x			x	x			x		x	x		x				x		
Tephrosia rosea var. *glabrior*													x																							
Threlkeldia diffusa		x		x																												x	x			
Tinospora smilacina						x																					x									
Trichodesma zeylanicum		x	x					x	x		x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x		x				x	x	
Triodia angusta	x	x		x	x		x	x	x		x	x	x	x	x		x	x			x	x	x	x	x	x	x	x		x		x	x	x		x
Triodia pungens	x	x	x	x		x	x					x			x	x							x	x			x	x		x	x					
Triodia wiseana		x				x		x	x		x		x	x			x	x			x	x	x	x	x		x	x						x	x	x
Triumfetta clementii		x																									x									
Triumfetta maconochieana																					x		x													
Vittadinia hispidula var. *setosa*																					x														x	
Waltheria indica		x										x																								
Whiteochloa airoides	x																								x											
Yakirra australiensis																					x						x							x		

Sources: *Mattiske 1993, RPS BBG 2005a*

Note: *'unique' indicates not recorded in any other subformations on Barrow Island on basis of source datasets*
Taxa only identified to genus level omitted

Appendix 3 Table 3: Extent of Detailed Surveys

Significant Ecological Elements are shaded in grey

Formation/ Subformation	Significance	Surveyed Extent (ha)
C1	Vulnerable - erosion	2.1
C1a	Vulnerable - erosion	7.5
C1d	Vulnerable - erosion	0.5
C1e	Vulnerable - erosion	8.8
C2	Vulnerable - erosion	0.4
C2a	Vulnerable - erosion	53.3
C2b	Vulnerable - erosion	31.0
C2c	Vulnerable - erosion	0.3
C2e	Vulnerable - erosion	0.3
C2f	Vulnerable - erosion	7.9
C2g	Vulnerable - erosion	6.0
C2h	Vulnerable - erosion	5.7
C2i	Vulnerable - erosion	1.8
C2j	Vulnerable - erosion	9.6
C3a	Vulnerable - erosion	7.8
C4	Vulnerable - erosion	1.4
C4e	Vulnerable - erosion	0.9
C4f	Vulnerable - erosion	0.2
C4g	Vulnerable - erosion	4.4
C4h	Vulnerable - erosion	0.2
C4i	Vulnerable - erosion	1.8
C5		0.1
C5a		8.9
C5b		0.2
C5c		0.5
D1a	Restricted distribution - undisturbed portions	68.1
D1c	Restricted distribution - undisturbed portions	4.8
D1d	Restricted distribution - undisturbed portions	1.4
D1e	Restricted distribution - undisturbed portions	2.4
D1f	Restricted distribution - undisturbed portions	0.6
D1g	Restricted distribution - undisturbed portions	0.7
D1h	Restricted distribution - undisturbed portions	6.1
D2	Restricted distribution - undisturbed portions	12.0
D2c	Restricted distribution - undisturbed portions	0.1
D2d	Restricted distribution - undisturbed portions	4.1
D2f	Restricted distribution - undisturbed portions	2.1
D2g	Restricted distribution - undisturbed portions	0.3
D2h	Restricted distribution - undisturbed portions	0.3
D2j	Restricted distribution - undisturbed portions	0.8
D2k	Restricted distribution - undisturbed portions	0.1
D2l	Restricted distribution - undisturbed portions	1.8
D2m	Restricted distribution - undisturbed portions	2.0
D2n	Restricted distribution - undisturbed portions	2.5
D2o	Restricted distribution - undisturbed portions	8.0
D2p	Restricted distribution - undisturbed portions	0.3
D2q	Restricted distribution - undisturbed portions	2.4
D2r	Restricted distribution - undisturbed portions	0.9

Formation/ Subformation	Significance	Surveyed Extent (ha)
D2s	Restricted distribution - undisturbed portions	0.2
Dis - Assoc unknown		125.2
Dis - C1		1.1
Dis - C2		1.8
Dis - L1		0.8
Dis - L2		0.1
Dis - L3		36.4
Dis - L4		3.0
Dis - L5		3.6
Dis - L6		2.8
Dis - L7		0.3
Dist - D		0.7
Dist - D1a		39.8
Dist - D1h		4.8
Dist - L1		0.3
Dist - L4		0.7
Dist – Old Track		0.0
Dist - Road		1.4
Dist - V1t		1.7
F4a	Restricted flora species - *Erythrina vespertilio*	1.2
F4b	Restricted flora species - *Erythrina vespertilio*	6.3
F4c	Restricted flora species - *Erythrina vespertilio*	0.6
F5a		2.9
F5b		2.6
F5c		2.2
F5d	Relict dunes - some are isolated inland occurrences of coastal associations	0.2
F5e	Relict dunes - some are isolated inland occurrences of coastal associations	3.6
F5f		0.3
F6a		1.0
F6b		1.1
F6c		0.2
F6d		0.9
F6e		5.9
F6f		4.3
F6g		1.0
F6h		4.1
F6i		0.3
F6j		0.3
F7a		3.3
F7b		4.9
F7c		0.4
F7d		0.8
F7e		4.9
F7f		1.6
F8a		190.0
F8b		2.4
F8c		41.4
F8d		11.0
F8e		3.7
F8f		1.7
F8i		4.4
F8j		14.8

Formation/ Subformation	Significance	Surveyed Extent (ha)
F8k		1.5
F8l		1.9
F8m		4.8
L1		2.4
L1a		19.3
L1b		5.8
L1c		1.2
L1d		0.9
L1e		6.7
L1f		27.3
L1g		3.6
L1h		55.2
L1i		9.5
L3		2.6
L3a		2.9
L3b		18.3
L3c		12.4
L3d		1.4
L3e		0.6
L3f		9.1
L3g		42.8
L3h		0.8
L3i		46.3
L3j		118.9
L3k		1.2
L3l		1.5
L3n		2.9
L3o		6.8
L3p		0.7
L3q		0.6
L3r		10.3
L3u		2.0
L3v		4.5
L4a		174.1
L5a		29.0
L5b		0.8
L5c		1.7
L6a	Restricted flora species - *Grevillea pyramidalis* ?subsp. *leucadendron*	3.8
L6b	Restricted flora species - *Grevillea pyramidalis* ?subsp. *leucadendron*	14.8
L6c	Restricted flora species - *Grevillea pyramidalis* ?subsp. *leucadendron*	9.3
L6d	Restricted flora species - *Grevillea pyramidalis* ?subsp. *leucadendron*	1.6
L6e		0.5
L6f		1.3
L7a	Vulnerable flora species - *Melaleuca cardiophylla*	10.9
L7b	Vulnerable flora species - *Melaleuca cardiophylla*	203.1
L7c		0.2
L7d		6.9
L7e		2.1
L7f		0.7
L7g		0.4
L9	Relict dunes - some are isolated inland occurrences of coastal associations	1.3
L9a		8.3

Formation/ Subformation	Significance	Surveyed Extent (ha)
L9b		8.0
L9c		21.7
L9d		63.7
L9e		9.3
L9f		1.7
L9g		1.3
L9i		5.2
L9j		2.1
L9k		7.8
L9L		2.1
L9m		0.5
L9n		3.0
L9o		4.0
L9p		12.1
L9q		2.0
L9r		0.2
L9s		5.0
L9t		0.3
M1	Restricted distribution	0.4
R		4.7
S1a	Restricted distribution & vulnerable (traffic)	0.7
S1b	Restricted distribution & vulnerable (traffic)	2.8
S2b	Restricted distribution & vulnerable (traffic)	0.2
T2	Restricted distribution	1.3
Unvegetated		0.6
V1		4.8
V1a		63.6
V1b		2.8
V1c		33.8
V1d		9.4
V1f		4.3
V1g		1.8
V1h		4.9
V1i		2.9
V1j		1.4
V1k	Vulnerable flora species - *Melaleuca cardiophylla*	119.0
V1m	Restricted flora species - *Grevillea pyramidalis* ?subsp. *leucadendron*	191.4
V1n		20.5
V1o		6.8
V1p		3.2
V1q		0.4
V1r		3.1
V1s		7.1
V1u		0.1
V2		2.9
V3a		37.1
V3b		71.0
Sum		2482.76

Source: RPS BBG 2005a

Appendix 4 Mammal Inventory

Appendix 4 Table 1: Barrow Island Mammal Inventory

Significant Ecological Elements are shaded in grey

Species	Present in Gorgon Gas Development Footprint	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA) Listing	DPaW Priority Listing	Short-range Endemic	Top Level Predator
Dasyuridae						
Planigale sp.	x					
Pseudantechinus sp.	x					
Peramelidae (bandicoots)						
Barrow Island Golden Bandicoot *Isoodon auratus barrowensis*	x	Vulnerable	Schedule 1			
Phalangeridae (possums)						
Northern Brushtail Possum *Trichosurus vulpecula arnhemensis*	x					
Potoroidae (potoroos and bettongs)						
Barrow Island Boodie *Bettongia lesueur* (Barrow Island race)	x	Vulnerable	Schedule 1			
Macropodidae (kangaroos and wallabies)						
Barrow Island Spectacled Hare-wallaby *Lagorchestes conspicillatus conspicillatus*	x	Vulnerable	Schedule 1			
Barrow Island Euro *Macropus robustus isabellinus*	x	Vulnerable	Schedule 1			
Black-flanked Rock-wallaby *Petrogale lateralis lateralis*	x	Vulnerable	Schedule 1			
Pteropodidae (fruit bats or flying foxes)						
Black Flying-fox *Pteropus alecto*		(vagrant)				
Emballonuridae (sheath tail bats)						
Common Sheathtail Bat *Taphozous georgianus*	x					
Mollosidae (mastiff bats)						
White-striped Bat *Tadarida (Nyctinomus) australis*		(vagrant)				
Verpertilionidae (vesper bats)						
Finlayson's Cave Bat *Vespadelus (Eptesicus) finlaysoni*	x					
Muridae (rats and mice)						
Rakali or Water-rat *Hydromys chrysogaster*	x			Priority 4		
Western Chestnut Mouse / Moolboo *Pseudomys nanus*	x					
Djoorri or Common Rock-rat *Zyzomys argurus*	x					

Notes: Non-indigenous terrestrial species considered eradicated from Barrow Island have been excluded.

Source: Chevron Australia 2005

Appendix 4 Table 2: Mainland Mammal Inventory

Significant Ecological Elements are shaded in grey

Species	Recorded along Pipeline Route	May Occur in Vicinity of Pipeline	EPBC Act / *Wildlife Conservation Act 1950* (WA) Listing/ DPaW Priority (no listings)	Short-range Endemic	Top Level Predator
Dasyuridae (Dasyurids)					
Dasycercus cristicauda		X	Vulnerable		
Dasykaluta rosamondae		X			
Dasyurus hallucatus		X	Endangered		
Ningaui timealeyi		X			
Planigale sp.		X			
Sminthopsis macroura		X			
Sminthopsis youngsoni		X			
Macropodidae (Kangaroos, wallabies and tree kangaroos)					
Macropus robustus		X			
Macropus rufus	X				
Pteropodidae (fruit bats)					
Pteropus alecto	X				
Pteropus scapulatus		X			
Emballonuridae (Sheathtail bats)					
Saccolaimus flaviventris		X			
Taphozous georgianus		X			
Vespertilionidae (Vespertilionid bats)					
Chaerephon jobensis		X			
Mormopterus beccarii		X			
Mormopterus sp. *(> loriae coburgensis part)*		X	Schedule 1		
Tadarida australis		X			
Muridae (rats and mice)					
Leggadina lakedownensis		X	Priority 4		
**Mus musculus*		X			
Notomys alexis		X			
Pseudomys delicatulus		X			
Pseudomys hermannsburgensis		X			
**Rattus rattus*		X			
Canidae (dogs and foxes)					
**Canis lupus*		X			
**Vulpes vulpes*	X				
Felidae (cats)					
**Felis catus*		X			

Source: RPS BBG 2006

*Note: * introduced species*

Appendix 5 Avifauna Inventory

Appendix 5 Table 1: Barrow Island Avifauna Inventory

Status:

R = resident

M = regular migrant

V = vagrant

Habitat:

T = terrestrial

O = oceanic (marine)

OI = oceanic but breeding on offshore islets

L = littoral (shoreline, shallows and inshore waters, including ephemeral wetlands)

EPBC Act Listing:

B = Bonn Convention

J/C = JAMBA/CAMBA

K = ROKAMBA

MS = Marine Species

Significant Ecological Elements are shaded in grey

Species	Status	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Phasianidae (pheasants and quails)						
Brown Quail *Coturnix ypsilophora*	R	T				
Anatidae (ducks, geese and swans)						
Black Swan *Cygnus atratus*	V	L				
Australian Wood Duck *Chenonetta jubata*	V	L				
Grey Teal *Anas gibberifrons*	V	L				
Podicepididae (grebes)						
Australasian Grebe *Tachybaptus novaehollandiae*	V	L				
Procellariidae (shearwaters)						
Wedge-tailed Shearwater *Puffinus pacificus*	M	OI	MS			
Diomedeidae (albatrosses)						
Yellow-nosed Albatross *Diomedea chlororhynchos*	V	O	J/C			
Hydrobatidae (storm-petrels)						
Wilson's Storm Petrel *Oceanites oceanicus*	V	O	J/C, MS			
Sulidae (gannets and boobies)						
Masked Booby *Sula dactylatra*	V	O	J/C, K, MS			
Brown Booby *Sula leucogaster*	V	O	J/C, K, MS			
Anhingidae (darters)						
Darter *Anhinga melanogaster*	V	L				
Phalacrocoracidae (cormorants)						
Little Pied Cormorant *Phalacrocorax melanoleucos*	R	L				
Pied Cormorant *Phalacrocorax varius*	R	L				
Little Black Cormorant *Phalacrocorax sulcirostris*	R	L				
Great Cormorant *Phalacrocorax carbo*	R	L				
Pelecanoididae (pelicans)						
Australian Pelican *Pelecanus conspicillatus*	R	L	MS			
Fregatidae						
Lesser Frigatebird *Fregata ariel*	V	O	J/C, K, MS			
Ardeidae (herons and egrets)						
White-faced Heron *Ardea (Egretta) novaehollandiae*	R	L				
Little Egret Ardea *(Egretta) garzetta*	V	L	MS			
Eastern Reef Egret Ardea *(Egretta) sacra*	R	L	J/C, MS			
Great Egret *Ardea (Egretta) alba*	V	L	J/C, MS			
Striated Heron *Butorides striatus*	R	L				
Nankeen Night Heron *Nycticorax caledonicus*	R	L	MS			
Accipitridae (kites, hawks and eagles)						

Species	Status	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Osprey *Pandion haliaetus*	R	L	J/C, MS			X
Black-shouldered Kite *Elanus notatus*	R	T				
Square-tailed Kite *Lophoictinia isura*	V	T				
Black-breasted Buzzard *Hamirostra melanosternon*	V	T				
Whistling Kite *Haliastur sphenurus*	V	T	MS			
Brahminy Kite *Haliastur indus*	R	L	MS			X
White-bellied Sea-eagle *Haliaeetus leucogaster*	R	T	J/C, B			X
Spotted Harrier *Circus assimilis*	R	T				
Wedge-tailed Eagle *Aquila audax*	V	T				
Falconidae (falcons)						
Brown Falcon *Falco berigora*	V	T				
Australian Hobby *Falco longipennis*	V	T				
Nankeen Kestrel *Falco cenchroides*	R	T	MS			
Otidae (bustards)						
Australian Bustard *Ardeotis australis*	V	T			Priority 4	
Scolopacidae (sandpipers)						
Black-tailed Godwit *Limosa limosa*	M	L	J/C, K, MS			
Bar-tailed Godwit *Limosa lapponica*	M	L	J/C, K, MS			
Little Curlew *Numenius minutus*	V	L	J/C, K, MS			
Whimbrel *Numenius phaeopus*	M	L	J/C, K, MS			
Eastern Curlew *Numenius madagascariensis*	M	L	J/C, K			
Marsh Sandpiper *Tringa stagnatalis*	V	L	J/C, K, MS			
Common Greenshank *Tringa nebularia*	M	L	J/C, K, MS			
Wood Sandpiper *Tringa glareola*	V	L	J/C, K, MS			
Terek Sandpiper *Xenus cinerea (Tringa terek*)	M	L	J/C, K			
Common Sandpiper *Tringa hypoleucos*	M	L	J/C, K			
Grey-tailed Tattler *Tringa brevipes*	M	L	J/C, K			
Ruddy Turnstone *Arenaria interpres*	M	L	J/C, K, MS			
Great Knot *Calidris tenuirostris*	M	L	J/C, K, MS			
Red Knot *Calidris canutus*	M	L	J/C, K, MS			
Sanderling *Calidris alba*	M	L	J/C, K, MS			
Red-necked Stint *Calidris ruficollis*	M	L	J/C, K, MS			
Sharp-tailed Sandpiper *Calidris acuminata*	M	L	J/C, K, MS			
Curlew Sandpiper *Calidris ferruginea*	M	L	J/C, K, MS			
Burhinidae (stone-curlews)						
Beach Stone-curlew *Esacus neglectus*	R	L				
Haematopodidae (oystercatchers)						
Pied Oystercatcher *Haematopus longirostris*	R	L				
Sooty Oystercatcher *Haematopus fuliginosus*	R	L				
Recurvirostridae (stilts and avocets)						
Black-winged Stilt *Himantopus himantopus*	V	L	MS			
Banded Stilt *Cladorhynchus leucocephalus*	V	L				
Charadriidae (lapwings and plovers)						
Pacific Golden Plover *Pluvialis fulva*	M	L	J/C, K			
Grey plover *Pluvialis squatarola*	M	L	J/C, K			

Species	Status	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Red-capped Plover *Charadrius ruficapillus*	R	L				
Lesser Sand Plover *Charadrius mongolus*	M	L	J/C, K			
Greater Sand Plover *Charadrius leschenaultia*	M	L	J/C, K			
Oriental Plover *Charadrius veredus*	V	L	J/C, K			
Glareolidae (pratincoles)						
Australian Pratincole *Stiltia isabella*	V	L	J/C			
Laridae (gulls and terns)						
Silver Gull *Larus novaehollandiae*	R	L	MS			
Gull-billed Tern *Sterna (Gelochelidon) nilotica*	R	L	MS			
Caspian Tern *Sterna (Hydroprogne) caspia*	R	L	MS			
Lesser Crested Tern *Sterna bengalensis*	R	L	MS			
Crested Tern *Sterna bergii*	R	L	MS			
Roseate Tern *Sterna dougallii*	M	L/O	MS			
Common Tern *Sterna hirundo*	M	L/O	J/C, K, MS			
Little Tern *Sterna albifrons*	M	L	J/C, K, MS			
Fairy Tern *Sterna nereis*	?	L	MS			
Bridled Tern *Sterna anaethetus*	M	OI	J/C, MS			
White-winged Black Tern *Chlidonias leucoptera*	M	L	J/C, K, MS			
Lesser Noddy *Anous tenuirostris*	?	O	MS			
Columbidae (pigeons and doves)						
Crested Pigeon *Ocyphaps lophotes*	V	T				
Peaceful Dove *Geopelia placida*	V	T				
Bar-shouldered Dove *Geopelia humeralis*	R	T				
Cacatuidae (cockatoos)						
Galah *Cacatua roseicapilla*	V	T				
Little Corella *Cacatua sanguinea*	V	T				
Cockatiel *Nymphicus hollandicus*	V	T				
Psittacidae (lorikeets and parrots)						
Budgerigar *Melopsittacus undulatus*	V	T				
Cuculidae (cuckoos)						
Oriental Cuckoo *Cuculus saturatus*	V	T	J/C, K, MS			
Pallid Cuckoo *Cuculus pallidus*	R	T	MS			
Horsfield's Bronze Cuckoo *Chrysococcyx basalis*	R	T	MS			
Black-eared Cuckoo *Chrysococcyx osculans*	R	T	MS			
Strigidae (hawk-owls)						
Southern Boobook Owl *Ninox novaeseelandiae*	V	T	MS			
Tytonidae (barn owls)						
Barn Owl *Tyto alba*	V	T				
Apodidae (swifts)						
Swiftlet species *Collocalia* sp.	V	T				
Fork-tailed Swift *Apus pacificus*	?M	T	K, MS			
White-throated Needletail *Hirundapus caudacutus*	?M	T	K, MS			
Halcyonidae (forest kingfishers)						
Red-backed Kingfisher *Todiramphus pyrrhopygia*	V	T				
Sacred kingfisher *Todiramphus sanctus*	R	L	MS			
Maluridae (fairy-wrens)						
White-winged Fairy-wren (Barrow Island) *Malurus leucopterus edouardi*	R	T	Vulnerable	Schedule 1		
Meliphagidae (honeyeaters)						
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*	V	T				
Singing Honeyeater *Lichenostomus virescens*	R	T				

Species	Status	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Brown Honeyeater *Lichmera indistincta*	V	T				
Crimson Chat *Epthianura tricolor*	V	T				
Dicruridae (flycatchers)						
Magpie-lark *Grallina cyanoleuca*	V	T	MS			
Willie Wagtail *Rhipidura leucophrys*	V	T				
Campephagidae (cuckoo-shrikes)						
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	V	T				
White-winged Triller *Lalage sueurii*	V	T				
Artamidae (woodswallows)						
White-breasted Woodswallow *Artamus leucorhynchus*	R	T				
Masked Woodswallow *Artamus personatus*	V	T				
Black-faced Woodswallow *Artamus cinereus*	V	T				
Corvidae (ravens and crows)						
Little Crow *Corvus bennetti*	V	T				
Motacillidae (pipits and TRUE wagtails)						
Richard's Pipit *Anthus novaeseelandiae*	R	T	MS			
Yellow Wagtail *Motacilla flava*	V	T	J/C, K			
Passeridae (finches and allies)						
Painted Firetail *Emblema picta*	V	T				
Zebra Finch *Taeniopygia guttata*	R	T				
Hirundinidae (swallows)						
Welcome Swallow *Hirundo neoxena*	R	T	MS			
Tree Martin *Hirundo nigricans*	V	T	MS			
Fairy Martin *Hirundo ariel*	V	T				
Sylviidae (Old World warblers)						
Spinifexbird *Eremiornis carteri*	R	T				
Brown Songlark *Cincloramphus cruralis*	V	T				
Zosteropidae (silvereyes)						
Yellow White-eye *Zosterops luteus*	R	T	MS			

Source: Chevron Australia 2005

Appendix 5 Table 2: Mainland Avifauna Inventory

Status:

R = resident

M = regular migrant

V = vagrant

Habitat:

T = terrestrial

O = oceanic (marine)

OI = oceanic but breeding on offshore islets

L = littoral (shoreline, shallows and inshore waters, including ephemeral wetlands)

EPBC Act (Cth) Listing:

B = Bonn Convention

J/C = JAMBA/CAMBA

K = ROKAMBA

MS = Marine Species

Significant Ecological Elements are shaded in grey

Species	Recorded in Vicinity	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Casuriidae (cassowaries and emus)						
Emu *Dromaius novaehollandiae*	X	T				
Phasianidae (pheasants and quails)						
Brown Quail *Coturnix ypsilophora*		T				
Anhingidae (darters)						
Darter *Anhinga melanogaster*	X	L				
Phalacrocoracidae (cormorants)						
Little Pied Cormorant *Phalacrocorax melanoleucos*		L				
Pied Cormorant *Phalacrocorax varius*		L				
Little Black Cormorant *Phalacrocorax sulcirostris*		L				
Great Cormorant *Phalacrocorax carbo*		L				
Pelecanoididae (pelicans)						
Australian Pelican *Pelecanus conspicillatus*	X	L	MS			
Ardeidae (herons and egrets)						
White-faced Heron *Ardea (Egretta) novaehollandiae*	X	L				
Little Egret *Ardea (Egretta) garzetta*		L	MS			
Eastern Reef Egret *Ardea (Egretta) sacra*	X	L	J/C, MS			
White-necked Heron *Ardea pacifica*						
Great Egret *Ardea (Egretta) alba*		L	J/C, MS			
Cattle Egret *Ardea ibis*		L				
Striated Heron *Butorides striatus*		L				
Nankeen Night Heron *Nycticorax caledonicus*		L	MS			
Threskiornithidae (Ibises and spoonbills)						
Glossy Ibis *Plegadis falcinellus*		L	J/C, MS, B			
Australian White Ibis *Threskiornis molucca*		L				
Straw-necked Ibis *Treskiornis spinicollis*		L				
Royal Spoonbill *Platalea regia*		L				
Yellow-billed Spoonbill *Platalea flavipes*		L				
Accipitridae (kites, hawks and eagles)						
Osprey *Pandion haliaetus*	X	L	J/C, MS			X
Black-shouldered Kite *Elanus notatus*		T				
Black-breasted Buzzard *Hamirostra melanosternon*		T				
Black Kite *Milvus migrans*		T				
Whistling Kite *Haliastur sphenurus*		T	MS			
Brahminy Kite *Haliastur indus*	X	L	MS			X
White-bellied Sea-eagle *Haliaeetus leucogaster*		T	J/C, B			X
Spotted Harrier *Circus assimilis*	X	T				
Swamp Harrier *Circus approximans*		T				
Brown Goshawk *Accipiter fasciatus*		T				
Collared Sparrowhawk *Accipiter cirrhocephalus*		T				
Wedge-tailed Eagle *Aquila audax*	X	T				

Species	Recorded in Vicinity	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Little Eagle *Hieraaetus morphnoides*		T				
Falconidae (falcons)						
Brown Falcon *Falco berigora*		T				
Australian Hobby *Falco longipennis*		T				
Nankeen Kestrel *Falco cenchroides*	X	T	MS			
Gruidae (cranes)						
Brolga *Grus rubicunda*		L				
Rallidae (rails, gallinules and coots)						
Buff-banded Rail *Gallirallus philippensis*		L				
Otidae (bustards)						
Australian Bustard *Ardeotis australis*	X	T			Priority 4	
Turnicidae (button-quails)						
Little Button Quail *Turnix velox*		T				
Scolopacidae (sandpipers)						
Black-tailed Godwit *Limosa limosa*		L	J/C, K, MS			
Bar-tailed Godwit *Limosa lapponica*	X	L	J/C, K, MS			
Little Curlew *Numenius minutus*		L	J/C, K, MS			
Whimbrel *Numenius phaeopus*	X	L	J/C, K, MS			
Eastern Curlew *Numenius madagascariensis*	X	L	J/C, K			
Marsh Sandpiper *Tringa stagnatalis*		L	J/C, K, MS			
Common Greenshank *Tringa nebularia*	X	L	J/C, K, MS			
Wood Sandpiper *Tringa glareola*		L	J/C, K, MS			
Terek Sandpiper *Xenus cinerea (Tringa terek*)		L	J/C, K			
Common Sandpiper *Tringa hypoleucos*		L	J/C, K			
Grey-tailed Tattler *Tringa brevipes*		L	J/C, K			
Ruddy Turnstone *Arenaria interpres*		L	J/C, K, MS			
Great Knot Calidris *tenuirostris*		L	J/C, K, MS			
Red Knot *Calidris canutus*		L	J/C, K, MS			
Sanderling *Calidris alba*		L	J/C, K, MS			
Red-necked Stint *Calidris ruficollis*		L	J/C, K, MS			
Long-toed Stint *Calidris subminuta*		L	J/C, K, MS			
Sharp-tailed Sandpiper *Calidris acuminata*		L	J/C, K, MS			
Curlew Sandpiper *Calidris ferruginea*		L	J/C, K, MS			
Burhinidae (stone-curlews)						
Bush Stone-curlew *Esacus grallarius*		L				
Beach Stone-curlew *Esacus neglectus*		L				
Haematopodidae (oystercatchers)						
Pied Oystercatcher *Haematopus longirostris*		L				
Sooty Oystercatcher *Haematopus fuliginosus*		L				
Recurvirostridae (stilts and avocets)						
Black-winged Stilt *Himantopus himantopus*		L	MS			
Charadriidae (lapwings and plovers)						
Pacific Golden Plover *Pluvialis fulva*		L	J/C, K			
Grey Plover *Pluvialis squatarola*		L	J/C, K			
Red-capped Plover *Charadrius ruficapillus*		L				
Lesser Sand Plover *Charadrius mongolus*		L	J/C, K			
Greater Sand Plover *Charadrius leschenaultia*		L	J/C, K			
Oriental Plover *Charadrius veredus*		L	J/C, K			
Black-fronted Dotterel *Elseyornis melanops*		L				
Glareolidae (pratincoles)						
Oriental Pratincole *Stiltia maldivarum*		L	J/C			
Laridae (gulls and terns)						
Silver Gull *Larus novaehollandiae*		L	MS			
Gull-billed Tern *Sterna (Gelochelidon) nilotica*		L	MS			
Caspian Tern *Sterna (Hydroprogne) caspia*		L	MS			
Lesser Crested Tern *Sterna bengalensis*		L	MS			
Crested Tern *Sterna bergii*		L	MS			

Species	Recorded in Vicinity	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Roseate Tern *Sterna dougallii*		L/O	MS			
Common Tern *Sterna hirundo*		L/O	J/C, K, MS			
Little Tern *Sterna albifrons*		L	J/C, K, MS			
Fairy Tern *Sterna nereis*		L	MS			
Bridled Tern *Sterna anaethetus*		OI	J/C, MS			
Whiskered Tern *Chlidonias hybridus*		L	MS			
White-winged Black Tern *Chlidonias leucoptera*		L	J/C, K, MS			
Columbidae (pigeons and doves)						
Feral Pigeon *Ocyphaps lophotes*		T				
Crested Pigeon *Ocyphaps lophotes*	X	T				
Spinifex Pigeon *Geohaps plumifera*		T				
Diamond Dove *Geopelia cuneata*	X	T				
Peaceful Dove *Geopelia placida*	X	T				
Bar-shouldered Dove *Geopelia humeralis*		T				
Cacatuidae (cockatoos)						
Galah *Cacatua roseicapilla*	X	T				
Little Corella *Cacatua sanguinea*		T				
Cockatiel *Nymphicus hollandicus*	X	T				
Psittacidae (lorikeets and parrots)						
Australian Ringneck *Barnardius zonarius*		T				
Budgerigar *Melopsittacus undulatus*		T				
Cuculidae (cuckoos)						
Pallid Cuckoo *Cuculus pallidus*	X	T	MS			
Horsfield's Bronze Cuckoo *Chrysococcyx basalis*		T	MS			
Black-eared Cuckoo *Chrysococcyx osculans*		T	MS			
Strigidae (hawk owls)						
Barking Owl *Ninox connivens*		T				
Southern Boobook *Ninox novaeseelandiae*		T				
Tytonidae (barn owls)						
Barn Owl *Tyto alba*		T				
Podargidae (Australian frogmouths)						
Tawny Frogmouth *Podargus strigoides*		T				
Caprimulgidae (Nightjars and allies)						
Spotted Nightjar *Eurotopodus argus*		T				
Aegthelidae (Owlet-nightjar)						
Australian Owlet-nightjar *Aegotheles cristatus*		T				
Apodidae (swifts)						
Fork-tailed Swift *Apus pacificus*		T	K, MS			
Halcyonidae (forest kingfishers)						
Blue-winged Kookaburra *Dacelo leachii*	X	T				
Red-backed Kingfisher *Todiramphus pyrrhopygia*		T				
Sacred Kingfisher *Todiramphus sanctus*		L	MS			
Collared Kingfisher *Todiramphus chloris*		T				
Maluridae (fairy-wrens)						
Rainbow Bee-eater *Merops ornatus*		T	J/C			
Maluridae (fairy-wrens)						
Variegated Fairy-wren *Malurus lambertii*	X	T				
White-winged Fairy-wren (Barrow Island) *Malurus leucopterus*	X	T				
Striated Grasswren *Amytornis striatus*		T				
Pardalotidae (pardalotes, bristlebirds, scrubwrens, thornbills and allies)						
Red-browed Pardalote *Pardalotus rubicatus*		T				
Striated Pardalote *Pardalotus striatus*		T				
Weebil *Smicrornis brevirostris*		T				
Dusky Gerygone *Gerygone tenebrosa*		T				

Species	Recorded in Vicinity	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Western Gerygone *Gerygone fusca*		T				
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*		T				
Meliphagidae (honeyeaters)						
Yellow-throated Miner *Manorina flavigula*		T				
Singing Honeyeater *Lichenostomus virescens*	X	T				
Grey-headed Honeyeater *Lichenostomus keartlandi*		T				
Grey-fronted Honeyeater *Lichenostomus plumulus*		T				
White-plumed Honeyeater *Lichenostomus penicillatus*		T				
Black-chinned Honeyeater *Melithrepus gularis*		T				
Brown Honeyeater *Lichmera indistincta*		T				
White-fronted honeyeater *Phylidonyris albifrons*		T				
Black Honeyeater *Certionyx niger*		T				
Pied honeyeater *Certionyx variegatus*		T				
Crimson Chat *Epthianura tricolor*		T				
Petroicidae (robins)						
Hooded Robin *Melanodryas cucullata*	X	T				
Mangrove Robin *Eopsaltria pulverulenta*		T				
Pomatostomidae (babblers)						
Grey-crowned Babbler *Pomatostomus temporalis*		T				
Cinclosomatidae (quail-thrushes and allies)						
Chiming Wedgebill *Psophodes occidentalis*		T				
Pachycephalidae (whistlers, shrike-thrushes and allies)						
Crested Bellbird *Oreoica gutturalis*	X	T				
Mangrove Golden Whistler *Pachycephala melanura*		T				
Rufous Whistler *Pachycephala rufiventris*	X	T				
White-breasted Whistler *Pachycephala lanioides*		T				
Grey Shrike-thrush *Colluricincla harmonica*		T				
Dicruridae (flycatchers)		T				
Magpie-lark *Grallina cyanoleuca*		T				
Grey Fantail *Rhipidura fuliginosa*		T				
Mangrove Grey Fantail *Rhipidura phasisana*	X	L				
Willie Wagtail *Rhipidura leucophrys*		T				
Campephagidae (cuckoo-shrikes)						
Black-faced Cuckoo-shrike *Coracina novaehollandiae*		T				
White-winged Triller *Lalage sueurii*		T				
Artamidae (woodswallows, butcherbirds and currawongs)						
White-breasted Woodswallow *Artamus leucorhynchus*	X	T				
Masked Woodswallow *Artamus personatus*		T				
Black-faced Woodswallow *Artamus cinereus*	X	T				
Little Woodswallow *Artamus minor*		T				
Grey Butcherbird *Cracticus torquatus*		T				
Pied Butcherbird *Cracticus nigrogularis*		T				
Australian Magpie *Gymnorhina tibicen*		T				
Corvidae (ravens and crows)						
Little Crow *Corvus bennetti*		T				
Torresian Crow *Corvus orru*	X	T				
Alaudidae (old world larks)						
Singing Bushlark *Mirafra javanica*	X	T				
Motacillidae (pipits and TRUE wagtails)						
Richard's Pipit *Anthus novaeseelandiae*	X	T	MS			

Species	Recorded in Vicinity	Habitat	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA)	DPaW Listing	Top Level Predator
Passeridae (finches and allies)						
Painted Firetail *Emblema picta*	X	T				
Star Finch *Neochima ruficauda*		T				
Zebra Finch *Taeniopygia guttata*	X	T				
Dicaeidae (flowerpeckers)						
Mistletoebird *Dicaeum hirundinaceum*		T				
Hirundinidae (swallows)						
White-backed Swallow Cheramoeca leucosternum		T				
Barn Swallow *Hirundo rustica*		T	MS			
Welcome Swallow *Hirundo neoxena*		T	MS			
Tree Martin *Hirundo nigricans*		T	MS			
Fairy Martin *Hirundo ariel*		T				
Sylviidae (Old World warblers)						
Spinifexbird *Eremiornis carteri*	X	T				
Rufous Songlark *Cincloramphus mathewsi*	X	T				
Brown Songlark *Cincloramphus cruralis*		T				
Zosteropidae (silvereyes)						
Yellow White-eye *Zosterops luteus*		T	MS			

Source: RPS BBG 2006

Appendix 6 Herpetofauna Inventory

Appendix 6 Table 1: Barrow Island Herpetofauna Inventory

Significant Ecological Elements are shaded in grey

Species	Occurs in Gorgon Gas Development Footprint	EPBC Act (Cth)/ *Wildlife Conservation Act 1950* (WA) Listing/ DPaW Priority (no listings)	Short-range Endemic	Top Level Predator
Agamidae (lizards)				
Ctenophorus caudicinctus caudicinctus	x			
Lophognathus gilberti gilberti				
Pogona minor minor	x			
Pygopodidae (legless lizards)				
Delma borea	x			
Delma nasuta	x			
Delma tincta				
Lialis burtonis	x			
Pygopus nigriceps	x			
Gekkonidae (geckos)				
Diplodactylus stenodactylus				
Gehyra pilbara				
Gehyra variegata	x			
Heteronotia binoei	x			
Strophurus jeanae	x			
Scincidae (skinks)				
Carlia triacantha	x			
Cryptoblepharus carnabyi	x			
Ctenotus duricola				
Ctenotus grandis	x			
Ctenotus hanloni				
Ctenotus pantherinus acripes	x		X	
Ctenotus saxatilis	x			
Ctenotus serventyi				
Cyclodomorphus melanops melanops	x			
Eremiascincus richardsonii				
Glaphyromorphus isolepis				
Lerista bipes	x			
Lerista elegans	x			
Lerista muelleri	x			
Menetia greyii	x			
Morethia lineoocellata				
Morethia ruficauda exquisita	x			
Notoscincus ornatus ornatus	x			
Proablepharus reginae	x			
Typhlopidae (blind snakes)				
Ramphotyphlops ammodytes	x		x	
Ramphotyphlops longissimus		Priority 3	x	
Ramphotyphlops grypus			x	

Species	Occurs in Gorgon Gas Development Footprint	EPBC Act (Cth)/ *Wildlife Conservation Act 1950* (WA) Listing/ DPaW Priority (no listings)	Short-range Endemic	Top Level Predator
Varanidae (goannas)				
Varanus acanthurus	x			
Varanus brevicauda				
Varanus giganteus	x			x
Boidae (pythons)				
Antaresia stimsoni stimsoni	x			
Elapidae (fanged snakes)				
Brachyurophis approximans				
Demansia rufescens				
Furina ornata				
Pseudechis australis	x			
Suta monachus				
Hylidae (frogs)				
Cyclorana maini				

Source: Chevron Australia 2005

Appendix 6 Table 2: Mainland Herpetofauna Inventory

Significant Ecological Elements shaded in grey

Species	Recorded along Pipeline Route	May Occur in Vicinity of Pipeline	EPBC Act (Cth)/ *Wildlife Conservation Act 1950* (WA) Listing/ DPaW Priority	Short-range Endemic
Agamidae (lizards)				
Ctenophorus caudicinctus	X			
Ctenophorus isolepis	X			
Ctenophorus nuchalis	X			
Diporiphora winneckei		X		
Lophognathus gilberti		X		
Lophognathus longirostris		X		
Pogona minor	X			
Tympanocryptis cephala	X			
Pygopodidae (legless lizards)				
Delma nasuta		X		
Delma pax		X		
Delma tincta		X		
Lialis burtonis		X		
Pygopus nigriceps		X		
Gekkonidae (geckos)				
Crenadactylus ocellatus		X		
Diplodactylus conspicillatus		X		
Diplodactylus stenodactylus	X			
Nephrurus wheeleri		X		
Strophurus jeanae		X		
Strophurus strophurus		X		
Gehyra pilbara		X		
Gehyra punctata		X		
Gehyra variegata		X		
Heteronotia binoei		X		
Scincidae (skinks)				
Carlia munda		X		
Cryptoblepharus plagiocephalus		X		
Ctenotus duricola		X		
Ctenotus grandis	X			

Species	Recorded along Pipeline Route	May Occur in Vicinity of Pipeline	EPBC Act (Cth)/ *Wildlife Conservation Act 1950* (WA) Listing/ DPaW Priority	Short-range Endemic
Ctenotus helenae		X		
Ctenotus pantherinus		X		
Ctenotus saxatilis		X		
Cyclodomorphus melanops		X		
Eremiascincus fasciolatus		X		
Glaphyromorphus isolepis		X		
Lerista bipes		X		
Lerista muelleri		X		
Menetia greyii	X			
Tiliqua multifasciata	X			
Typhlopidae (blind snakes)				
Ramphotyphlops ammodytes		X		X
Ramphotyphlops grypus		X		X
Ramphotyphlops hamatus		X		X
Varanidae (goannas)				
Varanus acanthurus		X		
Varanus brevicauda	X			
Varanus eremius	X			
Varanus giganteus	X			
Varanus gouldii		X		
Varanus panoptes	X			
Varanus tristis	X			
Boidae (pythons)				
Antaresia perthensis		X		
Antaresia stimsoni		X		
Aspidites melanocephalus		X		
Colubridae (colubrid snakes)				
Fordonia leucobalia		X		
Elapidae (fanged snakes)				
Demansia psammophis	X			
Furina ornata		X		
Parasuta monachus		X		
Pseudechis australis		X		
Pseudonaja modesta		X		
Pseudonaja nuchalis		X		
Simoselaps anomalus		X		
Suta fasciata		X		
Suta punctata		X		
Hylidae (frogs)				
Cyclorana maini		X		
Litoria rubella		X		
Myobatrachidae (frogs)				
Neobatrachus aquilonius		X		
Notaden nichollsi		X		
Uperoleia russelli		X		

Source: RPS BBG 2006

Appendix 7 Barrow Island Terrestrial Invertebrate Summary

Appendix 7 Table 1: Barrow Island Terrestrial Invertebrate Summary

Identifications and taxonomy are to be resolved

Most likely Significant Ecological Elements are shaded in grey

(Groups most likely to contain short-range endemics)

Group	Number of Taxa	Comments
ARACHNIDA		
Acarina (Mites)	TBA	Awaiting results from taxonomist.
Acarina (Ticks)	3	One widespread on Barrow Island. Two collected opportunistically from animals.
Araneae (Spiders)	138	Represents 93 genera from 30 families
Pseudoscorpionida (Pseudoscorpions)	13	Yet to be completed but short-range endemic *Synsphyronus* sp nov. *"barrow"* recorded at 8 sites
Scorpionida (Scorpions)	TBA	Awaiting results from taxonomist.
CRUSTACEA		
Isopoda (Slaters)	TBA	Awaiting results from taxonomist.
INSECTA		
Apoidea (Bees)	5	Bee species may be territorial on Barrow Island. Distributions and numbers of species may also be limited by resources.
Blattodea (Cockroaches)	20	Many of these were unable to be placed to known species, or past family or subfamily level due to taxonomic difficulties, as well as the natural variation of many species. Specimens of significant taxonomic value, include an undescribed genus of the Blaberidae, and a member of the Polyphagidae, unable to be placed to genus.
Coleoptera (Beetles)	230	The majority of these taxa were unable to be identified beyond family and morphospecies level, although there were many known species also found. Many of the taxa represent undescribed species, and three new species including two new genera were confirmed from the 2006 survey.
Diptera (Flies)	91	Identified to family and morphospecies level. Pronounced seasonal effects. Variation between sites, but no geographic effects apparent, and vegetation and soil information did not reveal any patterns. Some ubiquitous species were found.
Diptera: Culicidae (Mosquitoes)	1	Unable to determine the identity of the specimen beyond family and morphospecies level.
Embiidina (Web-spinners)	1	*Aposthonia spinulosa* was recorded in 50% of sample sites on Barrow Island and has been collected in many areas of Western Australia.
Formicidae (Ants)	75	Some seasonal effects apparent and some geographical effects apparent but vegetation and soil type information did not reveal any patterns.
Heteroptera (Shield bugs, assassin bugs)	10	Data from 2006 yet to be received from taxonomist.
Homoptera (Cicadas)	5	Many highly mobile, wide-ranging species.
Homoptera (Plant hoppers, scale, mealybugs)	114	Pronounced seasonal effects. Extreme variation between sites and some geographical effects apparent, but no associations with vegetation and soil apparent. Many taxa considered highly common.
Hymenoptera (Wasps)	165	Extreme seasonal effects, but few geographical effects apparent. Vegetation information did not reveal any patterns though soil type might explain clumping of certain assemblages.

Group	Number of Taxa	Comments
Isoptera (Termites)	13	Particularly frequent were members of the Nasutiterminae, which are major grassland herbivores, such as the Spinifex termite *Nasutitermes triodia*e and *Tumilitermes hastili*s.
Lepidoptera (Butterflies and moths)	91	Only identified to morphotypes level. Noticeable seasonal variation.
Mantodea (Praying mantids)	8	Some of the species wide-ranging, highly mobile, common taxa, others more cryptic.
Neuroptera (Lacewings)	23	Distribution of species patchy and random for these highly mobile and wide-ranging insects. Current sampling may under-represent certain Europteran taxa, due to complex lifecycles.
Odonata (Dragonflies and Damselflies)	3	Generally wide-ranging, common taxa.
Orthoptera (Grasshoppers, Crickets, Katydids)	70	Many of the Gryllid and Gryllacridid taxa have been poorly studied in the Pilbara region.
Phasmatodea (Stick insects)	2	Both with patchy distributions and likely new species in the subfamily Lonchodinae.
Psocoptera (Booklice)	18	Several taxa of interest which are not common in Australia, and a probable complex of species in the genus Liposcelis (Species O), which may need further taxonomic work.
Thysanoptera (Thrips)	42	The majority of species are representatives of widespread tropical and subtropical genera.
Thysanura (Silverfish)	8	Many specimens represented under-collected or under-studied species.
MOLLUSCA		
Camaenidae and Pupillidae (Snails)	6	Distribution of the snail fauna was patchy across most sites, and did not appear to be highly influenced by season. Four are common to the Pilbara coast, and *Quistrachia barrowensis* being endemic to Barrow Island.
UNIRAMIA		
Collembola (Springtails)	29	High variation between sites, but no noticeable geographic or strong patterns relating to vegetation and soil. Extreme variability between seasons. Many ubiquitous species.
Myriapoda (Centipedes, Millipedes)	15	Most taxa caught in higher numbers during wet season.

Source: Majer, Callan, Graham, and Edwards, K. 2008

Appendix 8 Barrow Island Subterranean Fauna Inventory

Appendix 8 Table 1: Barrow Island Troglofauna Inventory

Significant Ecological Elements are shaded in grey

(all subterranean fauna part of DPaW listed Priority Ecological Community [PEC])

Troglobitic Species	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA) Listing	DPaW Listing	Short-range Endemic	Recorded in Gorgon Gas Development Footprint	Only Recorded within Gorgon Gas Development Footprint
Arachnida *Scorpiones* sp. *bramstokeri*			PEC	X		
Schizomida *Draculoides bramstokeri*		Schedule 1	PEC	X	X	
Isopoda *Oniscidea pseudopyrgoniscus dalens*			PEC	X		
Isopoda *Oniscidea Philosciidae* sp.			PEC	X		
Isopoda *Oniscidea* sp.			PEC	X		
Pseudoscorpionida *Tyrannochthonius garthhumphreysi*			PEC	X		
Pseudoscorpionida *Ideoblothrus nesotymbus*			PEC	X	X	
Spirobolida *Speleostrophus nesiotes*		Schedule 1	PEC	X	X	
Blattodea *Blattodea* sp. nov. 1			PEC	X	X	
Thysanura *Trinemura* sp. nov			PEC	X	X	
Symphyla Symphyla sp.			PEC	X	X	X
Araneae Gnaphosidae sp.			PEC	X		
Scolopendrida Cryptopidae sp.			PEC	X		

Source: Biota Environmental Sciences 2007, 2013

Appendix 8 Table 2: Barrow Island Stygofauna Inventory

Significant Ecological Elements are shaded in grey

(all subterranean fauna part of DPaW listed Priority Ecological Community [PEC])

Stygofauna	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA) Listing	DPaW Listing	Short-range Endemic	Recorded in Gorgon Gas Dev't Footprint	Only Recorded within Gorgon Gas Dev't Footprint
Cyclopoida *Allocyclops barrowi n.* sp. */ A. census*			PEC	X		
Cyclopoida *Halicyclops rochai*			PEC	X		
Cyclopoida *Halicyclops longifurcatus*			PEC	X		
Cyclopoida *Diacyclops* sp.			PEC	X		
Cyclopoida *Diacyclops* aff. *humphreysi*			PEC	X		
Cyclopoida *Diacyclops humphreysi unispinosus*			PEC	X		
Cyclopoida *Allocyclops consensus*			PEC	X		
Cyclopoida *species*			PEC	X		
Harpacticoida *Sarsameira* sp.			PEC	X		
Harpacticoida *Phyllopodopsyllus* sp. *1*			PEC	X		
Harpacticoida *Phyllopodopsyllus wellsi*			PEC	X		

Stygofauna	EPBC Act (Cth) Listing	*Wildlife Conservation Act 1950* (WA) Listing	DPaW Listing	Short-range Endemic	Recorded in Gorgon Gas Dev't Footprint	Only Recorded within Gorgon Gas Dev't Footprint
Harpacticoida *Phyllopodopsyllus thiebaudi*			PEC	X		
Harpacticoida *Inermipes humphreysi*			PEC	X		
Harpacticoida *Biameiropsis barrowensis*			PEC	X		
Harpacticoida *species*			PEC	X		
Ostracoda *Phlyctenophora mesembria*			PEC	X		
Bathynellacea *Notobathynella* sp. nov. 1			PEC	X	X	
Bathynellacea *Atopobathynella* sp. nov.			PEC	X		
Amphipoda *Nedsia sculptilis/macrosculptilis*		Schedule 1	PEC	X	X	
Amphipoda *Nedsia humphreysi*		Schedule 1	PEC	X		
Amphipoda *Nedsia straskraba*		Schedule 1	PEC	X		
Amphipoda *Nedsia fragilis*		Schedule 1	PEC	X		
Amphipoda *Nedsia hurlberti*		Schedule 1	PEC	X		
Amphipoda *Nedsia urifimbriata*		Schedule 1	PEC	X		
Amphipoda *Amphipoda* sp. 1			PEC	X	X	
Amphipoda ?*Bogidomma* sp. 1			PEC	X	X	X
Amphipoda *Melitidae unknown* sp. 1			PEC	X	X	X
Amphipoda unknown sp. 3			PEC	X		
Amphipoda *Liagoceradocus subthalassicus*			PEC	X		
Amphipoda *Bogidomma australis*			PEC	X		
Isopoda *Haptolana pholeta*			PEC	X	X	
Isopoda Sub Order Oniscoidea undescribed sp.			PEC	X		
Thermosbaenacea *Halosbaena tulki*			PEC	X	X	
Decapoda *Stygiocaris stylifera*			PEC	X	X	
Decapoda *Stygiocaris* sp.			PEC	X		
Haplotaxida Enchytraeidae sp.			PEC	X		
Copepoda *Calinoida* sp. nov. *1*			PEC	X		
Oligochaeta *Phreadrilidae*: sp. 1			PEC	X		
Oligochaeta *Enchytraeidae* sp.			PEC	X		
Eleotridae *Milyeringa justitia*	Vulnerable	Schedule 1	PEC	X	X	
Synbranchidae *Ophisternon candidum*	Vulnerable		PEC	X		
Harpacticoida *Ameiridae* sp.			PEC	X		
Amphipoda *Bogidella* sp.			PEC	X		
Nematoda sp. *1*			PEC	X		
Polychaeta sp. *1*			PEC	X		
Ostracoda *Pilbaracandona* sp. nov.			PEC	X	X	X

Source: Biota Environmental Sciences 2007, 2013

Appendix 9 Barrow Island Fossil Sites

Appendix 9 Table 1: Barrow Island Invertebrate Fossil Sites

Significant Ecological Elements are shaded in grey

(all listed invertebrate fossil sites considered to be Significant)

Site ID	Site Description
Cape Malouet	The site contains a diverse suite of echinoids and molluscs.
Ant Point	The fossil bed consists of well preserved but very brittle fossils enclosed in an exceedingly tough matrix.
Just south of Ant Point	The site contains better quality fossil molluscs.
Locality 3	This locality, near the northern end of Flacourt Bay, is of great scientific importance and should have the highest priority for preservation. This locality is a 'Type Section', which is a site chosen as representative of a geological formation.
Cape Poivre	McNamara and Kendrick (1994) called the Barrow Island limestone the Poivre Formation, after the Cape Poivre 'type section' on the west coast.

Appendix 9 Table 1: Barrow Island Vertebrate Fossil Sites

Significant Ecological Elements are shaded in grey

(all listed vertebrate fossil sites on Barrow Island considered to be Significant)

Site ID	Site Description
V1. Boggs Beach	A large red fill at the inland end of the low south-facing cliff of Miocene limestone on the northern side of Boggs Beach contains mammal bones. The fauna contains marsupials but no rodents. Combined with palaeomagnetic data, this suggests a Pliocene age for the deposit of at least four million years. Bones that are eroding out on the surface of the deposit have largely been collected.
V2. Boggs Beach north	A single jaw of a 'primitive' kangaroo and a few other small bones were collected in 1996 from a large red fill in the west coast just to the north of Boggs Beach. Those were the only bones visible. This deposit is also likely to be of Pliocene age.
V3. John Wayne Country sites	The caves and fissures developed within and at the base of the inland limestone cliffs, that have given this area its name, contain bones that range in age from over 10 000 to just hundreds or tens of years.
V3a. Doig sites	These sites were discovered by Peter Doig, a WAPET employee. A large mass of limestone has fallen from the John Wayne Country cliff, and in doing so has broken open fissures containing mammal bones accumulated probably by owls and/or kestrels that roosted and/or nested in the holes in the cliff. The bone material in the various fissure pockets ranges in age from very recent back to a time when Barrow Island was part of the mainland (due to lower sea level during an 'ice age'). This material includes two mammal species now extinct on Barrow Island. This material has largely been collected and deposited in the Western Australian Museum, and the sites are no longer vulnerable to interference.
V3b. John Wayne Country caves	Several of the caves along the base of the John Wayne Country cliffs contain deposits with bones within them and on their surfaces. These deposits have the potential to be excavated to discover the recent environmental history of Barrow Island.
V4. "Wet Cave"	The location of this cave is not confirmed. It is a fairly typical cave, with stalactite/stalagmite columns, and wet sediment, if not standing water, in the bottom. There is some bone material in mineralised deposits in this cave. This site is probably is vulnerable to disturbance and damage.
V5. Boodie Cave	There is a large cave near the west coast just south of Y block, which had a Boodie colony living in it in 1996. This means that the deposit in the cave has been turned over by their burrowing activities and is therefore probably useless for environmental interpretation. There is, however, speleothem (stalactite) material on the wall, which could be sampled to obtain palaeo-environmental data.

Site ID	Site Description
V6. Y Block sites	A series of sites containing fossil mammal bones was discovered on the west coast of Y Block near Cape Malouet during the 1990s. The first sites found were given numbers in order of discovery, but once the complexity of the sites became apparent this orderly system broke down. This problem was exacerbated by the fact that the last two sites (which contained the most interesting fauna, and were nicknamed "bone city") were discovered during the filming of an ABC television series on Australian islands in 1999, but time to collect material was very limited.
Y1.	A red fill in the top of the cliff at the end of a track leading to a fishing spot on the west coast, south of Cape Malouet. A considerable amount of the red fill was excavated stratigraphically. The mammal material prepared from this contains only a few, mainly small species, suggesting that it was accumulated (probably by ghost bats) when Barrow was already an island. It is probably early Pleistocene in age. This site may equate with Locality 2 of McNamara and Kendrick (1994).
Y2.	The first red fill found in a vertical cliff face in a complex collapsed karst doline, between Y1 and Cape Malouet. This large feature is described in more detail below in the Y+ row of this table.
Y3.	One of a series of masses of wind-blown sand rock that drape the cliffs of the west coast of Barrow Island, this lies immediately to the north of Y1, and is unique in containing a few fossil mammal bones. The bones, including two fairly complete skulls, are particularly well preserved, but the matrix is very hard, making it extremely difficult to extract them. The deposit is estimated to be early Pleistocene in age. It was probably laid down under conditions of relatively low sea level when there was an extensive sand sheet to the west of the present Barrow Island, to provide a source of the wind-blown sand.
Y4.	Another red fill, lying to the north of, and vertically beneath, the Y3 sand rock (i.e. further down the same cliff face). It is not clear whether this is separate from Y1, or a continuation of the same very large red fill. Its fauna has not yet been investigated in detail, but it is likely to be of about the same age as Y1.
Y+. The doline	Between points to the north of Y1 and south of Cape Malouet, the top of the cliff forms an arc running inland. It is possible to descend the cliff face at this point. Work by Aplin, Baynes and particularly Chappell, has shown that this area is the remains of a collapse doline (a depression resulting from the collapse of the roof of a cave beneath). It was formerly a cave nearly as deep as the height of the present cliff. It has a long and complex history, and several important deposits have formed in the cave over hundreds of thousands or even millions of years. At some time in the past, probably in the Early Pleistocene, the western wall of the cave was breached by the sea coast and considerable erosion has occurred since. There are, however, remains of several deposits of differing ages in the doline complex, of which Y2 was just the first to be recognised. However, because it is difficult, time-consuming, and potentially dangerous, clambering around among boulders and limestone blocks that vary in size from a small car to a house, it took several visits to discover the full range of deposits in the area. In particular, there is a series of cave breccias (rock fragments cemented with calcium carbonate), interbedded with flowestones (flat speleothem), that contain bone, and outcrop at sea level at the southern end of the exposure in the cliff face. There are also the ‘bone city’ red fill deposits in fissures in the Miocene limestone, exposed on a wave-cut bench towards the northern end of the doline complex. Remains of mammals, particularly rodents, that have been prepared from these deposits come from species that are extinct (i.e. not known in any modern rodent fauna from anywhere in Australia), indicating a late Pliocene to early Pleistocene age for the deposits (roughly two million years). The fauna are diverse, indicating that Barrow was part of the mainland when they were living. These deposits also require a hammer and chisel to break them up, so are relatively safe from disturbance other than by machinery.

Source: Baynes pers. comm. 2008

Appendix 10 Definitions Used in Risk Assessment

Appendix 10 Table 1: Likelihood Definitions

Likelihood Category	Description
Almost Certain	Very likely to occur on an annual basis. Includes planned activities. Socioeconomic description includes the period during construction.
Likely	Likely to occur more than once during the lifetime of the proposed Development.
Possible	May occur within the life of the proposed Development.
Unlikely	Not likely to occur within the life of the proposed Development.
Remote	Highly unlikely and unheard of in industry, but theoretically possible.

Appendix 10 Table 2: Terrestrial Fauna Consequence Definitions

	Minor	Moderate	Serious	Major	Critical
Protected fauna species – Individual effects	Local, short-term behavioural impact	Local, long-term or widespread, short-term behavioural impact	Widespread, long-term behavioural impact		
Protected fauna species – Population level effects	Local, short-term decrease in abundance No lasting effects on local population	Local, long-term or widespread, short-term decrease in abundance Loss of small number of individuals without reduction in local population viability	Local, long-term or widespread, short-term decrease in abundance Loss of individuals leads to reduction in viability of local population No reduction in viability on Barrow Island	Local, long-term or widespread, short-term impact leads to loss of local populations and reduced viability of the race on Barrow Island	Widespread, long-term impact on population Extinction of Barrow Island race
General fauna – Individual effects	Local, long-term or widespread, short-term behavioural impact	Widespread, long-term behavioural impact			
General fauna – Population level effects	Local, long-term or widespread, short-term decrease in abundance Loss of small number of individuals without reduction in local population viability	Local, long-term or widespread, short-term decrease in abundance Loss of individuals leads to reduction in viability of local population No reduction in viability of race on Barrow Island	Local, long-term or widespread, short-term impact leads to loss of local populations and reduced viability on Barrow Island	Widespread, long-term impact on population Extinction on Barrow Island	Loss from immediate region

Appendix 10 Table 3: Flora and Vegetation Communities Consequence Definitions

	Minor	Moderate	Serious	Major	Critical
Protected flora species – Impact on species or community	Local and short-term decrease in abundance of flora or impact on community structure Sublethal physiological impacts	Widespread, short-term or local, long-term decrease in abundance of flora or impact on community structure	Widespread, short-term or local, long-term decrease in abundance of flora or impact on community structure	Widespread and long-term decrease in abundance of flora or impact on community structure	Widespread and long-term decrease in abundance of flora or impact on community structure
Protected flora species – Loss of species or community		No reduction in community/ taxon viability in local area	Reduced viability of community or taxon in local area, no reduction in viability on Barrow Island	Reduced viability of taxon or community on Barrow Island	Extinction on Barrow Island, or reduced viability in the immediate region
General flora – Impact on species or community	Widespread, short-term or local, long-term decrease in abundance of flora or impact on community structure Sublethal to lethal physiological impacts	Widespread, short-term or local, long-term decrease in abundance of flora or impact on community structure	Widespread and long-term decrease in abundance of flora or impact on community structure	Widespread and long-term decrease in abundance of flora or impact on community structure	Widespread and long-term decrease in abundance of flora or impact on community structure
General flora – Loss of species or community	No reduction in community/taxon viability in local area	Reduced viability of community or taxon in local area, no reduction in viability on Barrow Island	Reduced viability of taxon or community on Barrow Island	Extinction on Barrow Island, or reduced viability in the immediate region	Extinction in immediate region

Appendix 10 Table 4: Soils and Landforms, Water Quality and Air Quality Consequence Definitions

	Minor	Moderate	Serious	Major	Critical
Soils and Landforms	Local contamination that can be readily remediated Negligible impact on soil characteristics Local and minor change in recharge patterns within subcatchments Disturbance of well-represented landform habitats	Local contamination requiring a long-term remediation effort Local, short-term change in soil characteristics Local and major change in recharge patterns within subcatchments Widespread and minor changes in recharge	Local contamination that cannot be readily remediated Local, long-term, or widespread, short-term change in soil characteristics Major, widespread changes in subcatchment recharge patterns Widespread loss	Widespread contamination requiring a significant long-term remediation effort Widespread, long-term change in soil characteristics Minor changes in regional recharge patterns Widespread loss of a unique landform habitat	Widespread contamination that cannot be readily remediated Major changes in regional recharge patterns Regional loss of a unique landform habitat

	Minor	Moderate	Serious	Major	Critical
		patterns Local loss of well-represented landform habitats	of well-represented landform habitats Local loss of a unique landform habitat		
Water Quality (surface and groundwater)	Local, short-term and minor reduction in water quality	Minor reduction in water quality which is widespread, short-term or local, long-term Major reduction in water quality which is local, short-term	Widespread, long-term reduction in water quality	Regional, short-term reduction in water quality	Regional, long-term reduction in water quality
Air Quality	Local, short-term and minor exceedance of standards	Minor exceedance of standards that is widespread, short-term or local, long-term Major exceedance of standards which is local, short-term	Widespread, long-term exceedance of standards	Regional, short-term change in air quality	Regional, long-term change in air quality

Appendix 11 Review of Qualitative Risk Assessment

Note: The tables below include the risk assessment required in respect of the matters of NES listed in this Report, as required by EPBC Reference: 2003/1294 and 2008/4178.

Appendix 11 Table 1: Soil and Landform

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Clearing and Earthworks	Construction and commissioning	ALMOST CERTAIN	MODERATE	MEDIUM	MEDIUM Risk unchanged Permanent impacts to soil and landforms in areas of land use. Local loss of well-represented landform and local and major change in recharge pattern in subcatchment at Gorgon Gas Development site.
Clearing and Earthworks	Operations	LIKELY	MINOR	LOW	LOW Risk unchanged Limited clearing during operations
Liquid and Solid Waste Disposal	Construction and commissioning	LIKELY Assumed greywater used for dust suppression, all other liquid wastes disposed of into deep injection wells. Solids disposed of on mainland except concrete which may be used in deep gravel pit rehabilitation.	MODERATE	MEDIUM	MEDIUM Risk unchanged
Liquid and Solid Waste Disposal	Operations	POSSIBLE	MINOR	LOW	LOW Risk unchanged
Leaks or Spills	Construction and commissioning	LIKELY	MODERATE	MEDIUM	MEDIUM Risk unchanged Conservative assumptions used in that spill or leak that would have moderate impact is likely to occur.
Leaks or Spills	Operations	UNLIKELY	SERIOUS	MEDIUM	MEDIUM Risk unchanged

Appendix 11 Table 2: Surface and Groundwater

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Clearing and Earthworks	Construction and commissioning	LIKELY	MODERATE Assumed short-term impact on surface water quality	MEDIUM	MEDIUM Risk unchanged
Clearing and Earthworks	Operations	POSSIBLE	MINOR	LOW	LOW Risk unchanged
Physical Presence	Construction and commissioning	POSSIBLE	MODERATE Assumed short-term impact on surface water quality	MEDIUM	MEDIUM Risk unchanged
Physical Presence	Operations	POSSIBLE	MODERATE	MEDIUM	MEDIUM Risk unchanged
Liquid and Solid Waste Disposal	Construction and commissioning	POSSIBLE	MODERATE Impacts from storing, handling and deep well injection of liquid wastes	MEDIUM	LOW All solid wastes disposed of on mainland and handled through Quarantine Management System
Liquid and Solid Waste Disposal	Operations	POSSIBLE	MINOR	LOW	LOW Risk unchanged
Leaks or Spills	Construction and commissioning	LIKELY	MODERATE	MEDIUM	MEDIUM Risk unchanged
Leaks or Spills	Operations	UNLIKELY	SERIOUS	MEDIUM	MEDIUM Risk unchanged

Appendix 11 Table 3: Air Quality

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Atmospheric Emissions	Construction and commissioning	LIKELY Emissions from vehicle and equipment exhaust (NO_x, SO_x)	MINOR Local, short-term and minor exceedance of standards	LOW	LOW Risk unchanged
Atmospheric Emissions	Operations	LIKELY Combustion and fugitive emissions of SO_2, NO_x, CO_2, CO, CH_4, VOCs and particulates. Emissions from vehicle and equipment exhaust	MINOR Local, short-term and minor exceedance of standards	LOW	LOW Risk unchanged
Atmospheric Emissions	Non-routine operations	UNLIKELY	MINOR Local, short-term and minor exceedance of standards	LOW	LOW Risk unchanged
Clearing and Earthworks	Construction and commissioning	ALMOST CERTAIN Dust generation associated with clearing and earthworks, and vehicles	MINOR	LOW	LOW Risk unchanged
Clearing and Earthworks	Operations	LIKELY Dust generation associated with clearing and earthworks, and vehicles	MINOR	LOW	LOW Risk unchanged

Appendix 11 Table 4: Flora and Vegetation Communities

Stressor	Timing	Receptor	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Clearing and Earthworks	Construction and commissioning	Restricted Flora and Vegetation	ALMOST CERTAIN Restricted flora and communities will be avoided where possible, but both pipeline options impact on restricted communities.	SERIOUS Due to local, long-term loss of restricted communities at North Whites Beach	HIGH	HIGH Risk unchanged Community at North Whites Beach not considered restricted but other restricted communities occur in Gorgon Gas Development Footprint
Clearing and Earthworks	Construction and commissioning	General Flora and Vegetation	ALMOST CERTAIN Up to 332 ha (cumulative – proposed and possible future development) of general communities will be cleared for infrastructure.	MINOR Local, long-term reduction in the extent of general communities. No effect on viability of local populations.	LOW	LOW Risk unchanged
Clearing and Earthworks	Operations	Restricted Flora and Vegetation	UNLIKELY Disturbance to restricted communities will be avoided.	MINOR Local, long-term loss of restricted community. No effects on long-term survival.	LOW	LOW Risk unchanged Limited clearing during operations
Clearing and Earthworks	Operations	General Flora and Vegetation	POSSIBLE Clearing will be restricted to previously cleared areas, but some areas may have regrown.	MINOR Localised loss of general flora.	LOW	LOW Risk unchanged Limited clearing during operations
Fire	Construction and commissioning	All Flora	POSSIBLE Fire may burn large area and only be controlled near installations.	SERIOUS Potential for local, but long-term decrease in restricted community, may have long-term effect on community composition of restricted or general communities.	MEDIUM	MEDIUM Risk unchanged
Fire	Operations	All Flora	POSSIBLE As above, potential ignition sources throughout life of facility, but natural fires permitted to take their course.	SERIOUS As above.	MEDIUM	MEDIUM Risk unchanged
Atmospheric Emissions	Construction and commissioning	All Flora	UNLIKELY	MINOR Possible local and short term physiological effects on vegetation.	LOW	LOW Risk unchanged
Atmospheric Emissions	Operations	All Flora	LIKELY	MINOR Possible localised, long-term changes in general community composition.	LOW	LOW Risk unchanged

Stressor	Timing	Receptor	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Atmospheric Emissions	Non-routine operations	All Flora	UNLIKELY	MINOR Due to localised and short-term physiological effects on vegetation around emission source.	LOW	LOW Risk unchanged
Light/ Shading/ Heat/ Cold	Construction and commissioning	All Flora	LIKELY	MINOR Due to localised physiological effects, e.g. growth rates.	LOW	LOW Risk unchanged
Light/ Shading/ Heat/ Cold	Operations	All Flora	LIKELY	MINOR Localised effects on regrowth under pipelines, long-term change in general community composition.	LOW	LOW Risk unchanged Above-ground pipeline scenario assumed in Draft EIS/ERMP assessment. Below-ground option will be implemented which will decrease impact from permanent above-ground infrastructure but risk is already lowest category
Dust	Construction and commissioning	All Flora	ALMOST CERTAIN Creation of dust is unavoidable during earthworks and use of unsealed roads.	MINOR Limited to possible short-term decrease in growth rates of dust affected plants.	LOW	LOW Risk unchanged
Dust	Operations	All Flora	ALMOST CERTAIN Will be a continuing aspect of use of unsealed areas.	MINOR Dust levels low and effects limited to decreased growth rate of plants adjacent roads.	LOW	LOW Risk unchanged
Unpredicted CO_2 Migration (and release at ground surface)	Non-routine operations	All Flora	REMOTE	MODERATE Potential for localised long term effects on restricted vegetation in the vicinity of an ongoing leak.	LOW	LOW Risk unchanged
Leaks or Spills	Construction and commissioning	All Flora	UNLIKELY	MINOR Potential localised, long-term change in composition of restricted communities at leak site.	LOW	LOW Risk unchanged
Leaks or Spills	Operations	All Flora	UNLIKELY	MINOR Potential localised, long-term change in composition of restricted communities at leak site.	LOW	LOW Risk unchanged

Appendix 11 Table 5: Terrestrial Fauna

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Clearing and Earthworks	Construction and commissioning	ALMOST CERTAIN Clearing and earthworks planned and necessary for construction.	MODERATE On Barrow Island due to localised, long-term reduction of populations of listed fauna (Burrowing Bettongs, Barrow Island Euros, Spectacled Hare-wallabies, Chestnut Mice, Barrow Island Golden Bandicoots, White-winged Fairy-wrens (Barrow Island)) and rare invertebrates (*Urodacus* scorpion and pseudoscorpion). All fauna in secure populations on Barrow Island. General Fauna – scorpion and pseudoscorpion only known from vicinity of Gorgon Gas Development site. No critical habitats for any listed fauna within the proposed Development areas	MEDIUM	MEDIUM Risk unchanged for Listed Fauna Risk based on only on General Fauna would be reduced to LOW as consequence to reduced to minor as all terrestrial SREs now confirmed well-distributed outside Gorgon Gas Development Footprint
Clearing and Earthworks	Operations	UNLIKELY Clearing and earthworks will be minimal during operations and important fauna habitats will be avoided.	MINOR As above.	LOW	LOW Risk unchanged. Limited clearing during operations
Physical Interaction	Construction and commissioning	ALMOST CERTAIN Several roadkills of listed fauna (Burrowing Bettongs, Spectacled Hare-wallabies, Bandicoots, Euros, Chestnut Mice, White-winged Fairy-wrens (Barrow Island)) are expected each year in the vicinity of the gas processing facility and accommodation. No Rock Wallaby mortalities expected due to avoidance of their habitats in route selection.	MODERATE Localised, ongoing reduction in local abundance due to occasional mortality of listed species along roads in the vicinity of facilities without threatening population viability in local area.	MEDIUM	MEDIUM Risk unchanged Based on Listed Fauna (risk to General Fauna remains as LOW due to consequence remaining minor). Above-ground pipeline scenario assumed in Draft EIS/ERMP assessment. Below-ground option will be implemented which will increase impact from trenching but does not change risk as largely determined by vehicle strikes

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Physical Interaction	Operation	ALMOST CERTAIN As above, frequency of roadkills will decrease, but persist for the operational phase of the Development.	MODERATE	MEDIUM	MEDIUM Risk unchanged, which is based on Listed Fauna (risk to General Fauna remains as LOW due to consequence remaining minor). Above ground pipeline scenario assumed in Draft EIS/ERMP assessment. Below ground option will be implemented which will decrease impact from permanent aboveground infrastructure but does not change risk as largely determined by vehicle strikes
Leaks or Spills	Construction and commissioning: Non-routine operations	UNLIKELY Due to prevention and clean-up procedures.	MODERATE Potential worst case is localised, long-term decrease in the abundance of listed fauna due to irremediable contamination affecting habitat. No effect on viability of local population. Burrowing fauna, e.g. Burrowing Bettong, at most risk due to long-term effects of spill on underground burrows. No risk of spill effects on Rock Wallabies.	LOW	LOW Risk unchanged
Leaks or Spills	Operations: Non-routine operations	UNLIKELY Due to prevention and clean-up procedures.	MODERATE	LOW	LOW Risk unchanged
Light or Shade	Construction and commissioning	ALMOST CERTAIN Restricted areas of light and shading will be an unavoidable aspect of construction.	MINOR Short-term and localised reduction in general fauna abundance through increased predation, e.g. by Silver Gulls. Only minor impacts on listed fauna.	LOW	LOW Risk unchanged Note that seabirds are considered in risk assessment under Marine Environment in Draft EIS/ERMP
Light or Shade	Operations	ALMOST CERTAIN Gas processing facility will be lit, facilities will create shade.	MINOR Long-term and localised reduction in general fauna through increased predation, e.g. by Silver Gulls. Long-term behavioural changes in shade-seeking listed fauna, e.g. Euros resting under pipelines. Possible long-term behavioural changes in listed fauna (Bandicoots, Hare-wallabies, Bettongs) attracted to light pool.	LOW	LOW Risk unchanged Note that seabirds are considered in risk assessment under Marine Environment in Draft EIS/ERMP

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Light or Shade	Operations: Non-routine operations	POSSIBLE Emergency flaring is expected, but will rarely affect fauna.	MINOR As above	LOW	LOW Risk unchanged Note that seabirds are considered in risk assessment under Marine Environment in Draft EIS/ERMP
Atmospheric Emissions	Construction and commissioning	UNLIKELY Due to rapid dilution of emissions.	MINOR Negligible effects abundance of fauna from vehicle emissions.	LOW	LOW Risk unchanged
Atmospheric Emissions	Operations	POSSIBLE During periods of low rainfall, low wind and high humidity	MODERATE Potential localised, long-term reduction in abundance of listed fauna (Bettongs, Bandicoots, Hare-wallabies, Chestnut Mice, Euros, White-winged Fairy-wrens (Barrow Island)) if productivity of system is reduced through emission effects on vegetation near facilities.	LOW	LOW Risk unchanged
Atmospheric Emissions	Non-routine operations	UNLIKELY Dependent on right climatic conditions at time of leak.	MODERATE Release of large volume of toxic or asphyxiant gas may cause localised, short-term decrease in abundance of listed species (Bettongs, Bandicoots, Hare-wallabies, Chestnut Mice, Euros, White-winged Fairy-wrens (Barrow Island)).	LOW	LOW Risk unchanged
Dust	Construction and commissioning	ALMOST CERTAIN Clearing and use of unsealed roads will generate dust that will settle on roadside vegetation.	MINOR Dust will have negligible effects on listed and non-listed fauna.	LOW	LOW Risk unchanged
Dust	Operations	ALMOST CERTAIN As above, but sealed roads will reduce exposure of fauna.	MINOR As above.	LOW	LOW Risk unchanged
Unpredicted CO_2 Migration or Release	Non routine operations	REMOTE Low probability of leak coupled with low probability of leaking CO_2 affecting listed species, such as Burrowing Bettongs in their warrens, due to rapid dilution of plume by wind.	SERIOUS Potential for localised and long-term decrease in the abundance of listed fauna in the event of an ongoing leak in the vicinity of an active Burrowing Bettong warren or other low-lying fauna habitats. Possible decrease in viability of local populations of Bettongs, Bandicoots and the Chestnut Mouse.	LOW	LOW Risk unchanged

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Heat and/or Cold	Construction and commissioning	UNLIKELY Low probability that individual birds or bats may be injured by flaring during commissioning. Listed White-winged Fairy-wrens (Barrow Island)unlikely to venture as high as flare and will not be affected.	MINOR Localised and short-term decrease in abundance of unlisted species. No effects on viability of local population.	LOW	LOW Risk unchanged Note that seabirds are considered in risk assessment under Marine Environment in Draft EIS/ERMP
Heat and/or Cold	Operations	LIKELY Small reptiles and invertebrates attracted to Gorgon Gas Development will perish in hazardous areas, other larger fauna, including Euros, Bettongs, Bandicoots, Hare-wallabies, Chestnut Mice may seek water under feed gas pipeline.	MINOR Localised, long-term behavioural changes in listed fauna, potential small decrease in abundance of unlisted fauna. No effects on viability of local populations. No adverse impacts on listed species.	LOW	LOW Risk unchanged Above-ground pipeline scenario assumed in Draft EIS/ERMP assessment. Below-ground option will be implemented which will ensure water from dew will be available from Feed Gas Pipeline but does not change risk as largely determined by attractiveness of heat at Gorgon Gas Development
Noise and Vibration	Construction and commissioning	POSSIBLE Unlikely to occur but may occur during the life of the Development.	MODERATE Short-term impact in local area with no lasting effects to local population viability in Listed species	LOW	MEDIUM Risk increased. Likelihood is ‘almost certain’ from earthworks and consequence remains moderate with the Listed Fauna species White-winged Fairy-wrens (Barrow Island)identified as key receptor in this Report.
Noise and Vibration	Operations	LIKELY Noise from infrequent, planned flaring will affect fauna in local area.	MODERATE Impacts of noise from flaring will cause localised, short-term behavioural responses in listed species	MEDIUM	MEDIUM Risk unchanged
Fire	Construction and commissioning	UNLIKELY That a fire will be started by activities associated with the Development and cannot be controlled.	SERIOUS Potential short-term but widespread decrease in the abundance of listed fauna in areas of fast burn. Potential localised, long-term loss of listed fauna leading to reduction of local population viability in areas of intense burn. Effects similar to natural fires to which the fauna and general ecosystem resilient.	MEDIUM	MEDIUM Risk unchanged
Fire	Operations	UNLIKELY as above	SERIOUS as above	MEDIUM	MEDIUM Risk unchanged

Appendix 11 Table 6: Subterranean Fauna

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Clearing and Earthworks	Construction and commissioning	ALMOST CERTAIN	SERIOUS TO SEVERE Assumes worst-case scenario of Listed Troglofauna restricted to Gorgon Gas Development site	HIGH	MEDIUM Risk reduced Consequence reduced to Moderate as likely that no listed species restricted to Gorgon Gas Development site
Clearing and Earthworks	Operation	ALMOST CERTAIN	MINOR	LOW	LOW Risk unchanged Limited clearing and earthworks during operation
Wastewater Discharge	Construction and commissioning	ALMOST CERTAIN Assumes that treated greywater will be used for dust suppression	SERIOUS TO MAJOR	HIGH	LOW Risk reduced Consequence reduced to Moderate as likely that no listed species restricted to Gorgon Gas Development site
Noise and Vibration	Construction and commissioning	ALMOST CERTAIN Assumes 40–60% of Gorgon Gas Development site will require shallow blasting of caprock and installation of approximately 750 piles to depths of approximately 32 m.	SERIOUS Assumes that Listed subterranean fauna species are restricted to Gorgon Gas Development site.	HIGH	MEDIUM Risk reduced Consequence reduced to Moderate as likely that no listed species restricted to Gorgon Gas Development site
Leaks or Spills	Non-routine Operations	UNLIKELY	SERIOUS TO MAJOR	MEDIUM	MEDIUM Risk unchanged Conservative assumptions used in that contaminants disperse widely through aquifer
Unpredicted CO_2 migration	Non-routine Operations	REMOTE	CRITICAL	MEDIUM	LOW Risk reduced Consequence reduced to Moderate as likely that no listed species restricted to Gorgon Gas Development site

Stressor	Timing	Likelihood in Draft EIS/ERMP	Consequence in Draft EIS/ERMP	Risk in Draft EIS/ERMP	Reassessed Risk
Physical Presence	Operations	LIKELY	SERIOUS TO MAJOR	HIGH	MEDIUM Risk reduced No groundwater abstraction will occur as previously assumed. Likely that no Listed stygofauna restricted to Gorgon Gas Development site. Likely that no net change in watertable level as aquifer has been documented across Barrow Island

Appendix 12 Identification and Risk Assessment of Terrestrial Matters of National Environmental Significance (NES)